Changing Interactions between Humans and Nature in Sarayaku, Ecuadorian Amazon

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Abstract

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Increasing scarcity of natural resources is currently of serious concern for many people in the community of Sarayaku. In this thesis, a combination of participatory research, ecological modelling, GIS, and economic experiments was used to identify and examine problems regarding natural resource use in the community.

The study showed that the interactions between humans and nature in the area have undergone significant changes during the last four or five centuries, related to changes in population density, settlement pattern, and technology. The community is only partly integrated in the cash economy, and most food is locally produced. Wild game and fish are important sources of dietary protein and fat. Fields and fallows make up about 4% of the area, whereas the rest is dominated by old-growth forest. Near the village fallows dominate the landscape, and the distance from settlements to old-growth forest has increased. Several major game species are severely depleted, particularly in the vicinity of the village. The problem of game depletion can partly be explained as a "tragedy of the commons", i.e. the result of uncoordinated resource withdrawal by a large number of appropriators, in which each one behaves in a self-interested manner. However, unawareness of the impact of hunting on game populations has also been a contributing cause.

The community has long had some capacity for managing resources in a coordinated way, as shown by the existence of rules for how to harvest palm leaves for thatch. During recent decades, the community has created a democratic consensus-based community organization that has developed into a local government. Increasingly, this organization is dealing with regulating natural resource use, in order to solve conflicts and improve sustainability of resource use. Oil development threatens to damage the environment and undermine the local democracy. If this can be avoided, however, improving the sustainability of resource use is an achievable goal.

Keywords: Hunting, land use, natural resource management, environmental history, livelihoods, common property resources, experimental economics, indigenous people, participatory research, sustainability

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Resumen

Cambiante interacción entre la población humana y la naturaleza en Sarayaku, Amazonía Ecuatoriana

Antecedentes e introducción (Capítulo 1)

A primera vista, Sarayaku parece un paraíso. El viaje hasta la llamada frontera de la colonización desde el aeropuerto de la base militar de Shell, demora unos once minutos en una avioneta de cinco pasajeros. Desde ahí hasta Sarayaku restan doce minutos de viaje y todo lo que uno ve desde arriba es la selva verde, exuberante. Llegando al pueblo, uno encuentra que sus habitantes viven en lindas casas ovaladas hechas de materiales locales. La gente ríe mucho, parece feliz y de buena salud. Uno puede pensar que esto es un ejemplo poco común de gente que logra vivir de una manera sostenible, sin destruir la naturaleza.

Sin embargo, observando las cosas de cerca, se aprecia que Sarayaku está pasando en la actualidad por varias crisis. Importantes recursos naturales comienzan a escasear. Los habitantes están preocupados por la disminuición de los animales de caza. Hay asimismo una disminución, aunque menos drástica, en la abundancia de peces. También la tierra para cultivos se hace cada vez más escasa, sobretodo en la cercanía de los asentamientos humanos, obligando a los cultivadores a reducir los períodos de barbecho, lo que aumenta en su turno la maleza y las plagas, disminuyendo también la productividad. En resumen, cada vez cuesta mas esfuerzo conseguir el alimento. Mientras tanto, aumentan los contactos con el mundo exterior, lo que causa una creciente necesidad de dinero, a la vez de que hay pocas opciones de actividades generadoras de ingreso monetario. En vista de estos problemas, los habitantes de Sarayaku quieren encontrar una manera para lograr un desarrollo económico que mejore las condiciones materiales de vida de la comunidad, manteniendo al mismo tiempo, el medio ambiente selvático que ha llegado a ser parte de su identidad cultural.

El agotamiento de los recursos naturales no es un problema únicamente para la economía local de Sarayaku, sino que también afecta la biodiversidad y funciones ecológicas de una parte de la selva tropical más grande del mundo: la Amazonía. Esta disertación está basada en una preocupación tanto por la economía del pueblo de Sarayaku como por el medio ambiente natural. Su enfoque se concentra, por ende, en la interacción de la población humana con el medio ambiente natural. Las principales preguntas de la investigación son las siguientes:

1. Cómo afecta la explotación humana la base de los recursos?
2. Cómo afecta el estado de la base de los recursos el sustento de los pobladores locales?
3. Cómo influyen las características de la comunidad bajo estudio la manera de explotar los recursos naturales?

Estas preguntas fueron estudiadas particularmente para el caso de la agricultura y la caza, desde una perspectiva de variación en el tiempo y en el espacio. La dimensión espacial fue importante porque diferentes partes del territorio de Sarayaku están sujetas a diferentes tipos e intensidades de explotación. La dimensión temporal fue importante porque entendiendo el pasado, y conociendo a la vez la actual taza y dirección de los cambios, se puede hacer una evaluación de los desafíos que la comunidad tendrá que enfrentar en el futuro.

El agotamiento de los recursos naturales puede afectar tanto el sustento de los pobladores locales como la biodiversidad y el estado de los ecosistemas. La discusión de este problema está, en consecuencia, estrechamente relacionada con otros dos temas. Uno es la cuestión de los pueblos indígenas y el desarrollo; el otro es la cuestión de los pueblos indígenas y la conservación de la naturaleza.

Durante los últimos quinientos años, el desarrollo económico en la Amazonía ha sido predominantemente por y para gente de otras regiones. Los indígenas han sacado algunos beneficios, tal como el acceso a tecnología como herramientas de metal y armas de fuego y, últimamente, también a algunos servicios gubernamentales, pero la población ha sido generalmente aprovechada como fuerza de trabajo, por agentes foráneos, bajo condiciones poco favorables. Durante las recientes décadas han perdido también grandes extensiones de tierra por la invasión de colonos. La superioridad tecnológica de los foráneos en combinación con conflictos internos y falta de coordinación entre los indígenas, los ha hecho vulnerables a los abusos. En las últimas décadas, esta situación ha cambiado en alguna medida ya que los pueblos indígenas se han organizado y han logrado fortalecer su posición dentro de la sociedad nacional.

Investigadores y conservacionistas han estado involucrados en un debate intenso sobre la relación entre los pueblos indígenas y la conservación. Como evidencia del carácter benigno para la naturaleza de los pueblos indígenas, algunos autores mencionan el buen estado general de conservación de las áreas habitadas por ellos, los efectos presuntamente benignos de su manejo del medio ambiente, la existencia de tabúes y éticas tradicionales de conservación, así como sus luchas políticas para proteger sus tierras de la usurpación por parte de los afuerinos. Otros autores, en cambio, han mostrado como los pueblos indígenas han agotado los recursos naturales, particularmente los animales de caza y, en algunos casos, la madera. Basándose en tales observaciones, algunos autores sostienen que el buen estado de conservación en áreas habitadas por pueblos indígenas no implica que ellos sean más conservacionistas que otros agentes sociales. Estos autores sostienen que dicho estado de cosas es más bien resultado de la baja densidad poblacional y de la falta de acceso a la tecnología moderna.

En general, los académicos que han estudiado cuestiones relacionadas al desarrollo en la Amazonía han tratado de producir resultados relevantes para los gobiernos. En cambio, ha habido pocas investigaciones dirigidas a producir resultados relevantes para las comunidades indígenas en sí. Las investigaciones sobre el uso de los recursos naturales por parte de los pueblos indígenas han cambiado con el tiempo. Primero se enfocaban en describir, luego en explicar y, últimamente, en algunos casos, en comprender con el explícito propósito de mejorar.

Sarayaku: la comunidad y su territorio (Capítulo 2)

La comunidad de Sarayaku está ubicada en las orillas del Río Bobonaza, aproximadamente a 400 m. s. n. m., en la Amazonía Ecuatoriana, a 90 kilómetros al este del pie de la Cordillera de los Andes. La comunidad está rodeada por un paisaje escarpado dominado por una selva tropical lluviosa de antiguo crecimiento. La población basa su sustento en la agricultura, la caza, y la pesca. Mientras que desde los años 70, la colonización agraria y la explotación petrolera significaron drásticos cambios en otras partes de la Amazonía Ecuatoriana, la provincia de Pastaza, donde se encuentra Sarayaku, se ha visto mucho menos afectada.

La comunidad está constituida por cinco aldeas y tiene casi mil habitantes de nacionalidad Kichwa. La comunidad está bien organizada, y celebra regularmente asambleas comunitarias para tomar decisiones de manera consensual. Entre las asambleas, un Consejo de Gobierno está encargado de los asuntos comunitarios. La comunidad también ha tenido un papel activo en el movimiento indígena, en el ámbito provincial y nacional. No menos importante, la comunidad participó en la marcha de 240 kilómetros a la capital nacional en 1992 para exigir el reconocimiento legal de sus derechos a la propiedad de la tierra.

Antes del inicio de esta investigación, ya estaba en marcha un debate en la comunidad sobre el aparente agotamiento de los recursos naturales, y sobre las posibles medidas para cambiar esta tendencia. La comunidad estaba interesada en aprender más sobre el problema y es dentro de este contexto que la comunidad adoptó la presente investigación como un proyecto comunitario.

Proceso de investigación y métodos usados (Capítulo 3–4)

Para contribuir al aprendizaje de los pobladores locales, y para asegurar que la investigación sea relevante para la comunidad misma, ésta se llevó a cabo en estrecha coordinación con el Consejo de Gobierno de la comunidad. Las actividades incluían también la participación por parte del investigador en las seis escuelas primarias y en el colegio secundario, la organización de eventos de capacitación para los asistentes locales de la investigación y para los profesores, así como talleres para el público en general. Tales eventos proveían espacios para discusiones, las que influían las decisiones sobre qué investigar, y cómo investigar. Las actividades de investigación dependieron fuertemente de la participación activa e información proporcionada por los pobladores locales. Se usó una amplia gama de métodos para la colección y el análisis de los datos, yendo desde la observación participativa y entrevistas, a análisis de imágenes de sensoreo remoto y modelado de computadora. El proceso de investigación también incluía el diseño de experimentos económicos como herramientas de aprendizaje para los usuarios de recursos naturales locales.

El uso de recursos naturales en su contexto histórico y socio-económico (Capítulo 5-7)

La interacción entre la población humana en el área actual de Sarayaku y el medio ambiente natural ha estado cambiando desde la llegada de los primeros humanos al lugar, pero más que todo durante los últimos cinco siglos. Empezando en el siglo dieciséis, el contacto con los Europeos y sus patógenos hizo que la población disminuyera, llegando a su punto más bajo a fines del siglo dieciocho. Desde entonces, la población ha estado creciendo, especialmente desde alrededor de 1930, aunque durante las últimas décadas dicho crecimiento ha sido mitigado por la emigración. El descenso poblacional tuvo como consecuencia una abundancia de recursos para los sobrevivientes mientras que el crecimiento poblacional que siguió ha contribuido a la crisis actual del agotamiento de recursos.

El patrón espacial de asentamiento humano ha cambiado significativamente durante los últimos dos siglos. La gente vivía antes en grupos pequeños, dispersos y móviles, cultivando la tierra en las cimas de las lomas. Desde el inicio del siglo diecinueve, sin embargo, la gente comenzó a asentarse en el sitio de la actual comunidad de Sarayaku, empezando a cultivar las tierras de las planicies aluviales del Río Bobonaza. Mientras esta concentración ha contribuido al actual agotamiento de los recursos naturales alrededor de los asentamientos, también disminuyó el impacto humano en aquellas partes más lejanas de los asentamientos.

Introducciones tecnológicas facilitaron la explotación de recursos naturales que previamente habían sido poco explotados. La introducción de herramientas de metal facilitó probablemente el cultivo de las planicies aluviales, mientras que las escopetas y las linternas, facilitaron la caza de varias especies terrestres.

Entre los acontecimientos históricos más importantes en Sarayaku está el proceso de organización popular de las últimas décadas. Sarayaku estuvo anteriormente gobernado por autoridades foráneos, sean estas civiles, militares o religiosas, pero en la actualidad Sarayaku está gobernado en la práctica por un Consejo de Gobierno autónomo, democráticamente elegido. A través de la participación activa en el movimiento indígena en el ámbito provincial y nacional, la comunidad ha fortalecido su posición en el país. El proceso organizativo también ha llevado a un incremento de la coordinación y cooperación dentro de la comunidad y últimamente la comunidad ha logrado implementar algunos reglamentos con la finalidad de preservar los recursos naturales.

Hoy día, los problemas percibidos por la gente en Sarayaku respecto al deterioro de los recursos de los cuales dependen para su sustento preocupan a la población. La creciente escasez de buenas tierras para cultivar en la cercanía de los asentamientos tiene como consecuencia la cultivación de las tierras en barbecho, con períodos mas cortos de rotación, lo que en su turno, lleva a la disminución de la fertilidad del suelo y al incremento de plagas y malezas. La economía local de Sarayaku está en primer lugar orientada hacia la subsistencia, con poco comercio con el exterior, y poco flujo de dinero dentro de la comunidad. No obstante, hay un intercambio interno significante de productos a través de regalos recíprocos. La comida que se trae a casa provee cantidades de energía y proteína por sobre los niveles de requerimientos nutricionales, pero la grasa alimenticia es relativamente escasa. Los cultivos básicos, yuca y plátano, son ricos en carbohidratos, pero pobres en proteína y grasa. El pescado y la carne del monte, con sus contenidos más altos de proteína y grasa, son por lo tanto componentes importantes en la dieta. Los alimentos comprados en tiendas constituyen una parte minúscula de la cantidad total de comida, y su papel más prominente en la nutrición parece ser de proveer grasa adicional. La gente es de baja estatura, lo que parcialmente podría ser un efecto de dietas inadecuadas. Sin embargo, otras medidas antropométricas, como el índice de masa corporal y el área del músculo del brazo, indican un buen estado nutricional. En comparación con otros pueblos indígenas Amazónicos, no hay indicaciones de que el agotamiento de recursos naturales en Sarayaku haya afectado el estado nutricional de la gente.

Agricultura, caza, y pesca: La base del sustento (Capítulo 8-10)

Los habitantes de Sarayaku practican la agricultura típica de los pueblos indígenas de la Amazonía occidental, sembrando particularmente yuca y plátano, pero también cantidades pequeñas de una amplia gama de otros cultivos. En los años 80, mucha gente sembró pastos como parte de un proyecto gubernamental de ganadería, pero en los años 90 muchos de los pastos quedaron en barbecho. En aparente contradicción con la preocupación que la gente expresa sobre la escasez de tierra, tan sólo un 0.2% del territorio de la comunidad está bajo cultivos, y sólo un 3.4% corresponde a barbechos. La taza de deforestación anual es de sólo 0.015%, mientras que la taza anual de expansión del área intervenida (barbechos y campos de cultivo) es de 0.5%.

La percibida escasez de tierra tiene que ser entendida en una perspectiva espacial. La tierra es escasa cerca de los asentamientos, y la duración de los períodos de barbecho es más corta cerca de éstos. Todavía en los años 30, casi todos los campos de cultivos eran limpiados y sembrados en la selva. Desde los años 40, sin embargo, se cultiva cada vez más en tierras de barbecho. Desde la década de los 80, sólo una tercera parte de los campos de cultivo se realizan en la selva de crecimiento de antigua data.

La gente de Sarayaku caza más de 60 especies de animales, pero cinco especies de ungulados y dos especies de roedores constituyen el 58% del peso cazado. La presión de la caza es mayor en las cercanías de los asentamientos, siendo menor en las áreas más alejadas. Muchas especies están por tanto gravemente agotadas cerca de los asentamientos humanos y algunas parecen tener poblaciones fuertes únicamente en los lugares más remotos del territorio de Sarayaku. Particularmente afectados están el Mono Araña (*Ateles belzebuth*), el Mono Lanudo o Chorongo (*Lagothrix lagotricha*), y el Tapir (*Tapirus terrestris*). Por otra parte, la Guanta (*Agouti paca*) y la Guatusa (*Dasyprocta fuliginosa*) han sido poco afectados por la cacería. Muchas especies pequeñas son cazadas exclusivamente en las cercanías de los asentamientos, ya que la cacería en áreas más lejanas se especializa en especies más grandes. El agotamiento de animales de caza en la cercanía de los asentamientos obliga a los cazadores a caminar más lejos, lo que reduce la eficiencia general de la cacería. A largo plazo, hay un potencial considerable para aumentar la cantidad total de cosecha de carne del monte, y mejorar la eficiencia general de la cacería, dejando que las especies grandes de caza se recuperen. Esto también sería beneficioso desde el punto de vista de conservación de la biodiversidad. Esto requiere, sin embargo, que se solucione el problema, a corto plazo, que implicaría para los hogares el reducir su cosecha de animales del monte.

La abundancia de peces grandes ha disminuido durante las últimos décadas, mientras los peces pequeños se han visto menos afectados. Ya que muchas especies de peces migran largas distancias, las causas de su disminución tienen probablemente que ser buscadas a una escala espacial más grande que el territorio de Sarayaku. No sólo hay que tomar en cuenta la presión agregada de la pesca de las comunidades del Río Bobonaza, sino también la pesca comercial río abajo en el Perú, la que también puede jugar un papel importante. La contaminación, más que todo de las actividades petroleras proyectadas, es otra amenaza contra el recurso. Por la gran importancia que tiene la pesca para la población local, hay una necesidad urgente de investigaciones sobre el recurso pesquero, no sólo en Sarayaku, sino en toda la cuenca.

Los mecanismos sociales de agotamiento de recursos (Capítulo 11-12)

Existen ciertas reglas tradicionales que regulan el acceso a los recursos naturales en Sarayaku, pero éstas no han sido enteramente exitosas en prevenir el agotamiento de los recursos naturales. Una causa del agotamiento de los animales de caza ha sido cierta ignorancia del impacto que la caza tiene en la base del recurso. Sin embargo, a pesar de que la conciencia sobre este impacto ha crecido, la gente no ha podido coordinar acciones para proteger la base del recurso. La merma de animales de caza puede por lo tanto considerarse una “tragedia de los comunes”. La falta de confianza entre la gente parece haber sido el principal obstáculo para manejar el recurso de manera coordinada. Por otra parte, la disminución de la extensión de la selva no puede considerarse una “tragedia de los comunes” porque la gente lo considera como una consecuencia, hasta ahora inevitable, de la necesidad de tierra para cultivar el alimento de una población en aumento.

Para algunos en la comunidad, manejar los animales de caza de manera conjunta fue una idea bastante ajena. El manejo de las palmas para techo (*Geonoma* spp.), sin embargo, muestra que la gente de Sarayaku ha podido prevenir el agotamiento de un recurso a través del uso de reglas simples y universalmente aceptadas de cosecha. Para proveer una herramienta de aprendizaje para usuarios de los recursos locales, se diseñó dos experimentos, combinando conceptos de economía experimental e investigación participativa. Los resultados de uno de los experimentos sugieren que un aumento del nivel del empleo podría disminuir la presión de la cacería, mientras que un aumento solamente en el nivel de ingreso monetario podría tener el efecto opuesto.

Implicaciones para el futuro (Capítulo 13–14)

Algunos de los cambios que más pueden afectar el futuro de Sarayaku todavía no han alcanzado a llegar a la comunidad, o son tan recientes que no fue posible realizar un estudio de fondo dentro del alcance de esta investigación. En este contexto, se destaca la explotación petrolera, la que ha causado una extensa colonización y deforestación en el norte de la Amazonía Ecuatoriana, así como también una gran contaminación con incidencias elevadas de cáncer y otras enfermedades en la población. Casi la totalidad del territorio de Sarayaku está actualmente dentro de concesiones de exploración y explotación entregadas a compañías petroleras. Dado que Sarayaku posee título legal a sus tierras, no hay riesgo eminente de que la explotación petrolera traiga una colonización agraria, pero hay riesgo de contaminación, además de todos aquellos impactos secundarios que puedan venir con la apertura de carreteras hacía los pozos petroleros. Las petroleras tienden también a introducir corrupción y remplazar organizaciones comunitarias democráticas por un sistema de clientelismo. Actualmente, Sarayaku está involucrado en una enconada lucha contra la Compañía General de Combustibles (CGC). Por un tiempo, la comunidad estuvo dividida por este el asunto, pero pronto se unió en la resistencia contra las actividades petroleras. Después de luchar sola durante un buen tiempo, la comunidad logró el apoyo de federaciones indígenas regionales y nacionales así también como de ONG:s nacionales e internacionales. La asistencia legal dada por algunas de estas ONG:s ha sido particularmente importante. En todo caso, el asunto sigue sin resolver.

Sólo a 30 kilómetros río arriba de Sarayaku, los indígenas sacan madera de la selva para vender a los comerciantes. La explotación maderera puede llegar a Sarayaku en un futuro no muy distante. La explotación maderera en la Amazonía ha significado muchas veces grandes daños ecológicos y la explotación de la población indígena. No obstante hay casos donde los pueblos indígenas han logrado recibir un pago justo por la madera, y también limitar los daños ecológicos. Las carreteras facilitan la explotación maderera tanto como el cultivo de productos para la comercialización, siendo una causa principal de deforestación tropical alrededor del mundo. Tarde o temprano, la carretera puede llegar a Sarayaku, especialmente si se inicia la explotación petrolera.

La comunidad se ha puesto recientemente de acuerdo para tomar algunas medidas para detener el agotamiento de animales de caza tal como la prohibición de exportaciones de carne del monte desde la comunidad, y el celebrar la fiesta comunitaria cada dos años en vez de cada año. Tal vez lo más importante es que una de las aldeas ha designado una área de reserva, donde se prohíbe la cacería. La comunidad logró encontrar financiamiento internacional no sólo para el manejo de la reserva, sino también para la construcción de infraestructura para la avicultura y pisicultura, como fuentes alternativas de alimento. Está prevista la creación de dos reservas más durante los próximos años.

El presente trabajo es una contribución en el creciente número de estudios que muestran que el uso de recursos naturales por parte de los pueblos indígenas de la Amazonía no es del todo sostenible y, particularmente, causa la disminución de animales de caza. Con todo, muestra también que los miembros de la comunidad no son simples “hombres económicos” o “*optimal foragers*”, que explotan los recursos naturales según lo que es económicamente racional desde el punto de vista individual. Al contrario, tienen capacidad de reflexionar, adaptar, organizar, y actuar para lograr cambios. A través de la acción colectiva, la comunidad ha logrado proteger su territorio de actividades destructivas para el medio ambiente, tal como la colonización agraria y la explotación petrolera. También, en medida pequeña pero creciente, ha podido internamente reglamentar el uso de recursos naturales locales.

El futuro de Sarayaku estará determinado por las decisiones tomadas por los habitantes de Sarayaku, así como por los acontecimientos del país y del mundo. Puede ser que continúe la tendencia actual de agotamiento paulatino de los recursos naturales, pero puede ser también que se acelere, sobretodo si intereses económicos ajenos causan daños adicionales, no sólo al medio ambiente, sino también a la organización comunitaria. Si eso no ocurre, en cambio, un manejo sustentable de los recursos naturales no es una meta inalcanzable, siempre y cuando siga creciendo la capacidad de acción colectiva en la comunidad de Sarayaku.

Contents

Chapter 1: Background

1.1. Introduction

1.1.1. Sarayaku – a troubled paradise

At first sight, Sarayaku may look like a timeless paradise. When you travel to Sarayaku from the airport at the military base in the town of Shell, it takes about eleven minutes in a five-passenger airplane to reach the colonization[1] front, and during the next some twelve minutes until you arrive in Sarayaku almost all you see under you is lush green tropical rainforest. Once you arrive in the community you meet people who live in beautiful oval houses made of local materials and procure their own food by farming, fishing, and hunting. The people laugh a lot, and appear to be healthy and happy. One may believe that this is a rare example of people managing to make a happy living in a sustainable way, without destroying nature.

At a closer look, however, it turns out that Sarayaku society actually is experiencing crises on several fronts. Natural resources of crucial importance are getting increasingly scarce. Particularly, people are concerned about the decreasing abundance of wild game. Similarly, they also observe a decrease in the abundance of fish, although they consider this decrease to be less drastic. Also land to farm is getting increasingly scarce in the vicinity of settlements, forcing people to shorten fallow periods, which leads to increased problems with weeds and pests and decreased productivity. In sum, procuring food is becoming more and more worksome. Meanwhile, increasing interaction with the surrounding world causes a growing need for money, but there are few available options for income-generating activities. Facing these problems, many people in Sarayaku hope to find a way of achieving economic development that improves the material living conditions in the community while also maintaining the rainforest environment that has become part of their cultural identity.

The ongoing depletion of natural resources is a problem not only for the local economy of Sarayaku, it also affects the biodiversity and ecological functions of a piece of the world's largest area of tropical rainforest; the Amazon. This thesis is born out of a concern for the economy of the Sarayaku people as well as for the natural environment. The focus is therefore on the interface between human society and the natural environment.

1.1.2. Purpose of research, general approach, and research questions

Ideally, the present research project should have covered agriculture, fishing, and hunting, the three main activities that form the basis of the local economy, and which all are affected by depletion of the resource base. However, due to constraints of time and funding, this thesis focuses primarily on hunting and

[1] The word "colonization" is throughout this thesis used to describe the process of outsiders settling in the Amazon forest and clearing it in order to plant crops or pasture.

agricultural land use, whereas fishing is just briefly described and discussed. It would have been problematic to study fishing because of the migratory character of the fish, which would have required a much larger geographical scope of the study.

The research presented in this thesis attempted to be in the first place policy-relevant for the community where the research was conducted. The underlying purpose was to contribute to the solution of the problem of depletion of natural resources in the community, one of the multiple problems and challenges the community faces. Therefore, research activities were planned and executed in close coordination with the community. Producing a thesis does not solve any problems in itself, so this book is just part of the end product of the research. Another part, perhaps more important, is the development of human capacity among the community members during the process of research. Only the people from Sarayaku who participated in the research process can judge how successful this was. The research should, however, also be policy-relevant for any other stakeholders that are willing to work together with this community, or any other similar community, in order to reach common goals of improving the living conditions and protecting the natural environment. The thesis sets out to answer not only the simple question of whether local people deplete resources or not. Rather, it sets out to identify the extent of any such depletion, its effects, and its causal mechanisms. Understanding the existing problems will hopefully be one more step towards solving them.

The main research questions therefore were;

1. How does human exploitation of natural resources affect the resource base?

2. How does the status of the resource base affect local livelihoods?

3. How do the characteristics of the specific human society under study affect the way people exploit natural resources?

These questions, in turn, were studied particularly for hunting and agriculture, and were studied in a perspective of variation in space and time. The spatial dimension was important because different parts of the Sarayaku territory are subject to different types and intensity of exploitation. The time dimension was important because understanding the past, while also knowing the present rate and direction of change, permits making an assessment of the challenges to be met in the future.

1.1.3. The role of the researcher in the community

I first visited Sarayaku on three short occasions in 1990. I returned in 1992 as an in-married resident, and stayed for three years. Part of this period I worked as a secondary school teacher of biology and chemistry, therefore having most intense interactions with the school students. Within the community and the school, issues about environment and natural resource management were frequently discussed. Because of my background in ecology and environmental issues, it was natural that I frequently got involved. During such discussions, and through participation in regular subsistence activities such as hunting, fishing and agriculture, I was made aware of serious ecological and socio-economic problems that had not been apparent to me at first sight. Diminishing returns of hunting, fishing and farming seemed to be causing a general increase in workload and a decrease in nutritional status. Although signs of malnutrition were not apparent in Sarayaku, in other villages that were more closely connected to regional markets, and seemed to have higher population density, I did observe some apathic-looking children with swollen bellies and yellowish hair, which may be signs of deficient food intake.

As a teacher, I did my best to adapt the curriculum to local needs, but I realized that no textbooks covered the problem of natural resource depletion in forest-dependent Amazonian communities, and that my own knowledge was insufficient as well. The will to provide an adequate training in natural resource management to the youngsters in Sarayaku made me return to university studies in Sweden, studying some geography and economy in order to broaden my academic background previously limited to biology, chemistry and soil science. Finally, I developed a research proposal, which resulted in my being accepted as a PhD student in Rural Development Studies. My particular background has some important implications for the research methodology, in that the research is explicitly problem-driven, that it focuses on a particular place rather than on any particular body of theory, and in that the researcher, before the research activities started, already was part of the reality under study. The implications of all this will be discussed in Chapter 3.

1.2. Summary of the thesis

1.2.1. Indigenous people, development and conservation (Chapter 1.3)

As natural resource depletion may affect local livelihoods as well as biodiversity and the status of ecosystems, the discussion of this problem is closely related to two other issues. One is the question of indigenous people and development. The other is the question of indigenous people and conservation.

During the last five hundred years, economic development in the Amazon has mostly been by and for outsiders. The indigenous people have reaped some benefits, such as increased access to modern technology and lately also some governmental services. However, outsiders have often used them as a source of labour under exploitative conditions. During the last few decades, they have also lost much of the land, which they previously depended on for their livelihood, to encroaching colonists[2]. The technological superiority of the outsiders, in combination with the conflicts and lack of coordination among the indigenous people, has rendered them vulnerable to these kinds of abuses. This situation has changed somewhat during recent decades, as the indigenous people have organized themselves and gained a stronger position within national society.

Researchers and conservationists have been involved in a heated debate regarding the relation between indigenous people and conservation. As evidence of the nature-friendly character of indigenous people, several authors mention the generally good conservation status of areas inhabited by indigenous people, the

[2] The term "colonist" is throughout this thesis used meaning an outsider who settles in the Amazon forest, taking possession of a piece of land.

allegedly benign effects of the manipulations by indigenous people on the environment, the existence of traditional conservation ethics and taboos, and the political struggles of indigenous peoples in order to protect their land from encroachment from outsiders. On the other hand, other authors have shown how also indigenous people have depleted natural resources, particularly wild game and, in some recent cases, timber. Based on such observations, some authors claim that the good conservation status of areas inhabited by indigenous people does not imply that indigenous people are more conservation-oriented than others. Instead, they claim, it is a result of low population density and lack of access to modern technology.

Academic researchers studying questions of Amazonian development have, in general, attempted to produce results policy-relevant for governments. On the other hand, there has been little research aimed at producing results policy-relevant for indigenous communities. Research on natural resource use by Amazonian indigenous people has changed over time from describing to explaining and, lately, to the explicit purpose of understanding in order to improve.

1.2.2. Sarayaku: The community and its land (Chapter 2)

The research was conducted in the Sarayaku community, at the banks of the Bobonaza River, at about 400 m a. s. l., in the Ecuadorian Amazon, 90 km east of the foot of the Andean mountain range. The community is surrounded by a rugged landscape, dominated by old growth tropical rainforest. Whereas agrarian colonization and oil exploitation have brought drastic changes to other parts of the Ecuadorian Amazon since the 1970's, the Pastaza province, where Sarayaku is located, has been much less affected.

The community is made up of five hamlets and has about 900 inhabitants. Most of the people make their living based on agriculture, hunting, and fishing. The community is well organized, and regular community assemblies are held in order to make decisions in a consensus fashion. Between the assemblies, a so-called Government Council is in charge of community affairs. The community has also had an active role in the indigenous movement at provincial and national level. Not least, it participated in the 240-km foot-march to the national capital in 1992 in order to demand legally recognized land rights.

Before the start of the research project, there was already an ongoing discussion in the community about the observed depletion of natural resources and possible measures in order to reverse the trend. The community had an interest in learning more about the issue, and therefore adopted the research project as a community project.

1.2.3. Research process and methods (Chapters 3 - 4)

In order to contribute to local learning, and to make sure that the research was kept as policy-relevant as possible for the local community itself, the research project was run in close coordination with the Government Council of the community. The project activities included participation of the researcher in the local primary and secondary schools, arranging special training events for local research assistants and schoolteachers, and workshops for the public at large. Such events provided space for discussions, which influenced decisions on what to research and how to research. The research relied heavily on the active participation and information provided by local people. A wide range of methods for data collection and analysis were used, ranging from participant observation and interviews to remote sensing image analysis and computer modeling. The research process also included the development of economic experiments as learning tools for local resource users.

1.2.4. Natural resource use in its historical and socio-economic contexts (Chapters 5 – 7)

The interactions between human society and the environment have been changing ever since the first arrival of humans, but particularly during the last five centuries. Starting in the 16^{th} century, contact with Europeans, and their pathogens, caused the population to decline and reach its nadir in the latter part of the 18^{th} century. Since then population has been growing. In the period after 1930, population growth has been particularly rapid, although mitigated by emigration during the latter part of the 20^{th} century. The population decline led to abundance of natural resources for the survivors, whereas the subsequent population recovery has been a contributing factor to the resource crises observed today.

The spatial pattern of settlement has also changed significantly during the last two centuries. People used to live dispersed in small mobile groups, and farming only on the ridgetops. From the early 19^{th} century, however, people increasingly became settled at the site of the present Sarayaku village, and started to farm the alluvial plains of the Bobonaza River. Whereas this concentration of people has largely contributed to the present depletion of natural resources around the village, it also decreased the human impact in those parts of the area that are more distant from the village.

Technological introductions have facilitated exploitation of previously little exploited resources. The introduction of metal tools probably facilitated farming of the alluvial plains, while shotguns, particularly in combination with dogs, and later flashlights, greatly facilitated hunting of several ground-living game species.

Among the most significant historical developments in Sarayaku is the process of popular organization of the last few decades. Sarayaku used to be governed by outsiders, either civil, military, or religious authorities, but today Sarayaku is, in practice, largely governed by a democratically elected autonomous local government council. Through active participation in the indigenous peoples' movement on regional and national level, the community has strengthened its position in the country. However, the organizational process has also led to increasing coordination and cooperation within the community, and ultimately the community has managed to introduce and implement some restrictions aiming at preserving natural resources.

Today, the people in Sarayaku are, in general, very concerned about the perceived deterioration of the resources on which they depend for their livelihoods. Particularly, wild game is considered to be heavily depleted. The abundance of fish is also considered to have decreased, but not as drastically as the wild game. Another concern is the increasing scarcity of good land for farming near the settlements. According to the people, this leads to re-cultivation of fallows, with relatively short rotation periods which, in turn, leads to decreasing soil fertility and increased problems with weeds and pests.

The local economy of Sarayaku is mostly subsistence-oriented, with relatively little trade with the outside, and relatively little cash flow within the community. However, there is a significant exchange of food products in the community by means of reciprocal giving. The food brought into the homes provides amounts of total energy and protein that are above the nutritional requirements, but dietary fat seems to be in relatively short supply. The staple crops, cassava and plantain, are rich in carbohydrates, but poor in protein and fat. Therefore, fish and wild game, with their higher contents of fat and protein, are important components of the diet. Store-bought food constitutes a minute proportion of the total amount of food, and its most prominent role in the nutrition seems to be to provide additional fat.

The short stature of the people may possibly be partly an effect of inadequate diets. Other anthropometric measures, however, such as body mass index and upper arm muscle area, indicate good nutritional status. In comparison with other Amazonian indigenous peoples, there are no indications that the depletion of natural resources in Sarayaku has affected the nutritional status of the people.

1.2.5. Farming, hunting, and fishing: The basis of local livelihoods (Chapters 8 – 10)

The people of Sarayaku practice the type of swidden agriculture typical for indigenous people of western Amazonia, growing particularly cassava (*Manihot esculenta*) and plantains (*Musa* spp.), but also smaller quantities of a wide variety of additional crops. In the 1980's many people established pastures as part of a government-funded cattle project, but during the 1990's much of the pasture has returned to fallow. In apparent contradiction to the concern the people express about land scarcity, only 0.2% of the land is under crops, and only 3.4% are fallows. Annual deforestation rate is just 0.015%, whereas the rate of expansion of the intervened area (fields and fallows) is 0.5%. The perceived scarcity of land for farming must be understood in a spatial perspective. Land is scarce near the settlements, and the lengths of fallow periods are shorter the closer the distance to settlements. As late as the 1930's, almost all clearings for farming were made in primary forest. However, from the 1940's and onwards, people have increasingly been clearing secondary forests and since the 1980's only about a third of the clearings are made in primary forest.

The Sarayaku people hunt more than sixty species of game, but five ungulate and two rodent species make up 58% of the hunted weight. There is a steep gradient in hunting pressure from the area surrounding the settlement itself to the remoter areas. Therefore, several species are severely depleted around the settlement, and some seem to have strong populations only in the remotest corners of the Sarayaku territory. Particularly affected are the spider monkey (*Ateles belzebuth*), wooly monkey (*Lagothrix lagotricha*), and tapir (*Tapirus terrestris*). On the other hand, the paca (*Agouti paca*) and agouti (*Dasyprocta fuliginosa*) are little affected by hunting. Many smaller species are hunted almost exclusively near the settlement, as the hunting further away focuses on larger species. The depletion of wild game near the settlement forces the hunters to walk further away in order to hunt, and decreases the overall efficiency of hunting. In the long term, there is a considerable potential for increasing the total amount of game harvest, as well as the hunting efficiency in terms of harvest per unit of effort, by letting the populations of large game animals recover. This would also be beneficial from a biodiversity conservation point of view. It requires, however, that somehow a solution also is found to the short-term problem it would imply for local households to reduce their game harvest.

The abundance of large fish has decreased over the last decades, whereas small fish have been less affected. As many fish species migrate over long distances, the causes of these changes probably must be sought for on a larger spatial scale than just the Sarayaku territory. Not only must the aggregated fishing pressure of all the communities along the Bobonaza river be taken into account, also the increased commercial fishing further downstream in Peru, may play a significant role. Pollution, particularly from planned oil exploitation, is another threat against the resource. Because of the importance of the fishery for the local population, there is an urgent need for research about the potential for, and threats against, sustainable management of the fishery resource, not only in Sarayaku but in the entire river basin.

1.2.6. The social mechanisms behind natural resource depletion (Chapters 11 – 12)

There are certain customary rules that regulate access to natural resources in Sarayaku, but these have not been fully successful in preventing depletion of natural resources. One reason for the depletion of wild game has been an unawareness of the impact of game harvest on the resource base. However, in spite of a growing awareness of this impact, people have not been able to coordinate actions in order to protect the resource base, such that the game depletion may be considered a “tragedy of the commons”. Lack of trust among the people seems to have been the major obstacle to managing the resource in a coordinated way. On the other hand, the decrease in the old-growth forest cover cannot be explained as a “tragedy of the commons”, as the people basically consider it a hitherto inevitable consequence of the need for farmland to feed a growing population.

For some people in the community, managing wild game as a common pool resource was a very alien idea. Nevertheless, the management of the palms (*Geonoma* spp.) for thatch provides an example of how the Sarayaku people actually have been able to prevent resource depletion by applying simple, universally accepted, rules for how to harvest the resource. In order to provide a tool for local resource users to learn about the social mechanisms behind natural resource depletion, two experiments were designed and conducted, combining concepts from experimental economy and participatory research methods. The results from one of these experiments suggested that an increased level of employment may cause a decrease in hunting, while increased income alone may have the opposite effect.

1.2.7. Implications for the future (Chapters 13 – 14)

Some of the most important changes that may affect the future of Sarayaku have not yet reached the community, or are so recent that it was not possible to perform any in-depth study of them within the scope of this thesis. Most important, oil exploitation has caused widespread colonization and deforestation in the northern Ecuadorian Amazon, as well as pollution that has caused increased incidences of cancer and other diseases. Almost the entire Sarayaku territory is currently within concessions for oil exploration/exploitation. As Sarayaku possesses legal title to its lands, there is no imminent risk that oil exploitation would bring agrarian colonization, but there is a risk for pollution problems. Currently, Sarayaku is involved in a bitter struggle against the oil company CGC. Whereas the community, at one point, got divided over the issue, it soon became united in their resistance to oil exploration. After struggling almost alone during a long time, it later achieved various types of support from indigenous federations and national and international NGOs. Particularly important has been the legal assistance some of these have provided to the community. The issue remains unresolved.

Only 30 km upriver from Sarayaku, indigenous people sell timber from their forest to merchants. The timber exploitation may reach Sarayaku within a not too distant future. Logging in the Amazon has often implied great ecological damage and exploitation of indigenous people. There are also cases, however, where indigenous people have managed not only to get fair payment for the timber, but also to limit the ecological damage. Roads facilitate commercial logging as well as cash cropping, and are a major cause of tropical deforestation worldwide. Sooner or later, a road may reach Sarayaku, particularly if oil exploitation takes off.

A four-year university programme in “indigenous education” recently started in Sarayaku thanks to a cooperation with two universities in Ecuador and Spain. This may significantly elevate the quality of the school education, and thus increase the educational level in Sarayaku in general.

Recently, the community has agreed upon a few measures in order to halt the game depletion, such as prohibiting export of wild meat from the community, and celebrating the community festival every two years instead of every year. Perhaps most important, one of the hamlets of Sarayaku has set aside a wildlife reserve area where hunting is prohibited. The community managed to find international funding not only for the management of the reserve, but also for the construction of infrastructure for producing poultry and fish, as alternative food sources. The community plans to establish two more such reserves over the next few years.

The present study contributes to the growing body of evidence showing that the use of natural resources on the part of indigenous people in the Amazon is not fully sustainable and, particularly, cause depletion of wild game animals. However, it also shows that members of the community are not just simple “economic men” or “optimal foragers”, who exploit natural resources according to what is economically rational from the individual point of view. On the contrary, they have capacity to reflect, adapt, organize, and act in order to bring about change. Through concerted action, the community has been able to protect its territory from environmentally destructive activities such as agrarian colonization and oil exploitation. Also, to a small but growing extent, it has been able to internally regulate the use of local natural resources.

The future of Sarayaku will be shaped by decisions made by the Sarayaku people themselves, as well as by the developments in the country and the world. The current trend of gradual depletion of natural resources may continue, but it may also accelerate, particularly if oil and timber interests cause additional damage not only to the environment, but also to the community organization. On the other hand, if no external economic interests interfere with the current development in Sarayaku towards increased capacity for collective action, improved sustainability of resource use is an achievable goal.

1.3. Development, conservation, and indigenous people in the Amazon

1.3.1. Indigenous people – a problematic concept

Throughout this thesis, the term “indigenous people” is frequently used. This term is, however, problematic. As very few indigenous people in the Amazon continue to live in self-chosen isolation from the outside world, the distinction between indigenous and other people is not as clear today as it was five centuries ago. Being “indigenous” could be defined by genetic, linguistic, cultural or economic criteria, or by auto-identification, and these different criteria do not always coincide.

Today, many “indigenous” persons have, voluntarily or not, abandoned their previous ways of subsistence in favour of a life with a salaried job in town, or as a peasant at the roadside in a deforested landscape, producing cash crops and cattle for the market. On the other hand, there are many people in the Amazon who are of mainly indigenous descent, and make their living by farming, hunting, and fishing, but but who speak no indigenous language, such as the Peruvian *riberiños* or the Brazilian *caboclos*. On the other hand, there are also many people in the Amazon of mainly non-indigenous descent, whose ways of subsisting in the Amazon forest in many ways resemble those of modern indigenous people, for example the rubber tappers of Brazil. To complicate things even more, we could discuss the Quechua and Aymara Indians of the Andean highlands who recently have followed the new penetration roads down to the Amazon to establish themselves as settlers, or the Guaraní-speaking peasants and city-dwellers who form the majority population of Paraguay. But for now, we leave that aside and just ask the reader to keep in mind that the definition of “indigenous” is not clear-cut, and is continuously changing. Moreover, much of what is said in this thesis about modern “indigenous” people may not be relevant to all indigenous people, but may, on the other hand, be relevant also to some non-indigenous people.

1.3.2. Economic development in the Ecuadorian Amazon

1.3.2.1. Conventional development

Ever since the Spanish conquest and up to today, economic development in the Ecuadorian Amazon has mostly been about extracting resources, such as gold, Non-Timber Forest Products, timber and oil. More recently, the region has also been subject to a large influx of settlers. The indigenous people have, until very recently, had little say in the major decisions affecting the Amazon.

In the 16th century the indigenous people were formally property of Spanish *encomenderos* who had been granted land tracts by the Spanish king, including all the resources and people there within. In practice, the people constituting such "property" had to be tracked down and caught in so-called *correrías*, a practice that was still alive in some parts of Ecuador as late as 1918 (Muratorio, 1987, p. 143). At the turn of the 19th century, indigenous Amazonians were employed by the rubber industry under conditions that ranged from outright slavery to debt-bondage to voluntary employment (Stanfield, 1998; Ch.3; Barham & Coomes, 1996, Ch. 4). Slavery-like debt-bondage was commonplace well into the 1960's in the Napo province in the northern part of the Ecuadorian Amazon (Muratorio, 1991; Cabodevilla, 1996, p. 292). It should be noted, however, that the persistence of these exploitative systems well into the 20th century occurred in spite of governmental policies, rather than because of them, as Ecuadorian Government did not have effective control over the Amazonian part of the country (Muratorio, 1991, Ch.7). During the 20th century, working for oil companies on seismic crews has provided less exploitative labour conditions (Muratorio, 1987). However, decision-makers in the oil sector still view the indigenous people of Amazonia as little more than providers of cheap labour, as they are excluded from decision-making and only a minimal fraction of oil revenues return to the indigenous communities (Korovkin, 2002).

Since Ecuador's independence in the early 19th century, governments have attempted to promote colonization of the Amazon by non-indigenous settlers, in order to take effective control over contested borders, and as an escape valve for solving problems of landless peasants in the densely settled highland and coastal areas. In practice, the government often delegated the task of promoting colonization to religious missions. These also considered colonization to be desirable because of the "civilizatory" effect it would have on the indigenous people to live in close contact with "white[3]" settlers (Mejía, OD 1927:1, p. 11). In 1858 there were plans to colonize the Bobonaza River valley with British settlers[4], in order to pay a debt Ecuador had acquired with Great Britain during the

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[3] As Ecuador became increasingly racially mixed, the meaning of the term "white" changed – to some extent - from a *racial* to a *cultural* category. During much of the 20th century, the governmental policy was to solve the "Indian problem" by transforming the "Indians" to "whites" by means of cultural assimilation. (e.g., Whitten, 1976, p. 268)

[4] http://www.edufuturo.com/educacion.php?c=507 (2004-03-02); http://www.sir.edu.pe/Feria/Bernini/PaginaWeb/tratadoslimitrofes.htm#L6 (2004-03-02)

independence wars. Between 1890 and 1930, there were grandiose plans to construct a railway from the Ecuadorian highlands to the Curaray River (Esvertit-Cobes, 1995; see Fig. 2.2). In practice, however, colonization proceeded slowly. The speed of colonization accelerated only when the government got help from the oil industry, which built penetration roads and also provided revenues that were invested in further infrastructure development and colonization schemes (Wunder, 1997). The indigenous peoples' complaints about losing their land to settlers did not lead to any major policy changes until around 1990, when finally many indigenous communities were granted land titles, and the law of agrarian reform and colonization was abolished (Sawyer, 1997; Wunder, 1997).

Although the indigenous people have been able to reap some benefits from the process of economic change, the technological advantage of the outsiders, and the internal conflicts among the indigenous people, have put them in a disadvantaged position. Consequently, the response of the indigenous people to the economic changes affecting them has often been ambivalent, at the same time resisting and willing to participate.

Through contact with the outsiders, indigenous people got access to highly appreciated manufactured goods. This is particularly true for the early contacts when the Spanish brought metal tools, which made possible a virtual revolution in agricultural practices, and soon became indispensable for subsistence. Because of the limited access to such goods, indigenous people in some cases even accepted slavery-like labour relations in order to secure their access to metal tools and industrial goods (Stanfield, 1998).

The Spanish took advantage of the conflicts between different groups of indigenous people, particularly by trading metal tools for slaves, in the 17th and 18th century (Santos, 1992, p. 15-21). In the 19th and 20th centuries, the introduction of firearms, which was limited to a few points of contacts with the outsiders, led to an arms race and increased conflict among indigenous people (Steel, 1999). In the 1980's, the Ecuadorian government granted land titles to communities that collaborated with the oil companies and did not demand too much land (see Chapter 5). At present, the strategies used by oil companies are still similar, and only slightly less violent, as conflicts are induced between indigenous communities (see Chapter 13).

Similarily, outsiders have taken advantage of social stratification within indigenous communities. In exchange for their collaboration, powerful individuals were provided with industrial goods that further strengthened their power, thus increasing the social stratification. During the rubber boom, firearms were given to Machiguenga leaders in Peru in exchange for slaves from their own communities (Santos, 1992, p. 22). Present-day oil companies use similar strategies, identifying influential individuals in the indigenous communities, and providing them with resources that further increase their power in their communities, while they in exchange facilitate the entry of the oil companies (see Chapter 13).

Illiteracy and the lack of communication between geographically widely separated, sometimes hostile, communities has made it difficult for indigenous communities to learn from the mistakes of others. History has indeed been repeating itself in community after community. Indigenous people have often been happy with the presence of the first settlers, because of the access to industrial goods and/or the protection they provided against antagonistic groups, but they have later discovered that the increased presence of colonists threatens them with the loss of their lands and for them to become a minority in their own land. By then, it has often been too late to stop the invasion of settlers, but in some cases they have managed to stop further colonization and secure legal rights to their land (McDonald, 1989).

Thus, participating in "development" has resulted in some benefits, but sometimes these have been short-term, concentrated on a small portion of the society, and/or detrimental to other members of the society. Nevertheless, the benefits provided by access to industrial goods, should not be underestimated. The economic integration of the Amazon region has also resulted in government services such as education and health care reaching out to remote indigenous communities. With the possible exception of the few groups living in self-chosen isolation (often erroneously called "uncontacted"), such as the Tagairi and Taromenane (Cabodevilla, 1999), few, if any, indigenous Amazonians would want to resist all change or try to turn the clock back again.

1.3.2.2. Alternative Development Policies

Because of the largely detrimental effects that economic development of the Amazon has had on the environment and on the indigenous societies, lately some alternative development policies have been proposed and, to some extent, implemented.

Perhaps most prominent is the policy of development based on the extraction and marketing of non-timber forest products (NTFPs), such as fruits, fibres, latexes, nuts, etc., such that the forest can be profitably exploited without cutting it down (Clay, 1992a,b; May, 1991). Some proponents of such policies even claim that the value of the sustainable production of NTFPs can be higher than the potential production of timber, cattle or crops (Peters et al., 1989; Grimes et al., 1994), although other studies have shown quite the opposite (see Browder, 1992, for a review). The policy to promote extraction of NTFPs has been implemented in the so-called extractive reserves of Brazil, and has been partially successful. Deforestation has been halted and thus the resource base has been protected for local people engaged in tapping of wild rubber. Rubber tappers, however, degrade the environment themselves, as they increasingly engage also in farming, logging, and cattle raising. Most of them live in precarious socio-economic conditions, which has raised doubt about NTFP extractivism as a strategy for economic development (Browder, 1992).

Moreover, when NTFPs in the Amazon have been exploited for export purposes, this has ususally been done in an unsustainable manner. Such exploitation has typically followed a pattern of a boom followed by a bust when the natural stands have got depleted and/or plantations started to provide a cheaper supply (Coomes, 1995). In reality, transportation difficulties, perishable products, high variability in production, and competing subsistence demands, make marketing of NTFPs very difficult (Shanley et al., 2002). Even with the best intentions, any major increase in harvesting of NTFPs may prove unsustainable in the long run, because the impacts of harvesting are poorly understood at the ecosystem level (Boot & Gullison, 1995; see also Moegenburg & Levey, 2002). There is also concern that Non-Governmental Organizations (NGOs) that engage in projects for marketing NTFPs gathered by indigenous people may create unequal labour relations similar to those of the past, as well as dependency and vulnerability if the market collapses (Corry, 1993). The potential of NTFPs to serve for local development and forest conservation by means of commercializing them on the international market may have been overvalued. More important for local communities may be the role of NTFPs in subsistence and in local trade (Shanley et al., 2002). In spite of often being overlooked in discussions about NTFPs, the role of wild game in the nutrition of millions of inhabitants of the Amazon probably makes it the most important NTFP of them all.

Another proposed development strategy is payment for ecological services. The Amazonian forest plays important roles in the global carbon and water cycles and harbours a large part of the world's biodiversity. Therefore, some authors claim that it would be more profitable for the international community to pay people to let the forest stand intact than to let them cut it down (e.g., Fearnside, 1997). However, there are severe practical problems involved in order to make such a system operational. Whom to pay, how to pay, and how to monitor and enforce forest protection are questions that remain to be answered (Fearnside 1997). In any case, there is considerable willingness in industrial countries to pay for the conservation of tropical rainforests (e.g. Kramer & Mercer, 1997), and this is a potential source of income for Amazonian communities.

As explained above, for a long time indigenous people in the Amazon had little possibility to coordinate strategies and actions between any larger numbers of communities. Only occasionally, large numbers of communities united to revolt against the Spanish. Such rebellions often failed, such as the one of the Quijos in 1578 (Moreno, 1989) or in Curaray in 1909 (Muratorio 1991, p. 121). Others were more successful, such as the expulsion of the Spanish by the Shuar in 1599 (Moreno, 1989). An unprecedented event in the history of the Amazonian indigenous peoples is the gradual process of organization that started in the 1960's, with communities starting to elect their own officials and aggregating into federations and confederations (Corry, 1985; Gerlach, 2003). These federations have elaborated various studies and policy documents about indigenous peoples and development (e.g., Viteri et al., 1992; Smith & Wray, 1996; Ortíz, 2001). Initially, the prime focus of these organizations was to secure legal land titles to the indigenous territories. As this largely has been achieved, the focus is now increasingly on the sustainable management of the natural resources within the indigenous territories. The objectives are to improve the economic conditions, while avoiding the dependency and submission that has followed the former ways of improving material living conditions, and at the same time protecting the natural environment of the region.

1.3.2.3. Scientific approaches to the study of development and Amazonian indigenous peoples

There have been a number of studies on development and indigenous peoples in the Amazon. Some of these studies have focused on how indigenous people "adapt" to outside pressures (e.g., Whitten, 1989), while others have shown how indigenous people, even in the absence of such outside pressures, actively engage in the market economy in order to acquire industrial goods (Henrich, 1997).

Many authors have criticized current development policies in the Amazon for being unsustainable, causing unnecessary deforestation and being harmful to the indigenous people. As they focus on how governments should develop the Amazon, however, they tend to be policy-relevant in the first place *for governments* (e.g., Anderson, 1999). Given the power structures prevalent in the Amazon until recently this has indeed been reasonable if one wishes to be policy-relevant at all. Such authors often point to the importance of setting aside indigenous reserves, and of learning from indigenous peoples' local ecological knowledge and their management systems in order to be able to develop the Amazon in a sustainable way. The role of indigenous people in such proposals remains basically instrumental. They are supposed to protect the tropical rainforest within the reserve borders as defined by the government, and providing knowledge that facilitates the development of the areas outside the borders.

Little research has, however, been done on development policies appropriate *for indigenous people*. The literature that exists has been produced by NGOs rather than by academic researchers (COICA, 1996; Beauclerk, 1998). As the indigenous people of Amazonia have gained legal control over much of their lands (Davis & Wali, 1994; Sawyer, 1997), and started to engage in internal discussions about how to manage these lands, a need has emerged for studies that are policy-relevant for indigenous communities.

1.3.3. Amazonian indigenous people and conservation

1.3.3.1. Indigenous people and conservation of tropical forests

The impact of indigenous people in the Amazon on the environment is an issue that has generated intense debate among conservationists and researchers, and that has important policy implications. In sharp contrast to the heavily deforested landscapes of settler areas in the Amazon, the lands inhabited by indigenous people often have a largely intact forest cover with few apparent signs of environmental damage. The same is true for areas inhabited by indigenous peoples in many other parts of the world, and also for some areas inhabited by non-indigenous long established rural populations, such as the extractivists (rubber tappers) of the Brazilian Amazon (e.g., Schwartzman et al., 2000a). This has often been attributed to the active care and protection of the ecosystems performed by the indigenous and rural people. Not least, the organizations of the indigenous peoples themselves express this view:

> "We, the Indigenous Peoples, have been an integral part of the Amazonian Biosphere for millenia. We use and care for the resources of that biosphere with respect, because it is our home, and because we know that our survival and that

> of future generations depend on it. Our accumulated knowledge about the ecology of our forest home, our models for living within the Amazonian biosphere, our reverence and respect for the tropical forest and its other inhabitants, both plant and animal, are the keys to guaranteeing the future of the Amazon Basin." (COICA 1989:77-78, quoted by Redford & Stearman, 1993, p. 249)

Also major international conservation organizations have adopted this view:

> "Most of the remaining significant areas of high natural value on earth are inhabited by indigenous peoples. This testifies to the efficacy of indigenous resource management systems." (WWF, 1996, p. 3)…"WWF appreciates the enormous contribution indigenous peoples have made to the maintenance of many of the earth's most fragile ecosystems." (WWF, 1996, p. 4)

The good environmental status of areas inhabited by indigenous people has been attributed to sophisticated and complex systems of sustainable resource use based on detailed ecological knowledge (e.g., Dufour, 1990). These sustainable practices, in turn, are considered an expression of a traditional conservationist ideology:

> "Many Amazonian indigenous societies uphold a sort of Lavoisierian or zero-sum ideology in which all things, including life and souls, are recycled. Theirs is an ideology of limited exploitation of natural resources in which human beings are the sustainers of universe, nature and supernature included. Values, taboos on food and hunting, and institutional or supernatural sanctions provide the instruments for them to act according to this ideology" (Carneiro da Cunha & Almeida, 2000, p. 324).

This way, the ideology of the indigenous people is contrasted against the ideology of "Westerners". Whereas the indigenous people are said to have a "long-term interest in their habitat", and to use natural resources of the Amazon "mainly for food and other necessities", the "Western exploitation" of Amazonia is described as characterized by "arrogance, ignorance, myopia, greed, and destruction" (Sponsel, 1992, p. 243). In particular, it has been pointed out that there often are food taboos in indigenous societies, that restrict the consumption of certain animals, and therefore serve as mechanisms to prevent overhunting (Reichel-Dolmatoff, 1975; McDonald, 1977).

One the other hand, Hames (1991) points out that what is important for conservation is not ideology in itself, but how humans actually treat the environment. Furthermore, he argues that those studying the ideology of Amazonian indigenous people have not paid enough attention to the "correspondence between a belief system and the behavioral system it allegedly determines" Hames (1991, p. 175). Colchester (1981) and Hames (1991) both point out that food taboos often concern only a segment of the population (for example, pregnant women, and men undergoing certain rites), and that the taboos are about eating, not about killing. They also provide a few examples of how they have observed tabooed animals getting killed by indigenous Amazonians and then either given away to somebody not affected by the taboo, or just left to rot. Alvard (1993) empirically tested whether Piro hunters of the Peruvian Amazon show any restraining from harvesting vulnerable species, and concluded that their hunting behaviour was consistent with the short-term maximizing of harvest rate that was predicted by optimal foraging theory.

If the good conservation status of areas inhabited by Amazonian indigenous people cannot be attributed to any self-imposed restraints on resource exploitation, it may simply be a result of low population density in combination with lack of access to efficient technology for resource exploitation. That, in turn, would imply that, as indigenous populations grow, and as they get access to industrial technology, their impact on the tropical forest ecosystem will increase (Terborgh, 2000).

There is also a growing body of evidence that forests previously thought "pristine", actually have been significantly modified by indigenous people in modern or historic times (Balée, 1989; Gómez-Pompa & Kaus, 1992). Some authors point out that this impact, although accumulated during thousands of years, is negligible in comparison with the destruction brought about by the "western" exploitation during the last couple of decades (e.g., Sponsel, 1992). Others emphasize the benign effects for humans of such alterations; for example, the increased abundance of useful tree species, including those that produce fruit for human consumption and for attracting wild game (Dufour, 1990). Old fallows that have been allowed to regenerate on land cleared by indigenous peoples for farming have also been shown to have similar, or even higher, biodiversity than nearby "primary" forest (Balée, 1992), an assertion that, however, was based on a study of a limited group of organisms, namely trees, and of a small area (8 ha in total). Wood (1995) goes even further, considering the absence of human disturbance to be a potential threat to tropical forest biodiversity. Because of the lack of research performed in the tropics, however, he bases this argument on research in temperate regions, particularly the research by Romell (1956, quoted in Wood, 1995) on the role of domestic grazing animals in maintaining biodiversity of meadows in Sweden. However, Brandon (1995) argues that this reasoning is based on an ecological fallacy, as results from studies in one region cannot be directly applied to another region. Fearnside (1993, p. 109) also points out that: "A previous history of clearing does not render deforestation 'environmentally benign'".

There is also a growing body of literature suggesting that subsistence hunting by Amazonian indigenous people affects the fauna, dramatically reducing density of game species in many places, sometimes even to the point of local extinction, which may lead to cascading effects on whole ecosystems, because commonly hunted game animals perform important functions as herbivores, seed predators and seed dispersers (Redford, 1992; Redford & Stearman, 1993; Peres, 1994, Redford & Sanderson, 2000). Schwartzmann et al. (2000b, p. 1371), however, do not accept this view, claiming that: "no case of species extinction or severe depletion of large mammals has been reported from Amazonian indigenous or extractive reserves". Moreover, they accuse what they call the "people-free park advocates" of giving "disproportionate weight to the effects of local peoples' hunting" and of "seeing rural people as the enemy of nature" (Schwartzmann et al., 2000a, p. 1352).

An undisputed fact is, in any case, that the impact by Amazonian indigenous peoples is increasing. Not only are populations growing. Increasing access to industrial technology leads to a positive feedback cycle that exaggerates the speed of environmental destruction and leads to increasing dependence on outside society (Colchester, 1981). Some authors (e.g., Sponsel, 1992) are emphatic about blaming these changes on "western" society:

> "However, *victims should not be confused as villains*. Increased settlement size and sedentarization, land area decline, and market involvement usually result from Western penetration including missionization, colonization, and government administration." (Sponsel, 1992, p. 244)

But, on the other hand, Henrich (1997) shows not only how increased market incorporation among the Machiguenga of the Peruvian Amazon has led to a sharp increase in deforestation. He also challenges the view that such changes are imposed by external structures:

> "In contrast to these assumptions, this analysis shows that the Machiguenga are not compelled by external force (such as land tenure, migration policies of economic trends), but instead are active enthusiastic participants seeking to engage the market in order to acquire western goods." (Henrich, 1997, p. 319)

The change of indigenous societies towards more unsustainable resource use thus may seem inevitable:

> "It will not be long, I predict, before the Kayapó and other indigenous groups will be in possession of chainsaws, skidders, trucks – all the paraphernalia of the modern timber industry – and will be busily selling off their natural patrimony as the only ready means available to them of bringing prosperity to their villages." (Terborgh, 2000, p. 1359)

The question about how indigenous societies respond to the pressures and opportunities related to contact with the wider market economy is also related to the question of the existence of any traditional conservation ethic, discussed above. Redford & Stearman (1993) point out that while some societies hold strong religious views that favour the preservation of nature, other groups may not show such concern, or may be losing it:

> "Today, as they face the conflicting demands and expectations of outsiders such as settlers, traders, miners, loggers, missionaries, government officials, and development agents, these small ethnic groups frequently find it virtually impossible to hold onto traditional cultural values, including those that may have supported a conservation ethic." (Redford & Stearman, 1993, p. 251)

Moreover, overestimating the conservationist-mindedness of indigenous and rural people may cause a backlash:

> "To impute conservation values to people willy-nilly risks demonizing them when they fail to achieve conservation objectives by themselves." (Redford & Sanderson, 2000, p. 1363)

An example of such a backlash in the media can be seen in an article in Newsweek where a conflict between indigenous people and the administration of a national park in the Brazilian atlantic forests is described under the heading "Not as Green as They Seem"[5]. With her point of departure in a couple of newspaper articles about indigenous people of the Brazilian Amazon, Slater (1995) provides a deep analysis of the roots of the idea that indigenous people "should" protect the rainforest simply because of their identity of being indigenous, and get considered heretics when they fail to live up to these expectations. In her view, this idea has biblical roots, and reflects a wish of people in industrial countries to "rediscover paradise".

In spite of all this, it is an undisputed fact that indigenous and rural people in the Amazon have had important roles, as political actors, in halting deforestation. As a result of their political struggles, often in alliances with national and international environmentalist organizations, vast areas of tropical forest have been set aside for indigenous people or extractivists (rubber tappers), effectively halting the deforestation caused by encroaching settlers (e.g., Schwartzman et al., 2000a, Zimmerman et al., 2001). Not everybody, however, trusts that the indigenous and rural people in reality are as concerned about the environment as they claim to be:

> "If some indigenous peoples have presented themselves uncritically as 'natural conservationists', it is only because they recognize the power of this concept in rallying support for their struggle for land rights…" (Redford & Stearman, 1993, p. 251)

Similarly, Terborgh (2000, p. 1359) claims that "…the banner of conservation is only a politically correct mask for a deeper issue...". The struggle for land in the Amazon, he argues, is not about conservation, but rather "social competition over economic resources". The use of the tropical forest for economic purposes is, however, not absolutely incompatible with conservation. On the contrary, indigenous people in some cases have been able to reap economic benefits from conservation (Clay, 1988; Carneiro da Cunha & Almeida, 2000):

> "Until recently indigenous societies could only get cash from first-generation commodities (raw materials such as rubber, nuts, minerals, and the like). They have skipped the so-called second generation of value-added industrial production. Now they are starting to participate in the information economy of third-generation commodities derived from indigenous and local knowledge. And they have even entered the emerging fourth-generation market of "existence values", such as biodiversity and natural landscapes, whose existence some people deem to be valuable in themselves". (Carneiro da Cunha & Almeida, 2000, p. 325)

Likewise, one should be careful about too simplistic predictions on the direction of change in indigenous societies:

> "Change need not mean assimilation or unreflective substitution of their culture by ours. The emergence of indigenous organizations, the ethnic and cultural affirmations that everywhere accompany groups' territorial demands, and indigenous formulations of environmental concerns themselves are part of modern indigenous peoples' self-reinvention. There are excellent reasons for

[5] http://newsweek.com/nw-srv/printed/int/wa/a17614-2000mar20.htm; (2003-03-23)

> indigenous groups to seek sustainability in their own self-interest…" (Schwartzman et al., 2000b, p. 1371)

In sum, considerable controversy persists over the relation between indigenous people and conservation. One reason for these controversies may be because there are different perceptions of the meaning of "conservation", not only between indigenous people and "western" conservationists (Redford & Stearman, 1993; Alcorn, 1993), also among "western" conservationists there may be some disagreement upon the meaning of the term:

> "Forest conservation is a dangerous term because it means so many things to so many people. The very word forest has become a political term whose meaning is highly contentious. Whereas we may think of conserving a 'forest' as maintaining all of the components (genetic, species, community, and ecosystem) and attributes (structure, function, and composition…), Schwartzman et al. clearly consider a forest a collection of trees that sequesters carbon, that does not burn, and that provides a home to people making part of their living from the forest." (Redford & Sanderson, 2000)

The different views on the impact of indigenous people on the environment lead to different policy recommendations. On one extreme is the view that forests that are controlled by local people in the long run are doomed to destruction, such that government intervention is needed in order to ensure conservation:

> "If natural forests are to survive the twenty-first century outside formal protected areas, it will be because governments pass legislation establishing permanent forest estates comparable to our system of national forests". (Terborgh, 2000, p. 1360)

On the other extreme is the position that conservationists should give priority to supporting and building partnerships with local inhabitants and their organizations in order to influence political decisions:

> "It is precisely in the political arena of national development policies, incentives and allocation of resources that environmentalists – and the protection of biological diversity – have the most to gain from engaging constituencies such as indigenous, traditional, and rural people as partners". (Schwartzman et al., 2000a, p. 1355)

Schwartzman et al. (2000a) further argue that the "disproportionate weight" given to the effects of local peoples' hunting may be counterproductive, as the major effect has been to:

> "…cast the future of tropical forests as an artificial choice between conservation, defined as the preservation of pristine, uninhabited parks, and the destruction of nature (i.e., the inevitable outcome of human presence in forest)." (Schwartzman et al., 2000a, p. 1352)

Other authors, again, adopt an intermediate posture. While recognizing the existence of adverse ecological impacts of the activities of indigenous and rural people, some point out that these people themselves in some cases willingly have participated in attempts to improve the sustainability of their resource use, and even in the establishment of strictly protected areas (Colchester, 2000; Chicchón, 2000). Colchester (2000) also points out that “conservationists cannot rely on beleaguered state bureaucracies to defend isolated, protected areas on high biodiversity” (Colchester, 2000, p. 1365), and argues that local people may be more efficient than governments in defending protected areas. In some cases, indigenous people have even defended forests against government plans of exploitation (Chicchón, 2000). Going beyond the quest to set up local people against governments and “westerners” against the “indigenous” in order to identify victims and villains, Chicchón (2000) concludes:

> “The question is not whether local people deplete resources or not. The question is how different stakeholders can work together to compromise for a sustainable future.” Chicchón (2000, p. 1369)

1.3.3.2. Scientific approaches to the study of natural resource use by indigenous Amazonians

The approaches used in scientific studies of indigenous Amazonians’ use of natural resources have changed over time. The first stage mostly focused on describing the techniques indigenous peoples used to exploit the natural resources they needed for their livelihood (e.g., Stirling, 1938; Steward, 1963). In such studies, there is a tendency to focus on “authentic” societies, little affected by western civilization. Later studies attempted not only to describe but also to explain why indigenous people use the resources the way they do. Some of these studies attempt to explain the way indigenous people interact with their environment as a result of a long process of adaptation to a basically static environment (e.g., Hames & Vickers, 1982). Lately, however, it has become more common to explain current patterns of resource use as the result of historical events (e.g., Balée, 1994).

As the rate of change in Amazonia has increased, an increasing number of studies have also focused on how rapid socio-economic and environmental change affect the way indigenous people use natural resources (e.g., Sierra et al., 1999; Santos et al., 1997). The increasing concern for the biodiversity of the Amazon has also led researchers to inquire into how the activities of indigenous people affect the ecosystem (Redford, 1992). Recently, some researchers also have used approaches that have the explicit purpose to understand the current situation in order to improve it, in terms of human wellbeing, conservation of biodiversity, or both (e.g., Bodmer & Lozano, 2001; Shanley & Gaia, 2002).

1.3.4. Implications for the research

As shown above, during recent decades indigenous people in the Amazon have become increasingly organized, and have gained control, *de facto* and *de jure*, over large extensions of land. As they have become involved in internal discussion about how to manage these lands, a need has emerged for research that is policy-relevant for indigenous people, and this study is an attempt to respond to that need. Considerable debate has been going on about the positive or negative impacts of indigenous people on the environment. This study attempts to go beyond that debate, ultimately aiming at understanding the situation in order to improve it, both in terms of human wellbeing and conservation of ecosystems and biodiversity.

Chapter 2: The Sarayaku community

2.1. Introduction

Sarayaku (1°44'S, 77°29'W) is a community of almost a thousand inhabitants situated at the banks of the Bobonaza River in Pastaza province, in the Ecuadorian part of the Amazon basin (Figs. 2.1, 2.2, 2.3, and 2.4). The community consists of a central hamlet called Centro Sarayaku, surrounded by four smaller hamlets located two to five kilometers away; Kalikali, Sarayakillu, Chundayaku and Shiwakucha. At some distance away from the main settlement, most households also have a secondary home, called *purina*, where they live part of the year, particularly during school vacations. Sarayaku is located 65 km southeast of Puyo, the capital of Pastaza province. From Puyo, there is road connection and daily bus transport to the Canelos community, 35 km northwest of Sarayaku on the Bobonaza River. The rest of the way, one has to travel by river or by foot. One can also travel with small aircraft from the airport at the military base in Shell, near Puyo.

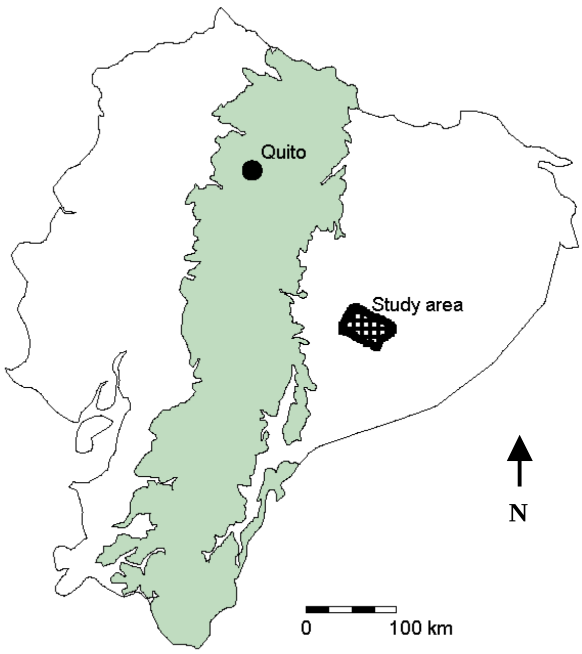


Fig. 2.1. The location of the study area in relation to the major geographical regions of Ecuador. The shaded area shows areas over 1200 m a. s. l., constituting the Andean highlands. To the west of the highland is the coastal region, and to the east is the Amazon region.

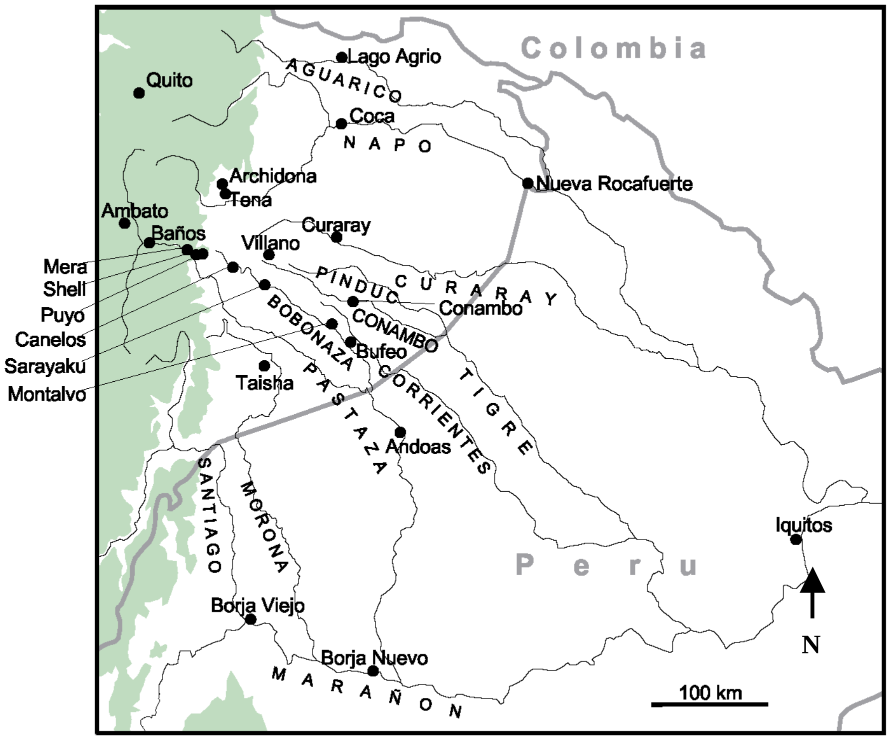


Fig. 2.2. The major rivers in the Ecuadorian and northern Peruvian Amazon, and some places mentioned in the text. The shaded area shows areas above 1200 m a. s. l.

The area that the community claims as their property covers approximately 1400 km^2, but the limits with adjacent communities are in many cases fuzzy or disputed. Since 1992, Sarayaku and neighbouring communities possess legal communal land titles, but the limits between communities are largely a desk product that reflects neither current land use, nor the previously existing customary or mutually agreed limits (Sawyer, 1997; see also Chapter 5). The geographical area of this study is roughly defined as the area used by the Sarayaku people. The extent of this area, however, has also been changing, and those changes, as such, are also part of the study. When there has been a need to set exact limits to the study area, as in chapters on agricultural land use (Chapter 8) and hunting (Chapter 9), this has been done separately for each chapter, with consideration to the specific research questions, the specific time frame, and the availability of data for the phenomena studied.

The Sarayaku people call themselves *Sarayakuruna*, meaning exactly "Sarayaku people". They call their language *Runashimi*, although it is more widely known as *Kichwa*[6], the language spoken by millions of people from Colombia to Argentina,

[6] Also called *Quichua, Quechua, Kechwa*, or *Inga*

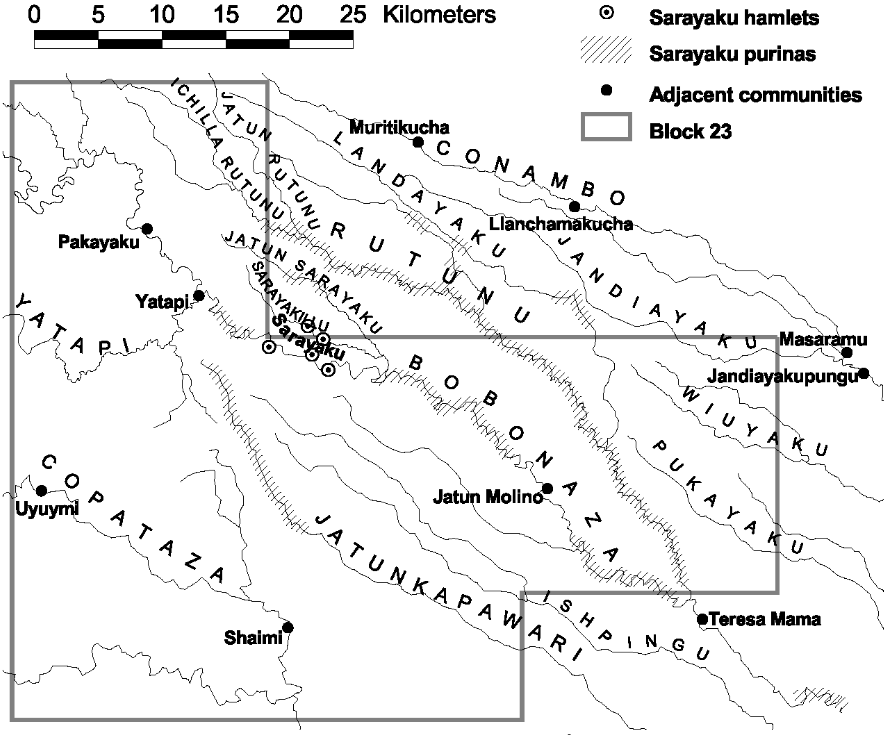


Fig. 2.3. The hamlets and *purinas* (secondary homes) of Sarayaku, in relation to major rivers, adjacent communities, and the oil exploration concession called “Block 23” (see Chapter 13). Except for Uyuymi, all communities shown on the map form part of the Sarayacu *parish*.

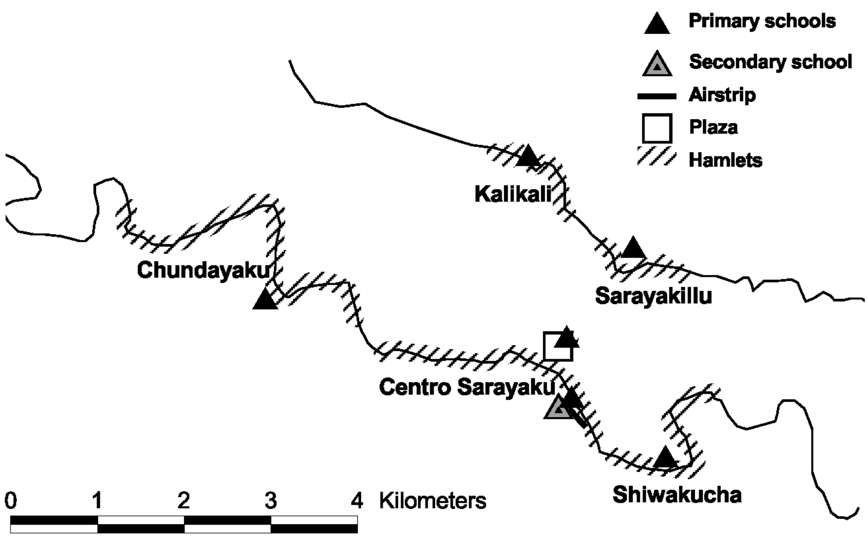


Fig. 2.4. The five hamlets of Sarayaku, along the Bobonaza and Sarayakillu rivers (see Fig. 2.3)

particularly in the Andean highlands. In the anthropological literature, the Sarayaku people and most other Kichwa-speakers of Pastaza province, as well as adjacent areas of Peru, are called the *Canelos Kichwa*[7] (Whitten, 1976; Guzmán-Gallegos, 1997). Although the Sarayaku people do not use this term themselves, it fairly well delimits the location of the people with which they feel the closest cultural affinity, marking their distinctiveness from the *Naporuna* of the northern Ecuadorian Amazon, as well as from the highland Kichwas.

The Sarayaku area is located on the edge of the western Amazonia tropical forest “hot spot”, one out of ten tropical forest regions in the world that have very high biodiversity while also suffering rapid deforestation (Myers, 1988). It also forms part of the Amazon wilderness area, one of the largest remaining wilderness areas in the world (Mittermeier et al., 1998).

2.2. Physical geography

Sarayaku is located 90 kilometers east of the foot of the Andean mountain range. The landscape consists of old fluvial deposits that have been uplifted by the eastward movement of the Andes and heavily dissected by erosion (Räsänen et al., 1990). The resulting landscape consists of steep-sided ridges interspersed with the recent alluvial plains that surround rivers and creeks. The ridges in the northwestern part of the Sarayaku territory reach up to 640 m a.s.l., whereas in the southeast they do not exceed 500 m a.s.l.

As one travels from east to west in the Ecuadorian Amazon, the climate gets slightly cooler, and average annual precipitation increases as one approaches the Andean mountains. There is also a north-south climatic gradient that involves a change in the timing of the dry season from the northern hemisphere winter months to the southern hemisphere winter months (Lewis et al. 1995). Although meteorological data from the direct vicinity of Sarayaku are absent or scarce, a rough interpolation of available data from surrounding meteorological stations indicates that the mean temperature is about 23°C, and the average annual precipitation about 3000 - 3500 mm. Local inhabitants recognize a main rainy season in May-June, followed by a dry season in July-August. A small rainy season is also said to occur in December or January (Fig 2.5). Considerable amounts of rain may, however, also fall during the “dry” season, and there is also considerable between-year variation regarding the timing, intensity, and duration of the different seasons.

The main river traversing the area is the Bobonaza, which has its sources at about 1000 m a.s.l., near the town of Puyo, and flows into the Pastaza river 190 kilometers to the southeast, at the border between Ecuador and Peru. It is a silt-laden whitewater river as is typical for the rivers of the Andean Amazon (see Sioli, 1984), but when the water level sinks due to prolonged periods without heavy rain, the water becomes transparent. The Bobonaza River enters Sarayaku territory at 390 m a.s.l. and leaves Sarayaku territory 45 km further southeast at 330 m a.s.l.. It

[7] The term *Alama* has also been used, particularly by the missionaries, to describe the same group of people.

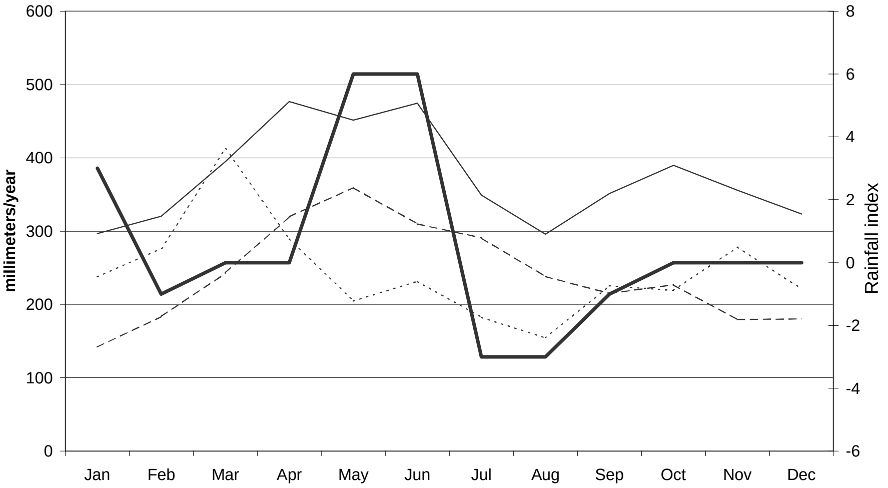


Fig. 2.5. Seasonality of rainfall in Sarayaku (broad line, right-hand y-axis) based on a subjective assessment made by local inhabitants during a workshop, and for the nearest meteorological stations (left-hand y-axis), average values of rainfall according to the Instituto Nacional de Meteorología y Hidrología (INAMHI): Puyo (960 m a. s. l., 1975 – 1999, narrow line), Taisha (508 m a. s. l., 1970 – 1972, broken line), and Nueva Rocafuerte (265 m a. s. l., 1976-2000, dotted line). For geographical locations, see Fig. 2.2.

has a width of about forty metres where it flows through the village, but is considerably wider in some places and narrower in other places. The river has a meandering form, but in the upper and middle Bobonaza, the slow-flowing stretches of the rivers are frequently intercepted by rapids. The Bobonaza is surrounded by an alluvial plain, which in turn is confined by the surrounding dissected old deposits. The plains of the Bobonaza are not seasonally flooded, but instead flood at irregular intervals directly after heavy rains in the headwaters. At such floods, the water level can rise up to nine meters within a matter of hours, and flood much of the alluvial plains along the river during one or a couple of days. Two such floods have occurred in Sarayaku since 1990. Processes of erosion and sedimentation are rapid.

The main affluent to the Bobonaza, the Rutunu river, is similar to the Bobonaza, although it is smaller. There are also more frequent rapids, as the Rutunu enters Sarayaku territory at 550 m a.s.l., and descends to 330 m a.s.l. where it flows into the Bobonaza. The alluvial plains of the Rutunu river are generally much narrower than those of the Bobonaza, except for the large plain formed where the Rutunu forks into the Ichilla Rutunu river and the Jatun Rutunu river. Processes of erosion and sedimentation are extremely rapid on this plain, and significant changes in the course of the river have occurred over just the last couple of decades. Many of the watercourses in the southern part of the Sarayaku territory do not form part of the Bobonaza river basin, as they drain southwards into the Pastaza via the Jatunkapawari river. In the north and northeast, some watercourses drain into the Corrientes and Conambo rivers, and ultimately into the Río Tigre (Fig. 2.2 and 2.3). In the east, there is an area of numerous lakes (Fig 2.6 and 2.7). Unlike most other Amazonian lakes, which typically are associated with floodplains (e.g., Junk

& Furch, 1985; Neller et al., 1992), these lakes lie in steep gorges between the hills, and have apparently been formed by landslides damming small watercourses, as has been observed even in recent years.

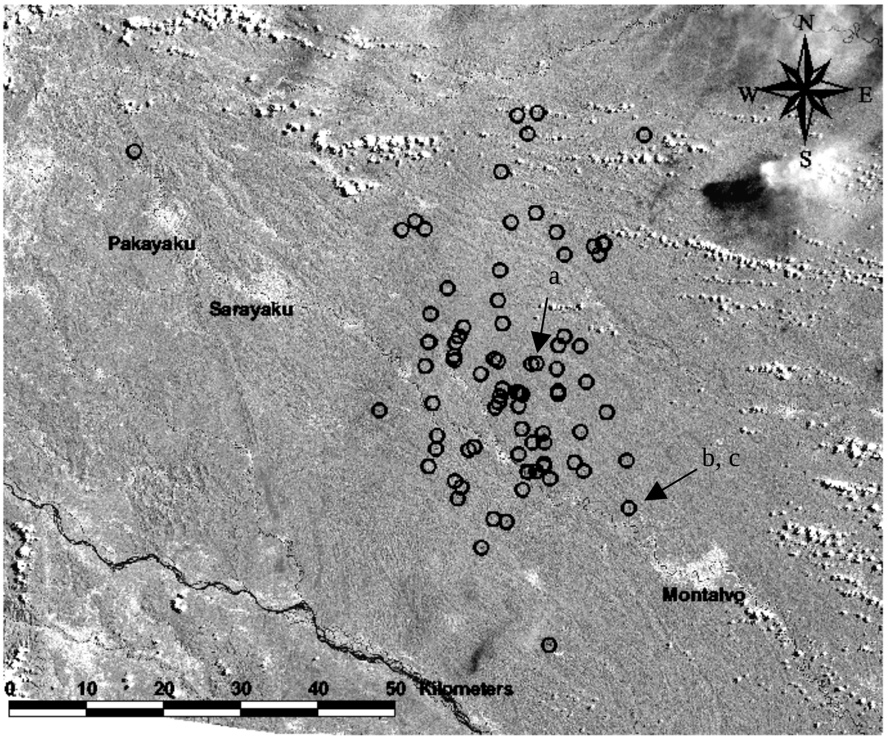


Fig. 2.6. Location of the lake zone. Each ring indicates a lake, according to visual inspection of 1:50 000 maps from the Instituto Geográfico Militar, and Landsat images from September 11, 1987 (TM), and August 24, 2001 (ETM+). Band 5 of the 2001 image is displayed. Arrows indicate lakes shown in figure 2.7.

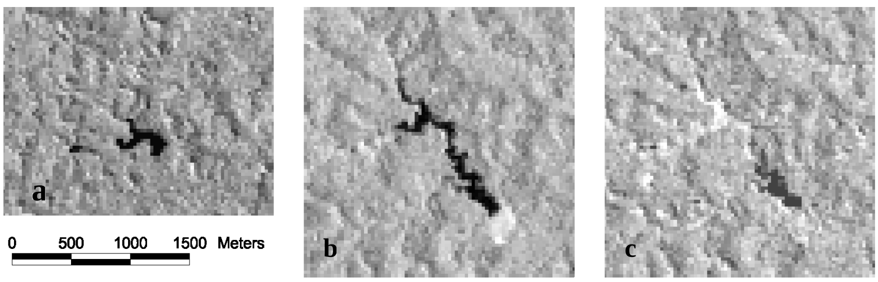


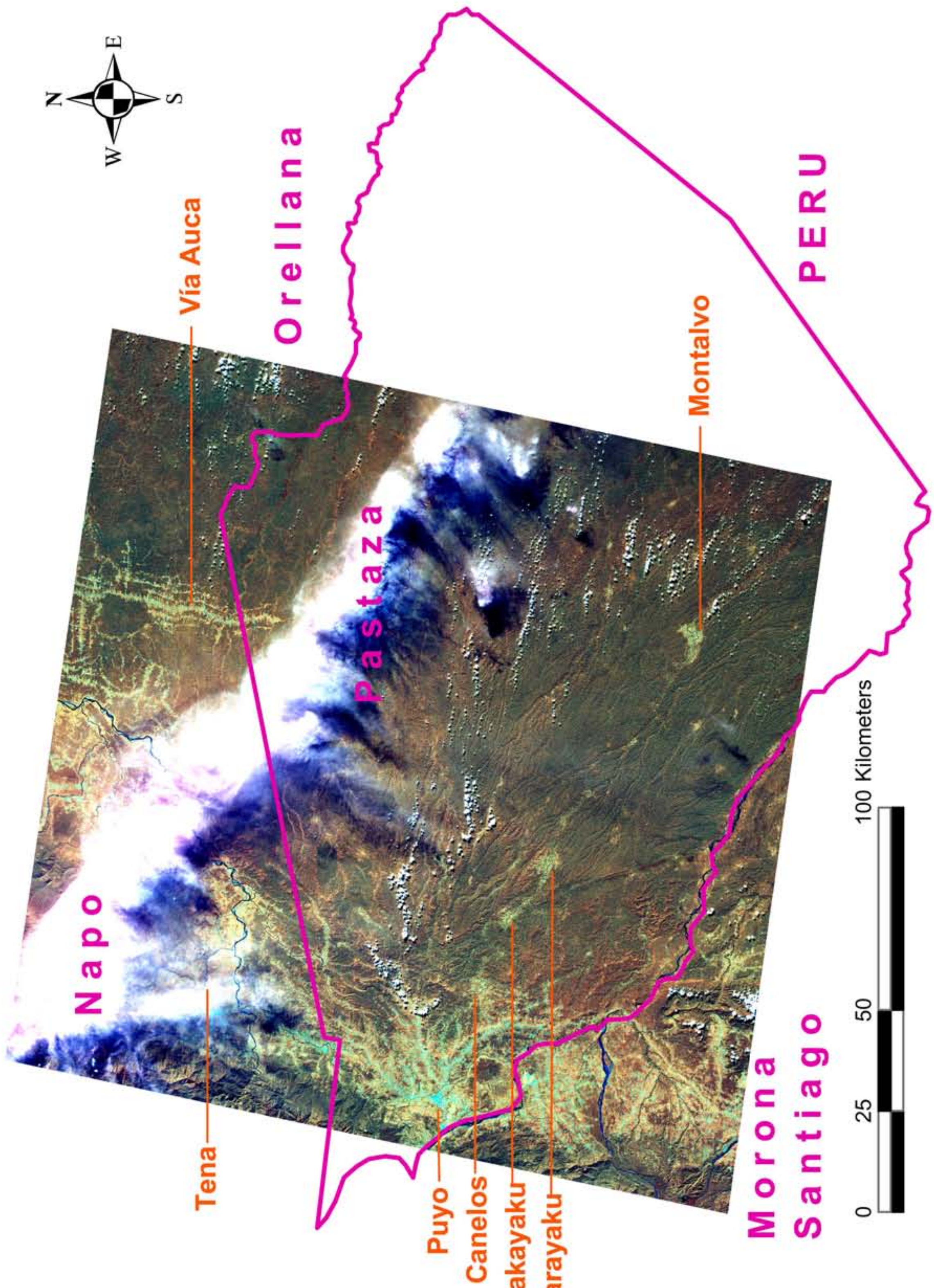
Fig. 2.7. Close up views of lakes. Dark colour indicates bodies of water. (a) *Jatun Kucha*, one of the largest lakes in Sarayaku territory. (b) A lake recently formed lake in 1987. The bright shade on the lower right of the lake indicates secondary vegetation, apparently grown up after a landslide. (c) The same lake in 2001, having decreased in size. Band 5 of Landsat ETM image from August 24, 2001 (a, c), and Landsat TM image from September 11, 1987 (b).

Most of the Sarayaku territory is covered by old growth tropical rainforest that bears no obvious signs of human disturbance, although some of it has been heavily disturbed by humans in the past (see Chapters 5 and 8). The forest has somewhat different structure and floristic composition depending on whether it grows on hill or plain, respectively, and some animal species prefer the one habitat over the other. There are also small areas of swamp forest, open swamp and bamboo forest, as well as young successional forest growing up following landslides, windfalls, or alluvial sedimentation creating new land. Fields and fallows are common only in the immediate vicinity of the hamlets and along the Bobonaza and Rutunu rivers.

2.3. Human geography

During the latter part of the 20th century, the Ecuadorian Amazon was heavily transformed by agrarian colonization and oil exploitation. Often these worked in tandem, as settlers followed roads built by oil companies, and as the Ecuadorian Government used revenues from oil exploitation in order to invest in further infrastructure development and settlement programmes (e.g., Wunder, 1997). The agrarian colonization caused heavy deforestation, and dispossessed indigenous people of the land where they had made their living since time immemorial. The oil exploitation caused severe pollution of soil and water (Kimerling, 1993). Pastaza province, however, was much less affected than the other provinces of the Ecuadorian Amazon. Only the western corner of the province, about a tenth of its total area, has been taken over by colonists and suffered heavy deforestation. And there is only one productive oilfield in the province, near the Kichwa community of Villano, developed in the mid-1990's (see Korovkin, 2002). Sarayaku has so far not been affected by intense colonization and deforestation, but not very far away, heavily deforested areas surround the community on almost all sides. To the west, it is only thirty-five kilometers to the colonized and heavily deforested area surrounding the town of Puyo. Ninety kilometers to the north are the areas along the "Via Auca" road, constructed by the Texaco oil company in the 1970's, deforested by settlers from the highlands and coast. Fifty kilometers to the south, the combined impacts of relatively recent settlers, and of the indigenous Shuar people who, similar to the settlers, also have taken up cattle ranching and cultivation of cash crops (e.g., Rudel & Horowitz, 1996), are also threatening to fragment the remaining primary forests. To the east and southeast, however, the forest is largely intact, all the way to the border between Ecuador and Peru and beyond (Fig. 2.8).

Fig. 2.8 (next page). False colour composite showing the land cover in the region that surrounds Sarayaku. Brown to dark green colour indicates forested land. Yellow shows young secondary succession and cultivated land. Blue indicates built up areas and well weeded fields with sparse vegetational cover. The green line shows the border of Pastaza province, and its location in relation to the neighbouring provinces of Morona Santiago, Napo, and Orellana (created in 1998, previously being part of Napo province). Landsat ETM+, August 24, 2001. Band 4 (red), 5 (green), and 7 (blue).


N
E
S
W
Vía Auca
Orellana
PERU
Montalvo
Pastaza
Napo
Tena
Puyo
Canelos
Pakayaku
Sarayaku
Morona Santiago
0
25
50
100 Kilometers

The upper part of the Bobonaza river basin has a relatively high population density in comparison with other parts of the Pastaza province that have not been subject to recent colonization by non-indigenous settlers. The reasons for this concentration of population are mainly historical (see Chapter 5), although soil productivity factors and the absence of malaria along the Bobonaza may also be contributing reasons. In any case, the relatively high population density results in a stronger pressure on local natural resources than in other indigenous communities in the parts of Pastaza province that have not been affected by agrarian colonization.

2.4. Social and political organization

About half of the households of Sarayaku are located in the central hamlet, "Centro Sarayaku", and the rest are distributed in the four peripheral hamlets. In this thesis, the *household* is often used as the basic unit of study, and therefore it is important to indicate what a household actually is. In terms of its members, a household may be constituted by just a nuclear family of husband, wife, and children, but many households span three generations, some even four. In terms of buildings, a household may consist of just one house used for cooking and eating as well as sleeping, but larger families often have one kitchen house and one or more dormitory houses. Residence used to be patrilocal, but nowadays the young couple may move in to the house of the parents of either of the spouses. If there are no other children left at home to accompany the parents, the young couple usually stays there for good. Otherwise, they reside there until they are able to construct their own house, often after a couple of years. The new house is commonly located near the parents' house, sometimes so close that it is not apparent at first sight whether it forms a separate household or not. However, once the young couple has got a kitchen of their own, this indicates that they function as a separate economic unit. Therefore, throughout this thesis, a *household* is defined as the *people who share the same kitchen*.

Membership in the community is not formally defined, but in practice one becomes a member either by growing up in the community, or by marrying a member of the community. In most marriages, both the man and the woman are already members of Sarayaku, but there are also several inmarried Amazonian Kichwa from other communities. Among the inmarried, there are also a few men and women of other ethnic origin, such as Shuar, Achuar, and Huaorani, as well as mestizo[8] and highland Kichwa. Many youngsters emigrate from Sarayaku and they often marry outside their own ethnic group. Consequently, many of the Sarayaku people have relatives in the mestizo society of Ecuador and also in other countries of South America, North America, and Europe.

The highest decision-making body in Sarayaku is the *General Assembly* of the community, where all members of the community, from about the age of fourteen and up, have the right to participate. General Assemblies are held about once a month, and decisions are taken through a consensus fashion. Between the General Assemblies, Sarayaku is governed by a *Government Council*. This is headed by a

[8] The spanish speaking majority population of Ecuador

President, since 1992 also called *Tayak Apu* ("Tayak chief"), marking the community's ethnic pride of its ancestry from the *Tayaks* (see Chapter 5), and the locally elected leaders taking over the power previously held by the *Teniente Político* (see below), a government official that locally used be known as *Apu*. The number of members of the Government Council has been increasing from a handful to about twenty, as more and more particular areas of action, such as community development, health, education, etc., have been assigned to a particular director, member of the Government Council. The members of the Government Council are elected by the General Assembly of the community for a period of two years, except for the *varayuks* (see below), who serve only for one year. As part of the organizational structure of the community, there are also specific organizations of the women and the youngsters, respectively, each of which also has a representative in the Government Council of the community. This type of community organization started in 1976, and initially it existed parallel to other authority systems (see below). However, today people in Sarayaku consider it the only legitimate authority in the community. This type of community organization has also gained a large degree of recognition on part of the national governmental structures, both in practice and in the political constitution of the country (Sabin, 1998; see also Chapter 5).

An older, but still functioning, system of authority is the one of the *kurakas*, also called *varayuks*, literally meaning "staffholders". The five kurakas are appointed every year, being given a staff made out of palm wood as a symbol of their authority. They are in charge of keeping peace and order in their respective hamlets and, particularly, to arrange communal work parties called *minga* every two weeks. Each household in the community belongs to one of five staffs, each related to one of the five hamlets. However, the relation between hamlet of residence and staff is not absolute, particularly because many of the people residing in the central hamlet belong to the staff of one of the peripheral hamlets. The varayuks are exclusively male, and are elected by their respective constituencies at a General Assembly of the community. There is a social pressure that each man should assume the responsibility of being a varayuk at least once in his life. The origin of the varayuk system goes back to the 19th century, when the catholic missionaries appointed functionaries among the indigenous population. The varayuks originally had different ranks, the highest one being the *kuraka*, followed by *capitan*, and *aguacil*. Since 1992, all *varayuks* officially are called *kuraka*. The role of the priest is nowadays limited to blessing the staffs and handing them over to the new kurakas at a Sunday service. A similarly surviving institution is the *likuati*, formerly called *fiscal*, a handful of men functioning as a sort of police. The kurakas, but not the likuatis, are also members of the Government Council.

Another local authority is the *Teniente Político* (literally: political lieutenant), a salaried representative of the national government in the Sarayaku parish, locally also known as the *Apu*, in kichwa originally meaning "boss". Formerly always occupied by an outsider, this post has since the 1980's been appointed by democratic election in a General Assembly in Sarayaku. Although officially it is the governor of the Pastaza province who appoints the teniente político, this is usually just a formality. The role of the teniente político is today limited to assisting the Government Council in handling internal conflicts. The teniente político held considerable power in Sarayaku during much of the 20th century. It has its roots in the first attempts by the Ecuadorian government to appoint civil or military (the distinction may not always have been clear) authorities, around the turn of the 19th century, in the remote areas formerly governed by religious authorities (see Chapter 5). The jurisdiction of the teniente político is the Sarayaku Parish, which in addition to Sarayaku proper encompasses several adjacent communities as well. There have been some discussions about involving also those communities in the election process. However, the institution as such is considered to be outdated and contrary to the community's ambitions of local autonomy, so there have also been discussions about abolishing the teniente político institution in Sarayaku. In the end, Sarayaku has always accepted the status quo, considering the teniente político institution as a link to the national governmental structure, and as a source of a salary that can rotate among different members of the community.

In year 2000, however, the governor of Pastaza appointed a teniente político of his choice, disregarding the candidate elected by the Sarayaku community. Sarayaku reacted strongly, not least because the new teniente político was considered to be a pawn of the oil company CGC (see Chapter 13). Sarayaku responded by closing the teniente politico's office, which was located in a building owned by the Sarayaku community. During the following three years, there was no teniente político in Sarayaku without anybody noticing much difference. In 2003 a new governor again approached Sarayaku asking them to elect a teniente político, and the institution was reinstalled.

Finally, since 2000 there is a Junta parroquial (parish committee), elected by popular multi-party vote in connection with national elections. In practice, however, the members of the parish committee have been elected in a community assembly in advance, and then officially registered as candidates of the Pachakutik movement, the political branch of the CONAIE (Confederation of Indigenous Nationalities of Ecuador) (see Gerlach, 2003). No other parties have bothered to attempt to present candidates. The role of the parish committee has largely been limited to lobby municipal and provincial authorities for funding for infrastructure projects, and its members have made clear that they in no way attempt to challenge the authority of the Sarayaku Government Council.

Women are in a minority in the Government Council, but their representation has increased during the last few years. The women who are elected to the Government Council are often educated women working as teachers, or young unmarried women. Combining the traditional role of a married woman, in charge of the fields, the kitchen, and the children, with serving on the Government Council is, however, uncommon. Female participation in community government does not seem to be restricted by any prejudices per se against having female community leaders. Rather, the obligation to keep up with domestic duties puts limits on their possibilities to participate in community affairs. Women have also had less access to education, but this is now changing rapidly. The wives of the kurakas bear a particularly heavy workload, as they are in charge of preparing a cassava brew, called *asua*, for the work parties. Many women, particularly the old, are vociferous opinion-makers who take a very active part in the community assemblies, and enjoy much respect for their words of wisdom. The status of the women in

Sarayaku is therefore not only considerably stronger than among the neighbouring and ethnically closely related Achuar people (see Kelekna, 1994), it also appears to be stronger than in other Kichwa communities along the Bobonaza River.

The religious missions - and the conflicts between them - have had important roles in shaping the history of Sarayaku and the region (see Chapter 5). Sunday service is still an important social event that helps to maintain the social cohesion in the community.

2.5. Sarayaku's struggle for self-determination

During the last few decades, the indigenous peoples of Ecuador have organized in order to improve their position in society. This indigenous peoples' movement has become a major political force in Ecuador (Gerlach, 2003). Sarayaku has played an active role in this movement since the 1970's, when it participated in the creation of the Organization of Indigenous Peoples of Pastaza (OPIP). OPIP was formed with the prime objective to secure legal ownership to Indian lands. Colonization of Pastaza had started around the turn of the century with the official establishment of the town of Puyo, today administrative centre of the province. However, colonization peaked in the 1970's and 1980's, when governmental anti-Indian policies promoted the overtaking of the western part of Pastaza by Spanish-speaking farmers (Whitten, 1976; McDonald, 1989).

In the 1980's and early 1990's, the situation looked desperate, as the government was unwilling to grant land titles to the communities of OPIP, while on the other hand it granted several concessions in the province to oil companies for exploration. At that time, it was hard to envision any other future for Pastaza than what had already happened further north in the provinces of Napo and Sucumbíos: Oil companies polluting the soils and rivers, and building roads, and thousands of settlers following the roads and taking over the indigenous peoples' lands. Sarayaku, however struggled so successfully against the oil company ARCO in the late 80's that the company was unable to complete its seismic exploration in Sarayaku territory (see Mendez, 1998). This gave the community some fame, and led to many subsequent visits by national and foreign journalists, filmmakers, and environmentalists.

The struggle for land rights culminated in 1992. After gathering in the province capital of Puyo, some two thousand indigenous people from throughout Pastaza walked the 240 kilometers to the Ecuadorian capital Quito, in order to demand legal recognition of ownership to their land, as well as political and administrative autonomy. The march got high media coverage and moral and material support from a wide array of social sectors. During the thirteen days until the marchers reached Quito, a popular consensus had emerged in the country that the Amazonian Indians had a right to their land. Balancing other interests, the government finally decided to grant titles of land ownership to the indigenous people, leaving aside their claims for political and administrative autonomy. However, the land titles were arbitrarily divided into blocks that did not coincide with the limits according to custom or existing mutual agreements between communities, and neither reflected the patterns of land use by the different communities. The government also retained control over subsoil resources. Moreover, the indigenous people only got titles to 58% of the land they claimed, as a 40-kilometer wide zone along the Peruvian border was declared as a military security zone, and another large area, north of the Curaray river (see Fig. 2.2) got national park status (Sawyer, 1997). However, so far there has been no acute threat to the remaining 42%.

The community has also continuously struggled in the field of education, first in order to get primary schools and then a secondary school. A legal reform in 1992 established a separate authority for “Bilingual Intercultural Education”, a largely autonomous school system controlled by the indigenous peoples’ movement itself. Sarayaku has taken advantage of this in order to take over control of the education from the mestizo teachers and tried to adapt curricula to local conditions. Most teachers in Sarayaku are now natives of the community. Although many of them want change, however, they have received their own education in a deficient system not adapted to their local reality. In practice, therefore, the process of change has been slow, but some progress has been made.

The granting of communal land titles in 1992 led to significant shifts in the agenda of Sarayaku. Having secured at least partial ownership rights to its territory, economic development became a prime objective of the community. Natural resource management was considered an important component in the strategy for economic development. Whereas the focus previously had been on defending the natural resources of the community from being taken over by outsiders, it now shifted towards improving the way the community itself handled its resources. That is where this research project fits into the long-term agenda of the community.

Chapter 3: General methodology and research process

3.1. Science and local resource users

Natural resource depletion is a phenomenon occurring through interaction between human society and ecosystems. Research aiming at understanding natural resource depletion therefore has to deal with both. Restricting oneself to stay within disciplinary boundaries would frustrate any attempt to grasp the problem. Instead, an interdisciplinary approach is needed, drawing on several different disciplines from both natural and social sciences. This thesis draws on theories and methods from such diverse disciplines as ecology, geography, history, economics, nutrition, and political sciences. Any contribution I happen to make to any particular discipline may be considered a positive side effect, while my primary ambition is to gain a broad understanding of the causes of effects of natural resource depletion in the study area, using theories and methods from whatever discipline is needed.

Deductive research, particularly the so-called “Scientific Method” of hypothesis testing, is of limited use when doing research in a field where little theory development has been achieved. Therefore, the approach used in the present thesis is mainly inductive, and no pre-conceived hypotheses were formulated before the start of fieldwork. Instead, the first step in the research process was to make an assessment of what data was relevant to collect in order to answer the research questions (see Chapter 1). Then, after collecting the data, I analyzed it in order to find patterns that may help understand the problem and identify possible ways to search for solutions. In accordance with the research questions, special emphasis was put on collecting data that permitted analysis of variation in space as well as in time. Data were collected both on the ecological system and the system of human society, with emphasis on the interface between the two.

Natural resource depletion is a worldwide phenomenon that has been going on for thousands of years (Jacobsen & Firor, 1992) and is regarded to have accelerated lately (Vitousek et al., 1997). While the underlying purpose of this research is to contribute to the solution of the problems under study, it must be clear from the outset that it would be unrealistic to believe that a few years of research would result in a complete solution of any of the problems. Within a foreseeable future, solutions will be partial, and if this piece of research somehow contributes to such a partial solution, that is enough to consider it successful. The approach adopted in order to contribute to such solutions, however, goes beyond the mere formulation of management recommendations. Experience shows that the recommendations formulated by scientists for the management of complex ecosystems are not always considered relevant by local resource users such as farmers and fishermen, who therefore do not put them into use (Hamilton, 1995; Acheson et al., 1998; Pálsson, 1998). On the other hand, participatory approaches, that involve the people in the community under study in the research, have been shown to produce results that participants consider relevant and make use of in practice. Such participatory research has been undertaken in such diverse fields as business organization and industry, health, occupational therapy, agriculture, community development and environmental monitoring (Hamilton, 1995; Shanley & Gaia, 2002; Sanford, 1981; Elden, 1981; Karlsen, 1991; Whyte et al., 1991; Abbot & Guijt, 1998; Chambers, 1992).

Some authors justify the use of participatory research with epistemological arguments, reacting against the realist-positivist epistemology supposedly dominating science today, and advocating for research based in constructivist epistemology (e.g., Röling, 1996; Tacconi, 1998). Central in constructivism are the ideas that there is no single truth, but rather multiple realities, which inter-subjectively emerge from human interaction (Jiggins & Röling, 1999). In constructivism research, therefore, it is not the researcher or expert who analyses and learns, so that he/she can transfer the learning to others, but the 'others' themselves who analyse and learn, and the role of scientists is to develop tools for discovery learning by people themselves (Hamilton, 1995; Jiggins & Röling, 1999). Constructivist thinkers also point out that when studying human societies, research cannot be value-free, objective-detached analysis is unviable, and that an approach based on falsification of hypotheses is not the only one that should be considered scientific (Tacconi, 1998).

These notions are highly relevant for the research presented in this thesis. The role of the researcher could not be the one of "detached observer", because the underlying rationale for doing the research at all was a desire to halt or reverse the ongoing depletion of natural resources. This, in turn, implies changing the reality under study, which is incompatible with a role as "detached observer". For me, taking the role of "detached observer" was even less of an option, because although being an outsider I was already somehow part of the community, and had had an active role in educating the young generation about natural resources and the environment. Attempting to renounce from that role in order to become a "detached observer" would have been both counterproductive and intellectually dishonest. It would have been counterproductive, because it would have decreased the overall contribution of the research project to the ongoing process of inquiry in the community about ways to improve the management of local natural resources. It would have been dishonest, because to some degree I had already affected the reality under study before the start of the research project, and this could not be undone. Instead, as a researcher I chose to continue working in close connection with the primary and secondary schools, and to arrange workshops and training events as important parts of the project. This role of the researcher, as an active actor and part of the reality under study, resembles Action Research (Masters, 1995; Seymour-Rolls & Hughes, 1998), and demands that the researcher acknowledges his own role in the process, and puts himself into the story (Smith et al., 1997).

The constructivist notion of "multiple realities" is not free from problems, as it recalls science-fiction-like images of parallel worlds, and it may be better to talk about different *perceptions* of reality as some authors do (e.g., Pearson & Ison, 1997). In addition, when proposing an alternative to the realist-positivist epistemology supposedly dominating scientific practice today, constructivist thinkers tend to argue not against the philosophical foundations of realism and positivism, but against some self-made caricature of mainstream scientists. For example, Röling & Wagemakers (1998), when describing the "conventional" paradigm of natural science, sketch a picture of natural scientists who are absolutely certain that they piece by piece add to the human store of entirely true and objective knowledge that will solve all the problems of the world. I would argue, however, that this picture is invented by the authors themselves, as they do not present references to any literature that would provide support for their view. I believe that most natural scientists would not recognize themselves in this description, being perfectly aware of the temporary and incomplete character of all scientific theories, as well as the shortcomings of natural science alone when it comes to solving real problems in the world.

In any case, the philosophical debate about constructivism (e.g., Sundqvist, 1996) may be beyond the immediate concerns of applied researchers dealing with natural resource use problems. The advantages of participatory research methods are obvious enough to justify them on pragmatic grounds, regardless of their philosophical aspects (see e.g., Shanley & Gaia, 2002). Scientists and local resource users both possess knowledge relevant for natural resource management. Interaction between the two provides learning opportunities for both, and the more they learn from the other, the more able will they be to communicate with each other. Participatory research methods provide learning opportunities for both the researcher and the local natural resource users. They provide feedback mechanisms that serve to maintain the research relevant for local natural resource users, and they facilitate data collection.

3.2. The role of the research project in the community

3.2.1. Main issues

The participatory research literature commonly deals with the question about how to involve local communities, or other stakeholders, in the research (e.g., McAllister, 1999, p. 7). It may, however, be more relevant to ask the opposite question: How to ensure participation of the research project in the local community. In Sarayaku, a process of inquiry about ways to improve livelihoods while preserving the ecosystem had been going on during a long time, even before the onset of this research project. The role of the research project, therefore, was not to initiate a process, but to strengthen one that was already in progress. This implied not just the use of a set of participatory research tools, but most of all to create a working relation beneficial to all parties involved. As the community consisted of nine hundred individuals, each one with his/her particular way of thinking, this was not very straightforward, and there were some main issues that had to be resolved. It was important that everybody in the community felt invited, but not obliged, to participate in the research. Also, beyond the role of mere informants, there had to be mechanisms for community members to have real influence on the research process. However, as I had the responsibility to my university to administrate research funds in a responsible way and to produce a PhD thesis, decision power as such could not be delegated to the community. There was considerable concern in the community about outsiders exploiting the indigenous people for personal benefits without giving enough in return. Whereas it was obvious that I would benefit from the research by earning a salary and achieving a PhD title, it also had to be assured that the community would benefit from the research. The administration of research funds was initially a quite tricky issue, as the community had no previous experience of any similar kind, and therefore sometimes tended to discuss research funds as if they were my private property, or as if they were NGO development funds. After making clear how the administration of a PhD project works, however, there was little discussion about the absolute amount of money that I provided to the community, and more interest in how I made use of the limited funding available for field work costs.

The essence of the spirit of the project was a mutual sharing of information for the benefit of all. A fair daily wage was paid to those who participated in fieldwork or other activities that competed for time with their other daily subsistence activities. However, no compensation was given for provision of information as such. The purpose of this arrangement was partly to ensure the quality of any information provided by local people. People who have no interest in a particular research project, and who provide information only in order to receive material compensation, may not care much about providing correct information, and may even purposefully lie (see Chagnon, 1997, p. 20). More important, however, was to ensure that the research was kept as relevant as possible for the local community. If people felt it was irrelevant, they should demand changes in the research activities rather than just remaining content with the money they were earning. Whereas I could reach agreement with the Sarayaku community on this, I failed in my attempts to involve also the Jatun Molino community, which broke away from Sarayaku in 1983 (see Chapter 5), in the research process. In order to follow the correct protocol, I first approached the president of the Federation of Protestant Indigenous Communities in Pastaza, AIEPRA, in his office in the town of Shell. Although he was very supportive of the idea to perform this kind of research, he explained that the people in Jatun Molino would demand that I brought some gifts to them on my first visit, such as a sack of salt or similar. Establishing that kind of relationship with the community was contrary to the spirit of the research project, and as discussions about alternative ways to approach the community did not lead forward, I dropped the idea to include also Jatun Molino in the research project.

3.2.2. Degrees of participation

Local participation in research can be of different degrees. The most simple form of local "participation" may be when local people provide data, as informants or data collectors (e.g., Marks, 1994). A narrower definition of participation, however, is when local people affected by the research actually influence the following decisions (Elden, 1981)

(a) What is the research problem? (PROBLEM DEFINITION)
(b) How is the problem to be studied? What methods will provide the necessary data? (METHODS CHOICE)
(c) What do the data mean? (DATA ANALYSIS)
(d) How can the findings be used? Who learns from the results of the research? (USE OF FINDINGS)

Moreover, according to Elden (1981), for participation to be meaningful it must involve more than merely being consulted but not necessarily as much as exercising control. It must be added, however, that when working with a community of 900 inhabitants, some people will be more interested in participating than others. Participation in research also competes for time with other activities. Providing economic compensation for participation helps overcome this obstacle, but instead introduces another dilemma, as the economic compensation may be seen as more important than real influence over the research process. In this way, local people may be co-opted and manipulated to serve the purposes of the researchers, without having real input or power in the research process. Cornwall (1995) lists six different types of participation with decreasing outsider control and increasing potential for sustaining local action and ownership: co-opted, via co-operating, consulted, collaborating, co-learning, and collective action (Table 3.1).

The participation of the local community in the present research project was different for the different research components, ranging approximately from Co-operating, via Consulted and Collaborating, to Co-learning. As discussed above, local "participation" in research can mean a lot of different things, such as (1) providing data to the researcher, (2) the use by local people of pre-designed tools for discovery learning, and (3) influence on decisions regarding the research process. Therefore, the type and degree of participation in the different components and stages of the research process will be clarified below.

3.2.3. General mechanisms of participation and coordination

The research project was carried out in close coordination with the Sarayaku Government Council, and decisions of principal character were remitted to the general assembly of the community (see Chapter 2). In this way, the community decided to adopt the research project as a cooperation project between the community and me as a researcher. The community also provided office space for free, in the form of a room in its administrative building made of boards and a tin roof, and with (somewhat unreliable) access to electricity through a cable from the solar panels of the health centre 200 metres away.

One of the first key decisions, in early 1999, to be taken in consensus by the researcher and the community was the appointment of local research assistants. These would receive special training, and their role would not only be to assist in data collection and processing, they were also supposed to have an active role in deciding about the direction of the research process, in order to make sure it served the interests of the community. The original plan was to name two men and two women who would work as research assistants on a half-time basis. Because of financial constraints, because all women with the required competence had got better offers of jobs or study elsewhere, and because of the needs emerging during the research process, however, things turned out slightly different. First, two young men were appointed at a special meeting called by the Sarayaku Government Council, where all secondary school graduates were invited to present their interest in becoming a research assistant. The members of the Government Council, together with a few other specially invited persons from each hamlet were to take the decision in consensus with me. The community president held a speech to the

Table 3.1. Different modes of participation (Source: Cornwall, 1995)

Mode of participation	**Type of Participation**	**Outsider Control**	**Potential for sustaining local action & Ownership**	**Research & Action**
Co-opted	Tokenism; manipulation; representatives are chosen, but no real input or power	********* ********* ********* *********		ON / FOR
Co-operating	Tasks are assigned, with incentives; outsiders decide agenda and direct the process	********* ********* ******* *******		FOR
Consulted	Local opinions asked, outsiders analyse and decide on a course of action	******* ******* ***** *****		FOR / WITH
Collaborating	Local people work together with outsiders to determine priorities, responsibility remains with outsiders for directing the process	***** ***** *** ***	* * *** ***	WITH
Co-learning	Local people and outsiders share their knowledge, to create new understanding and work together to form action plans, with outsider facilitation	*** *** * *	***** ******* ********* ***********	WITH / BY
Collective action	Local people set their own agenda and mobilize to carry it out, in the absence of outside initiators and facilitators		*********** *********** *********** ***********	BY

youngsters, explaining that accepting the position implied hard work and a serious commitment in order to learn more about natural resource management, asking them to consider very seriously whether they were prepared for this. I suggested the same two young men I earlier had hand-picked for the problem identification interviews (see Chapter 6), but the meeting ended up recommending two others, and as I had no objections, these got the job as research assistants.

After a few months of half-time work, at the request of the research assistants themselves, they got employed full-time. Another few months later, however, one of them resigned. The remaining one, José Machoa, on the other hand, took an increasingly active role in the research process. When first appointed as a research assistant, he had already been studying "Integrated Rural Development" for one year, on distance, in the "University of the Indigenous Nationalities of the Ecuadorian Amazon" (UNIDAE), a joint project of the University of Cuenca and the Confederation of Indigenous Nationalities of the Ecuadorian Amazon (CONFENIAE). His background of living in the community in combination with his experience of higher-level formal education and practical experience in the research project made him a very skilled and reliable co-worker whose points of views often were of crucial importance in the choice and design of specific research methods. If not indicated otherwise, the word "we", when used in this thesis, usually refers to José Machoa and myself.

Instead of appointing a new full-time research assistant to replace the one who resigned, we decided to appoint two persons, one male and one female, in each hamlet. These would assist us when working in the respective hamlets. These *hamlet assistants* were between 16 and 36 years old. All had finished primary school, and some had finished secondary school, whereas some were still studying in secondary school. On an average, they worked a few days per month, and got paid per day worked. However, they were also supposed to function as a link facilitating communication, passing on to us any complaints or suggestions among the people in their respective hamlets, and answering any questions the people in their hamlet may have about the research project. In order to assign the hamlet assistants, we consulted the Government Council or the *kuraka* (see Chapter 2) of the respective hamlets. As the hamlet assistants were appointed through consensus between the community authorities and the researcher, their active participation in the research project was supposed to guarantee that the opinions of the local people were taken into account. This turned out to work only to some extent, however. While some of the hamlet assistants worked very well, others limited themselves to fulfilling concrete tasks of collecting data, passing on invitations and messages, and responded to criticisms from the people of their hamlet by becoming defensive instead of seriously listening to the concerns the people expressed.

At irregular intervals we held workshops (Fig. 3.1), usually separately in each hamlet, and sometimes inviting people from all hamlets. On these occasions, we presented and discussed preliminary research results, used some Participatory Rural Appraisal (PRA) tools (see Chambers, 1992) in order to elicit and systematize information the people already possessed, and discussed general concerns about the research process.

Fig. 3.1. Workshop in the Sarayakillu hamlet. José Machoa presents results from the hunting study (see Chapter 9)

Other important partners were the local schools. A common view expressed by the middle-aged and elderly in the community was that they, in principle, supported the objectives of the research project, but that they were not in a condition to take a very active part. Instead they requested us to work with the school students. Consequently, we held a number of workshops with secondary school students. One of these workshops had as a direct outcome the study of the relations between income and hunting habits (see Chapter 12). Also, both myself and José Machoa collaborated with schoolteachers in primary as well as secondary schools.

Particularly, we taught the students and teachers how to conduct research, based on the "Schoolyard Ecology" methodology (see Feinsinger et al., 1997). To students of primary schools we assigned simple research questions and methods, the students then completed fieldwork for data collection, data processing, and presentation to their fellows, within a couple of hours. Such research questions could deal with, to mention one example, comparing diversity or abundance of the soil fauna under different types of vegetation, such as high forest, young fallow, grass, and bare soil (Fig. 3.2). Teachers and secondary school students got more advanced research tasks, for example to explore how the number of plant species on a soccer field changed with increasing size of the inventoried plot. They also got training in the whole process from formulating research question to presenting results. Some secondary school students also applied the methodology for making their graduation theses, for example about fisheries and fish culture.

Fig. 3.2. “Schoolyard ecology”: Schoolchildren compare the abundance and diversity of soil fauna under different types of vegetation cover.

The “Schoolyard Ecology” methodology, when fully applied, actually bears much resemblance with the principles of participatory research, in that it lets the students themselves take the lead in formulating research questions, elaborating methodology, processing data, and analyzing results. The actual results of such “research” conducted by school students were usually of little use for this thesis as such. However, sometimes the process did provide opportunities also for the academic researcher to learn from the local knowledge of the students. Some of the graduation theses of the secondary school students, although lacking in scientific rigor, had a value as exploratory studies, for example about the amount of fish caught in different rivers (see Chapter 10). Particularly, involving school students in research activities had the advantage that in this way they learned what research is about, that it is not dangerous, and that it is lots of fun! Unfortunately, we started the “Schoolyard Ecology” work only when fieldwork already had been going on for almost a year. For anybody else intending to do a similar research effort in a similar community, I would highly recommend to start out with a six-month concentrated effort on teaching research skills to the younger generation using the “Schoolyard Ecology” method. I believe that would dispel many doubts and misunderstandings about the nature and purpose of research, and greatly increase the capacity of the community to provide meaningful input into the research process.

Kichwa was used as the working language during the whole research process, with only one exception (see Chapter 7). Although my own Kichwa was quite fluent, I did recognize my limitations when it came to explaining more complicated matters in a way comprehesive also for those without formal education. Instead, José Machoa often assumed that task. The process of research and learning can be pictured as a sharing of knowledge in both directions through a double funnel (Fig. 3.3). At one end is the local community at large, and at the other end is the scientific community at large. The closer you get to the middle of the funnel, the more participation each person has in the research project, and in the middle is the researcher, who has the crucial function of processing the knowledge coming from one side of the funnel, so that it makes sense to the people on the other side.

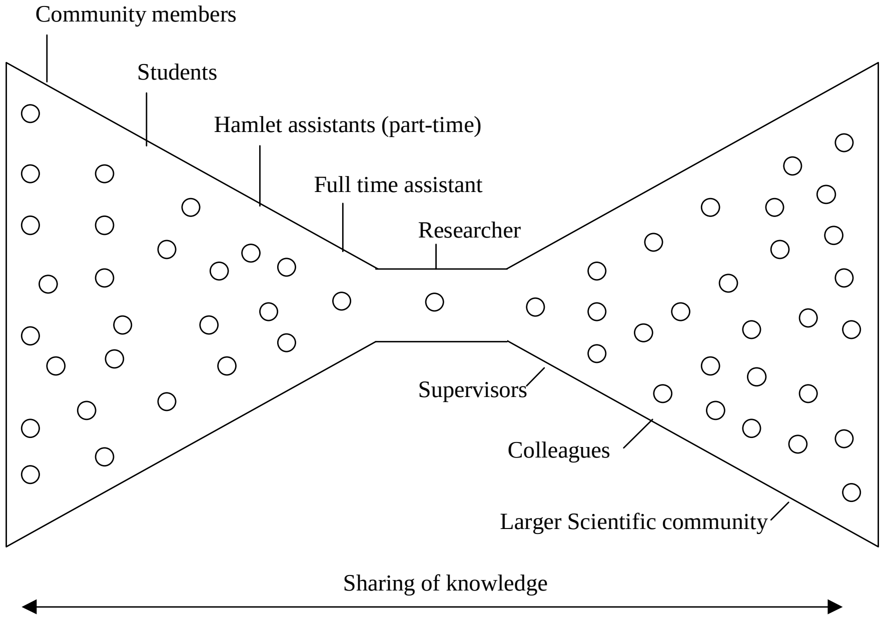


Fig. 3.3. A schematic representation of the sharing of knowledge between local people and the scientific community in the research project. The closer any person is to the centre of the double funnel, the more effort he puts into the research project, and the more he learns.

3.3. Conflicts that arose and how they were solved

The main fieldwork, after completion of the problem identification phase (see Chapter 7) started in May 1999 with the collection of data for the hunting study (Chapter 9). After five months of fieldwork, there had been several occasions where we had explained the objectives of the research project and where there had been opportunities to voice any concerns about it:

- A community assembly before the problem identification phase
- The interview sessions for problem identification
- The seminar held after the problem identification interviews
- A community assembly before starting the hunting study
- One workshop in each hamlet where we presented the preliminary results
- A number of community assemblies where we had informed briefly about our planned activities.

Nevertheless, we found that the research activities gave rise to rumours and criticisms of various kinds. Some of these rumours resemble pure fantasy:

- That I recorded where people walked in the forest in order to wait there and cut off their heads, which I would sell and make big money.
- That I sent away the filled-in forms and received big money for each recorded hunting kill.
- That I received money that I had asked for in the name of the indigenous people, so that it was very unfair that I did not share this with the others, and even expected help without paying for it.
- That the purpose of everything I did was to bring in tourists and make big money.
- That we recorded hunting kills because we condemned hunting altogether.

However, all these rumours did have some kind of a background in real experiences or oral accounts of what other people had done before, in the community or elsewhere. Even the killing of people in order to manufacture shrunk heads and sell them as souvenirs is an historical reality that was a significant cause of increased violence further south in the Ecuadorian Amazon from the late 19th century and up to the 1950's (Steel, 1999).

Other rumours were founded in real happenings during our work, that were distorted or misinterpreted:

- That I would privatize hunting grounds, prohibiting people to hunt elsewhere than on their own hunting grounds.
- That I would prohibit the use of shotguns, even confiscate them.
- That I would prohibit the annual festival where hunting plays a central part.
- That I was helping certain members of the community in land conflicts with others, measuring their land claims in order to acquire legal land titles.

These ideas can be traced back to the proposals made by the people themselves at the problem identification interviews, which were re-presented to the community at the workshops held after the interviews (see Chapter 7). Among the solutions that people had proposed in order to reverse the trend of diminishing returns to hunting were the strict prohibition of hunting on other peoples' land, prohibition of shotguns, and discontinuing the tradition of the annual festival, where hunting plays an important role (see Chapter 9). Somehow, this had been distorted whereby some people thought these proposals were mine. As far as we could understand, people who held these ideas, and who also were generally supportive of my person and of my research, had made reference to me in order to put more strength behind their own arguments, and sometimes also made reference to me and my research in oral disputes about land rights. In this way I had gained a reputation I did not deserve. Additionally, on one occasion our visit to some fields and fallows in order to record ground-truth data for remote sensing analysis (see Chapter 8) coincided with our hosts having given a friend of theirs permission to fell a nearby tree, as I had asked him to sell boards to me, which I needed in order to improve my housing. However, it turned out that still another person made claims of owning the land where the tree had stood, and denounced the felling to the Government Council. The felling of the tree in combination with observing us walking around the area with measuring tape, compass and GPS receiver made him suspect that we were surveying the land in order to help our host to get private legal title to the land (which, anyway, would have been impossible, as the existing communal land title does not permit subdivision of the land into private parcels).

As soon as we knew about all these rumours and criticism, we repeatedly said during workshops and community assemblies that in no case we would continue our work against the will of the community. Nevertheless, the situation got to the point that people started to drop out from participation in the hunting study because they did not agree with it, or because although they themselves agreed they did not want to get in conflict with other community members who did not. The Government Council always supported our work, and it seemed that the majority of the community did so too. Many people complained about the “stupid” ones who did “not understand” why our work was important. Nevertheless, as our research became a source of social conflict within the community, and at one point even escalated to physical violence, we decided that we could not continue working under such circumstances.

Some weeks before, a member of the Government Council had suggested that there should be a meeting for evaluating our research work, but no suitable date had been found. Now we approached the Government Council again to demand that the community pronounced a “yes” or a “no” to our research. We agreed upon first having an evaluation meeting on a Friday with the Government Council and some others they would select. Then, on the following Sunday, our research would be a principal item on the agenda for a general assembly, in order to reach a decision about whether to continue or discontinue the work.

At the evaluation meeting, speaker after speaker stated that they agreed with our work. We had to bring up the points of conflict ourselves: That there was jealousy about money, and that people thought we were condemning and trying to prohibit hunting partly or totally. Once we brought up these themes, again speaker after speaker confirmed that these were the issues that had caused conflict. I clarified the following:

- That no money whatsoever had been asked for or given in the name of the community and that whatever money existed had been granted in my name for me to learn and become a knowledgeable man.
- If the research project in Sarayaku would discontinue, I would search for another community interested in doing the same kind of research work, and start over there.
- That our purpose was nothing else than, together with the community, learning more about the problem of depletion of game and other natural resources, hoping that this knowledge would help to solve the problems some time in the future.
- That we were not preparing for head-cutting, not sending away the filled-in forms anywhere, not condemning hunting, not prohibiting shotguns or the festival, etc.
- That the community must decide whether they find our research beneficial to the community or not. In the latter case, the research activities would be discontinued with immediate effect.

The meeting ended up recommending that our work would continue. Several speakers also reiterated that we must assure that there would be a strong component of capacity building.

At the following community assembly, the community president informed about the evaluation meeting. We repeated the points above, and asked the assembly to pronounce a “yes” or “no” to continued work. Some speakers unconditionally argued for continuation, others told us that if we had explained everything in this way from the beginning, there would not have been any problems. The assembly ended up pronouncing an overwhelming “yes” to continuation of the research activities.

This was not the end, however. Although almost half of the community’s adult population had been present at the assembly, the other half had not, particularly people from the more distant hamlets. The following week we held a series of workshops in all five hamlets in order to present results from the hunting study. In one hamlet, about half of the people had come of curiosity to learn about our results, the other half in order to chase us away. So we had to repeat the points mentioned above again, this time however saying that the decision to continue the research already was taken, but that it was up to each and everyone to decide whether to participate or not. We asked the people to respect each and everyone’s decision in this respect, and put emphasis on that we did not demand participation nor condemn those who did not wish to participate. At this point, after eight months of data collection, we also had enough data on hunting to present quite interesting results. Using visual means, we managed to discuss quite theoretically complex concepts such as “maximum sustained yield” and “catch per unit of effort” with the people. In light of our data, we could also revisit and further discuss some of the proposals put forward during the problem identification phase, such as prohibiting shotguns or ‘privatizing’ hunting grounds. As these discussions focused on the impact on local livelihoods in the short term and in the long term, doubts about the purpose of the research, and fears that it aimed at unilaterally imposing restrictions, were dispelled.

Shortly after the workshops, the hunting for the annual community festival started. Out of 48 festival hunters, 40 reported their hunting activities. Another three had agreed to do so, but left the community soon after the festival so we were unable to collect the information. That such a large proportion of the festival hunters agreed to participate in the study was, for us, a sign of confidence, and confirmation that the previous problems had been resolved.

Nevertheless, similar rumours would emerge again every now and then during the following two years of fieldwork. The initial problems of rumours and conflict had been of a rather innocent kind, resulting from lack of knowledge and suspicion of the unknown that was not completely unjustified. Later, however, similar rumours were spread more purposefully. During the early part of my fieldwork, there had been some dialogue going on between the Sarayaku community and the oil company CGC, about the planned oil exploration activities in the area (see Chapter 13). During this time, the community liaison officer of CGC proposed that Sarayaku, with my guidance and participation, would create a company for environmental studies, which would become a subcontractor of CGC. I declined the offer, and CGC did not return to contact me since then. Several witnesses, however, later testified to me how a small number of individuals from Sarayaku and its vicinity strongly criticized my person in my absence. These were influential people, current or previous community leaders, who had had several opportunities to ask questions or express criticism directly to me, but had never done so. They had close ties with (and, as far as is known, were paid by) the CGC company. On one occasion, for example, a community leader from Jatun Molino arrived in Sarayaku and gathered a number of people from the Shiwakucha hamlet in order to hand out rice and canned food on behalf of CGC, while also attempting to convince the people to accept the oil exploration. His discourse involved accusations against the Sarayaku community leaders for corruption, and also the statement that I had become a multi-millionaire and a world famous “king of the jungle” by stealing the knowledge of the indigenous people. Although these accusations became a constantly recurring nuisance, it seemed that few people took them seriously, and they did not significantly affect the continuation of the research work in Sarayaku.

3.4. Lessons to learn

What can be learned from these experiences? What could have been done differently in order to avoid these kinds of problems?

Probably, some of these problems could have been avoided by starting the research work in a different way. Looking at the problem identification phase (see Chapter 7) retrospectively, I was in too much of a hurry, and I was too obsessed with using a well-defined methodology and producing publishable “scientific” results. Therefore, only about a third of the adult population were invited to the interview sessions. Whereas this was enough to ensure that the views expressed in the interviews were fairly representative of the community as a whole, it also meant that two-thirds of the community members were excluded from this opportunity to express their concerns, doubts, and questions in a fairly small group and in a comfortable setting. More important than the actual results of the problem identification interviews, was to initiate a transparent dialogue, sort out doubts, and create confidence. Given how alien the idea of a research project was to many community members, and the potentials for confusion, this initial phase would have needed more time, and the involvement of everybody in the community, not just a sample. I might also have been able to avoid some of the problems if I had had better understanding of the community’s past, particularly the coercive nature of past relations to outsiders such as missionaries and militaries (see Chapter 5).

Another mistake was to underestimate the implications of myself being both an insider and an outsider in the community, being in-married and previously having lived in the community, and having worked as a teacher for a few years. The strong support for the research expressed by many people at community assemblies in the initial phases was perhaps largely an expression of personal trust. People who did not have much personal experience of interacting with me had no reason to feel such trust. Nevertheless, they did not openly express any doubts, perhaps in order to avoid open conflict. A complete outsider would not even have been allowed to enter the community without previous careful scrutinizing of his/her proposal. I was already inside, and my proposal therefore was not subject to the critical analysis it should have deserved.

But on the other hand, these problems may have been inevitable. Being suspicious of the new and unknown is not only a universally common human behaviour, it is often also quite wise. Simply, time was needed in order to show in practice what the research project was all about. The first round of hamlet workshops after three months of fieldwork only partially served this purpose, as we still had not enough data to be able to draw any conclusions, and as our techniques of presentation were still not very well elaborated. During the second round of hamlet workshops, however, we already had enough data to draw some conclusions, and we had better techniques of presentation, so the nature and purpose of the research project became much clearer for the people at that time. Additionally, the capacity building that the community asked for did not become visible until after several months, as the first step was the on-the-job training of José Machoa, the research assistant.

Chapter 4: Methods

A lot of general information was gathered by participant observation, informal discussions with local resource users, and group discussions at the various workshops that were arranged during the fieldwork. Chapters 10 (Fishing) and 11 (Explaining natural resource depletion) are based almost exclusively on such methods in combination with literature studies. For the other chapters, also other specific methods were used in order to collect quantitative data, or in order to collect qualitative data in a more structured way.

4.1. History: Combining written and oral sources

The purpose of this study (Chapter 5) was to document the historical changes of the relations between human society and natural resources in the study area, in order to provide a historical context to help understanding of the current situation. A combination of three basic methods was used: Compilation, extrapolation in space and time, and deduction. Compilation is the accumulation of data and information from written or oral, primary or secondary sources, and from secondary sources based on archeological or paleobotanical remnants. This method is quite feasible for the time period known by the informants of oral history. For older times, it is more problematic, and particularly source data about hunting and fishing are scarce and consist either of very sweeping general statements, or of accounts from single observations. Therefore, it is more difficult to use the compilation method in order to understand the status of hunting and fishing before the 20th century.

The further back in time one goes, the scarcer is the data about the Sarayaku area itself. Paleobotanical data is absent from the Sarayaku area, and archeological excavations have only been carried out at one single site (Netherly, 1997). However, there are paleobotanical and archeological data from other sites in the Andean Amazon. By extrapolating data from ecologically similar areas, one may get some insights about the early history of the region as a whole, including the Sarayaku area. For the latter centuries, information about the Achuar (a subgroup of the Jívaro ethnolinguistic family) and Zaparo people living relatively near the Sarayaku area can also be used in order to understand the history of Sarayaku. The present day Sarayaku population is constituted primarily by a fusion of these two ethnic groups, but they also continued to exist as separate ethnic groups, changing their ways of life slower than the Sarayaku population. To some extent, also the 20th century history of the Huaorani may be relevant to understand the history of Sarayaku up to the 19th century. Although the Huaorani ethnically are not closely related to the Sarayaku people, they occupy a similar ecosystem not very far away. In terms of population density, technological level, and contact with non-indigeous people, the situation of the Huaorani in the 20th century in many respects resembles the situation in the Sarayaku area during the 18th and 19th centuries (see Cabodevilla, 1996).

Data on hunting and fishing is far too scarce to draw conclusions based only on compilation. However, the compilation method does provide basic data on population density, technology and settlement pattern, from which it is possible to draw some tentative conclusions about hunting and fishing by deduction. However, it must be borne in mind that these conclusions by necessity are somewhat speculative.

In order to focus data collection on the kind of data relevant for answering the research questions, a conceptual model was developed, based on general theory about the interactions between human societies and the environment, as well as on the known specific characteristics of the study area (Fig. 4.1). The population density and its spatial distribution, as well as the technology available for resource exploitation, are included in many theories as key factors influencing environmental change, although the direction of impact may vary according to the context and according to different, sometimes contradictory, theories (for reviews, see Kaimowitz & Angelsen, 1998; Angelsen & Kaimowitz, 2001; Van Wey et al., 2003). Integration in the wider market economy also affects, in multiple ways, how indigenous communities in tropical forests exploit their resources. Through such integration, they gain access both to technology for resource exploitation and markets for selling resources, which may cause increased pressure on the resource base. On the other hand, market integration may lead to higher income levels and lower prices on products that can substitute for resources taken from the forest (Godoy, 2001). In the end, however, resource use is the direct result of human

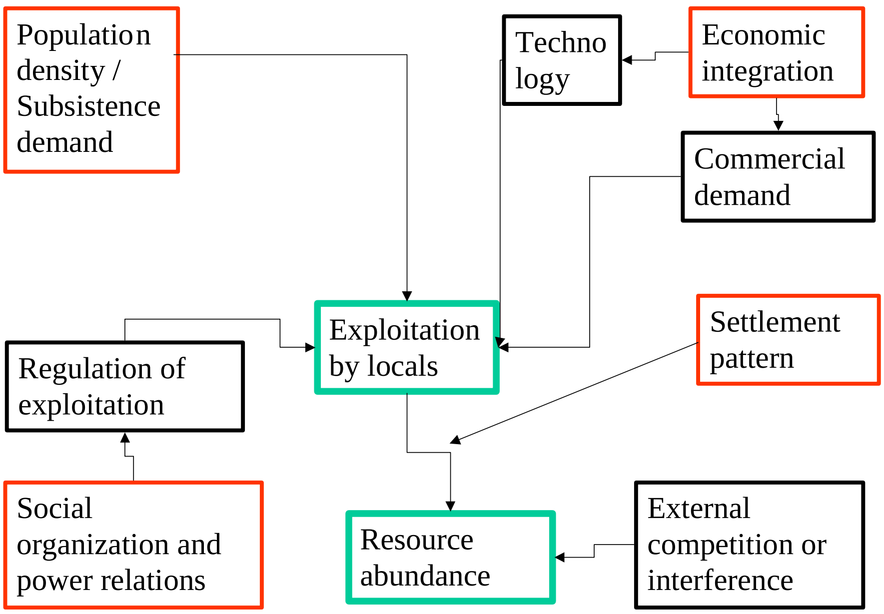


Fig. 4.1. Conceptual model of the factors considered important in influencing resource use and resource abundance.

decisions, and these are influenced both by the characteristics of each actor, the environmental characteristics, and the socioeconomic and policy environment at different scales, from local to global (VanWey et al., 2003). Of particular interest was whether, and to what extent, there have existed any rules regulating exploitation of natural resources, and whether any such rules have been imposed top-down or negotiated among resource users themselves (see Ostrom, 1990; Baland & Platteau, 1996). Finally, it was important to know whether there have been any external actors competing for the same resources as the Sarayaku people. Such competition would not only decrease the amount of resources available to the Sarayaku people, but also change the incentive situation for collective action aimed at conserving the resource base.

Much of the general history in Chapter 5 is based on material written by historians or historical anthropologists (e.g. Naranjo et al, 1984; Casewitz et al., 1988). In some cases, I have also gone back to the historical source material, mainly in order to find accounts specifically from the Sarayaku region or of hunting, fishing and agriculture in the region. Much of the source material is written by members of the Jesuit and Dominican missions, which themselves have been key actors in the history of the region, so the information they provide, particularly regarding their own role, may be biased (Naranjo 1984, p. 101). Also many of those who have written historical works about the region are themselves missionaries (e.g., Jouanen, 1948; Cabodevilla, 1996, 1999). Most recent books about Amazonian Indians in Ecuador are published by the publishing house Abya-Yala, founded in 1975 by the Salesian mission. In any case, early missionaries often spent considerable time in a place and came to know it quite well, and their accounts therefore may often be more accurate than those of explorers and adventurers who just rapidly passed through the region (Sweet, 1969, p. 14). A particularly useful source of information was the Oriente Dominicano, a bulletin published by the Dominican mission from 1928 up to 1978, providing many contemporary accounts about the area, as well as historical information[9].

Adventure writers may even have purposefully misrepresented reality in order to make their journey appear more exciting and exotic. One such example is Flornoy (1940) who visited Sarayaku in the 1930's describing it as a "village of three huts" (Flornoy, 1940, p. 62), whereas missionary records indicate that there were over 400 people living in the community at the time. Early missionaries may also have exaggerated dangers in order to glorify themselves. This is a reason to have some doubt about their frequent descriptions of jaguars roaming around their temporary camps in the forest.. Scientists such as Spruce in 1857 (Spruce, 1996) and Karsten in 1918 (Karsten, 1998) were perhaps more neutral observers, but just passed through the area very rapidly. However, I do not go deeply into source criticism of the written material, because largely I rely on material already written by professional historians. Descriptions of hunting, fishing and agriculture in the source material are unfortunately scarce. Many of them are just brief incidental mentions, while a few are detailed descriptions. Others resemble lively "fishermen's stories" that must be viewed with a sound amount of skepticism.

[9] References to the *Oriente Dominicano* are indicated with the author's name and the letters "OD", or only "OD" when the author is anonymous.

Fig. 4.2. The first step of retrospective mapping. Sarayakillu youngsters make a map of all the households currently existing in the hamlet.

In order to collect oral information, first a workshop was held in Centro Sarayaku with some elders in order to construct a historical line, outlining the major historical events considered important. This served to get a general picture of the history of Sarayaku, and to identify a number of particular events well defined in time, which later would be used as fixed points in order to make people recall a particular epoch or point in time. Second, "retrospective mapping" (see Sadomba, 1996) was done at hamlet workshops in order to reconstruct the demographic history of the community. Typically the young people started by making a map of the hamlet as of the present, indicating all households, and finally counting them (Fig. 4.2). Then the slightly older people continued making a map of the hamlet "at the time of the creation of FECIP" (1978)[10], then the elders made one for the time of the "arrival of the Protestants" (~1960), and at a couple of the workshops the very old finally made one for the time of "just before the war" (1941).

Finally, a series of group interview workshops were conducted exclusively with the elders. These group interviews were organized as follows. First, a scheme was made defining eight distinct historical epochs (Table 4.1), based on the previously made time-line. Six broad themes were defined: Demography and settlement pattern, Agriculture and domestic animals, Hunting, Fishing, Trade, and finally, Social organization and power relations. For each theme, a list of questions was made that should be asked for each epoch. The workshops were typically held in a private home. All elders approximately above the age of 60 and living in a

[10] In one case, an estimate was instead made for the "time of the FODERUMA cattle project" (1984).

particular hamlet were invited, and sometimes a few from an adjacent hamlet. Also, secondary school students or, in one case, primary school students, were invited. For each workshop, two or three of the six themes were selected as the main focus. Interviews had a semi-structured character. The hostess served drinks of *asua* (cassava brew) to create a comfortable setting for the elders, and they were encouraged to talk freely, without too much concern about strictly following the interview scheme. The students were also encouraged to participate, asking questions to the elders. At the end, all people present were offered a lunch, and the elders also got paid a daily wage, although we had not informed about this payment in advance.

José Machoa (see Chapter 3) did the interviewing, while I took notes and made some follow-up questions. Also an additional assistant took notes. Often several discussions took place simultaneously in different corners of the house, and therefore the three of us always were seated spread out so that at least one of us would catch what was said in each corner. The following morning the three of us would meet in order to write out our notes on the computer. After having done three such workshops, the resulting material was codified and restructured according to the time epochs and themes previously defined. The material was analyzed in order to identify what particular pieces of information were missing, and a corresponding list of specific questions was elaborated. During the fourth and fifth workshop, this list was used in addition to the original interview scheme[11].

The oldest interviewees were born around 1920, so the information they provided was first-hand information at the earliest from about the late 1920's. When making statements in the kichwa language, there is a grammatical difference indicating whether the statement is based on first hand observation, or on secondary information[12]. This was helpful in order to assess the trustworthiness of the information, but we did not always manage to take notes with such detail that we afterwards could see which of the grammatical forms had been used. In the text, the division of time into different epochs is slightly different from the one used for the interviews (Table. 4.1). This is foremost in order to make the text more fluid. Also, using the end of the rubber epoch for defining the dividing line between two epochs proved inappropriate, as it became evident that the decline of the rubber trade had been less abrupt than initially had been thought, as the trade actually continued on a smaller scale and even had a resurgence in the 1940's. For each epoch, first the regional and local context is presented, including those general characteristics of society that affect natural resource exploitation and abundance according to the model in Fig. 4.1, such as population density, settlement pattern, economic integration, social organization and power relations. This is followed by a section specifically about the use of natural resources during that particular epoch.

[11] References to the information provided by the Sarayaku elders are indicated by the letters "SE" in the text.
[12] For example, the statement "That's the way it was" in Kichwa can be expressed as either "*Chasna mara*" (first hand experience or observation) or "*Chasna shashka"* (Based on secondary sources, not confirmed by own observation).

Table 4.1. The time divisions in the text in comparison with the time divisions used for the interviews.

Time division of chapter	Time division of interviews
Before 1550	
1550 – 1830	Before the missionaries came
1830 – 1890	After the missionaries came
1890 – 1941	The rubber epoch
	After the rubber epoch
1941 - 1976	The war and afterwards
	After the arrival of the Protestants (~1960)
1976 – 2003	After the creation of CAS
	After the footmarch to Quito (1992)

4.2. Local perceptions of the resource crisis: Semistructured interviews

This study (Chapter 7) was carried out during September and October 1998, before any other fieldwork. The purpose was to document, in a systematic way, the perceptions of the people in the community regarding problems related to their natural resources and livelihood systems. My previous stays in Sarayaku had already given me a fairly good picture of the resource crises the community experienced. However, I had discussed these issues mostly with secondary school students and a fairly limited circle of intimates and intellectuals. In order to initiate a research effort at community level, it was desirable to check with a wider range of people whether there were any perceptions and opinions about natural resources in the community that previously had escaped my attention. Also, in order to initiate a process of participatory research, it was desirable to include a larger number of people in such a discussion, so that the community at large would feel that the point of departure of the research actually was the problems they themselves perceived. In that sense, this study served as a “problem identification phase”. After completing this study, I returned to the university in order to do more detailed planning of the rest of the fieldwork.

The basic methodology used was semi-structured open-ended group interviewing. The first activity in the community, after a brief introduction at a general community meeting, was a workshop to which carefully selected persons were invited in order to analyze the questions and translate them from Spanish to Kichwa. After a lunch together, the meeting started in the secondary school. I opened the meeting in Spanish, explaining that my objective was to make Kichwa the main work language, but that I preferred to use Spanish on this occasion, as I had been studying in English at the university, and that the translation of scientific terms and concepts is much easier from English to Spanish than from English to Kichwa. I explained the background and goals of the research, and that the first phase of the work was the problem identification phase, which would be done through group interviews. The purpose of the meeting, I said, was to receive some assistance in the design of the interviews, particularly in terms of translation. I said that during the interviews I would need one assistant, whose function would be to help me in case of misunderstandings, to pick up bits of information that I may miss, and to immediately after each interview sit down with me to help me remember everything and write down the principal findings. There was a suggestion that I would use a tape recorder, but others thought that a tape recorder would make some people uncomfortable. It was also suggested that I would create informal and comfortable settings for the interviews, as people actually like talking about these issues, if the setting is comfortable. A comfortable setting, they said, would be to meet in somebody's house, drinking cassava brew together.

I read aloud all the questions and the themes that each question is supposed to cover. First, it was suggested that I should ask much more concrete questions, such as:"Do you think the animals are vanishing?" or "The animals are vanishing, what do you think about this?". Using some examples well known by some of the participants, I explained why I wanted to use neutral and open-ended questions. At this point, people started to discuss with each other very actively, both about the questions and answering the questions themselves. We proceeded to discuss and translate each question one by one. I read out each question aloud, and people suggested different translations. Word by word translation often was not possible or appropriate, so it was more a question of capturing the purpose and essence of the questions and expressing it in Kichwa. A teacher wrote the suggested translations on the blackboard. The discussions proceeded until a fair degree of consensus about the proper translation was reached. From the discussions it also became apparent that the participants thought about themselves as being the interviewer, rather than being just assistants.

A list is given below of the questions in Kichwa, and a translation back from Kichwa to English (which was not always identical to the original formulation in English):

Questions in order to open the discussion:

1. "Can ricucpi, imashinata tucusha riun ñucanchi (cancuna) causai?
   [In your view, what is our (your) life becoming like?]

2. "Maicancuna rimanaun caipi tucuimi tian nisha allita causangahua. Shuccunarandi mana imas tianchu nisha ninaun. Campac yuiaipi imashina tan?"
   [Some people say that here there is everything you need in order to live well. On the other hand others say that there is nothing. According to your thinking, how is it?]

3. "Ima tan campacraicu alli causana?"
   [What is 'living well' for you?]

Final questions

4. "Maican llactacunai yanapashun nisha shamunaun. Cai llactai imashinata ricushcangui can?"
   [In some communities people have arrived saying that they will help. Have you seen that in this community?]

5. "Imashinata cai Sarayaku achun ningui cunanmanda ishcai chunga huatai?"

[How would you like Sarayaku to be like 20 years from now?]

In the same way, a number of follow-up questions were formulated.

One interview session was held in each hamlet, in usually in a private home or, in some cases, in a school or other public building. At each occasion, about ten to twenty persons were invited to participate. In the Centro Sarayaku hamlet, also a separate interview session was held exclusively with women, and there was also one interview session with the students of the secondary school.

During the first two interviews, I did the interviewing, while also taking notes. A field assistant did the introduction, helped to explain any misunderstandings, and also took notes. However, after these experiences, strategies were revised. Two additional field assistants were recruited and given training in interviewing techniques. During subsequent interviews, one assistant gave the introduction and interviewed, while another assistant and myself took notes and occasionally asked follow-up questions. The notes were transcribed on a computer and printed out, normally within 24 hours. The fourth question provoked strong complaints about the absence of aid from the outside, particularly monetary aid. I became worried that the wording of the question might be such that it transmits an idea that somebody from outside ought to give such aid. As I wished to focus on the potential to solve problems with the resources available within the community, I decided to drop this question in later discussions. During training of the interviewer, it was emphasised that the introduction to the interviews must be given in a neutral way. As there is no Kichwa word equivalent to “natural resources” or “livelihood”, we agreed to speak about “our life, our soil, our forest, our air, and our water”. The exact wording of the introductions naturally varied. An example is given below, a transcription of the only tape-recorded introduction:

”This way we have coordinated with the varayuk in order to come here today. In the last assembly we talked a little, in the general assembly. Anders said that we would go to all villages, all small hamlets, in order to talk this way. Now we have been accomplishing that, we have already conversed in Kalikali, Sarayakillu, with the women of the Centro, Shiwakucha, and the people around the airstrip. So now the turn has come for us to come here. So we have agreed with the varayuk to come here today. Alright, we come in the first place, what’s it called...to converse with you, but most of all we want to hear your thoughts. We do not come in order to say that your thoughts are bad or that your thoughts are good, but we come now only to listen to your thoughts. Now you may talk about our forest, about our land/soil, our air, about our water/rivers. Furthermore, from now on we will continue conversing with you, with everybody. Now we are just in the beginning of this conversing, in order to from now on begin researching in order to know, all of us. For example, if one single person knows, that is no good. But conversing with you, with the whole community every now and then, that is good, in order to learn together, in order to, in the future, reach a good understanding about what is happening to us. So we have talked a little about these things, that was the way we have thought. This idea is the same that we have been talking about each and every time in the assemblies. Anders has picked that up, and we thought we would all do a research effort together, in order to learn all of us together. So, perhaps it would

be good to start the conversation. In your view, what is our life becoming like? How do you think when I say that?"

After completing the interviews, the results were summarized on posters. These were then re-presented and further discussed at two workshops, first with some 50 secondary school students, and then at an open meeting attended by about 25 people. On these occasions, some additional points of view were added to the posters. The figures and boxes shown in Chapter 7 are based on such posters. It should be noted that it was not possible to make the posters during the interview sessions themselves, as many of the participants were illiterate. Illiteracy was also a problem when presenting the results on the posters, but less so, as mostly the young and educated attended these meetings.

4.3. Natural resources in local livelihoods: Household livelihood study and anthropometric measurements

The purpose of this study (Chapter 7) was to put the use of specific natural resources in its socio-economic context. In order to assess the importance of different types of natural resources in the local economy, and the impact of the perceived depletion of natural resources, two complementary approaches were used. One focused on household economy, and the other used anthropometric measurements as indicators of nutritional status.

4.3.1. Household livelihood study

Describing the livelihood system of the Sarayaku households, and quantifying the flows of natural resources and money, was important in order to understand the interactions between human society and the natural resources. This, however, demanded quite intrusive data collection procedures, not only because of the required frequency of visits to the households, but also because, in the local culture, being inquisitive about what and how much other people eat is considered very impolite. This could potentially have caused unease and conflict that might have put the continuation of the whole research project at risk. Paying people to make them participate in actions they considered unpleasant and against their cultural norms might have been possible but would have been contrary to the general ethical and methodological principles guiding the research (see Chapter 3).

Therefore, this component of the research was left until near the end of the fieldwork period. By this time we had built up a great deal of confidence with the students of the secondary school, by participating in teaching and supervision of graduation theses. Thirteen students, most of them in their upper teens or early twenties, were informed about the purpose of the study and agreed, after asking their parents for permission, to record the income and expenses in terms of money and food in their respective households, during one week each. They would also keep a copy of the data in order to use it in class, under the guidance of José Machoa, for practicing calculations of nutrient content, using tables of nutrient composition that we provided

With minor variations, either I, José Machoa, or both, visited each household in the afternoon every day except Sunday during one week, beginning and ending on Monday. At each visit, all food items that had entered or exited the “home” since the last visit were recorded. The *home* was defined as the houses and the surrounding open area and home gardens. Usually the parents of the student provided most of the information. The researcher (myself or José Machoa) and the student took notes on separate data sheets, and the student retained his/her sheet for use in school. For food items the origin or destination was recorded (own produce, sold, bought, gift). If still available, food items were weighed with a simple spring balance. Otherwise their weight was estimated by either recording their quantity in known units such as “bunches” of plantains or “baskets” of cassava, or, particularly for fish, by letting the respondents indicate the volume using a 10-litre plastic bucket. By weighing fish in the same bucket we got a conversion factor that permitted us to convert the volume measurements into weight measurements. For monetary exchanges, the amount of money as well as the item bought or sold was recorded, and also whether the other part in the exchange was a private person or a shop. The number of domestic animals possessed by each household was also recorded.

The original intention was to also record actual food intake, but this was very difficult to estimate with any reasonable accuracy. Moreover, it proved to be too intrusive according to local cultural norms, and became very embarrassing for all parties involved. For these reasons, this component of the study was discontinued after only three days of trial. The drawback of dropping this component of the study was that food that was consumed without having crossed the border of the “home”, as defined for this study, was then not recorded at all. This concerned, for example, fish or wild fruits consumed on site, fruits grown in the home garden, and poultry and eggs produced at home. On the other hand, the figures presented include also those foodstuffs that are brought home, but end up getting thrown away or given as feed for dogs or poultry. We attempted to quantify these “losses”, but it was difficult to do with any accuracy, and those data are therefore not included in the analysis. All these biases must be taken into account when using the resulting figures as approximations for actual food intake.

The data were recorded from April to June 2001, except in one household for which data were recorded in August. A total of 87 household-days were recorded. After applying a factor to calculate the edible portion of each food category, the nutrient contents of the food items were calculated based on Junk (1985), Franco (1987), Dufour (1988), Bienvenido (1993), and Aguiar (1998). It was somewhat problematic to calculate the nutrient content of wild game, and even more so to calculate the nutrient content of fish. For wild game, data on nutrient content were available for the five species that top the list of annually harvested weight, and make up about half of the total annual game harvest in Sarayaku (see Chapter 9). Based on these five species, an average nutrient composition for wild game meat was calculated, in order to apply to all game meat recorded. For fish, there were data available for very few species present in the study area. The average nutrient composition was therefore calculated based also on some other species inhabiting the Amazonian river system, and closely related to common food fishes in the study area. Selecting these species, altogether twenty-five, was done with help of

Castro (1994), Salinas-Coy & Agudelo-Córdoba (2000), and the internet-based database FishBase (Froese & Pauly, 2003). It was complicated by the fact that the fish in Franco (1987) are listed only by vernacular name, which often may correspond to several species. While the data on protein content was quite similar between species, there were large variations in fat content, which ranged from 1.2% to 3.8% for wild game and from 0.5% to 24.9% for fish. For a couple of species of wild game, more occasionally hunted, and not included in the calculations, also fat content figures exceeding 20% were reported (Franco, 1987). It should be noted that Amazonian fish show high seasonal variation in fat content (Junk, 1985). This is also well known by the people in Sarayaku who, moreover, claim that also game animals show similar variations in fat content. In sum, there is considerable uncertainty about the real fat content in the fish and wild game consumed in Sarayaku, and this must be borne in mind when interpreting the results.

4.3.2. Anthropometric measurements

Anthropometry is a series of standardized techniques to measure the body and its parts. It is a practical field method to assess nutritional status on community level. However, it must be remembered that nutritional status not only depends on food intake, but also on other factors such as disease and parasite infestation. As all these factors depend on general socio-economic conditions, anthropometric measurements may mainly be useful as a general socio-economic indicator (Siqueira, 1997). The most commonly used anthropometric indicators are Height-For-Age and Weight-For-Height. Chronic malnutrition inhibits growth and leads to low Height-For-Age, also called *stunting*. Acute malnutrition leads to loss of fat and muscle tissue and therefore low Weight-For-Height, also called *wasting*. Measurements of arm circumference and skinfold thickness provide additional information about the proportions of muscle and fat. The data for the study population are compared with a reference population, and reference data from the United States in the 1970's are most commonly used (Frisancho, 1990), being a population with basically unlimited access to food.

For this study, anthropometric measurements were made on 444 individuals of all ages, but children under one year of age were excluded from the analysis. This included most inhabitants of the four peripheral hamlets and, in the central hamlet, the members of a few households and the pupils of the two primary schools. Except for the school pupils, all measurements were made in the homes of the persons measured. I was accompanied by the respective female hamlet assistant of each hamlet (see Chapter 3), and the nurse of the local health station. We had all practiced on beforehand, calibrating our measurements between each other. In addition to assisting with the measurements, the nurse also provided some medical attention when needed. Standardized procedures were used according to Frisancho (1990). For practical reasons, however, weight was measured with a bathroom type scale, which was checked against a platform-beam scale located in the health centre near the central plaza of Sarayaku, in order to ensure that it measured weights accurately and that it did not deteriorate over time due to humidity and dirt. Similarly, height was measured with a homemade portable standiometer. As floors often were uneven, the bathroom scale, as well as the standiometer, was placed on a wooden platform, carefully placed in horizontal position with the help of a water level. Upper arm circumference was measured with measuring-tape, and triceps skinfold thickness with a skinfold caliper. The measurements were made in August 2000, except for 63 measurements that were made in December.

Height-For-Age (HFA) was used as an indicator of linear growth. Using Weight-For-Height as an indicator for relative fatness/thinness was impractical, because some individuals were so short that there was no corresponding weight data in the reference population. Moreover, Weight-For-Height is very age-dependent, particularly during adolescence, but data for the reference population (Frisancho, 1990) is provided only for broad age categories. As the age distribution of the study population was uneven over these age categories, this may potentially have caused biases of the results. Therefore, Body Mass Index (weight/height^2, BMI) was used instead as an index of relative fatness/thinness. Finally, Upper arm Muscle Area (UMA) was used as an index of protein reserves. The formula for calculating Upper arm Muscle Area assumes that the upper arm and its constituents are cylindrical. The upper arm muscle area is calculated by first calculating the total area of the cross-section of the upper arm, then subtracting the fat area, and finally subtracting a standard value in order to correct for the bone area (Frisancho, 1990). In order to facilitate comparison and interpretation, all measures were transformed in to z-scores, based on the age- and sex-specific means and standard deviations provided by Frisancho (1990), using the formula:

z-score = (mean value of reference population - value of subject) / (standard deviation of reference population)

Accordingly, a z-score of zero means that the measurement is equal to the average of the reference population, whereas a z-score of –1 means that the measurement is one standard deviation below the average of the reference population. Establishing cut-off points to indicate malnutrition at the individual level are necessarily arbitrary, but in accordance to Gorstein et al. (1994), here a z-score lower than –2 is used as an indicator of risk of malnutrition at the individual level.

In addition to using the standard reference population from the United States (Frisancho, 1990), comparison was also made with anthropometric data from the mixed Kichwa-Achuar community of Conambo, collected in 1993 and kindly provided by Patton (Orr et al., 2001). I recalculated HFA, BMI, and UMA from the original data set in order to ensure that comparisons were valid. The use of the data from Conambo allowed comparison with a community less affected by depletion of wild game and other local natural resources. According to standard procedures (Frisancho, 1990), pregnant women should not be included when calculating average body mass index. However, in order to treat the data for Sarayaku and Conambo, respectively, in a consistent manner, and because no women in Sarayaku admitted to be pregnant unless it was obvious at sight, pregnant women were included in the calculations. The mean z-scores shown for Body Mass Index for women in reproductive age are therefore somewhat higher than the correct values.

4.4. Agricultural land use: Remote sensing and field plot data analysis

This study (Chapter 8) focused on quantifying the area affected by agriculture, and assessing how the location of a particular place affects land use. The aspects of land use studied were, in the first place, whether any particular place was cultivated or not. For cultivated areas, the focus was also on the intensity of cultivation, in terms of the length of the fallow periods. Moreover, the study aimed at assessing the recent changes in land use. All this involved considerable methodological challenges.

The concern for the fate of the tropical rainforests has inspired numerous studies of land use dynamics in tropical rainforest areas over the last couple of decades, also spurred by the developments in remote sensing technology. Studies of land use dynamics in tropical rainforests tend mostly to focus on areas where drastic immigration or socio-economic changes have caused obvious changes in land use (e.g., Hayes et al., 2002; Wood & Porro, 2002). Studies of more gradual land use changes in shifting cultivation systems in sparsely populated tropical rainforest areas are less common (but see Wilkie, 1994). One reason for this scarcity may be methodological difficulties, as will be discussed further on. Putting more attention on this kind of situation is, however, motivated by the fact that local people may experience problems in the form of land shortage even when deforestation is limited (see Chapter 6). In order to avoid future problems of deforestation it is also important to detect changes while there is still time to act.

Remote sensing technology has proven very useful in order to map land cover and understand land use dynamics in tropical rainforest areas (e.g., Moran et al., 1994; Brondizio et al., 1994; Steininger, 2000; Lucas et al., 2002). Methodological progress has been rapid. There is a wide variety of methods for classifying images according to the spectral properties of each pixel (e.g., Adams et al., 1995; Hill, 1999; Mausel et al., 2002; Salas et al., 2002). In order to facilitate between-image comparison, methods have been developed for pre-processing of images that correct for differences in solar angle, atmospheric conditions, and sensor variation (Green et al., 2002). Also, remotely sensed data is increasingly linked to botanical, historical and socio-economic data, in order to get a better understanding of the causes of land use change (e.g., Brondizio et al., 1996; Liverman et al., 1998; Fox et al., 2003). However, the interpretation of satellite images rests on the assumption that the land cover classes to be distinguished from each other actually have different spectral properties. This is not always the case, and often land use classes are confused with each other. Also, it is important to point out that image interpretation is not an objective scientific method. It relies on extrapolation, to the whole image area, of the analyst's knowledge of a small subset of the area, based on on-the-ground observation. This process involves a number of subjective decisions. In spite of these inherent limitations of the information provided by satellite images, few authors nowadays use alternative methods to study land use dynamics in the tropics (but see Lawrence et al., 1998).

For this study, I used two complementary methods for studying the dynamics of land use. The first method is based on analysis of interpretation of remotely sensed data, the other is based on direct analysis of data recorded for each field plot, using each plot as one data point.

4.4.1. Remote sensing

4.4.1.1. The principles of vegetation classification by digital image analysis

The smallest element of a satellite image is the *pixel*. In this study, Landsat TM and ETM+ images were used, where each pixel represents a 28.5 × 28.5 m area on the ground. For each pixel, there are a number of *digital numbers* (DN), each one representing the radiance, received by the satellite sensor, within a particular wavelength interval. In this study, six such wavelength intervals, also called *bands*, are used, corresponding to blue, green and red, and three infrared bands. Because of the limits of our eyesight, only three of these bands can be used simultaneously for visual observation of the image.

However, the analyst can freely choose to assign blue, green and red colour, respectively, to any of the bands. Satellite maps made this way are often called *false colour composites*. For digital analysis of the image, on the other hand, one can simultaneously use the information contained in all bands. Any particular piece of land has a characteristic combination of reflectance in each band, called a *spectral signature*. Based on such spectral signatures, it is possible to digitally classify the image into different classes, as defined by the analyst. This requires, however, that the difference in spectral signature between the classes is large enough not to be obscured by the variation in spectral signature within each class.

There are two basic methods of digital image classification: (1) *Supervised classification*, where the analyst indicates a limited number of areas, called training areas, on the image, for each land cover class. Based on this information, the computer calculates one spectral signature for each land cover class. Then the computer compares the spectral signature of each single pixel on the image with the spectral signature for each land cover class, and each pixel is assigned to the class that has the most similar spectral signature. (2) *Unsupervised classification*, where the computer classifies the image into spectrally similar clusters by means of pure mathematics, and the researcher afterwards decides which cluster corresponds to which land cover class. Doing supervised classification requires that the analyst has made observations on the ground, called ground-truth, which can be related to the corresponding pixels on the image, and this is often necessary also for unsupervised classification. Therefore, both the image and the ground-truthed field plots must be put onto the same coordinate system, a process called georeferencing. In order to georeference field plots, their coordinates are collected with a GPS receiver. In order to georeference the image, a number of landmarks, well distinguishable on the image, are selected as ground control points (GCPs). Coordinates for these ground control points are measured either with a GPS receiver in the field, or on a good map.

Depending on the land cover classes one wishes to distinguish, and the particular characteristics of the area in question, image classification can be very straightforward, very complicated, or even impossible. Therefore, after having completed the image classification, it is important to assess its accuracy (Lillesand

& Kiefer, 1994, p. 612). Unfortunately some studies are published without such an assessment (e.g., Behrens, 1994), and the results of such studies need to be taken with caution.

For the present study, the image interpretation procedure was extraordinarily complicated. There were challenges related to the environment as such, particularly haze and topographic shade, and there were also challenges related to the agricultural system, particularly that cultivated areas are small and often have a dense vegetation cover, and they also change over time according to a succession of different cultivars (see Chapter 8). These challenges are further described below, followed by a description of how they were dealt with.

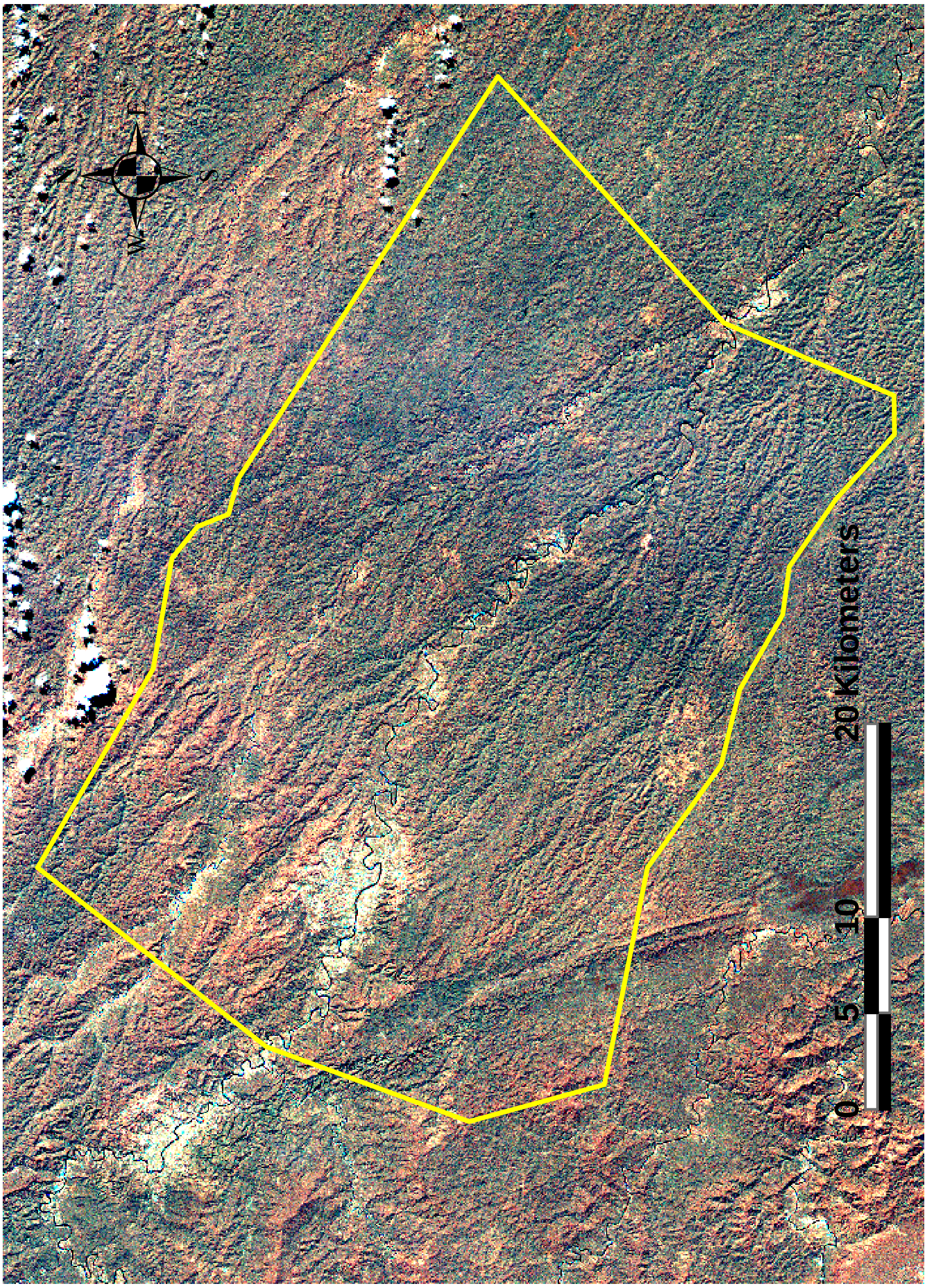
4.4.1.2. Challenges to land use classification by remote sensing

The study area is often covered by clouds or haze, as is typical for the Andean Amazon. Therefore there existed only two or three Landsat scenes over the study area that were both fairly cloud-free and of good technical quality. The images analyzed were acquired on September 11, 1987 (Landsat TM) and on August 24, 2001 (Landsat ETM+), respectively. Unfortunately there was haze on both images, which varied in degree not only between images, but also within each image.

The area also has a rugged terrain, which causes marked differences in illumination on east- and west-facing slopes, respectively (Fig. 4.3). Such topographic effects have often been corrected for with the help of Digital Elevation Models (e.g., Colby & Keating, 1998). This, however, was not an option because the resolution of the contour lines on the existing maps was too coarse in comparison with the size of the land use units under study. The almost unbroken cover of vegetation and the absence of built-up areas also meant that points for georeferencing and registering had to be sought for almost exclusively among natural features and that there were no non-vegetated areas suitable to use for radiometric rectification (see Green et al., 2002).

The average field size is just 0.2 ha, corresponding to a square with 45 m sides, just barely larger than the pixel size of the images used (28.5 m). The error margin of the GPS receiver (Silva Forest XL 1000) was, according to the manufacturer, 15-20 m, that is, also almost pixel size. During field work, this error sometimes got considerably larger due to thick clouds or heavy rain. Georeferencing of the image and the field plots therefore had to be made with extraordinary care in order to avoid that the field plots, when laid over the image, ended up in the wrong place.

Fig. 4.3. (Next page). False colour composite of the study area. The fields and fallows surrounding the Sarayaku village show up as light blueish-yellowish spot towards the left extreme of the yellow polygon. Note that the topography causes marked differences in illumination between east- and west-facing slopes. The yellow polygon delimits the study area as defined for the quantitative analyses of agricultural land use, and is not identical to the limits according to traditional arrangements or the recent legal land titles (see Chapter 2.1). Landsat ETM+, August 24, 2001. Band 4 (red), 5 (green), and 7 (blue)


0
5
10
20 Kilometers

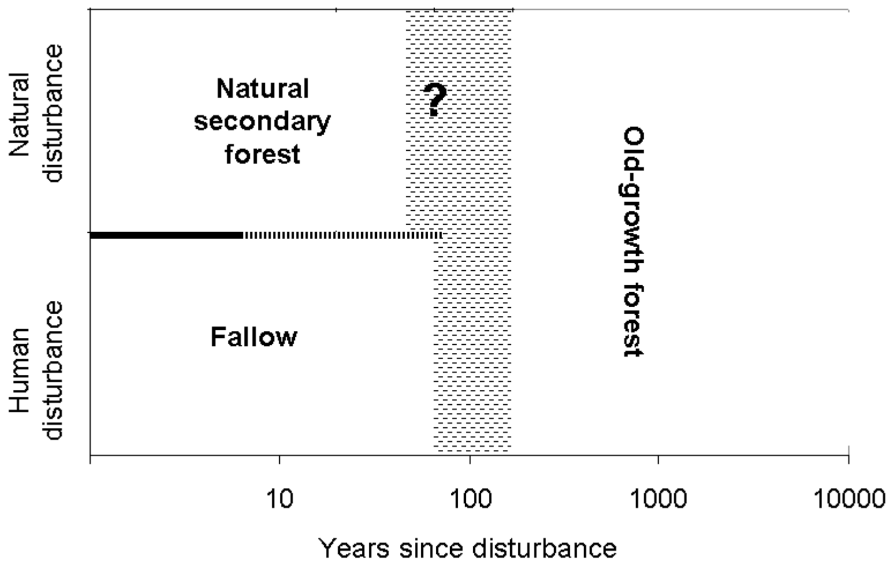


Fig 4.4. Distinction of wooded land cover types by means of visual observation. Fallows grown up on abandoned fields have, at least initially, a different appearance than natural secondary forests, grown up after windfalls or landslides. Fallows are distinguishable from old-growth forest during at least some 60 – 65 years, but hardly during more than 150 - 200 years after disturbance. Natural secondary forest probably acquires the appearance of old-growth forest more rapidly than fallows do, particularly when the disturbed area is small.

Except for cassava and maize fields, cultivated areas tend to be almost completely covered with vegetation, making them spectrally similar to fallows and old forest. The vegetational structure of cultivated land in the area also changes over time, so defining land use classes requires establishing cut-off points along what essentially is a continuum. First, fields change according to a succession of different cultivars, for example cassava-barbasco or maize-cassava-plantain (see Chapter 8). Then they become fallows, which finally become old growth forests bearing no obvious signs of ever having been cut down. As this process is gradual, there is no clear-cut dividing line between what is fallow and what is old growth forest. There are borderline cases, such as the so-called *tawaypurun*, old fallows scattered on the ridgetops, as remnants of those days when the people lived dispersed in the forests (see Chapter 5). Except for the *tawaypurun*, however, fallows tend to be cut down again when they still are easily distinguishable from the old-growth forest. In sum, the total area of the borderline cases is small. Distinguishing fallows from natural secondary forest, grown up after windfalls, landslides, or alike, is also quite easily done in the field by simple visual observation. Thus, on the ground, “fallow” is a fairly well distinguishable category of *land cover* as well as a quite clearly defined category of *land use* (Fig. 4.4).

However, when using remote sensing in order to classify the vegetation, things were less straightforward. Although there seemed to be slight differences in the spectral properties of fallows and natural secondary forests, there was too much of an overlap between them to make it meaningful to attempt to separate them based on their spectral characteristics alone. Moreover, although their botanical structure

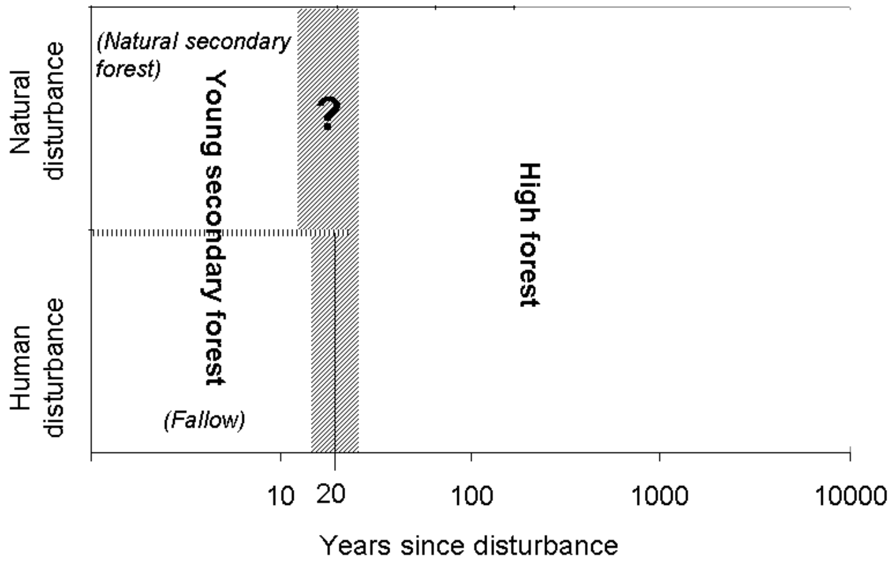


Fig. 4.5. Distinction of wooded land cover classes by means of remote sensing analysis based on the spectral properties of the vegetation. Fallows and natural secondary forests had very similar spectral characteristics and were therefore treated as one single land cover class (called "young secondary forest"). The age at which fallows become spectrally indistinguishable from old-growth forest was initially unknown, but could after the evaluation of the classification be estimated to about 20 years. Fallows older than this were classified as "high forest".

and composition may remain distinctive from old-growth forest during several decades, fallows tend to acquire spectral characteristics indistinguishable from old-growth forest much more rapidly (Moran et al, 1994; Steininger 1996, Lucas et al. 1993, Steininger 2000, Lucas et al. 2002). In sum, it was not going to be possible to distinguish the *land use* class "fallow" from old growth forest by means of spectral analysis alone. Instead, as a first step, it was necessary to do a classification of *land cover*, distinguishing "young secondary forest", including fallows as well as natural secondary forests, from "high forest", including old-growth forest as well as the fallows that had reached the stage of maturity when they become spectrally indistinguishable from the old-growth forest (Fig. 4.5.). At this point, there was still no way to relate the spectral characteristics of the vegetation to its age. That could only be done after classifying the image and also evaluating the classification (see section 4.4.1.5).

4.4.1.3. Pre-processing

Pre-processing involved the following major steps: (1) georeferencing, (2) radiometric calibration in order to convert raw digital numbers to physical measures of at-sensor radiance, (3) atmospheric correction in order to convert measures of at-sensor radiance to measures of on-ground reflectance, and (4) radiometric rectification in order to eliminate or reduce any remaining differences between images that would complicate between-image comparison.

For the purpose of georeferencing, twenty ground control points (GCP) were collected, which we believed would be possible to locate within pixel distance on the 2001 satellite image. Most of these points were spread out within the study area, but some were located to the northwest or the southeast along the Bobonaza River. No ground control points were collected to the northeast and southwest of the study area due to the difficulty of transportation. Features used as ground control points were rivermouths and river junctions, lake ends, small (one-pixel size) clearings, and road forks. Several GPS measurements were made for each GCP during a period of 20 to 40 minutes, and for several of the GCPs this procedure was repeated two or three times on different days, in order to get independent measurements and increase the precision. The exact location of rivermouths and river junctions can change within a time span of a few hours due to fluctuations in water level, and in the time span of a few years due to erosion and sedimentation processes. Therefore, care was taken to collect such GCPs primarily in places with steep slopes of hard material. Nevertheless, some GCPs were collected at rivermouths on flatter places of loose material, but only very soon after the image acquisition date when there had been no flood, and when the water level had changed little. About forty additional GCPs, particularly lakes, were collected from 1:50 000 topographical maps. GCPs with measurement errors were discarded one by one, by discarding the GCP with the highest residual error, then re-calculating residual errors, again discarding the GCP with the highest residual error, and so on until about 30 GCPs remained and the root mean square (RMS) error was about half pixel size.

The 1987 image was then registered onto the 2001 image. Several of the GCPs used for georeferencing were also used for registering, but those that may have changed over time, such as rivermouths in loose material, were not used. Instead, several one-pixel sized shaded areas were used. These represent steep depressions that are unlikely to change over time.

Radiometric calibration was made according to Green et al. (2002) with one important modification. This process involves identifying a minimum and a maximum value of digital numbers for each band, between which all information that is relevant to the study is contained. Values outside this interval are cut off. According to Green et al. (2002) this should be done by visually inspecting the histograms of digital numbers for each band, cutting off the values on the tails of the histograms. Doing it this way would, however, have implied losing information for the pixels representing fields. These were a very minor fraction of the total number of pixels, and had very high reflectance in most of the bands, such that some of these pixels appeared far out on the barely visible tails of the histogram. Therefore, the maximum values were instead set by inspecting the digital numbers of known objects on the ground with very high reflectance, namely bare soil and tin roofs, and set above the digital numbers of these objects, but below the digital numbers of the clouds that were present in the image.

Atmospheric correction was made according to Green et al. (2002). Lakes within the study area were too small and shallow to function as dark area objects. Instead, a lake outside the study area was chosen. As the atmospheric conditions visibly showed great variation within each image, this procedure obviously produced far from perfect results. Radiometric rectification based on non-vegetated dark and bright areas that do not change over time (see Green et al., 2002) was impossible because no such areas could be identified on the image.

Preliminary unsupervised classification of the whole study area indicated that the spectral differences caused by different degrees of haze in different parts of the images were of the same magnitude as the spectral differences between different types of land cover. Preliminary unsupervised classification of small parts of the study area also indicated that topographic effects considerably affected classification. Particularly, primary forest on sun-facing slopes got confused with secondary forest. Thus, it was necessary to correct for the effects of topography and haze.

In order to correct for topographic effects, I opted for a classification method that would account for the relative value, rather than the absolute values of each spectral band. One such method is the spectral angle method, which has successfully been used in order to map secondary succession and agricultural land in Yucatán (Sohn et al., 1999). However, I chose to use the NORMALIZE function of ERDAS IMAGINE. This function uses an "equal area normalization" algorithm that shifts each pixel spectrum to the same overall average brightness. Thus, it removes differences caused by different amount of light falling on each pixel. The drawback is that it also removes differences in spectral properties that consist of different total reflectance rather than different relative reflectance between the bands.

The normalization significantly reduced the topography-dependent variation in the infrared bands, but also caused some overcompensation in the visible bands. (Figs. 4.6 and 4.7). This may be because visible light, particularly blue, scatters more in the atmosphere, so the vegetation gets illuminated not only directly by the sun, but also by the light scattered in the atmosphere.

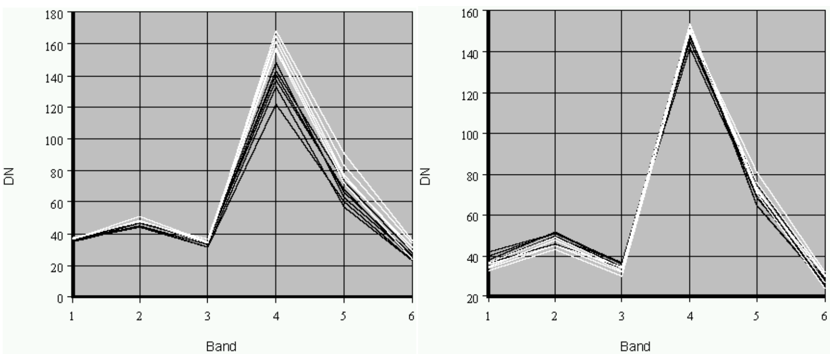


Fig. 4.6. Effect of normalization on spectral signatures. Spectral signatures of 21 old-growth forest pixels located on the sunny side (white lines), and the shaded side (dark lines) of a ridge, before normalization (left), and after normalization (right). The topography-related spectral variation is strongly reduced in the infrared bands (4 - 6), but in the visible bands (1 – 3), the topography-related spectral variation is overcompensated for, so that variation increases.

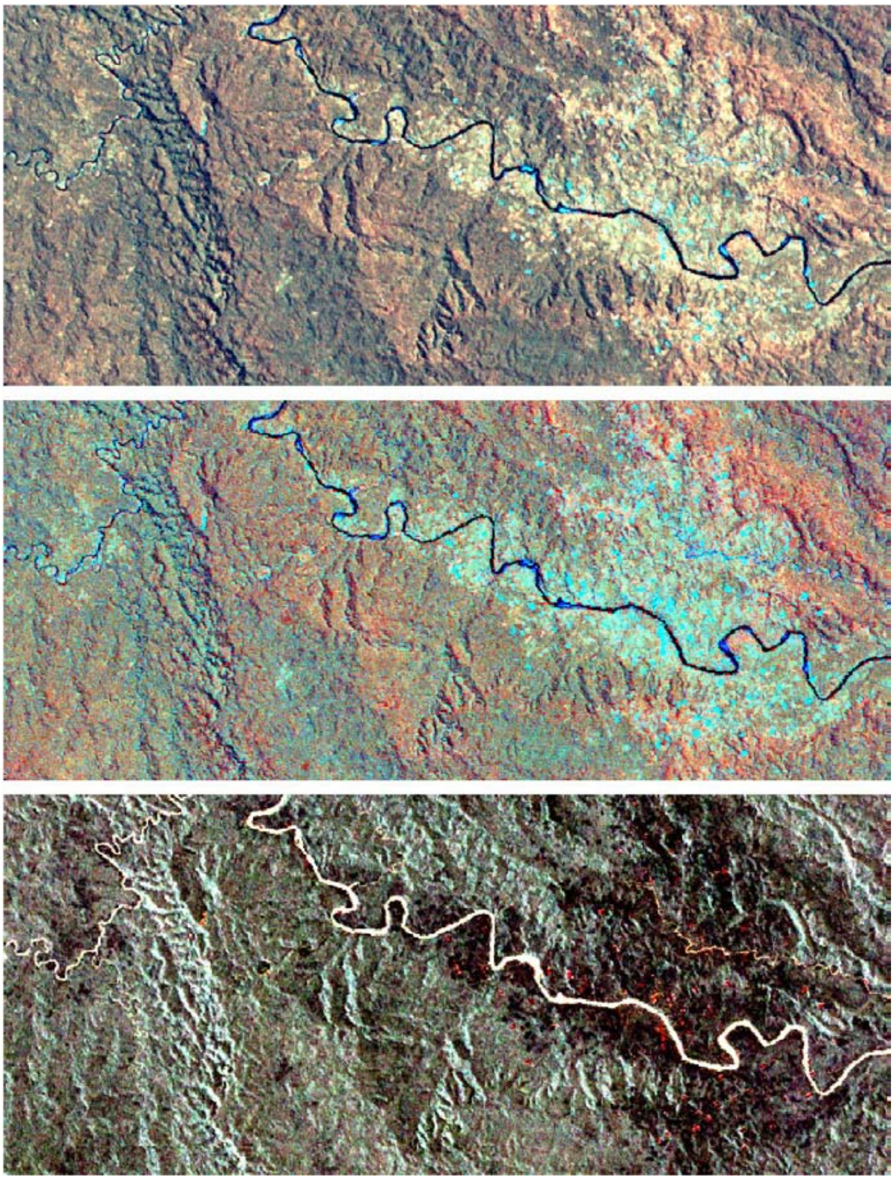


Fig. 4.7. The effect of normalization on topographic shade. Top: Original image; band 4 (red), 5 (green), and 7 (blue). Middle: Normalized image, band 4 (red), 5 (green), and 7 (blue). Bottom: Normalized image, band 3 (red), 2 (green), and 1 (blue).

Nevertheless, the major land cover classes were easily visualized on false colour composites using the visible bands of the normalized images (band 3=red, band 2=green, band 1=blue), high forest showing up green-gray, young secondary forest black, and fields bright red (Fig. 4.7c). Preliminary unsupervised classification indicated that a lot of the confusion created by topographic effects had been removed by the equal area normalization.

Later, a comparison of spectral signatures of training areas (see section “classification") indicated that the equal area normalization procedure somewhat increased the overlap between the spectral signatures of old-growth forest and young fallow in the infrared bands. On the other hand, the overlap in the visible bands was substantially reduced (Fig. 4.8), apparently improving the overall separability between the spectral signatures of old-growth forest and young fallow. The spectral signature of fields was distinct from old-growth forest and young fallow both before and after normalization.

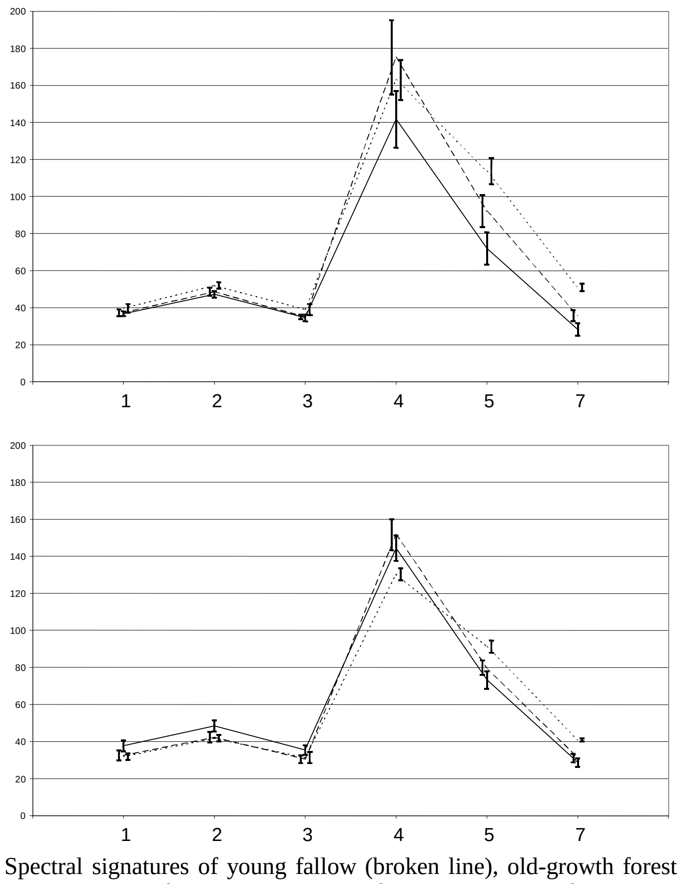


Fig. 4.8. Spectral signatures of young fallow (broken line), old-growth forest (solid line), and field (dotted line) of the 2001 image before (above) and after (below) equal area normalization. Error bars indicate one standard deviation, and are horizontally spaced in order to facilitate reading. Young fallow: left error bar. Old-growth forest: middle error bar. Fields: right error bar.

Still it was necessary to correct for the differences in atmospheric conditions within and between images, as well as rectify for any remaining radiometric differences between the images, so as to allow between image comparison. In order to do this, the haze conditions of each image were visually assessed, using the visible bands, and histogram equalization contrast in order to highlight the haze. Based on this, each image was divided into sections within which haze conditions were fairly homogeneous. This resulted in the 2001 image being divided into four "haze areas" and the 1987 image into three. Superimposing the divisions of both images on each other, six "haze areas" resulted, and accordingly each image was split up into six subsets (Fig. 4.9a,b). A number of reference areas were selected in each "haze area" for the purpose of within-image rectification. As far as could be seen by visual inspection of the infrared bands of the original (not normalized) images (Fig. 4.3), and according to my previous knowledge of the area, these areas had not undergone any change between the dates of the two images. The spectral signatures of these reference areas were collected, and the average and standard deviation for each band for each subset was calculated. Using the MODEL MAKER module of ERDAS IMAGINE, the pixel values of each image subset were recalculated according to a formula I designed to make the average and standard deviation of the primary forest reference areas become equal for all subsets of both images:

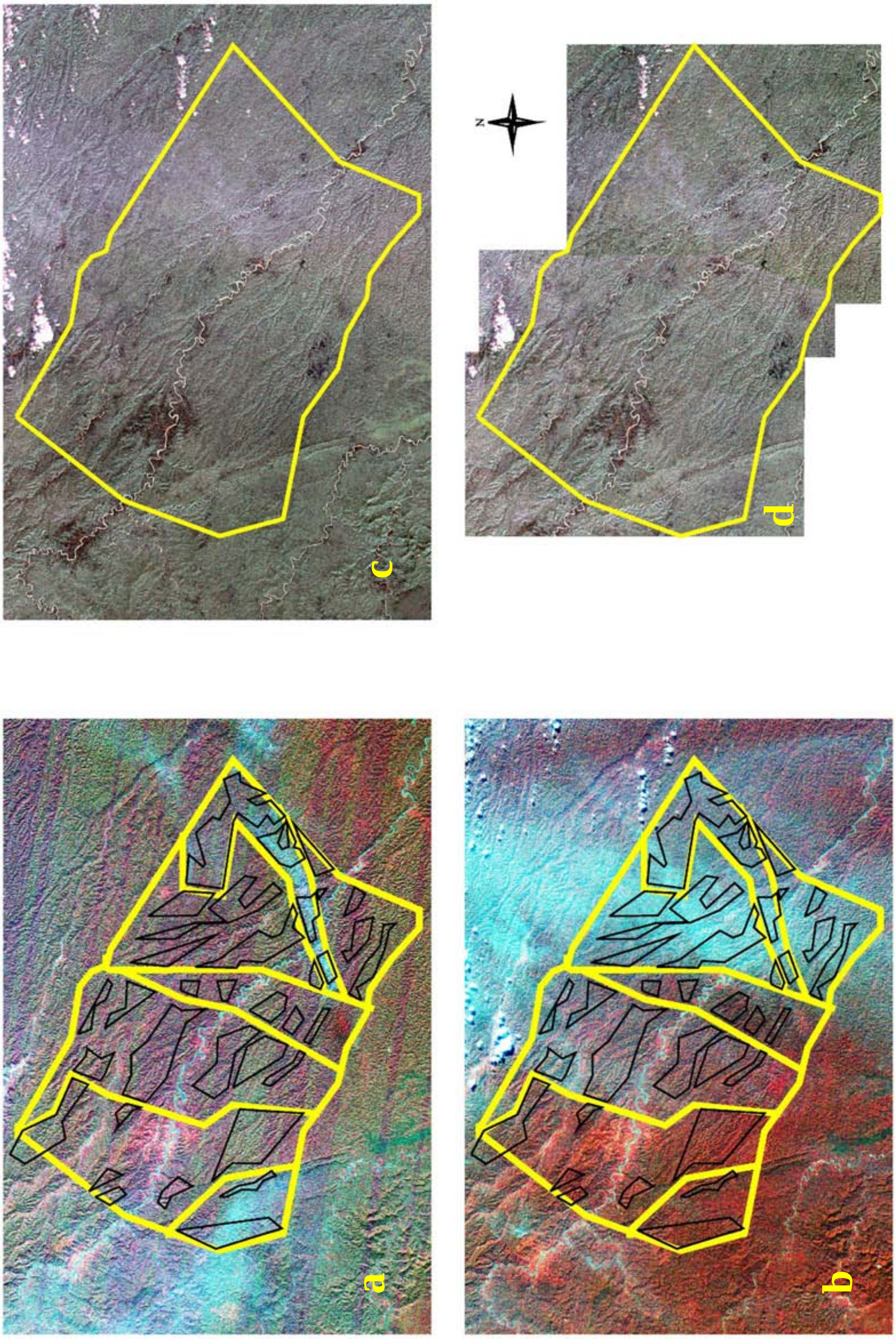
$$DN_{rectified} = Average_{reference} + (Stdev_{reference} (DN_{input} – Average_{input}) / Stdev_{input})$$

Finally, the subsets were mosaiced back together (Fig. 4.9c,d). In order to exclude water, beaches, and clouds from the vegetation classification, a mask containing those pixels was made for each image by unsupervised classification, and then combined into one single mask, which was excluded from the subsequent analyses.

4.4.1.4. Classification

Ground truth data were collected in the field between 1999 and 2001. Sampling was initially opportunistic, with a bias towards large land use units, in order to minimize problems with mixed or misplaced pixels. Usually four persons participated; the (male or female) owner of the plots, myself, José Machoa, and a (male or female) hamlet assistant (see Chapter 3) who knew the owner well. Land use plots were georeferenced with GPS receiver (Silva Forest XL 1000). Typically, GPS points were taken in four to twenty "corners" of each such plot, walking around them three to four times. Average coordinates were then calculated for each corner. A basic botanical description was written down and current land use was recorded. An interview with the owner regarding the land use history was conducted, usually starting with asking when the plot had been cleared for the first

Fig. 4.9 (next page). Correction of haze effects. (a) 1987 image and (b) 2001 image: The images were divided into six subsets (yellow polygons), each one with relatively little internal variation in haze conditions. Within each subset, a number of areas of unchanged old-growth forest were selected as reference areas (black polygons). Bands 1 (blue), 3 (green) and 5 (red), histogram equalized in order to highlight the haze. See text for more details about the procedure. (c) Normalized 2001 image before correcting for haze effects, and (d) after subsetting, radiometrically rectifying, and mosaicking the subsets back again. Bands 3 (red), 2 (green), and 1 (blue).


c
d
a
b

time, and then recording every change in land use that the owner could recall, such as making a field, or letting a field grow back to fallow. The owners could not always tell the exact year or month of any particular land use change, but as they made reference to the age of their children at the time, to particular events in the history of the community, to school vacations and religious holidays, it was possible to reconstruct the history of most plots with a fair level of precision.

After the Landsat ETM+ image was acquired in September 2001, land use plots for which any major change in vegetation could be expected since the date of fieldwork, particularly areas that may have gone from field to fallow, were visited again for visual inspection. Also, the owners were consulted again about the approximate time of abandonment or any other observed changes in land use and land cover. However, the small size of the plots made it problematic to use them as training areas for supervised classification. Even if georeferencing would have been perfect, not many pixels were entirely inside the limits of georeferenced land use plots, making the sample size very small. On the other hand, to increase the sample size, one had to include pixels that might have been mixed or, in cases of even minor errors in georeferencing, totally outside the land use plot it was supposed to represent. Therefore, first unsupervised classification was made, using a small number of classes on small subsets of the image, containing the training areas. Training areas were then digitized based on this unsupervised classification in combination with the GPS-measured polygons (Fig. 4.10).

Visual interpretation of spectral signature diagrams and separability analysis using a Transformed Divergence algorithm indicated that plantain fields, barbasco[13] fields, pastures, and secondary regrowth on abandoned pastures, could not be well separated from other types of land cover. Old-growth forest, fallows (grown up on former fields) and fields, on the other hand, could be fairly well separated from each other (see Fig. 4.8b), and it was decided to classify the image into these categories only.

Supervised classification worked fairly well for the 2001 image. However, it was less satisfactory for the 1987 image, because there were not enough training areas of the field class for this image. Using also the spectral signatures from the 2001 image in order to classify the 1987 image improved the result. However, it was still not good enough for comparison between the two images. This was probably due to minor errors in the atmospheric correction and possibly also to differences in moisture content of the soil and vegetation on the two dates

Instead, each image was run through unsupervised classification with 200 clusters. Based on the spectral signature and spatial pattern of each cluster, they were aggregated into the *land cover* classes “high forest”, “young secondary forest” and “open land”, with the intention that the latter two should correspond to the *land use* classes “fallow” and “field”. Clusters that were difficult to assign to a land cover class were run through unsupervised classification once again. Classifying the open land was quite straightforward because of the distinctive shape and location of the fields.

[13] *Lonchocarpus nicou*, a native plant used as fish poison (see chapter 11),

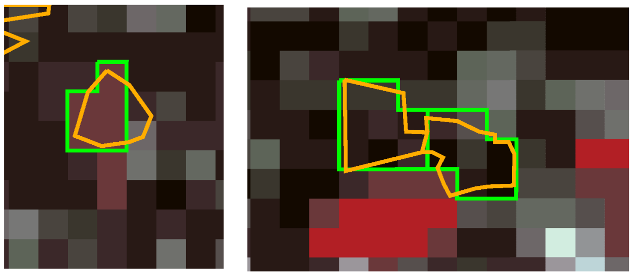


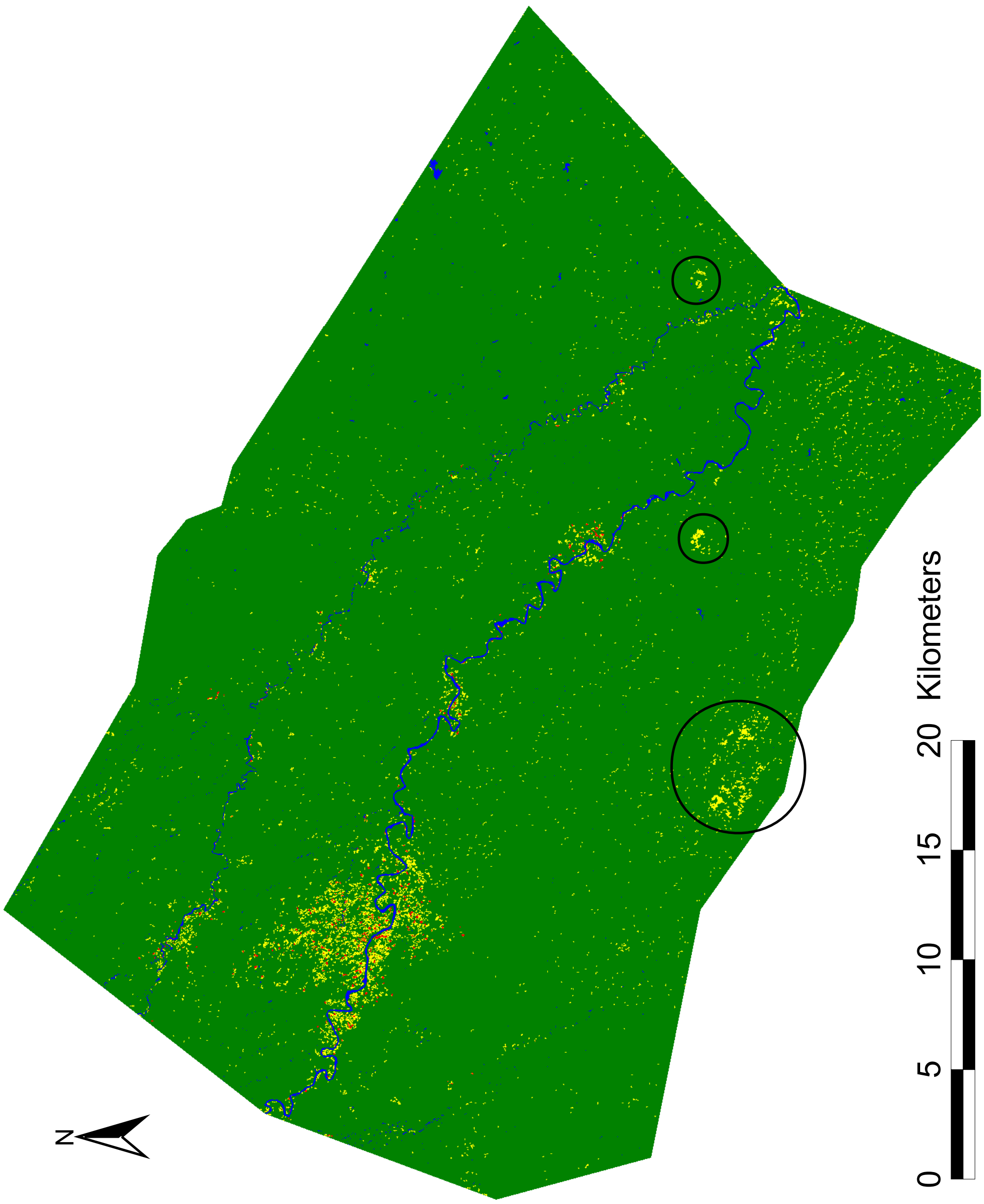
Fig. 4.10. Selection of pixels to use for collection of spectral signatures was done based on GPS-measured polygons, field notes and unsupervised classification. The unsupervised classification aided the decision about whether or not include in the training areas those pixels that were only partially inside the GPS-measured polygons. Orange polygons represent land use units as measured in the field with GPS-receiver. Green polygons represent areas used for collection of spectral signatures.

It was, however, difficult to classify young secondary forest in a way that was consistent for both images. For this purpose, I attempted to visually compare the amount of primary forest pixels that got classified as young secondary forest, in order to keep this equal for both images. After the classification, the percentage of the old-growth forest reference areas (see Fig. 4.9) that had been classified as young forest or field was tabulated. For both images, 0.5% of the old-growth forest reference areas had been classified as young secondary forest, and an insignificant number (eight pixels on the 1987 image, and none on the 2001 image) had been classified as field (Table. 4.2). The variation between the different haze areas within each image was also quite small, indicating that the classification procedure was quite consistent across the two images. The resulting classification seemed quite satisfactory. However, some pixels classified as “young secondary forest”, and a few pixels classified as “open land”, remained scattered all over the image. Using the CLUMP and SIEVE functions, areas of this “young forest/open land” class consisting of two pixels or less were eliminated. The basis of this was that even a very small clearing in the old-growth forest would affect at least three pixels, given the impact of falling trees on the surrounding forest.

Table 4.2. Percent pixels within the old-growth forest reference areas shown in Fig. 4.9 that were classified as young secondary forest.

	Haze zone						
Image	A	B	C	D	E	F	All
1987	0.42	0.56	0.29	0.49	1.1	0.59	0.52
2001	0.51	0.64	0.41	0.79	0.47	0.43	0.54

Fig. 4.11 (opposite page). *Land cover* classification of the 2001 image. Green=high forest. Yellow=young secondary forest. Red=open land. Blue= water, beaches, clouds, and heavily shaded land. See Fig. 4.5 for definitions. The circles indicate larger areas of natural secondary forest, apparently grown up after a windfall around 1990.



N
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5
10
15
20
Kilometers

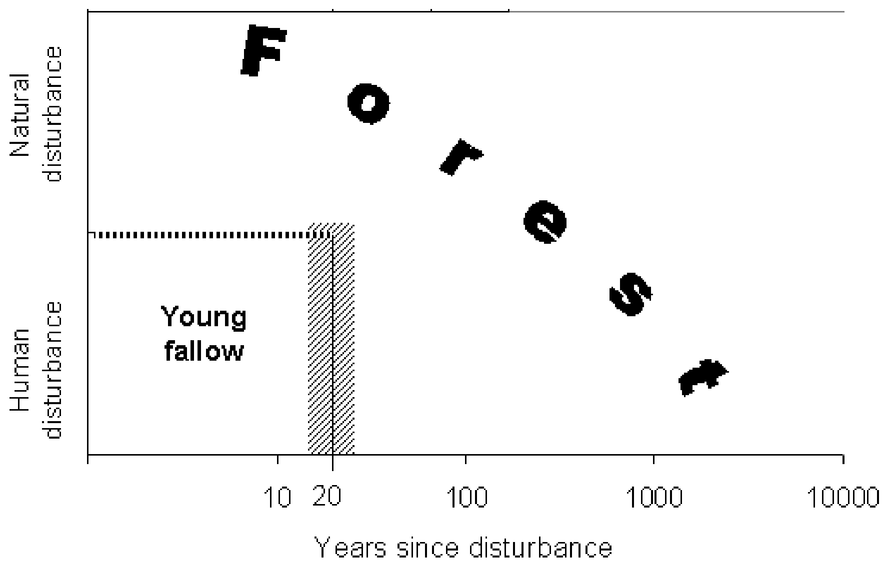
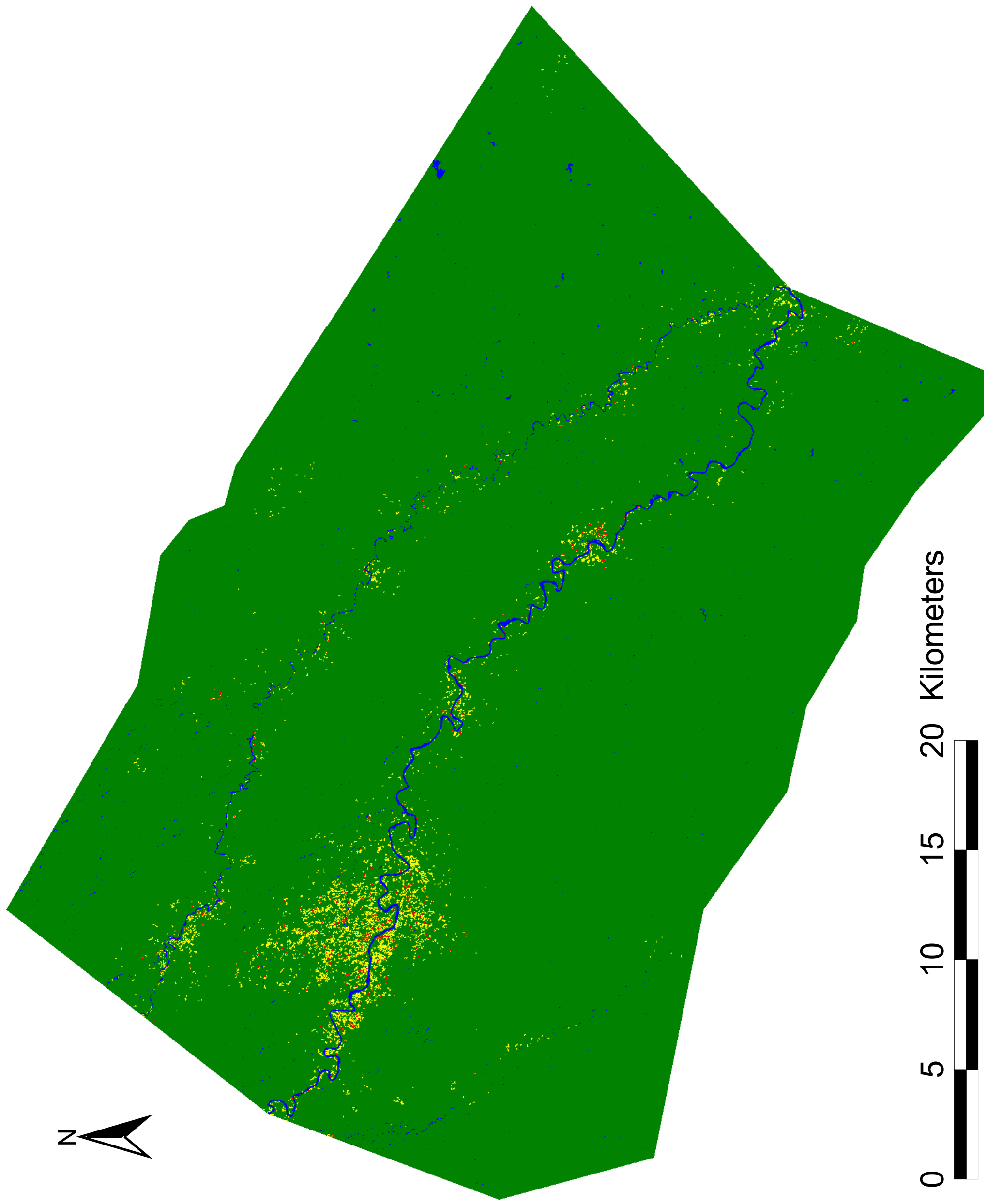


Fig. 4.12. Distinction of wooded *land use* classes by means of remote sensing and GIS, based on analysis of spectral properties, as well as contextual information. The young fallows could be distinguished from the natural secondary forests based on their location in the landscape. The "forest" class contains old-growth forests as well as natural secondary forests.

The resulting *land cover* classification of the 2001 image is shown in Fig. 4.11. Classifying areas as small as three pixels (0.24 ha) as "young secondary forest" is somewhat questionable, as they may better be thought about as part of the gap dynamics of the old-growth forest (see Chokkalingam & De Jong, 2001). However, this is of minor importance in this context, because the *land cover* classification was just one step on the way towards a *land use* classification

In order to convert the land cover classification to a land use classification, those pixels of "open land" and "young secondary forest" that, due to their location, could not correspond to "field" and "fallow", respectively, were eliminated. First, the "open land" class was displayed on top of a topographic map and manually edited, removing those pixels that were both single and in a location unlikely to be used for a field, such as in deep gorges or very far from settlements. The result was the *land use* class "field". This "field" class was laid over the "young secondary forest/open land" class, and all "young secondary forest/open land" pixels that were not "field" got assigned to the "young secondary forest" class. In order to separate those pixels representing anthropogenic fallows from natural secondary forest, manual editing would have been too arbitrary. Instead, a buffer was made that included all areas within one kilometer's distance from all the fields on both images, or within the same distance from the Bobonaza or Rutunu rivers. Only those "young secondary forest" pixels that were within this buffer got assigned to

Fig. 4.13 (opposite page). *Land use* classification of the 2001 image. Green=forest. Yellow=young fallow. Red=field. Blue= water, beaches, clouds, and heavily shaded land. See Fig. 4.12. for definitions.


N
0
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Kilometers

the *land use* class “young fallow”. Pixels of “young secondary forest” outside this buffer got assigned to the *land use* class “forest”, which included old-growth forest as well as natural secondary forests (Fig. 4.12). The resulting *land use* classification is shown in Fig. 4.13.

Table 4.3. The percentage of ground-truthed areas classified into different types of land cover. The 1987 “ground-truth” data is based on interviews, not on field observation at the time of image acquisition. 1987 "ground-truth" data on fields is omitted because any minor temporal error in interviewee information about date for clearing could have led to totally erroneous information regarding actual land cover at the time of image acquisition.

	Classified as											
	1987				**2001**				**Pooled 1987 and 2001**			
Ground-truthed class	**Forest**	**Young fallow**	**Field**	***Number of pixels***	**Forest**	**Young fallow**	**Field**	***Number of pixels***	**Forest**	**Young fallow**	**Field**	***Number of pixels***
Cassava/maize field					28	25	47	*85*				
Old cassava field					54	31	15	*13*				
Barbasco					63	37	0	*19*				
Plantain					59	34	7	*29*				
Fallow	60	38	1	*143*	45	53	2	*157*	52	37	1	*300*
Pasture	62	26	12	*155*	84	10	6	*80*	69	16	8	*235*
Regrowth on pasture	61	36	4	*28*	71	29	0	*70*	68	20	1	*98*
Chili palm plantation	73	9	18	*11*	100	0	0	*16*	89	2	5	*27*
Old growth forest	88	12	0	*102*	29	71	0	*7*	84	15	0	*109*

4.4.1.5. Evaluation of classification

In order to evaluate the accuracy of the classification, I made an error matrix, with a finer division into classes of land use than the three classes used in the classification (Table. 4.3). The error matrix shows that about half of the training area pixels of cassava and maize fields were correctly classified as fields, whereas the rest were classified either as forest or young fallow. Plantain fields, barbasco, pasture, and regrowth on pasture were mostly classified as “forest”, and the same was true for old cassava fields that were beginning to get invaded by regrowth, apparently an effect of the image normalization (cf. Fig. 4.8). Of the training area pixels known to be fallow, about half were classified as "young fallow", and the other half as "forest".

However, this evaluation also needs to be evaluated. The error matrix most certainly overestimates the classification errors, because many of the errors indicated in the matrix are probably not due to misclassification as such. Rather, they may depend on mixed pixels and on errors in georeferencing, meaning that the GPS-measured field plots were slightly misplaced when laid over the image. This can be seen by comparing the GPS-measured field polygons with the field class of the classified image (Fig. 4.14). The magnitude of such effects can also be assessed by comparing the result of the classification of the large old-growth forest areas (Fig. 4.9), with the small GPS-measured plots located near human settlements in a landscape characterized by a mosaic of old forest, fallows and fields. Out of the large old-growth forest areas (Fig. 4.9), only 0.5% got classified as young secondary forest (Table. 4.2), but the corresponding figure for the smaller GPS-measured old forest areas near the settlements was as much as 15% (Table. 4.3). This indicates that 14.5%, or more, of the pixels in the image may be misplaced, leading to a corresponding overestimation of the amount of misclassified pixels.

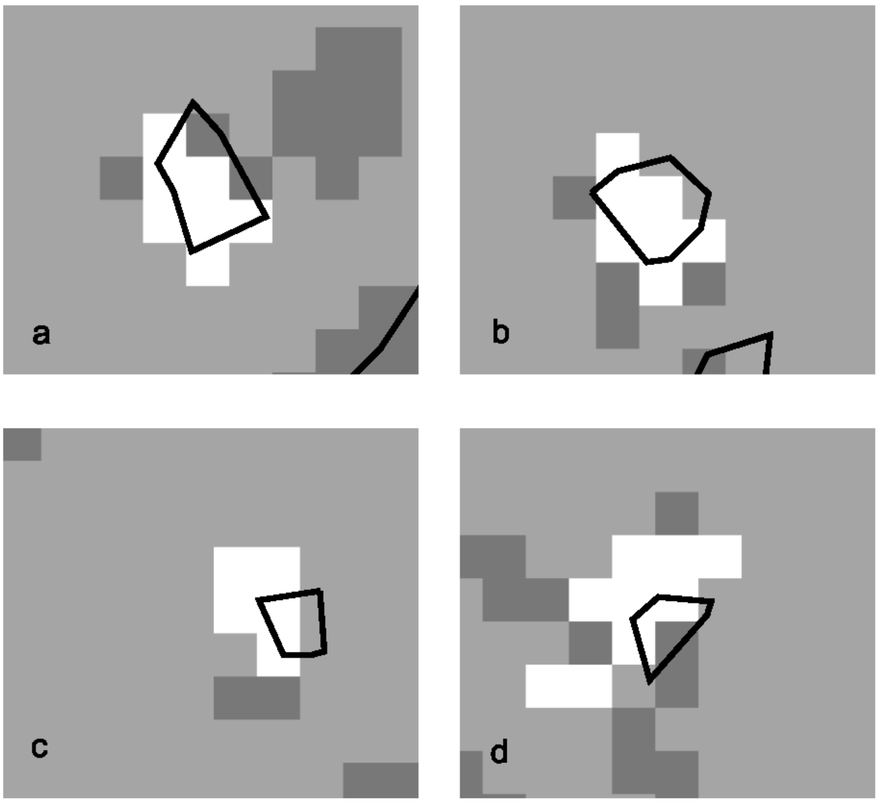


Fig. 4.14. Examples of field polygons measured with GPS-receiver, in comparison with the classified 2001 image. The areas classified as "field" were often larger than the GPS-measured polygons (a, b, c, d), and in some cases also slightly misplaced (c, d). White = field; Dark grey = young fallow; Light grey = forest.

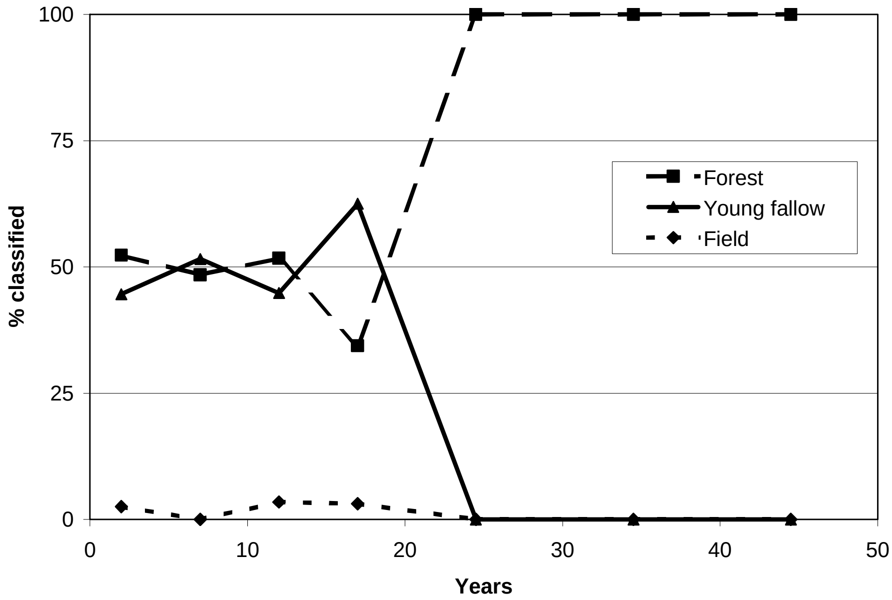


Fig. 4.15. Evaluation of classification of fallows according to their age. Up to 20 years of age, about half of the pixels got classified as "young fallow", and the other half as "forest". After 20 years of age, all pixels got classified as "forest". Based on pooled ground truth data for 1987 and 2001.

Another important question is how the age of fallows influenced how they got classified. In order to get enough pixels for making such an analysis, I had to use training area pixels from both the 1987 and the 2001 images, and aggregated the pixels into the age classes 0-5, 5-10, 10-15, 15-20, 20-30, 30-40, and 40-50 years. For all age classes up to 20 years, about half of the fallow pixels got classified as "young fallow" whereas the other half got classified as "forest". All fallow pixels above 20 years of age got classified as old forest (Fig. 4.15). Based on this, the age when "young fallows" become "forest", according to the image classification, was estimated to 20 years.

The 50% classification error of the young fallow pixels was not a big problem for the quantitative analyses, because other than these, very few pixels were misclassified. Even if a considerable percentage of the field pixels may be misclassified (Table. 4.3), their absolute number is low. The proportion of misclassified old-growth forest pixels was minimal (Table. 4.2), and became even smaller when most of them got deleted using the CLUMP and SIEVE functions as described above. Therefore, the 50% classification error could be compensated for by simply multiplying by a factor two to calculate the total area of young fallow.

4.4.1.6. Units of analysis

The study area for the analyses made in Chapter 8 is defined by the yellow line in Fig. 4.3. It approximately represents the area that was used by the Sarayaku community, for farming as well as hunting, fishing and harvesting of other forest products, during the period between the two images. It includes also Jatun Molino, the small outbreak community that in 1983 formed a new settlement in a former area of secondary homes (see Chapter 2) along the Bobonza river, but does not include the Teresa Mama community, which is loosely associated with Sarayaku. The delimitation of the study area is by necessity somewhat arbitrary, given the absence of long established and undisputed community boundaries, and it does not imply any standpoint regarding the complicated questions on the exact location of the valid boundaries of the community.

In order to allow comparison between alluvial plains and hills, respectively, the alluvial plains of the major rivers (Bobonaza, Rutunu and Jatunkapawari, see Fig. 2.3) were manually digitized based on visual interpretation of the images. The alluvial plains of the smaller rivers were narrow and difficult to discern, and were therefore analyzed together with the hill areas.

In order to analyze how land use varies with distance from settlements, 500 metre wide concentric circular buffers were created around settlement centres (schools), and the area of each land cover class was tabulated for each buffer. Similarily, 1 km buffers were created along the alluvial plain of the Bobonaza river. The area within a 5 km radius from Jatun Molino was excluded from these analyses, and instead analyzed separately.

4.4.2. Field plot data analysis

In common with many other authors studying land use dynamics, I started out with a great deal of confidence in remote sensing methodology. The sole purpose of fieldwork was regarded to be the collection of ground-truth data for image classification.

Gradually it became evident that these field data had a value of their own, regardless of their value as ground truth for image classification. Indeed, the owners could often recall land use histories far back in time, long before the times of the first Landsat images of the area, sometimes as far back as the 1930’s. Meanwhile, some preliminary explorations of Landsat images also made me realize that remote sensing technology does have its limitations. Therefore I started to collect field data more carefully, also for its own sake. In addition to the mostly opportunistic sampling of cultivated land and fallows, a random sample of five families was selected, and for all the currently cultivated areas of these families, the same data as for other land use plots was collected; a botanical description, GPS points, soil type, topography, and land use history. Of particular interest was the year of the first clearing, and the fallow age at the last clearing of each plot.

By using each land use plot as one data point, the variation in land use intensity over time and space was analyzed. The distance from each plot to the river and to nearest settlement was measured on the image.

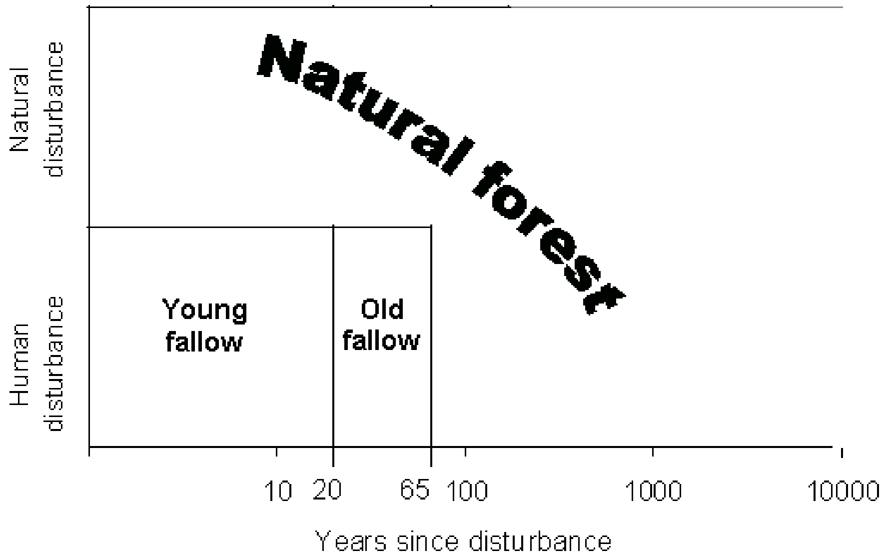


Fig. 4.16. Definition of wooded *land use* classes, whose extent was quantified by means of remote sensing and GIS, in combination with field plot data analysis. The analysis of field plot data allowed quantification also of the area of fallows between 20 and 65 years of age, which had not been possible based on remote sensing alone.

The age distribution of fallows was also estimated in order to complement the estimate provided by the remote sensing analysis of the area of fallows younger than 20 years. This calculation was based on the age of the fallow at the last clearing of each land use plot, according to the formula

$$\%A_{a_i} = 100 \times \sum_{a=a_i}^{a_{\max}} C_a \div \left(\sum_{a=a_{\min}}^{a_{\max}} \left(\sum_{a=a_i}^{a_{\max}} C_a \right) \right)$$

where A is the area of fallow of age class a, and C is the number of clearings of fallows of age a. The resulting age distribution of fallows was also combined with the estimate of the area of "young fallow", provided by the remote sensing analysis, in order to also calculate the area of "old fallow" (Fig. 4.16), meaning fallows between 20 and 65 years old, the latter figure being based on the age of the oldest fallow. The formula assumes equilibrium between clearing and regrowth, and may therefore give somewhat biased results if the system is not in such an equilibrium. The random sample of households was used in order to estimate total cultivated area, and to compare this estimate with the estimate provided by the remote sensing study.

4.5. Hunting: Hunters' reports and computer modeling[14]

This study (Chapter 9) aimed at assessing the extent of overharvest of wild game, both in terms of the range of species that were overharvested, and the spatial extent of any such overharvesting. Also, it aimed at assessing the socio-economic impact of game depletion, in terms of reduced harvest and increased hunting effort. As there were no appropriate standard methods available, this implied a considerable effort of method development, involving both a field study and the development of a computer model in order to facilitate interpretation of the field data.

4.5.1. Evaluating the status of game and impact of hunting: Previous methods

Adjusting harvest levels based on the productivity of each game species requires understanding of how different harvest levels affect game populations. In that respect, two important models have been constructed. First, Robinson and Redford (1991) calculated maximum sustainable yield (MSY) for Amazonian game mammals, based on species-specific estimates of carrying capacity and intrinsic rate of natural increase (see also Slade et al., 1999). The MSYs are then compared with observed harvest rates to evaluate whether these rates are sustainable. The model has been used for evaluating the sustainability of hunting in tropical forests of South America (Alvard et al., 1997; Mena et al., 2000; Hill & Pawde, 2000) and Africa (Fa et al., 1995; Fitzgibbon et al., 1995; Muchaal & Ngandjui, 1999). Second, Bodmer (1994, see also Robinson & Bodmer, 1999; Bodmer et al., 2000; Townsend, 1996) used a model based on population-specific birth rates and densities, to calculate production values for comparison with harvest rates. A practical problem with this method is that it requires the use of labour-intensive line transects to calculate population density.

Milner-Gulland and Akçakaya (2001) evaluated how the current methods for evaluating sustainability of hunting in tropical forests performed under conditions of uncertainty, bias in parameter estimation and habitat loss, and concluded that current methods are prone to overestimate the sustainable level of harvest. These authors also point out that current methods do not incorporate spatial heterogeneity. Hunting effort in tropical forests is typically highest near human settlements. Therefore, densities of major game species tend to decrease with distance from settlements (Robinson & Bennett, 2000; Peres & Lake, 2003). Moreover, Townsend (1996), Begazo and Bodmer (1998), and Novaro et al. (2000) suggest that many areas function as source-sink systems, where remote areas with low hunting pressure produce a surplus of animals that disperse to areas closer to settlements, where they are hunted. Thus, to understand the dynamics of the interactions between hunters and game populations, it is necessary to take into account two separate spatial phenomena, (1) the uneven distribution of hunting

[14] This section is based on Sirén, A., P. Hambäck & J. Machoa (in press). Including spatial heterogeneity and animal dispersal when evaluating hunting: A model analysis and an empirical assessment in an Amazonian community. *Conservation Biology*. Blackwell Publishing Ltd.

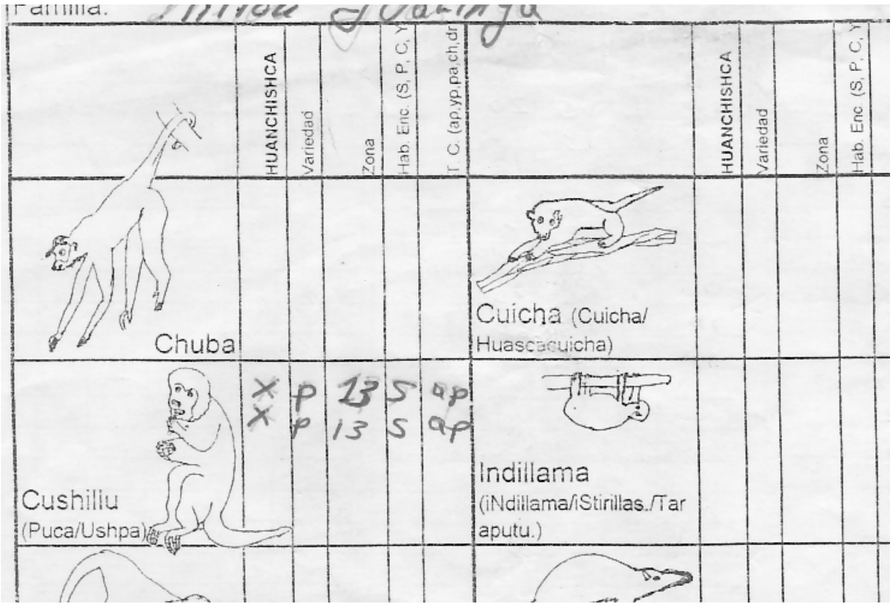
effort, which tends to create gradients in animal densities, and (2) animal dispersal, which tends to smooth out these gradients.

The approach we used is different from previous models. Instead of asking "How much can be sustainably harvested?" we asked "Where can production be increased?" We believe this question is relevant for the management of Amazonian wildlife because, for instance, no-take areas have been proposed by scientists as promising management tools for situations with a high level of uncertainty (e.g., Quinn et al., 1993; Mosquera et al., 2000; Milner-Gulland & Akçakaya, 2001; Lockwood et al., 2002). Specifically, we show in Chapter 9 that hunting effort, harvest rate and catch per unit of effort (CPUE) varied over the study area. We then used this spatial gradient of hunting effort as a quasi-experimental setting and, for each species, made a preliminary assessment of the spatial extent of overharvest, where overharvest means that the animal density is reduced to a point where its full reproductive potential is not realized. Finally, we developed a spatially explicit model to evaluate how animal dispersal affects observed spatial patterns of harvest rates and CPUE. We used this model to evaluate the results of the field study.

4.5.2. Field study

Volunteer community members reported on hunting activities. Primarily, we used the household as our sampling unit because this provided a sample of both frequent and occasional hunters. Random sampling was not an option because some people initially regarded the project with suspicion and might have misinterpreted a random selection of their households as an attempt at coercion (see Chapter 3). Avoiding such potential sources of conflict was particularly important because the fieldwork coincided with a period of extreme social tension related to planned oil-prospecting activities in the area (see Chapter 13). Therefore, because sampling was based on voluntary participation, we might have obtained a skewed sample. To control for this possibility, we asked key informants from each hamlet to group the households into four categories according to their level of hunting activity: (1) do not hunt, (2) hunt little, (3) hunt much nearby, or (4) hunt much far away. This grouping showed that households of all categories, except do not hunt, were fairly equally represented among participants. Excluding the households that do not hunt, 122 households remained. Out of these, 85 households (70%) participated in the study. We are therefore confident that the participating households constitute a representative sample of the community.

At the start of the study, participating households received a form (Fig. 4.17) for reporting their hunting activities. One person, usually the most active hunter in the household, recorded his own hunting activities and those of other household members. One side of the form featured a map of the community territory and its surroundings divided into 145 areas, each with a unique number, that were similar in size and had limits represented by well-defined terrain features. Out of these 145 areas, we excluded 48 from the analysis because interviews with key informants showed that these were principally used by hunters from neighbouring communities. On the map, hunters drew the trajectories traveled while hunting and marked with a cross places where they used sit-and-wait hunting methods.



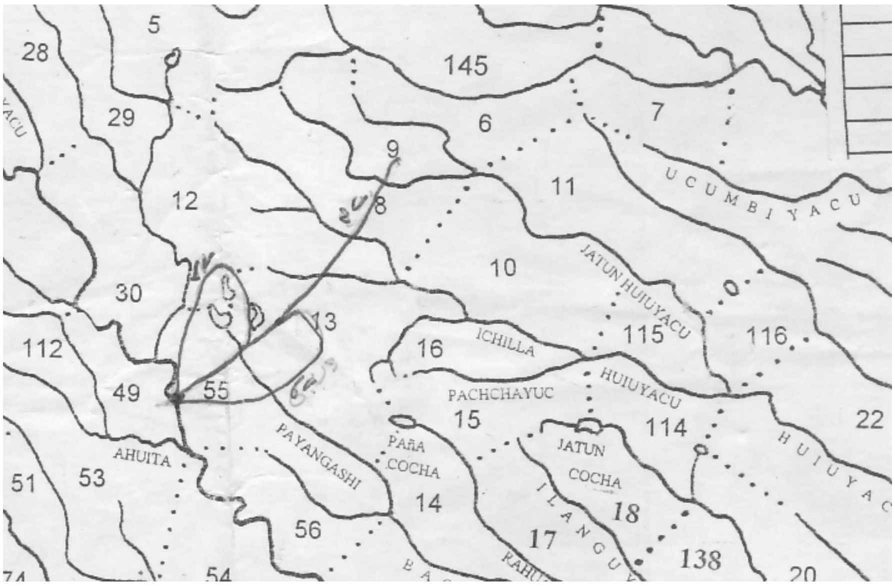


Fig. 4.17. Details from a filled-in form for collecting data on hunting: The side with drawings of the game animals (top), and the side with the map (bottom)

Later, we measured trajectories with a ruler in order to use the trajectory length as a measure of the hunting effort in each area. The other side of the form contained drawings of 58 game animals, with the local name, and columns for indicating the area number, hunting method (according to categories indicated in Table. 9.4) and habitat. The drawings made it possible for illiterate people to indicate the number of animals hunted by putting crosses next to the animal. When collecting the forms, about every 2 weeks, we performed detailed interviews to double-check and complement the recorded information. After 8 months of data collection, we recruited assistants in each hamlet to collect data (see Chapter 3). On a rotational basis, we accompanied the assistants to supervise their work. Occasionally, assistants switched duties, collecting data forms in hamlets other than their own.

Because of an annual hunting festival and adjustments in the sampling regime half way through the study, there are three data sets: nonfestival, festival, and large animals. The nonfestival data set was collected from May 1999 to July 2000 and includes all regular hunting activities by the participating households. During this period, participating households in hamlets changed about every 3 months, usually in connection with hamlet workshops where we presented results and treated issues related to the project. The sample was geographically stratified because the number of participating households from each hamlet was roughly proportional to the total number of households in the hamlet. Similarly, during school vacations, when households move to secondary homes to enjoy better hunting and fishing, households were grouped into eight geographical zones. The number of households in the sample increased with time from 14 to 24. To avoid bias due to variation in sample size between seasons, we applied month-specific weighting factors when converting the harvest data to an estimate of annual harvest in each area.

Prior to the hunting festival, groups of hunters, belonging to three festival houses, spend about a week going to the remotest corners of the community territory to hunt huge amounts of game. Consequently, we collected data at the individual rather than household level during festival time. Out of 48 festival hunters, 40 reported their hunting activities, providing a weighting factor of 1.2 for estimating annual harvest rates for festival hunting. At the same time we collected the festival data, recording of hunting activities not directly related to the festival continued as usual. To estimate total annual harvest, we added annual harvest rates from the two datasets, festival and nonfestival.

After 1 year of data collection, we had sufficient data on hunting effort and harvest of most small species but insufficient data for larger species. Therefore, from April 2000 to April 2001, we collected data on large animals using a simplified form featuring only a limited number of species, namely the ungulates, the large primates, the caymans, and the largest bird in the area, *Mitu salvini*. On this form, data were filled in only on harvest and not on hunting effort. We assumed that our results on hunting effort from the first year could be extrapolated to the following year. The sample size for this data set was 35-40 households but varied between hamlets, such that we applied hamlet-specific weighting factors when calculating annual harvest rates.

For species not included in the large animal dataset, all calculations were based only on the nonfestival and festival data sets, which included data from 7532 household participation-days (the sum of the number of days each household participated) and 12716 km walked by hunters. For the species included in the large animal data set, the annual harvest was calculated as a weighted (according to the number of household participation days) average of one estimate based on the nonfestival and festival data sets, and another estimate based on the large animal data set. Together this included data from 20800 household participation-days and approximately 35000 km walked by hunters.

Because the majority of recorded hunting kills were made when hunters were walking (Table. 9.4), we used the kilometers walked per square kilometer per year as a measure of hunting effort in each area. Other researchers have used time rather than distance as a measure of hunting effort in tropical forests (e.g., Vickers, 1988; De Souza-Mezurek et al., 2000), but this was not possible because of the high spatial resolution of data collection. To aggregate the areas into hunting effort zones, we first smoothed the hunting effort using GIS-software. We converted the map into a grid of cells sized 250 × 250 m, where each cell was assigned the average hunting effort of all cells within the surrounding 8 × 8 km square. We calculated the smoothed value for each area as the average value for all cells within the area. Finally, areas were grouped in seven zones according to the hunting effort: zone 1 had the lowest hunting effort and zone 7 the highest (Fig. 9.4). The hunting effort for each zone was calculated by summing the original (unsmoothed) values for all the areas within a zone and dividing by the total area of the zone.

In order to check for differences in habitat quality between the hunting effort zones, the percentage of different land cover types in each zone was quantified by means of remote sensing (see section 4.4.1. for details about the procedure).

Harvest rates were calculated as annual harvest in a zone divided by its area in square kilometers. Catch per unit effort (CPUE) was calculated as the number of killed individuals in a zone divided by the hunting effort. We used CPUE as a proxy for population density, as is commonly done in studies on fish (e.g., Salthaug & Godø, 2001; Marchal et al., 2002) and occasionally in studies on game mammals (Novak et al., 1991; Lancia et al., 1996). Using CPUE as a proxy for density rests on the assumption that an animal encounter always leads to a hunting attempt. We considered this to be a fairly reasonable assumption for 12 of the species (see Table. 9.4), and therefore we analyzed these species first. For *Agouti paca*, *Dasyprocta fuliginosa*, and *Nothocrax urumutum*, which frequently were hunted using sit-and-wait methods, only hunting kills achieved when walking were included in the calculations of CPUE. For other species, particularly *Mazama* spp., *Tapirus terrestris*, and *M. salvini*, even when these species had been hunted using sit-and-wait methods, the actual encounter (finding tracks or hearing song) occurred while walking. Therefore, all hunting kills of these species, regardless of method, were included in the calculations of CPUE.

For each species, we examined harvest rate as a function of hunting effort and CPUE as a function of effort. To interpret this data, we performed linear regressions on harvest rate versus hunting effort, and on ln(CPUE) versus ln(hunting effort). The log-transformation in the latter regression was made because of the obvious non-linearity in the data. A decreasing harvest rate with an increasing hunting effort indicates overharvest as the local population is reduced below the density that yields maximum production. Also, decreasing CPUE with increasing hunting effort indicates that hunting reduces population densities, and when this decrease is substantial, it may indicate overharvesting.

In late year 2000, we gave away scales to twelve persons who had agreed to weigh animals hunted in their respective household and record on a form. These data forms were collected every couple of months during a year. However, this did not yield as much data as had been hoped for. For the calculations of hunted weights, most species were assigned weights according to the literature (Mena, 2000; Peres, 2000), but weights based on our field data are used for some species for which figures were missing in the literature.

4.5.3. Model of spatial interactions between hunters and prey[15]

To examine whether observed patterns could be affected by animal dispersal, we developed a spatially explicit model of hunter-prey interactions that mimiced the hunting practices in the village. With this model, we evaluated the role of animal dispersal and total hunting intensities on the spatial distribution of CPUE and harvest rates.

We used a standard, discrete-time population model (Yodzis, 1989) to which we added spatial structure (for a similar continuous time model see Quinn et al., 1993). Spatial structure was introduced by separating the area into 100 patches that were linearly connected (results are independent of the number of patches and the specific location of patches relative to each other). Within each patch, population dynamics depended on the local reproduction, the number of animals killed, and the number of animals migrating to and from the patch. Mathematically, the different processes were entered sequentially into the model and the dynamics of individuals (N) in patch i from time t to t+1 were then described as

$$N_{i,t+1} = (1 - E_i)(1 - H_i)R_i(N_{i,t})N_{i,t} + \sum_j E_j N_j \ , \qquad (1)$$

where E_i is the emigration probability from patch i, H_i is the proportion of individuals killed in patch i, $R_i(N_{i,t})$ is the density dependent reproductive rate, and the last term is the sum of immigration from other patches.

To make the model specific to the problem, we made the following additional assumptions: (1) prey birth rates were density-dependent as a logistic growth function; (2) hunting effort was normally distributed with the highest effort at the village in the centre (see Fig. 9.5); and (3) most dispersal was local with a smaller number of long-range dispersers, as is known for both mammals and birds (Waser, 1987; Turchin, 1998). We assumed that the redistribution of individuals followed a Gaussian distribution similar to dispersal functions used in fisheries management models (Quinn et al., 1993; Lockwood et al., 2002).

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[15] Peter Hambäck made this computer model.

We introduced these assumptions into Eq. 1 in the following way. First, local birth rates were assumed to depend on the local density according to a standard logistic growth function,

$$R(N) = r\left(1 - \frac{N}{K}\right)^{\beta} , \qquad (2)$$

where r is the maximum number of offspring per individual, K is the maximum number of individuals per patch, and β is a parameter describing the shape of the density dependence. Second, the local hunting effort (h) was modeled as a Gaussian distribution,

$$h = ah_{max} e^{-\frac{1}{2}[z/s]^2} , \qquad (3)$$

where h_{max} is the hunting intensity at the area centre, s is the standard deviation of the distribution in hunting intensity, z is the distance from the village, and a is a parameter describing the probability of discovering and killing an animal in the patch. Assuming a standard type-I functional response (Yodzis, 1989), the local hunting effort was transformed to the proportion of surviving animals (S_i) as

$S_i = 1\text{-}H_i = e^{-h}$. (4)

Third, we assumed the redistribution of animals followed a Gaussian distribution

$$E_x = \frac{1}{2\sqrt{\pi d}} e^{-\left[x^2/4d\right]} , \qquad (5)$$

where E is the probability of dispersing x distance units from the previous position and d is a space-independent dispersal rate. Dispersal here means the redistribution of individuals over time (sensu Turchin, 1998) and does not necessarily correspond to speed of movement or similar physical measures. When calculating the redistribution, we assumed there was no net migration across area borders.

We started each simulation with animal densities at carrying capacity and ran it 100 time units, at which point the total number and the distribution had stabilized. Through simulations, we explored a range of hunting intensities (h_{max} = 0.1-65000), animal dispersal rates (d = 0-1250), and maximum birth rates (r = 0.01-0.6), while keeping the remaining parameters fixed (K = 100, β = 2.4, s = 7).

4.6. Economic experiments as learning tools for local resource users

Chapter 12 describes two economic experiments that were designed and conducted within a participatory research framework. The purpose was, in the first place, to provide a learning tool for local resource users about their own behaviour in relation to natural resources and other resource users.

The experiment “Wildlife management in the lab” was based on the classical type of economic experiments. For such economic experiments, researchers typically create conditions that closely match the conditions specified in a theoretical model. By inducing value, usually cash rewards, the laboratory situation leads laboratory subjects to perceive and act on payoffs that have the same mathematical properties as the payoffs in the linked mathematical model. In this experiment, participants had a limited nuber of "units of effort" which they could allocate either to "raising of domestic animals" or to "hunting". Whereas the rate of return to units of effort allocated to raising of domestica animals was fixed, the rate of return to units of effort allocated to hunting varied according to the size of the resource pool which, in turn, changed over time, according to the amount withdrawn by the participants, and to the replenishment of the resource, calculated based on a logistic growth function. The game ended after forty rounds of play. Each animal harvested represented a fixed sum of money, and at the end of the game, each player got a cash reward corresponding to his total harvest of animals.

The experiment "Effects of income on wildlife harvest", on the other hand, was made in the form of a lottery at a community assembly. The purpose was to test two opposing hypotheses, formulated by community members, regarding the relation between monetary income and wildlife harvest. Some claimed that an increased monetary income would ease the pressure on wildlife resources, as people would switch to other food sources. Others meant that monetary income typically is spent on hunting equipment, thus aggravating the problem of wildlife depletion. At the lottery, there were alternative prizes of equal monetary value, consisting either of hunting equipment, or items related to alternative food sources. Each person present got a lottery ticket, but had to indicate which of the prizes they wanted in case of winning. By providing real incentives to the participants, in the form of the chance to win the prizes of their choice, it was hoped that their answers would reflect the choices they would make in case of receiving a real additional monetary income.

The methods of these experiments are described in more detail in Chapter 12 itself.

4.7. Participatory methods: Summary

The study was not participatory research in a strict sense (see Elden, 1981; Whyte, 1991), but it was in many ways inspired by participatory research methods. Local people were involved, in one way or another, in all research activities, particularly José Machoa and the hamlet assistants, but also the public at large. The type and amount of participation by the general public, however, varied between the different components of the research (Table 4.4). The study of hunting not only relied on data provided by local hunters, also several workshops were arranged in order to discuss preliminary research findings and the problem in general. Such discussions also gave rise to new specific research questions, such as the role of the hunting for the annual community festival (Chapter 9.4.2) and the relation between monetary income and hunting (Chapter 12.3). In addition to the hunting study itself (Chapter 9), also the economic experiments (Chapter 12) dealt with questions related to hunting, and they provided additional opportunities for learning reflection. The historical study provided an opportunity for direct transmission of historical information from old to young people, and both old and young could influence the process. On the other hand, the studies of household economy, anthropometry, and agricultural land use were somewhat less participatory. The role of the general public in these studies was mainly limited to that of informants, and there was not time to present research results back to the community at large. Although I did show satellite images over the area at some workshops in the beginning of the project, and let some people do some hands-on exercises with the images on a laptop computer, using Multi-Spec software, the methodology used for the study of agricultural land use remained largely uncomprehensible for the local people. In sum, participatory methods were used in an undogmatic fashion, when it was found convenient, and to a reasonable extent, given that, for most people, research is not the most immediate concern.

Table. 4.4. Types and degrees of participation in the different specific studies presented in this thesis. More stars indicate more participation. The role of cash or material incentives in motivating participation is indicated with a different symbol (crosses) because by giving such incentives one may possibly (but not necessary) co-opt local participants, which is contrary to true participation. The parentheses indicate that any concerns about possible co-option can largely be discarded because participants did not know in advance that they were going to get a cash reward (Chapter 5), because only some of the participants received any material benefit (in the form of medicines, Chapter 7.4), or because providing material incentives were part of the research method (Chapter 12.2 and 12.3)

Chap-ter	Study	Effort by local people in providing data	Role of cash or material incentives	Learning during data collection	Influence on problem definition and methods choice	Separate presentation of, and discussions about, results
5	History	***	(†)	***	*	
6	Local perceptions of resource depletion	***		*	*	*
7.2	Household economy	**		*		
7.4	Anthropometry	*	(†)			
8	Agricultural land use	***	†††			
9	Hunting	****			*	***
12.2	Wildlife manage-mentt in the lab	***	(†††)			
12.3	Effect of income on hunting	*	(†††)	**	**	**

Chapter 5. The history of the people and the environment

5.1. Environmental and human history in the Amazon

On detailed examination, the history of a landscape or an ecosystem is often different than what one may believe at first sight, or after insufficient study (Fairhead & Leach, 1996; Nyerges & Green, 2000). Lack of understanding of the history of the environment, in turn, may lead to erroneous conclusions about the rate and nature of environmental change. Many early scientists studying the Amazon did not comprehend the history of human impact on the ecosystems (Cleary, 2001). Also, the Amazonian societies have often been viewed as static, in equilibrium with their environment. Although recent research largely has refuted these views (e.g., Balée, 1989; Gomez-Pompa & Kaus, 1992), the accounts of the Amazon that reach the general public often are coloured by similar perceptions, where Amazonian Indians often are portrayed almost as just another animal species inhabiting the rainforest (Slater, 1995).

Environmental historians sometimes recognize three levels of analysis: The first is nature itself or the ecological level, the second is human modes of production, and the third is the way humans think about nature (Worster, 1988; McEvoy, 1988). This chapter mainly focuses on how human modes of production have changed over time, how this has affected the ecosystem, and how the changes in the ecosystem have affected socio-economic conditions. However, the chapter also provides a general history of the Sarayaku community, because one can not understand the history of natural resource use in the area without knowing how society itself has been evolving and changing over time.

Previous studies of the past of Amazonian indigenous peoples have largely focused on the human modes of production, and how these have been influenced by environmental conditions (e.g., Lathrap, 1968; Meggers, 1954; Roosevelt, 1980; Carneiro, 1995). Recently, other authors have focused on the human impact on the Amazonian environment, such as Sponsel (1992), who argues that the disturbance by indigenous people on the ecosystem is not very big, when compared with natural disturbances, and that “Western” society has brought about environmental changes on a different scale that threatens the Amazon as a biome. On the other hand, Cleary (2001) summarizes the environmental history of the Amazon as a whole from prehistory up to 1850. He points out that the Amazonian ecosystems were quite strongly influenced by human activities before European contact. European contact caused depopulation that allowed forest recovery, but the Europeans also initiated large-scale extraction of plant and animal resources for export, which caused serious ecological impacts.

Changes must be put in their context. Recognizing that change has occurred does not mean that all change is equal or that it is good (Cronon, 1993). The fact that indigenous people have affected the ecosystem in the past does not in itself justify what their descendants do to the ecosystem today. The large extent of the cumulative damage done by non-indigenous people over the last five centuries in the Amazon, does not in itself justify any any damage, although of a smaller magnitude, that indigenous people may be doing today. This chapter does not aim to put the blame on anybody for the past, instead it aims to understand how the past led to the present, and thus help to understand how different actions today may affect the future.

The focus of this chapter is resource abundance, particularly the resources farmland, wild game and fish. I will discuss how local people have exploited natural resources, and how resource abundance has been changing. Abundance may be defined as the absolute amount of a resource that exists, such as for example the number of tapirs within the Sarayaku territory. But another definition of abundance is the availability of a resource to human society. This in turn is a function not only of the absolute amount of the resource, but also of the technology available in order to exploit the resource. This distinction is important to keep in mind.

Some recent authors have successfully combined information from ethnographic source material and from oral accounts by Amazonian indigenous peoples themselves, in order to understand their history. Such studies are Muratorio (1991) on the upper Napo Quichua, Stanfield (1998) on the impact of the rubber trade on the people of the Putumayo region in the borderland between Colombia and Peru, and Cabodevilla (1996, 1999) on the Coca region of the middle Napo river, and on the Huaorani people. Similarily, this chapter is based on literature studies in combination with information provided by local inhabitants, particularly elders, during group interviews and PRA exercises. The methods used are described in detail in Chapter 4.

5.2. The Sarayaku area from prehistory to present

5.2.1. Environment and society in the region before European contact (before 1550)

5.2.1.1. Regional and local context (before 1550)

At the end of the pleistocene (last glacial cycle, 22 000 to 10 000 BP), the temperatures of the Neotropics were about 5 - 7º cooler, and precipitation about 30 – 35% lower than today. Therefore, the forests of western Amazonía resembled those that today are found at higher altitudes on the Andean slopes (Colinvaux et al., 1997; Piperno & Pearsall, 1998, pp. 91-97). Around 10 000 BP there was a quite abrupt climate change, leading to temperature and precipitation levels similar to those of today.

The first evidence of human occupation in western Amazonia is from the Araracuara site in Colombia, where midden charcoal indicating human presence has been dated to about 9200 years BP. Agriculture had been taken up by 8100 years BP, apparently based on a set of cultigens quite different to the one that is predominant in the area today, as indicated by phytoliths of squash (*Cucurbita* spp.) and leren (*Calathea* spp.) (Cavalier et al., 1995; Piperno & Pearsall, 1998). At Lake Ayauchi in the southern Ecuadorian Amazon, the watershed started to be cut for cultivation of maize, and possibly also manioc and other crops that leave little pollen and phytolith record, in about 5300 B.P. (Piperno, 1990). Fruit trees, particularly palms, were probably an important component of the diet and were, perhaps incidentally, planted and, in some cases, domesticated by humans (Cavalier et al., 1995; Piperno & Pearsall, 1998, pp. 155-158). In the Ayauchi area, intensification of maize cultivation seems to have occurred from about 2400 B.P. until 800 B.P., when maize disappears from the pollen record. Nevertheless, the amount of pollen from species typical of secondary forests indicates that cultivation probably continued to increase, although not resulting in massive deforestation as in other neotropical regions outside Amazonia (Piperno, 1990; Piperno & Pearsall, 1998, pp. 259-260).

Archeological excavations in the Yasuní area in northeastern Ecuadorian Amazonía have shown that in interfluvial areas of Amazonía, Pre-Columbian human settlements were found primarily on ridgetops (Netherly, 1997). Sediment cores taken from this area, however, seem to lack evidence of human landscape disturbance during the last 11 000 years, indicating that population densities in the interfluvial areas always were low (Weng et al., 2002). On the other hand, complex societies with large populations emerged on the floodplains of the large rivers, in Ecuador particularly on the Napo river (Evans & Meggers, 1968, 1973). Large and complex societies also developed in the transition zone between the Amazonía and the Andes, such as at Huapala, 80 km southwest of Sarayaku, in the Upano river valley (Rostain, 1999). Also on the Zulay tea plantation near the town of Shell, 75 km northwest of Sarayaku, there is a site, still not excavated, of some forty probably man-made mounds that present remnants of ceramics on the surface, probably also vestiges of a dense population with a high level of organization (Almeida-Reyes, 2000, p. 164).

When sedentary agricultural societies evolved, so did extensive trade networks. For example, stones for making axes had to be supplied to the societies of the floodplains from the uplands (Myers, 1979, 1983). On the other hand, the complex societies of the transition zone towards the Andes are believed to have played the role of intermediaries in commercial networks between the Amazonian lowlands and the Andean highlands. Through such commercial networks, Sarayaku may have been linked both to the floodplain societies to the southeast in what today is Peru, and to the Andean societies to the northwest.

5.2.1.2. Natural resource use in the Sarayaku area (before 1550)

The earliest archaelogical evidence for human occupation of the Sarayaku area dates from about 580 A.D., consisting of pieces of pottery found at the Moretecocha-1 exploratory well site. The site, situated on a ridgetop, has been repeatedly occupied up to the late 19th century (P. Netherly, pers. comm.). Based on this single excavation, it cannot be ruled out that the Sarayaku area was inhabited even before 580 A.D. In any case, the repeated occupancy of this site over a time span of 1300 years indicates that the ridgetop habitats have been subject to long-term repeated human disturbance, and most of the "primary" forests found on the ridgetops may actually be old fallows. The Sarayaku people sometimes encounter pottery fragments on the forest floor, typically on the ridgetops. Although these objects have not been dated, they constitute further evidence of long occupation of ridgetop habitats.

Faunal remains are seldom well preserved in the Amazonian environment, and very little is known about the hunting and fishing habits of early Amazonians. However, just as stone-age people hunted many animal species to extinction in other parts of the world, the same probably happened in the Amazon. Particularly large arboreal game would be susceptible to missile type weapons such as blowguns or bows and arrows. Colinvaux and Bush (1991) argue that the hunting by large agricultural societies that inhabited the Amazon right before European conquest probably already had exterminated many canopy-living species.

Regarding fishing, it is equally plausible that the invention of fishing with plant poisons such as barbasco (*Lonchocarpus nicou*) and others, caused a major impact on the fish fauna. Today, the Tilapia, an introduced species used in fish culture, is much more sensitive to barbasco than the native fish species (A. Sirén, pers. obs, Arturo Silva, pers. comm), indicating that an evolutionary process may have occurred since the invention of barbasco fishing, selecting for resistance to barbasco.

5.2.2. Impacts of contact with the Spanish (1550 – 1830)

5.2.2.1. Regional and local context (1550 - 1830)

The first impact of the arrival of the Spanish to the Americas on the Sarayaku area may have come in the form of pathogenic microbes long before any Spanish themselves came to the area (cf. Posey, 1994). In 1524-28 a smallpox epidemic ravaged the Ecuadorian highlands, killing about one-third to half of the population, and several other epidemics in the Ecuadorian Andes soon followed (Alchon 1991, p. 37). Given the existence of regular trade linkages between the Andes and the upper Amazon it is possible that some of these epidemics also reached the Amazon. The first Spanish expedition reached the upper Amazon in 1538, and between 1557 and 1561 they founded several towns among the Quijos and the Jivaro. (Hudelson, 1987; Moreno, 1989). From then on, severe epidemics with massive mortality must have been commonplace, and during the 17th century, they appeared about every twenty years (Taylor, 1986, pp. 511-512). Slave raiding was commonplace in the Ecuadorian Amazon already during the 16th century, but as the slave raiders did not leave any written records themselves, it is unknown how far the impact of their activities reached (Casewitz et al., 1988 p. 135). The increased mobility of people who either fled the slave raiders or were caught by them, must have contributed even further to the propagation of pathogens. For most indigenous groups, the situation at the first recorded contact in no way represents any original state, but rather a society severely hit by disease and slave raids, resulting in mass death and movements of people.

At the time of the first recorded contact, the northern side of the Bobonaza river was inhabited by the Gaes (also called Gayes or Gayas) tribe, belonging to the Zaparoan linguistic family. Although the Achuar, a subgroup of the Jivaroan linguistic family, later would expand into what today is Sarayaku territory, there are no accounts of any Jivaroan populations northeast of the Pastaza river at the time of the first recorded contact (Casewitz et al., 1988, p. 154). Therefore, it remains unclear which ethnic group inhabited the area between the Bobonaza river and the Pastaza.

Missionaries of the Dominican order descended for the first time to the upper Pastaza valley (the area around the present town of Puyo) in 1634 (Taylor,1988, p. 137). They "pacified" over a hundred of "Gaes", "Ynmundas", "Guallingas", and and "Santes"[16] (Cevallos, 1776, in Rumazo, 1970, p. 163), and formed a settlement on the banks of the upper Pastaza. Also, they established contact with a group of highland Indians who had settled in the area, escaping from the abuses of the Spaniards (Gonzalez-Suarez, 1970, p. 202). During the next half century, the Dominicans limited their missionary activity to occasional visits to these small groups of Indians, as well as occasional *correrías* in order to catch "infidels", reaching to the mouth of the Rutunu river (Cevallos, 1776, Rumazo, 1979, p. 164). Meanwhile, the rivaling Jesuit mission expanded its zone of influence. Around 1640, exploration journeys departing from the Jesuit mission of Maynas on the Marañon River (see Fig. 2.2), reached the upper Pastaza valley, and in 1669 Jesuit Priest Lucas de la Cueva managed to ascend all the way to the upper reaches of the Bobonaza River and continue to Baños (see Fig. 2.2) (Casewitz et al., 1988, p. 137).

In 1668, the Jesuits established the mission "San Javier de los Gayas" on the Pastaza River, in what today is Peru (see Fig. 2.2). The Dominican and Jesuit missions then entered into a conflict about the monopoly to the spiritual conquest of the Gaes, that inhabited the area north of the middle stretches of the Bobonaza river (OD, 1941:95, pp. 35-36; OD, 1941:96, pp. 74-76; Reeve, 1988, p. 83). The litigation was solved in favour of the Jesuits in 1683, and the dominion of the Dominicans became limited to the upper part of the Bobonza basin (Casewitz et al., 1988, p. 135). There the Dominicans established their first relatively permanent mission, called Canelos, in 1684 (Gonzalez-Suarez, 1970, pp. 202-203). The Jesuits, on the other hand, relocated the San Javier de los Gayas to the lower Bobonaza River, near the site of the present community of Montalvo (see Fig. 2.2). In this way, the Sarayaku territory of today came under Jesuit dominance. The Jesuits managed to baptize a large portion of the "infidels" living around the Rutunu River (Jerves, OD 1930:12, p. 52).

The Sarayaku people themselves claim the first people who lived in the Sarayaku territory of today were the "Tayak". Whitten, cited in Reeve (1988, p. 109) suggests that the Tayak are more of a mythical people, but the Sarayaku people definitively use the term as to describe a historical people. It is uncertain, however, if the Tayak were a particular ethnic group or if it is just a generic term describing any people that inhabited the area before the establishment of the mission. The Tayak are said to have lived in big communal houses totally enclosed by leaves reaching all the way down to the ground, with only one door, similar to Huaorani houses used until recently (Cabodevilla, 1999). They practiced frequent warfare among different groups (SE).

[16] With sligtly different spelling, these are today the surnames of about half of the Sarayaku population

Slave raiding continued during the 17th century. In 1680, a Dominican priest complained to the Spanish King that some Spaniards had entered the Canelos region in order to force the Indians to pan gold for them, so that the Indians fled out to remote forests, giving the missionaries a hard job to find them and gather them again (Casewitz et al., 1988, p. 136). Slave raiders from downriver also reached the lower stretches of the Bobonaza River during this epoch, so that the Gayas had to flee to the north (Reeve, 1988, p. 64). In the early 18th century, slave raiders from Borja (Peru) almost wiped out the Gaes that did not live in the missions (Steward & Metraux, 1948, p. 632).

During the 16th to 19th centuries, the Canelos mission received a considerable influx of inhabitants. In general, the reason for settling in the missions seems to have been the desire to get access to the metal tools provided by the missionaries, rather than religious devotion (Cevallos, 1775, in Rumazo, 1970, p. 124; Magnini, 1998, p. 190), and to get protection from antagonistic indigenous groups and from Spanish slave raiders (Cevallos, 1775, in Rumazo 1970, p. 124; Casewitz et al., 1988, p. 154). The Dominicans were only sporadically present in their missions, and did not perform as brutal control over the Indians as the Jesuits. Therefore, many refugees came to Canelos, fleeing not only from the military aggressions of the Spaniards, but also from the brutal control in the Jesuit missions (Naranjo et al., 1984; Casewitz et al., 1988 p. 135). Nevertheless, the number of inhabitants in the Canelos mission remained low: Several contemporary observers between 1737 and 1798 provide informations indicating that the total popoulation never exceeded 250 persons, and at times was only about 120 (Tobar-Donoso, 1960, p. 131; OD, 1941:97, p. 94; Cevallos, 1775, in Rumazo, 1970, p. 162; de los Reyes, 1775, in Rumazo, 1970, p. 123; OD 1928:4-5, p. 115). The figures presented by Costales (1975) and Sweet (1969) of 3000 to 5000 persons of the ethnic group "Canelos", at the time, are not supported by references to historical source material and, in light of the source material available, seem to be grossly exaggerated.

In 1767-1769, the Spanish king expelled the Jesuits from their American colonies. This permitted the Dominicans to expand their dominion, and they established the Andoas mission on the Pastaza River, ninety kilometres downstream of the mouth of the Bobonaza. The Jesuit missions on the middle and lower Bobonaza, however, were abandoned. In 1814, the Governor of Quijos, Manuel Fernandez Alvarez, reported about the Rotuno: "belongs to infidels, of which half were baptized in the times when Maynas was jurisdiction of Quito" (Jerves, OD 1930:12, p. 52). Some of them, however, got caught again in the raids or *correrías* of the Dominicans and brought to the mission in Canelos. In the late 18th century, people from Canelos used to come to Sarayaku in order to pan gold (Cevallos, 1775, in Rumazo, 1970, p. 172).

The first contemporary population estimate made in the region is of the population of the Gaes, which was estimated to over 7000 in 1671 (OD 1928:4-5 p. 106). Newman (1996), for the same epoch, provides a figure of 6000 to 8000 for the Gaes and the Semigaes together, and calculated a population density of 0.34 – 0.53 inhabitants /km^2 (see also Sweet, 1969). During some fifteen years 4030 Gaes were baptized, but even more probably lived dispersed on the ridgetops without contact with the missionaries (Casewitz et al., 1988 p. 148). Grohs (1974, p. 68) considers such estimates of the Gaes population to be “absurd”, given that the mission of the Gayes only had 70 inhabitants in 1696, but this may be a less relevant point of criticism, as escapes from the missions were commonplace.

Taylor (1986) suggests that the demographic nadir of the western Amazon occurred in about 1760. This seems to be confirmed by the written records from middle and lower stretches of the Bobonaza at the time. In 1737, finding footsteps near the mouth of the Rutunu river was a curiosity, leading to speculations about whether these belonged to the remnants of the Gaes or to christianized Indians who had returned to the forest (Tobar-Donoso, 1960, p. 132). In view of this, the figures provided by Costales (1975), indicating a population of 12 000 people of the Zapara ethno-linguistic family along the Bobonaza River during the period 1665 – 1731, must be discarded as poorly substantiated speculation. In 1769, there were no human habitations along the Bobonaza river downstream of Canelos, and the only survivor of a shipwrecked party on the lower Bobonaza had to walk for nine days until she met two Indians who saved her life (Smith, 1990; Pierre, 1983). According to Taylor (1986) the population of the western Amazon started to increase again sometime around 1780. About this time also the Jivaro population, previously not encountered northeast of the Pastaza River (Casewitz et al., 1988), started to expand towards the northeast into what today is known as Sarayaku territory.

5.2.2.2. Natural resource use in the Sarayaku area (1550 - 1830)

The Tayak lived only on the ridgetops, where they farmed mostly maize, using stone axes, and knives made of bamboo (SE). According to Steward & Metraux (1948), the Zaparo used knives made of Chunda palm (*Bactris gasipaes*) wood.

There is one written record from the lower Bobonaza that supports the view that maize was the dominant crop in the region at that time. In 1707, the Gayas tribe killed a missionary at the San Xavier mission on the lower Bobonaza River, and then fled, persuading the Semigaes and Zapara people on the way to burn their maize plantations, in order to prevent the Spaniards from following them (Tobar-Donoso, 1960, p. 239). Indeed, burning maize fields would have been of little use if there also were fields of manioc, the tubers of which can be stored in the ground for several months. The Indians of the Canelos mission traded metal tools with the “infidels” (Cevallos, 1775, in Rumazo, 1970, p. 161). Nevertheless, metal tools continued to be in short supply for a long time, so that the “infidels” also had to rely on stone tools (Cevallos, 1775, in Rumazo, 1970, p. 124).

Why did the Tayak not live on the fertile alluvial plains that today are the most highly prized farmland? The question becomes even more intriguing when considering the suggested reliance of maize cultivation, given that maize today is almost exclusively cultivated on alluvial plains and only occasionally on the ridges. Some of the Sarayaku elders claim that it was because of fear of floods, which supposedly were more severe in those days than now. However, these accounts bear too much resemblance to the biblical story of Noah and the Flood to be taken at face value. Possibly it could be because of reasons of defence against tribal enemies and/or slave raiders, but it could also be because of technological reasons[17]. Because the crowns of big trees tend to grow wider on the downslope side, which is more exposed to the sun, they can easily be felled in downslope direction, and the momentum of the fall often makes them come loose from the stump and fly several additional meters. Thus the crown lands outside the field area, and this saves much work of chopping up branches and twigs. When clearing for a field on a ridgetop, the trees can be felled in this way to both sides of the ridgetop. Saving labour this way must have been particularly important when the people had no metal tools. Moreover, setting fire to big trees was used as an auxiliary technique (SE; Carneiro, 1979) and this was probably easier on the ridgetops where the forest tends to be drier[18]. Also, weeds tend to grow faster on the alluvial plains, such that fields may have been very hard to weed without metal knives. Particularly, the plantain fields, that today are common on the alluvial plains, tend to get infested by a thick mat of grassy weeds, which would be extremely hard to weed without steel machetes. These explanations, however, still leave us with the puzzle of why the alluvial plains of the Napo river at the time, in contrast to the alluvial plains of the Sarayaku area, were densely populated (Evans & Meggers, 1968, 1973).

The Tayak are said to have hunted mostly with bow and arrow, and with spears. Some elders claimed that also the blowgun "always" has existed, but many attribute the introduction of the blowgun to the priests, the Achuar, the "llamishtu" (Lamista people of Peru), or just say it came from "downriver" (SE). In any case, the people of the Sarayaku region must have had access to blowguns for a long time, as blowguns were observed in Canelos as early as 1775 (Cevallos 1775 in Rumazo, 1970, p. 141, 168), in Archidona (Napo province) as early as 1577 (Oberem, 1980 p. 185), and existed on the contintent already before year 500 BC (Jett 1991). Stirling (1938) indicates that, at the time of conquest, the Jívaro possesed bow and arrow, but probably not blowguns, and Metraux (1949) indicates that, on the contrary, the Zaparo had blowguns, but not bow and arrow.

Interestingly, during the 16th century the Jivaro were reported to have hunted deer as well as tapir, although these more recently have been reported not to be eaten by the Jivaro because of fear of spirits in them (Steward, 1948, p.619). The Jívaro did not yet live in the Sarayaku area during the 16th century but, in any case, this is an interesting observation of how food taboos in the region may not be ancient static phenomena, but rather have appeared and disappeared for reasons we only can speculate about. According to local elders, the Tayak used the bow and arrow also for fishing, and made fish hooks out of the jaw of a small fish called *chuti* (*Crenicichla* spp.), or the wood of the *chibu* palm. Perhaps they also fished small creeks by stirring up mud, clogging the gills and suffocating the fish, as the famous shaman Panduc observed among the Zaparo people somewhat later, in the mid 19th century (SE). Barbasco grew wild in the forest, but the elders in Sarayaku are not sure about whether or not it already was used for fishing during this time.

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[17] Thanks to Juan Gualinga Cuji for making this point

[18] See fig. 4.3, where the forest on the ridgetops has a brighter colour than on the plains, due to less water content, and thus less absorption of infrared light.

Zarate, who travelled through the region in 1736-37, indicated that "the Indian guides not always find what they search for, and there are places sterile of game and fish.[19]" (Bayle 1948, p. 564). However, oral history considers this epoch to have been characterized by great abundance of wild game and fish. This is logical, as the human depopulation must have eased the pressure on the resources and allowed recovery of any resources that may have been depleted.

5.2.3. Establishment and consolidation of the Sarayaku mission (1830 - 1890)

5.2.3.1. Regional and local context (1830 – 1890)

The independence struggles of the first decades of the 19th century ended up with Ecuador becoming an independent country in 1830, but this went almost unnoticed in the Amazonía (Cabodevilla, 1996, p. 149). However, territorial disputes resulted between the new nations of Ecuador and Peru who had overlapping claims in the Amazonía, including the Bobonaza river valley. In 1890, Peruvian militaries reached Sarayaku in order to take control over the gold panning area in Balsayacu (Romero-Teran OD 1927:1 p. 47) and the territorial disputes between the two countries later became an important factor shaping the history of the region.

But even more important for the history of Sarayaku, this was the time when the mission was established there, probably between 1830 and 1833 (Jerves, OD 1930:12, p. 52; Espinosa, OD 1943:122, p. 147) or perhaps already in 1817 (Reeve, 1988, p. 67). The first inhabitants of the Sarayaku mission were some of the Tayak, as well as some people coming from the Canelos mission, who had come to know the people of the Sarayaku area when visiting the area in order to hunt (SE). According to some of the elders, there were already a handful of houses established on the banks of the Bobonaza River at the time that the Sarayaku mission got established. First the mission was set up at the southern bank of the Bobonaza river, but it later was relocated to its current place on the northern side (SE; Espinosa, OD 1943:122, p. 146). When selecting the site for the mission, an important criterion was the ability to defend it against attacks by antagonistic groups (Spruce, 1996, p. 439). Such attacks by the Jívaros continued until the 1880's (OD 1945:146-148, p. 168). Christianization and sedentarization was a gradual process. Even after the establishment of the Sarayaku mission, many of the Tayaks continued to live scattered in the forest, much as they done before. There was fighting between these Tayaks and the Gualingas, who were allied with the mission. Measles took a heavy toll on the population of Sarayaku as well as on the Achuar, and is said to have wiped out the Tayak (SE). More significant than epidemics for the dissappearance of the Tayak, however, was probably the gradual assimilation into the Sarayaku mission population over several decades.

In 1867, the Dominicans withdrew due to lack of personnel, and the Sarayaku mission was abandoned. However, the Ecuadorian government decided to grant the area to the Jesuit mission instead, so after four or five years, the mission was re-established. The Sarayaku people did not get along well with the Jesuits, and the

[19] Translation by the author

Dominicans also wanted to recover their lost territory. Finally, after a decision by the Pope, the Dominicans returned again in 1887 (SE, Pierre, 1983, p. 8, 99).

Sarayaku was an ethnically mixed community consisting of Jivaro-speakers (Villavicencio, 1858) and Zaparo-speakers, each group occupying a different sector of the community (Pierre, 1887; Reeve, 1988, p. 69). The Kichwa language was used as lingua franca, and was the native language of those inhabitants who had come from the Canelos mission. Gradually, the Kichwa language became the first language of more and more children born in Sarayaku. The forests surrounding the mission community were occupied by Zaparos in the north (SE), and Jivaros (Achuar) who mostly lived south of the Bobonaza river (Pierre, 1887; p. 169), although some refugees from internal feuds lived along the Balsayacu and Sarayakillu rivers, north of the Bobonaza (Villavicencio, 1858, p. 84). To the east lived the Rutunu people, a “tribe of the Zapara family” (Villavicencio, 1858, p. 170). Gradually, more and more Zaparos and Jivaros came to settle in the mission. Some, however, did not get along well with the missionaries, and returned to the surrounding forests (SE).

Some Sarayaku elders claim that the establishment of *purinas* (secondary homes, see Chapter 2) along the upper Rutunu river and on the Bobonaza river immediately downstream of Sarayaku, as well as the establishments of settlements along the Sarayakillu river were direct responses to game depletion around the densely populated mission, which led to the search for areas with better hunting. However, in 1857, Spruce (1908, p. 125) passed the Rutunu River at the height of Pakayaku, and noted that all along it people from Sarayaku, Pakayaku and Canelos had *purinas*, where they went to wash gold. This indicates that the system of *purinas* was well established already in the early days of the mission, and supports the view that the people who came to settle in the mission never completely abandoned their areas of origin, which instead became the areas of their *purinas* (Guzman-Gallegos, 1997, p. 147).

The missionaries ruled the community with a firm hand, and appointed local functionaries in charge of keeping order. These were the six so-called “varayacus” (staffholders), married men with different ranks, the highest being the Curaca, followed by the Capitan, Alcalde and Alguacil (see Reeve, 1988 p. 180). There were also four Fiscals, a kind of police force consisting of young unmarried men. Those who did not obey were put in the *sipu*; a sort of wooden block in which the feet were locked so that the person had to lie on his back in the sun all day long with the feet upwards. Rebellions of the Sarayaku people against the missionaries are described to have occurred in 1888 (Reeve, 1988, p. 68), 1890 (Romero-Teran, OD 1927:1 p. 47) and 1896 (Mejía, OD 1927:1 p. 33). These rebellions in general soon calmed down and did not lead to any dramatic consequences.

Apart from metal tools, the missionaries also introduced clothes and salt. Long-distance river travel started as people went to the Amazonas in order to acquire dart poison (Pierre, 1983 [1887], p. 189), and to the Ucayalí in order to extract salt (Simson, 1993, p. 104). Through the contact with the people from the Andoas area, they also learned to paint their pottery in elaborate patterns (SE; Reeve, 1988, p. 102), a skill which nowadays is considered a central part of the culture of the Kichwa in Pastaza (Bowser, 2000), and often described as a “traditional” or “ancient” custom (Whitten, 1989; Whitten & Whitten, 1978, p. 91). In general, the christianized Indians of the region ceased to manufacture traditional crafts, as they became middle-men who provided the “infidels” with industrial goods in exchange for blowguns and other crafts (Spruce, 1996, p. 435).

Population estimates from Sarayaku during the epoch vary widely, from 150 in 1866 (Jiménez de la Espada et al., 1998) to 900 in 1887 (Pierre, 1983). However, the estimates of “50 families” in 1858 (Villavicencio, 1858 p. 415) and “400 inhabitants” in 1890 (Jerves, OD 1930:12, p. 52) are fairly consistent with the quite detailed population estimates by Magali (1890) of the area under influence of the Dominican mission in 1890, indicating that Sarayaku had 460 inhabitants. Magali (1890) also provides numbers of the Achuar Jivaros living along the Jatunkapawari river, and Zaparos living along the Conambo and Corrientes. Translating these figures into population number for the present Sarayaku territory is difficult, because of the mobile habits of these groups. However, it seems reasonable to add some forty Achuar Jivaros in the southwest and some fifty Zaparos in the north, giving a total population number 550 for present day Sarayaku territory in 1890. While travelling from Andoas up the Bobonaza river in 1857, Spruce (1996, pp. 436-439) does not report having encountered any human habitations until he reached the mouth of the Sarayakillu River, where he found a field and a house with several people who were panning gold, indicating that whatever population existed in the area still had not settled by the river, and that population density probably was low.

5.3.2.2. Natural resource use in the Sarayaku area (1830 – 1890)

At the Sarayaku mission the people started to farm the fertile alluvial plains, but also continued to farm nearby ridgetops. The people in the area who did not enter the mission continued to farm the ridgetops in the surrounding forest. Villavicencio (1858, pp. 172-173) indicates that “only some [zaparos] have small fields of maize, manioc and plantains, others live by hunting, fishing and wild fruits. They are almost nomads, following the ripening of the fruits. This distinguishes them from the Jivaro who have fixed residence, make large fields with a variety of crops, and who also raise a great quantity of pigs that they sell in Macas and Canelos.” This description is strikingly similar to the oral tradition in Sarayaku about the famous shaman named Panduk, living at the time, who is said to have travelled widely in the Amazonía, and on one occasion found a group of Zaparos who relied heavily on forest fruits, game and fish, and whose agriculture was limited to small fields of maize.

The shift from dispersed settlement and farming of ridgetops to nucleated settlement and farming of alluvial plains was a major event changing the interactions between human society and the environment. However, the establishment of the mission itself was probably not the only driving force behind this change. Rather, it was to a large extent a consequence of technological changes in which also the missionaries played an important role, by introducing steel tools and new crops, particularly plantains (Steward, 1948, p. 512). Plantains are particularly suited for planting on the alluvial plains. On ridgetops, on the other hand, plantains grow well only on the relatively rare black soils, but not on the more common red soils. The introduction of plantains may therefore have contributed to the settling on the plains. The introduction of metal tools not only facilitated clearing and weeding, but also canoe-making, thus adding the facility of river transport to the benefits acquired by farming the alluvial plains near the major rivers.

In any case, just as the "infidels" typically acquired metal tools through trade with the Indians in the missions (Cevallos, 1775, in Rumazo, 1970, p. 160) or through theft (Magnini, 1998, p. 190, Cabodevilla 1999), also the plantains, once established in the region, spread far beyond the missions themselves. Further down the Bobonaza River, Castrucci de Vernazza (1845) described a Zaparo community called Bufeo settled by the river, cultivating manioc and plantain. He also observed plantains in an abandoned chacra of "infidels" in Tigriyacu (probably Río Tigre, see Fig. 2.2). In a similar way, as late as in the 1950's, two atypical houses of the still "uncontacted" Huaorani were photographed from the air, located close to a river and surrounded by fields on the alluvial plains (Cabodevilla, 1999, pp. 320-326), whereas most Huaorani settlements continued to be on the ridgetops. Obviously, settlement and cultivation of alluvial plains often predates the establishment of missions, in full agreement with the assertion of some of the Sarayaku elders that, already before the establishment of the mission, there were a few families living at the site. This seems to support the view that the main driving force for this change was technological.

Villavicencio (1858) observed that the Jivaros of Sarayaku were dedicated to extract the latex of the laurel tree (*Cordia alliodora*), make blowguns, and raise pigs. The people of Sarayaku hunted mostly quite near the settlement, and did in particular not travel very far south of the Bobonaza River (SE). The surrounding forests were still inhabited by people who had not joined the mission. Therefore, there were no such almost unhunted refuge areas that exist today in the distant corners of the Sarayaku territory.

Castrucci de Vernazza (1845) describing the Zaparo of Bufeo on the lower Bobonaza (see Fig. 2.2), mentions that they had blowguns and spears. In spite of the assertion of the Sarayaku elders that the bow and arrow used to be the principal hunting weapon, references to bow and arrow are absent in the literature over the area. It has been suggested, however, that bow and arrow was the original hunting weapon for the Jivaro (Steward, 1948, p. 620), and that the blowgun was adopted after the 16^{th} century (Metraux, 1949, p. 249). In any case, if a switch from bow and arrow to blowgun has occurred, it must have occurred no later than the early 19^{th} century. The blowgun is considered to be more apt for hunting canopy-living animals, while the bow and arrow is more apt for hunting ground-living animals (SE) This distinction is, however, not exclusive, as also ground-living species may be killed by blowgun hunters, although this required the use of a particularly strong dart poison (SE). Similarly, hunters with bow and arrow may also kill canopy-living species (e.g., Chagnon, 1997, p. 51). The use of dogs also facilitates hunting of ground-living species. Dog remains have been found during excavations of a cave in the Ecuadorian highlands, inhabited about 8000-6000 B.C. (Lynch & Pollock, 1981)**,** and in 1857 dogs were common in the mission communities in the region (Spruce, 1908). However, it is unknown whether dogs were used for hunting in the area, prior to the establishments of the missions. The nearby Huaorani people, for example, did not use hunting dogs until they established regular contact with outsiders around 1960 (Yost & Kelley, 1983).

One may speculate about the reasons behind the suggested changes in hunting technology. Ground-living game, in general, have relatively high productivity and are not very susceptible to overhunting. Canopy-living game, on the other hand, in general have low productivity and are quite susceptible to overhunting (see Chapter 9). Changes in hunting technology between arms suited for canopy-living animals, and arms suited for ground-living animals, may therefore be a cause or an effect of changes in game abundance. Also, the disruption and (re-) establishment of trade routes for high-quality dart poison (Cipoletti, 1988) may be a reason. However, because too little is known about what changes in hunting technology have occurred, and, if so, when they occurred, any attempt to provide explanations is doomed to become mere speculation.

Sarayaku elders relate that the people in those times were quite selective about what meat they ate: "They ate only good meat. In those days they did not eat capuchin mokey (*Cebus albifrons*), saki monkey (*Pithecia Monachus*) or deer (*Mazama* spp.)." The name of a ridge near the village, Kushilluurku or "Wooly Monkey Ridge" – that today is dominated by secondary forests and void of wooly monkeys (*Lagothrix lagotricha*), save occasional visits, bears witness to the fact that the wooly monkey once was common even in the vicinity of the village itself.

Steward & Metraux (1948, p. 640) indicate that the principal fishing method of the Canelo and Zaparo was barbasco, that they also used spears (and the Canelo, harpoons), but not bow and arrow. Fishing with nets was observed in Canelos in 1887 by Pierre (1983). This may have been a very recently introduced technology, as the Sarayaku elders claim that the fish nets were introduced by refugees from Napo who arrived during the rubber boom.

The account by Pierre (1887, p. 149) from a fishing event near Canelos indeed suggests that fisheries were rich during that time. Catching fish with hands, feet, and spears, a few people (two canoes) managed to catch over fifty fishes, and in addition one 60-cm catfish caught with a castnet, just within fifteen minutes. He makes no mention of the use of barbasco, but is is plausible that somebody in the party had, unnoticedly, taken off upstream to apply barbasco to the water.

5.2.4. The rubber boom and its aftermath (1890 - 1910)

5.2.4.1. Regional and local context (1890 – 1941)

The increasing world demand led to an exponential growth of the rubber production in the Amazon in the mid 19th century. Gradually, the frontier of rubber exploitation expanded from the lower Amazon in Brazil towards the headwaters in the Andean countries. In the department of Loreto, Peru, the rubber trade started slowly in the early 1870's and took off around 1884, the town of Iquitos (see Fig. 2.2) becoming centre of the trade (Reeve, 1988 p. 144).

The rubber boom had severe impact on the indigenous people of the region. Those who did not live in missions were often caught and forced into slavery, often under extremely cruel conditions, whereas christianized Indians were subjected to debt-bondage labour on very unequal terms (Reeve, 1988; Cabodevilla, 1996; Stanfield, 1998). Sometimes, however, the rubber traders even attacked the missions, and captured the people in order to force them to work extracting rubber, or sell them as slaves to other rubber traders, as happened to the Andoas mission in 1888 (Magalli, 1890, in Vargas, 1976, p. 43; Reeve, 1988, p. 77). The people were not always in the same place as the rubber stands, so they were moved, more or less forcefully, to where their labour was needed. These movements of people and their insertion into the rubber economy caused the disappearance of many ethnic groups, which became assimilated into the mestizo society or into other indigenous groups (Barham & Coomes, 1996, p. 53; Stanfield, 1998, p. 39-62).

When Pierre (1983) visited Sarayaku in 1887, there were no signs of rubber trade going on in the area, but already in 1890 it had taken off (Magalli, 1890, in Vargas, 1976, p. 44, 82). The rubber traders came mostly from downstream (Peru), but some came from the Ecuadorian highlands and coast. The rubber was shipped downstream to Iquitos in the Peruvian Amazon, and Sarayaku got economically integrated with Peru more than with Ecuador. Working for the rubber traders was voluntary, and there are not any memories of resentment of any bad treatment by the rubber traders, a striking contrast to the situation in such nearby areas as the Napo and Curaray (Reeve, 1988; Cabodevilla, 1996).

All adult men participated in collecting rubber out in the forest, so that only women and children remained in the village. Actually, also many women collected rubber. The rubber collectors were paid in money or in kind. The rubber traders also sold industrial goods. This way the Sarayaku people acquired metal axes, metal pots, clothes, and even some sewing machines, guitars, and muzzle-loaded shotguns (SE). Some people from Sarayaku also went all the way down to Iquitos transporting rubber. Given the economic transformation the rubber trade caused, participating in it must have rapidly become a necessity.

The Achuar Jivaro continued to live in the Jatunkapawari area, whereas the Zaparos lived in the Conambo and Landayaku area. Whereas the Achuar and Zaparos continued to join the Sarayaku mission, there was also a movement in the other direction: The Sarayaku Kichwa who could not get used to living with the rubber traders and who escaped to Conambo to “become Zaparos”. The Sarayaku people had good relations with the Zaparo, and used to come to visit each other.

In Sarayaku, the rubber boom contributed even further to the ongoing ethnic fusion. Several refugees arrived from the upper Napo region where the indigenous peoples were very badly treated, kept in slavery-like debt-bondage. Also, some Andoas Indians came to Sarayaku from downstream with the rubber traders and both men and women married Sarayaku people and stayed. Also a few mestizo rubber traders married Sarayaku women and settled in Sarayaku. On the other hand, the Kichwa people expanded their area of occupation, as the community of Wankiri or Juanjiri (later Montalvo) was founded on the lower Bobonaza river, with participation of some people from Sarayaku (SE, Magalli, 1890, in Vargas, 1976, p. 84; Leon, OD 1932:27, p. 187). In 1912, however, it was totally abandoned, all the people being taken to work for a rubber baron, and was reestablished with new inhabitants (Reeve, 1988, p. 77).

The rubber prices, which up to then had been steadily increasing, fell during the 1910's to a third or quarter of their maximum level (Roux, 1995; Barclay, 1995), and continued to fall during the 1920's (Marín, OD 1929:12, p. 2). Although the rubber lost its dominant role in the regional economy, the trade was not abruptly abandoned. In 1927, Sarayaku was still fairly frequently visited by Peruvian, Ecuadorian and Colombian tradesmen, who traded rubber or gums, as well as Europeans dedicated to "gold panning and collection of insects for museums" (Mejía, OD 1927:1, p. 11). The Peruvian merchants, however, diversified the trade, increasingly buying other forest products such as the latex of leche caspi (*Couma macrocarpa*) and balata (*Mimusops globosa*) and the seeds of the tagua or fibra palm (*Aphandria natalia*) (Barclay, 1995), and the Sarayaku people continued to travel to Iquitos selling such products (SE). Peruvian timber traders also came to cut mahogany or *Awanu* (*Swietenia macrophylla*) in the headwaters of the Yatapi River, and float it downriver.

Whereas the trade with Peru decreased as the rubber prices fell, the trade with the Ecuadorian highlands increased. People started to travel from Sarayaku to the highlands to sell gourds of *pilchi* (*Crescentia cujete*), the fruits of the *manduru* (*Bixia orellana*) which were used as a food colorant, ginger or *ajirinri* (*Zingiber officinale*), the fruits and barks of the American cinammon (*Ocotea quixos*), fibres of the *chambira* (*Astrocaryum chambira*), and birds and small animals from the forest (SE; León, A. M., OD 1940:89, p. 264). This trade ceased towards 1940, as the gold price rose, and people turned to panning gold, which they sold to merchants (León, OD 1940:89, p. 264), often in exchange for clothes (SE).

During the 1920's and 1930's, oil companies, such as Leonard Exploration Company, Anglo-Saxon Petroleum Company, and Shell, carried out geological studies searching for oil in the Ecuadorian Amazon (Cabodevilla, 1996, p. 284; Valladares OD 1930:12, p. 147). For the Sarayaku people, these years marked the beginning of migratory work, as some people went to Napo to work on seismic crews (SE).

The oil companies contributed to increased integration of the Ecuadorian Amazon with the rest of the country. The Leonard company constructed a road from the highlands down to Mera (see Fig. 2.2), although in 1937 it still only permitted travelling by mule and foot (Blomberg, 1938, p. 32). The oil companies constructed an air base near Mera, today the site of a town called Shell (see Fig. 2.2). In 1939 it was inagurated and handed over to the Ministry of Defense (OD 1939(70-71).

Socially, Sarayaku was quite fragmented. People living in different parts of the community did not visit each other's homes, and there was even antagonism between different family groups living in different parts of the community. Only the varayuks had frequent contact with each other in spite of being from different parts of the community (SE). The people spent much of the year out in their purinas, gathering only for one to three months when a missionary came to visit the community, followed by three to five months out in the purinas (Mejía, OD 1927:1 p. 10; Mejía, 1931 OD 21-22, pp. 126-129; SE). The Dominican mission disliked this custom, which they saw as an obstacle to progress. The policy of the mission was to support colonization, which they thought would bring “civilization and progress”. They argued for the construction of roads and economic incentives for colonization (Marín, OD 1932:27, p. 117-118). There were plans to create a colony of “whites” in Sarayaku, but the Sarayaku people strongly opposed these plans, considering themselves to be the only owners of the land, an idea the mission considered completely erroneous. In spite of being appointed by the missionaries, the Curaca, Capitán and Varayucs in this matter took the side of the community, and expelled any “whites” who intended to settle in the community (Mejía, 1927:1 p. 11).

The presence of the state was sporadic. According to Sarayaku elders, a military camp was established during the rubber epoch, and a military became the first representative of the government in Sarayaku, locally known as *apu* (see Chapter 2). There are references to a *Jefe Político* in Sarayaku in 1918 (Karsten, 1998, p. 198) and in 1927 (Romero-Teran, OD 1927:1, p. 49). But in 1929, the state was absent again, and the only authority present to resolve conflicts between the Sarayaku people and the tradesmen was the priest (Marín OD 1929, p.2). In the late 1930’s a military garrison was established in Sarayaku. A power conflict arose as the military demanded the right to appoint the varayaucs, whereas the mission refused to cede its “rights over the Indians”, and accused the military of inhuman treatment of the Indians they forced to work as carriers (Monteros, OD 1938, p. 399, OD 1938, p. 441; Marín, OD 1940:87, p. 195). By 1940, some sort of power balance between church and governmental authorities seems to have been reached, as the priest consulted the *teniente politico*, before appointing the *varayucs* (León, OD 1940:90, p. 295). In the case of fighting, or other offences, the varayucs in turn reported this to the teniente político, who then went together with his secretary in order to take the perpetrator into custody (SE).

In 1940 there was also a *junta parroquial* (parish committee), working for the “moral and material progress” of Sarayaku (León, OD 1940:89, p. 264). The Sarayaku elders, however, made no mention of this parish committee when talking about the history of community organization in Sarayaku, indicating that participation by the indigenous population probably was minimal or absent, and that the labour of the parish committee did not have much impact on the community.

All married men were obliged by the church to have a house in the centre of Sarayaku (SE). In 1940, no less than twenty-five men were notified by the priest because they did not fulfill this obligation (León, OD 1940:90, p. 296), an indication that the power of the church was starting to erode.

Although outsiders held much power in the community, the Sarayaku people consider themselves to have been free (SE). Contemporary observers also noted, sometimes with surprise and consternation, that the Sarayaku people were free to choose whether to work or not, and for whom to work. This was in contrast to the Quichua of the Napo who were owned by “white” masters through debt-bondage (SE; Valladares, OD 1929:8, p. 20; OD 1945:146-148, p. 168). Labour relations were unequal, but the Sarayaku people did not accept excessive abuses. Once, a timber patron who physically abused a Sarayaku man had to pay for it with his life, getting killed on the spot by the brother of the victim (SE).

In 1890, there was an epidemic of measles that had taken a toll of fifty lives along the Bobonaza, so that the people in all communities had fled out to the forest (Magalli, 1890, in Vargas, 1976, p. 44). Taylor (1986) indicates that population figures of the western Amazon decreased between 1880 and 1900, and then started to increase again. The rate of increase, however, seems to have been pretty modest, as described by a contemporary missionary in Sarayaku: "The marriages of the Indians are in general very fecund: ten or twelve children is the fruit of a union. Nevertheless, the population remains stagnant, because of the death of almost all of the children that succumb, victims of diseases and lack of food and disgraces of an abrupt nature." (Vargas, OD 1931:23, p. 164.)

As indicated in the previous section, at the onset of the rubber boom there were 460 inhabitants in the Sarayaku mission community, and perhaps another ninety Achuar and Zaparos in the surrounding forests. In 1927, a missionary estimated the Sarayaku population to 600 (Mejía, H. M. OD 1927(1):10), and in 1928 the Dominican mission started to regularly publish population figures. These figures show a population decline for Sarayaku from 510 in 1928 to 457 in 1938. This apparent decline in population stands in contradiction to the positive balance of births (as indicated by number of baptisms) versus deaths seen for each year. It is possible that the priests did not record the deaths that occurred during the times of the year when they were absent and the people were dispersed in the *purinas*. But even if deaths are multiplied by a factor four to correct for such a bias, there is still a small birth surplus inconsistent with the population decline indicated. This can hardly be attributed to emigration either, because according to the Sarayaku elders, emigration was still not a significant phenomenon during this epoch. Obviously there are errors in the counting procedures, and all that can be said is that the population of Sarayaku during the epoch probably was about 500 persons.

5.2.4.1. Natural resource use in the Sarayaku area (1890 – 1941)

There were several species of trees that provided rubber of different quality and price. Most commonly exploited in the region was the *caucho* tree (*Castilloa elastica*), but the most highly priced rubber came from the *shiringa* (*Hevea brasiliensis*). In contrast to the caucho, the shiringa could be tapped repeatedly without felling it (Roux, 1995; Weinstein, 1983, p. 26). Nevertheless, in Sarayaku usually also the shiringa trees were felled. As the stands of rubber trees got depleted, the people soon had to travel quite far away from the mission in order to collect rubber. This led to the establishment of *purinas* (secondary homes, see Chapter 2) in more distant places than before, such as the Jatunkapawari River, the lower Rutunu River, and far downriver on the Bobonaza River, and thus constituted an expansion of the area used by the Sarayaku people.

For agriculture, there was still no scarcity of land, and land was free for anybody to cultivate. Agricultural pests were less common than today (SE). After the decline of the rubber trade, people started to plant *manduru* (*Bixia orellana*) in order to sell the fruit, which was used a food colorant. The supply of metal axes improved during the rubber boom, which facilitated forest clearing. However, also a feared grassy weed, the *millaykiwa* is said to have come from the Marañon (see Fig. 2.2) during this epoch. Poultry was introduced from Peru, but the people did not eat either its meat or its eggs, as they found it repulsive to eat domestic animals, and had them just as alarm-clocks. The raising of pigs, described by Villavicencio in 1858, had by now disappeared. The only people who raised pigs were some of the mestizo traders who had settled in the community, but it was not very productive and was not adopted by the people at large (SE).

Hunting was mainly carried out with blowguns. Also spears were used, particularly to kill tapirs. Sometimes also women speared tapirs, and the elderly women of Sarayaku remark that nowadays the women would not be able to do that. Among the many trade items that circulated during the rubber epoch was the dart poison, brought by the *Llamishtu* (the *Lamista* Indians of Peru), or by the rubber traders. Also, a few Sarayaku people traded rubber for muzzle-loaded shotguns. This was the first introduction of firearms as a hunting weapon in Sarayaku (SE). Later, Peruvian merchants living in Montalvo also brought cartridge shotguns from Peru, some of which reached Sarayaku (SE). When, a couple of decades later, people went to Napo to work on oil company seismic crews, some also bought shotguns which they brought back to Sarayaku (SE). These were, however, rare exceptions, and most people never used a shotgun.

The areas in the immediate vicinity of the village were already hunted out, and a missionary noted that therefore these areas “lacked the joy offered by the song of birds” (OD 1932:23, p. 163). Not very far away, however, game was still abundant. Spider monkey (*Ateles belzebuth*) and Wooly Monkey (*Lagothrix lagotricha*) were common at Supayyakupungu, just four kilometers downstream of the Sarayaku central plaza. People hunted a lot of toucans and small parrots. By this time, they sometimes also hunted deer, previously not held in high esteem (SE).

Although Steward (1948) indicates that the fish poison Barbasco (*Lonchocarpus nicou*) was widely cultivated in Ecuador and Peru already at the time of “contact”, Sarayaku elders say that only wild barbasco was used until the rubber epoch, when the people started to cultivate it. Before that, according to the Sarayaku elders, fish was so abundant that it was easy to catch enough of them with just hook and line. Therefore, barbasco was not used very frequently, and mostly for fishing in small creeks. *Gamitana* (*Colossoma macroporum* and *Piaractus brachypomus*) were still in the 1930’s abundant in the Rutunu river, and also in Rio Bobonaza up to Pakayaku. Stranded catfish could sometimes be found lying on the beaches (SE).

5.2.5. Integration and political awakening (1941 - 1976)

5.2.5.1. Regional and local context (1941 – 1976)

In 1941, Peru attacked Ecuador. According to some authors this happened because old rivalries between Ecuador and Peru regarding the dominion of contested Amazonian territories were fueled by the prospects of finding oil in the area (e.g., Galarza-Zavala, 1970). Troops passing Sarayaku on the way to the front-line recruited some young men as carriers, while many others fled out to their *purinas*. Just declining to get recruited was obviously not an option. One man from Sarayaku got killed in the war. Ecuador lost the war, and the boundary between the two countries effectively was set at the point where the Bobonaza River meets the Pastaza. Having lost much of its Amazonian territory, Ecuador after the war increased its effort to consolidate its control of what was left. The number of militaries stationed in Sarayaku increased from about five to forty. Military posts were also set up in Pakayaku and Montalvo. The relations with the soldiers were bad. The soldiers were ruthless and responded to any complaint by pointing their gun. As part of their efforts to integrate the Sarayaku people into Ecuador, the military confiscated any clothes and blankets that were of Peruvian origin.

This gave rise to a rebellion. A man called Cesar Santi walked around the plaza refractorily wearing a Peruvian hat. The secretary of the teniente político called to attract his attention, but he did not obey, so they came to grab him. When he slipped from their grip and ran away a soldier shot at him and he got hit in the arm. Hearing the gunshot the people started a riot armed with spears, machetes, sticks and stones. They took down the Ecuadorian flag (and, according to some, burned it) and looted a store set up by a mestizo merchant. However, the next day things returned to normal. Three varayucs were put in jail in the highland town of Ambato, and their families had to pan gold for a long time in order to pay for them to get liberated (SE). There were even cases of rape, committed by soldiers. Because of this the varayucs went to Quito to complain to the government. Finally, the military base in Sarayaku was closed down, and instead a big military base was constructed in Montalvo.

After the war, the new border between the two countries was closed, and the old trade routes were cut off. This led to scarcity of salt and dart poison. People started to bring salt back from their journeys to the highlands instead. After the war, mestizo merchants also came to Sarayaku.

Shell initiated seismic work in Sarayaku soon after the end of the war, and work for the Shell company gave an increased access to money and industrial goods (OD 1943:124, p. 178). In 1945 there were 80 Shell company workers in Sarayaku (OD 1945:144, p. 73), a figure probably not including the residents of Sarayaku who worked for the company.

In 1947, the road from the highlands reached Puyo (Whitten, 1976, p. 238). With the road came colonists, and the indigenous people around Puyo got dispossessed of much of their lands (OD 1947:168-169, p. 42; Blomberg, 1949; Whitten, 1976). On the other hand, the road connection also permitted movement in the other direction. The Sarayaku people still had to travel 65 km by river and foot in order to reach Puyo, but from Puyo the central parts of Ecuador could now be reached in a matter of hours rather than days or weeks. When the Shell company left Sarayaku in the latter part of the 1940's, the first big wave of migration to the coast started. The coastal region of Ecuador was in an economically expansive phase, and the skills of Amazonian Indians, used to manual agricultural work in a hot climate, were appreciated. Some settled there and never came back, but many others returned to Sarayaku after living many years in the coastal region.

During these years, the official policy of the government was to colonize the Amazon. The indigenous people were seen as obstacles to development (Whitten 1976, 1989; Reeve 1988, pp. 196-198).

In 1950, the Shell company announced its withdrawal from the Ecuadorian Amazon, without having encountered oil reserves that would be profitable to exploit. During the following years, USA-based Protestant missions took over the installations left by Shell. Around 1960 they arrived in Sarayaku, having coordinated with the teniente politico of the time. They constructed a church, and a bitter struggle over the souls of the Sarayaku people followed between the Catholic and the Protestant missionaries, respectively (SE, see also Blomberg 1964, p.22). Finally, this led to a deep split of not only the Sarayaku people, but of the indigenous people of the province of Pastaza in general. Today, this split has still not healed, and is a major obstacle to any attempt to coordinate actions for the common good of all communities in the region.

The Protestants used material incentives in order to make the people change religion. Particularly, they gave medicines to people who attended their sermons. The Protestants also directed the construction of an airstrip in the community. With the airstrip, suddenly one could reach the town of Puyo in half an hour by air, instead of, as before, four days by canoe and foot. The Protestants, however, had total control of the air traffic, not only because the cost of air transport as such was prohibitive for the Sarayaku people, but also because the only airplanes available were the ones of the Protestant, US-based, *Missionary Aviation Fellowship*, in Ecuador called *Alas de Socorro*. Thus, the only way to get access to air transport was to gain the goodwill of the Protestant missionaries, particularly by attending their sermons.

In the early 1970's, the oil company Western initiated another round of seismic prospecting in Sarayaku. The Sarayaku people were not informed in advance, and did not know anything about the plans before the helicopters of the company suddenly arrived in the community. Nevertheless, there was no opposition, and people considered the oil exploration as a welcome opportunity for cash income. Again, there was a short period with increased access to wage labour. (SE) Oil was not found in Sarayaku, but the Texaco company had found oil near Lago Agrio in the northern Ecuadorian Amazon. This marked an abrupt change in the history of Ecuador and of the Amazonian region in particular. Pipelines and roads were built to the oil wells. Colonists from the coast and the highlands poured into the area, displacing the indigenous people living there (Kimerling, 1993). Also a few families from Sarayaku emigrated to the area, lured by reports of plenty of fertile land and abundance of game and fish. Soon, however, the area would be more known for rampant pollution and deforestation than for pristine land up for grabs (SE, see also Chapter 2 and 13).

The system of varayucs, appointed by the priest, was still in force. For this purpose, the mission applied a division of the community into two districts; the *partido alto* (upriver) and *partido bajo* (downriver) and appointed for each partido one Capitan, one Alcalde, and one Fiscal, as well as a Curaca in charge of the whole community (OD 1953:237, p. 19). The one who had the power to decide about internal affairs, as well as in dealings with outsiders such as oil companies, military, and merchants, was the teniente politico, up to the 1970's always a mestizo outsider.

In 1943 there was a school with 14 Indian children and 4 "white" children (OD 1943:118, p. 27.). The priest came and went in three-month intervals, and most people lived dispersed in the *purinas* when the priest was not present (SE, OD 1946:160, p. 135).

The publications of the Dominican mission in the 1940's reveal a change in the perception the missionaries had of the Indians, with a new sense of admiration of ancestral customs and the free life close to nature. Even the previously so hated custom of the *purinas* was described in neutral, or even appreciating, terms (OD 1946:160, p. 135). The Dominican mission also started to recognize the problems caused by the colonization of the area around Puyo and began to defend the interests of the Indians, although it still did not oppose the colonization as such (OD 1947:168-169, pp. 42, 46; Freire, OD 1955:263-281, pp. 21-23). In the 1970's this process of change in the ideology of the Dominican Mission, headed by Bishop Tomás Romero, led to the Mission starting to arrange meetings and courses with participation from various indigenous communities. The purpose of these events ranged from strengthening the indigenous peoples' cultural identity, to training people to become community leaders, nurses, and teachers (SE, OD 1974:375-376, p. 36; OD 1976:382, pp. 4-5; Romero, OD 1976: 323, p. 2).

By now, the indigenous population had gained some participation in the *Junta Parroquial* (SE; OD 1975:378-379, p. 12). The Dominican Mission also managed to convince the civil authorities to appoint, for the first time ever, an indigenous Sarayaku native as *Teniente Político* (Romero, OD 1976: 323, p. 2). Sarayaku was becoming the showcase of the Dominican Mission. A Dominican missionary describes the Sarayaku people to be "cleaner, happier, more talkative and more hospitable" than the people in other communities along the river. (OD 1976:382, p. 7)

Sarayaku elders relate that the border between Sarayaku and Pakayaku used to be in Yatapi, and the border between Sarayaku and Montalvo in Ramizona, half way between Montalvo and the mouth of the Rutunu River (see Figs. 2.2 and 2.3). However, they also relate that the concept of borders between communities was not very important, as land was not a scarce resource. However, some people from Sarayaku started to live permanently in their purinas, right downriver of the mouth of the Rutunu river, thus forming a new community called Teresa Mama. Also the communities of Shaimi, Muritikucha, and Yatapi were established (see Fig. 2.3). The Shaimi community was established by the Achuar people that had lived dispersed in the same area around the Copataza River for a long time. The Yatapi community, on the other hand, was established by people from Pakayaku, thus constituting a territorial expansion by Pakayaku at the expense of Sarayaku. The Muritikucha community was established by some Kichwas from Pakayaku, and later increased with some Achuaras from the Copataza region who had fled fearing revenge of killings in internal feuds.

The population figures given by the Dominican mission jump from 457 in 1938 to 590 in 1942, and then drop again to 343 in 1944 and 374 in 1946 (Fig. 6). Again, there is no explanation of these variations other than errors in the counting. The retrospective mapping exercises (see Chapter 4) indicate that there were 83 households in Sarayaku in 1960. If one assumes an average of 6.3 members per household (as of today, according to the official census), this corresponds to about

520 inhabitants. However, households in those days were often larger, including several related nuclear families (SE), so this is a conservative estimate.

5.2.5.2. Natural resource use in Sarayaku (1941 – 1976)

Right after the war, fields were still established only on good sites; ridgetops and plains, preferably new land created by sedimentation of the river. Most fields were established by clearing primary forest. However, from the 1940's up to the 1980's, primary forest near the village became increasingly scarce, and clearing of secondary forest became more common than clearing of primary forest (SE, see also Chapter 8). Agricultural pests started to increase (SE).

In the 1940's, people had no domestic animals other than dogs and poultry. They did not eat the poultry (SE), but used to sell them to "travelers" (OD 1946:160, p. 135). However, by the 1960's, poultry breeding became more common, and the people gradually got accustomed to eat poultry meat. A few people had cattle or pigs, particularly the children of the mestizos who had come during the rubber boom and married Sarayaku women.

New varieties of cassava were brought back by people returning from the coast and largely replaced the old varieties. Also, the morocho type of maize started to replace the native variety of maize. The advantage with the native maize is that it dries slowly so that there is a prolonged period when it is suitable to eat fresh. On the other hand, the morocho maize is characterized by higher yields and by drying faster, and is therefore more suited for poultry feed. Although the native maize is still cultivated, there is a concern that it has lost some of its original characteristics due to cross-pollination with the morocho maize. Migrants to the coast not only brought back new cultivars, but also new weeds. During a short period in the 1940's, barbasco (*Lonchocarpus nicou*) was planted and sold as a cash crop (SE, OD 1942:109, p. 98).

In the 1940's, the blowgun was still the dominating hunting weapon (OD 1946:160, p. 135), but already in the 1950's, they were gradually being replaced by muzzle-loaded shotguns (Maya, OD 1959:311, p. 94), a process that continued during the 1960's (SE). Those who had a shotgun typically carried both the shotgun and the blowgun while hunting, using the blowgun for small prey and the shotgun for big prey. Ammunition was expensive, so people used to load just 3-5 shots, and carefully retrieved the shots from the dead animal in order to reuse them. Hunting with flashlight started during this period. People returning from the coast had learnt how to wait for pacas (*Agouti paca*) in the dark in fields or under fruit trees. Also, people started to search for caymans (*Caiman crocodilus*) along the rivers with torchlight (SE).

In comparison with the present situation, wild game was still abundant in the 1940's, but a decrease was already perceived. Vulnerable species such as Wooly Monkey (*L. lagotricha*), Tapir (*T. terrestris*), Paujil (*M. salvini*), and Blue-throated Piping-guan (*Pipile pipile*), were only occasionally found near the village although they still were relatively abundant further away. Herds of white-lipped peccary (*T. pecari*) sometimes entered the village itself (SE). In order to hunt for the community festivals in the 1960's it was not necessary to travel more than 6 – 15 km away downriver.

After the war and up to the 1960's, Ecuadorian merchants bought furs from spotted cats, otters, giant otters and collared peccaries, as well as gold, toucan feathers, canela, pottery and live monkeys (SE, Blomberg 1964, p. 19). The Sarayaku elders claim that the hunting for the fur trade did not cause any decline in the populations of animals. This is somewhat surprising, given that commercial hunting for furs is considered to have contributed to severe declines of particularly jaguars and giant otters (Redford, 1992). However, apparently the Sarayaku people never changed their hunting behaviour much in order to specifically hunt for furs. The main purpose of hunting continued to be to acquire meat, and the people killed otters or spotted cats only if they happened to come across them while hunting for meat. The fur trade disappeared in the 1970's.

In the 1940's and 1950's the *teniente político* prohibited barbasco fishing of the Bobonaza river, except for once a year, for the community festival. Dynamite fishing was practiced near the town of Puyo already in 1945 (OD 1945:153, p. 221). In Sarayaku, the introduction of new fishing methods seems to have occurred in the 1960's. The Protestant missionaries traded divers' masks. A merchant sold dynamite. People returning from the coast brought pesticides. Masks are particularly used in order to catch small armoured catfishes (Loricariidae spp.). Dynamite indiscriminately kills all living organisms in a fairly limited area. Pesticide fishing can cause massive death of fish as well as other organisms over long river stretches. Dynamite fishing became common during this period. Pesticide fishing occurred more occasionally.

In the 1970's a growing demand emerged for the fibres of the leaf bases of the palm *Aphandra natalia*. People exploited wild stands, often felling the palms. Around 1970, the first small plantations of this palm were established, but it would take fifteen years until they could be harvested.

5.2.6. Struggling for land rights and autonomy (1976 - 2003)

5.2.6.1. Regional context (1976 – 2003)

The governmental ideology of colonization of the Amazonía continued during the 1970's and 1980's. As oil was found in the northern Ecuadorian Amazonía, the road network expanded rapidly, not only as roads were built to the oilfields but also because the oil exports finally provided the money that the government needed to make reality out of their old dreams to build penetration roads and colonize the Amazon (e.g., Wunder 1997). The colonization accelerated at an unprecedented pace. In the province of Pastaza, there was rapid colonization of the area surrounding the provincial capital Puyo, and along the roads leading north and south from Puyo (Whitten, 1989; McDonald, 1989), but still most of the province remained unaffected by colonization.

The Ecuadorian Institute for Agrarian Reform and Colonization, IERAC, proposed that the southern side of the Bobonaza River would be given to colonists, while the northern side would remain for the indigenous people. Some mestizos with a background as rubber traders still lived in Sarayaku and held considerable power, and they supported the idea. However, the indigenous people rightfully felt threatened, and this time they reacted in a more concerted way than ever. Whereas some of the children of the ex-rubber traders also were supportive of opening up Sarayaku for colonization, some of their grandchildren put up opposition, as they identified themselves more with the indigenous people of Sarayaku than with their respective mestizo grandfathers. The *teniente político*, now a Sarayaku native, also refused to sign his agreement to the colonization.

The teniente politico also got in touch with a Sarayaku youngster who was studying at secondary school in town. This youngster had during his studies made contacts with other indigenous groups in the Ecuadorian Amazon that had long had their own organizations (see Corry, 1985). Among them were the Shuar, previously known as Jívaros, in Sarayaku mostly known for their many attacks against Sarayaku in the 19th century. He arranged for a representative of the Shuar Federation to come to Sarayaku to talk about the process of organization among Amazonian indigenous people. The Sarayaku people who were used to consider the Shuar as head-shrinking savage enemies were first unwilling to listen, but gradually they accepted the new ideas.

The ideology of the Dominican mission during this time was to transfer community responsibilities to the Indians, giving them the "necessary preparation to assume their responsibilities". In line with this ideology, it was also working for the formation of a federation of the Kichwa people of Pastaza, the incorporation of the indigenous communities in the governmental structures of the country by registering them as "communes", and for granting of legal titles to their lands (OD 1977:383, p. 10). However, the Dominicans were not prepared for the indigenous people themselves organizing independently of the Mission, and with a more radical political agenda. Therefore, the first attempts by the indigenous people to create representative organizations met firm resistance from the Dominican Mission (SE).

In 1976 the Sarayaku people formed their first community organization, "Centro Alama Sarayaku", which got officially registered in 1978. Although primarily formed in order to cope with the external threat of colonization, the organization was also a forum for regulating internal affairs and resolving internal disputes. It also actively struggled in order to provide opportunities for education for the younger generation, and in order to raise the public awareness in general regarding the situation of Sarayaku in relation to national society. In 1977, Sarayaku took the initiative to found the Federation of Indigenous Communities of Pastaza (FECIP), which later changed name to OPIP. In the 1980's it became customary that Sarayaku elected a candidate for teniente politico by vote, and that the governor then formally appointed this candidate.

In the 1970's some people moved from Kalikali and Saryaquillu to the Centro in order to put their children in school, but in the 1980's OPIP helped to create schools in each hamlet. Also Chundayaku, previously an area of purinas, became a hamlet with its own school.

In 1980, the different indigenous federations in the Amazon joined to form the Confederation of Indigenous Nationalities of the Ecuadorian Amazon

(CONFENIAE), and then in 1986 with the indigenous people of the highlands and the coast, forming the Confederation of Indigenous Nationalities of Ecuador (CONAIE). Land rights was one of the most important issues for this movement. While the highland Indians struggled for a redistribution of land to the Indians from a small circle of landlords, the Amazonian Indians struggled against the loss of their land to settlers from the highlands and the coastal region (Gerlach, 2003).

Powerful sectors of society considered OPIP as a threat to their interests. The pioneers of the organization had to cope with accusations of being "communists", "thieves", "guerilleros", and the like. Also some segments of the indigenous people struggled *against* the OPIP. Communities that did not demand any substantial change of the status of the indigenous people in the society, could get minor benefits in exchange. Such benefits could be limited land titles or funding for community development and infrastructure. Some individuals also managed to gain considerable power in their respective communities, and make significant personal profit, by acting as intermediaries between the community and economically strong external actors.

An important role was played by North American Protestant missionaries who, according to cold war logics, were not happy with the indigenous peoples organizing themselves in what they considered a "communist" fashion. Intentionally or not, they were also undermining the emerging democratic local political-administrative structures by creating other platforms of power. In Sarayaku, they handpicked a young man, who had resigned from his position as vice president of the young community organization, in order to make him a pastor. They provided him free airflights to town and free housing right beside the airstrip. As he could decide whom to give a seat in the airplane to town and whom not, he started to become a powerful person. The Sarayaku elders also tell that he spread false rumours that created discord in the community and threatened to destroy the still fragile organization. Therefore, he got expelled from Sarayaku in 1983. This, however, lead to a community fission, as his closest relatives followed him and founded a new community, called Jatun Molino, 20 km downriver from the Sarayaku village, where some of them had their *purinas*, forming an enclave within Sarayaku territory. Soon afterwards the pastor himself moved to town where he became a leading person in the newly formed AIEPRA, an organization of Protestant indigenous communities in Pastaza. Several of the member communities of AIEPRA had been formed by similar community splits. Others were remote, or recently founded, communities, where the catholics had not yet established a firm foothold, so that the Protestants could operate without competition. AIEPRA, and its communities, often opposed the policy of OPIP. The Jatun Molino community, for example applied for, and was granted, a communal land title to a small area of land surrounding the community. This procedure was contrary to the policy of OPIP, who feared that the granting of such small communal land titles would serve to justify colonization of the large interstitial areas that would remain, a process that could be observed further south in the lands of the Shuar people (Rudel & Horowitz, 1996).

In 1987 the oil company ARCO received a concession that included the northern part of Sarayaku territory. This time, the Sarayaku people had become aware of the environmental and social consequences of oil exploitation in the northern Ecuadorian Amazon and, together with OPIP, they firmly opposed the oil activities. When ARCO seismic crews entered Sarayaku territory, the people responded by confronting them in the forest and expelling them. When functionaries of ARCO and the government, without previous notice, entered the community in order to negotiate, the Sarayaku people made them stay for several days in order to treat the issues at stake exhaustively. After several days of discussions, a treaty was signed, implying that the government committed itself to immediately legalize all the indigenous territories of Pastaza province, and pay indemnity to Sarayaku for the damages caused by the seismic explorations[20]. In exchange, Sarayaku would allow the sesimic exploration activities to resume. Soon afterwards, however, the government publicly disowned the treaty, claiming that it had been signed under coercion.

ARCO did not complete the seismic works in territory controlled by Sarayaku. However, by this time the community of Muritikucha had come under the influence of Protestant missionaries, and belonged to AIEPRA. The community therefore was in opposition to the OPIP and happily received the ARCO company which provided them some labour opportunities and gifts. The two communities, which used to maintain friendly relations, then entered into a bitter conflict. ARCO managed to finalize the seismic exploration in an area disputed by the two communities. The government granted a communal land title to Muritikucha that reached far into the hunting grounds of the Sarayaku people. In this area, ARCO then drilled an exploratory well, backed by military guards (SE, see also Mendez et al., 1998).

When twelve years struggle to achieve communal land titles through the regular bureaucratic procedures almost completely had failed, OPIP changed strategy. In 1990, OPIP proposed the creation of one autonomous territory for each one of the indigenous “nationalities” Kichwa, Shiwiar, and Achuar, of Pastaza province. The proposal met firm rejection from the Ecuadorian power elite, who argued that the proposal implied creating a “state within another state”, and military intelligence service classified OPIP as subversives.

Two years later, however, OPIP staged a footmarch to Quito in order to put force behind the demand. The march got extensive media coverage and resulted in a partial victory, in spite of opposition from AIPEPRA, including a countermanifestation in Quito the day before the arrival of the OPIP marchers. The government granted land titles to part of the area, leaving aside a 40 kilometre “security zone” along the Peruvian border, and another large piece of land, north of the Curaray river (see Fig. 2.2) that became declared as a national park. Together with previously titled communal lands, these land titles amounted to about 58% of the land that OPIP had claimed. The land titles were also arbitrarily divided into nineteen “blocks”. The limits between these blocks did not coincide with the limits already in use based on tradition or mutual agreements, and neither did they reflect prevailing land use patterns. This later became a source of conflict between

[20] Copy of the treaty, in possession of the author

communities. The government disregarded the demand for political autonomy, and it also maintained the right to exploit subterranean resources (SE, Sawyer, 1997).

In 1992, Centro Alama Sarayaku changed name to Tayac Yuyaita Jatachic Sarayaku Runaguna Tandanacui (TAYJA-SARUTA), meaning "The Organization of the Indigenous People of Sarayaku for the Revival of the Ideology of the Tayaks". The board changed its name to "Government Council", reflecting that its role was increasingly becoming that of a local government. The role of the *teniente politico* had already diminished and was limited to helping to solve internal conflicts. The president of TAYJA-SARUTA now was the real authority, recognized by the Sarayaku people themselves, and to a large degree by the state as well (see Sabin, 1998). In 1996, the indigenous movement participated actively in national elections for the first time, through the movement "Pachakutik", and has since then had considerable political representation in the national parliament as well as at provincial and local level in the highlands and the Amazon. Among the victories for the indigenous peoples' movement was the adoption of a new Political Constitution of Ecuador in 1998, where the rights of the indigenous peoples are considerably strengthened (Gerlach, 2003).

In 1996, the Argentine oil company CGC was granted a concession for oil exploration, called "Block 23", of which about half is within the territory of Sarayaku. During several years the company tried to overcome the resistance posed by the communities by bribing community leaders, offering money to the communities, and slandering community leaders whose collaboration could not be bought. CGC managed to get access to several communities this way, but Sarayaku maintained its resistance. In 2002 CGC initiated seismic operations in spite of Sarayaku's resistance, but the Sarayaku people physically impeded the seismic operations within their territory. The situation has led to severe conflicts between and within communities (see Chapter 13).

Several times, Sarayaku considered to abolish the teniente politico institution altogether, considering it to be an anachronical remnant of centralized power structures. But, because of the salary provided to a community member, and in order to have a contact link to the government, the community always ended up deciding to accept the continued presence of the teniente político institution. In 2000, however, the governor did not heed the custom of appointing as teniente político the candidate proposed by the community, and instead handpicked a person that the Sarayaku people considered a pawn of the oil company CGC. Sarayaku refused to receive the new teniente político, and closed the office, located in a building owned by the community.

From the beginning of the 1990's, the dangers and opportunities of tourism have been heatedly debated in the community. After several years of reluctance, the community finally decided in 1998 to embark on a tourism programme. Big hopes were put on tourism as an income source that would be under the control of the community itself and not damage the environment. Tourism does indeed bring some income to the community. However, fears that hordes of tourists would create social impacts were soon replaced by the insight that it is difficult to attract enough tourists to significantly improve the economy of the community.

According to the retrospective mapping exercises, there were 106 households in Sarayaku around 1980 and in year 2000 this figure had increased to 147, to which should be added the fifteen households of the outbreak community of Jatun Molino. Official censuses during the period are of limited value because the geographical units censused do not correspond to the limits of the Sarayaku community, and the censuses also most probably suffer from severe errors in procedures. In connection with the 2001 pre-census and census, however, I had the opportunity to review the data sheets before they were sent in for central processing. The pre-census showed that Sarayaku had 961 inhabitants. The census itself, however, gave a figure of only 776 inhabitants, partly because of negligence of the people working in the census, partly because many inhabitants happened to be visiting town at the day of the census.

5.2.6.2. Natural resource use in Sarayaku (1976 – 2003)

During this period, land for farming got scarcer around the village, and consequently fallow periods became shorter (SE, see also Chapter 8). People started to clear steep slopes and stony soils. The community decided that secondary forests belong to the people that first cleared it, and must not be cleared by others without the permission of the owner. This had long been the custom in the Centro Sarayaku and Shiwakucha hamlets, but now it became a rule in the whole community. In 1984, about half of the households in Sarayaku cleared forest and sowed pasture, funded by loans from the Fund for Development of Marginal Rural Areas (FODERUMA). However, cattle raising did not turn out to be very profitable, and by 1998, most of the pasture had returned to fallow. This failure was largely due to the high transport costs. However, also in indigenous communities with road access, cattle raising has diminished, perhaps because cattle raising does not fit well into the Amazonian Indian cultures (Rudel et al., 2002).

Wild game populations continued to decline. Festival hunters had to travel further and further away in order to hunt wooly monkeys. In the mid 1990's a trail was made all the way to Wiuyaku (see Fig. 2.3), which up to then had been perhaps the only remaining part of the Sarayaku territory where there were no hunting trails. Soon it became a custom for festival hunters to go there almost every year. In 2002, the community decided to celebrate the festival every two years instead of every year, in order to ease the pressure on the resource base.

Lately, a demand for wild meat emerged in the indigenous communities near the towns of Puyo and Tena. These communities had already lost much of their land to colonists and have themselves converted much of their remaining land to pasture as they have become integrated in the cash economy. At the same time, they experience a resurgence of ethnic pride, and wish to celebrate community feasts and weddings in the "traditional" way with lots of wild meat, although they do not have enough hunting territory to supply for this new demand. A few times, inhabitants of Sarayaku have been paid, in money or in ammunition, by relatives living near Puyo or Tena, to hunt for their feasts. This, however, has caused criticism and in 2001 the community finally decided to prohibit the export of wild meat. Soon after the decision, the government council learned about two cases of people who were going to provide meat from Sarayaku for such events. In the first case, it was too late to stop it. In the second case, the government council stopped it beforehand, by approaching the person in charge, explaining why it was not allowed to hunt for "export" from the community. In 2003, the Chundayaku hamlet established a wildlife reserve, with international funding (see Chapter 13).

The catch of large fish, particularly large catfish, has decreased during the last few decades. Given that these species are migratory, the causes of this decrease cannot be attributed to the harvest by the Sarayaku community alone. Instead, the cause is probably an increase in fishing all along the migratory routes of the fish, which includes the Peruvian part of the Pastaza river. The increased commercial fishing further downriver (e.g. Bailey & Petrere, 1989; Ruffino & Barthem, 1996) may have been one important cause of the decline. On the other hand, the abundance of small fish has changed little. In 2001, when the Sarayaku people fished the Bobonaza river with barbasco, they actually caught *bulukiki* (*Pimelodus* spp.) in amounts never before witnessed. Lately, people who fish with dynamite receive much criticism from other people because of the destructive effects of this fishing method, and therefore dynamite fishing has diminished. Fishing with pesticides causes outrage, and has therefore basically ceased, although there have been a couple of cases of a creek suddenly becoming void of fish, shrimps and snails, which has led to suspicions that somebody had fished with pesticides. People of Muritikucha are also reported to have repeatedly fished the Landayaku River (see Fig. 2.3) with pesticides during the last couple of years, almost exterminating the fish downstream in Sarayaku territory. Because of old conflicts, related to the Muritikucha taking sides with the Protestant missionaries and the oil company ARCO, against OPIP and Sarayaku, there is little contact between the two communities, and it is therefore difficult to solve this problem.

5.3. Demographic change: A synthesis

Assessing the demographic changes over time in the study area is difficult for several reasons:

- Demographic data is scarce, particularly for older periods.
- The geographical area for which population numbers are given varies between the different population estimates, is not always well defined, and often differs from the area of this study.
- The data quality is either unknown or known to be poor.
- Frequent movements in and out of the study area make it difficult to define whom to count as a resident and whom not.

During the few years preceding this study a number of censuses had been made, or at least initiated, on the initiative of various governmental or non-governmental institutions, as well as individuals, unaware of the previous efforts of the others (Fig. 5.1). This had created a "census fatigue" in the community. In addition, an official census was to be made in 2001, and given all this it was not appropriate for me to conduct another separate census. In spite of all these difficulties, I will here attempt to summarize the demographic changes of the Sarayaku area during the last five hundred years, and particularly during the 20th century.

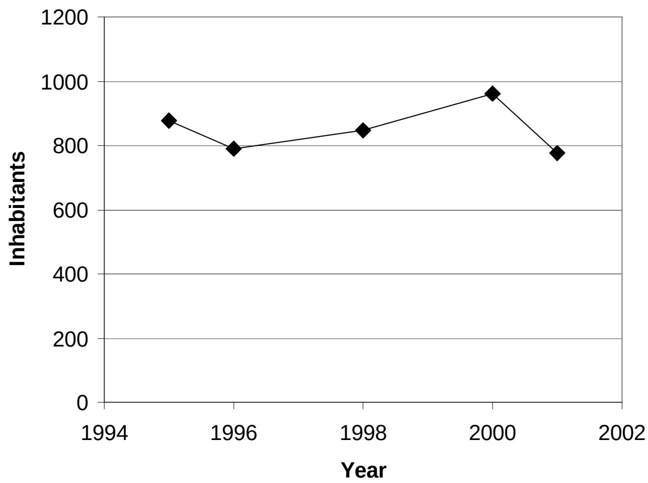

Fig. 5.1. Results of five recent censuses of the Sarayaku population. The apparent changes reflect different procedures, definitions, and levels of accuracy, rather than true changes in population. Sources: IESS health centre in Sarayaku (1995), Sirén, Santi, Santi, Santi & Viteri (1996), Edeli & Colegio Técnico Agropecuario de Sarayaku (1998), Ecuadorian Institute of Surveys and Censuses, INEC, pre-census (2000) and census (2001).

Estimating the population density before contact with European pathogens is particularly problematic (see Thornton et al., 1991). Denevan (1976) estimated these population densities to 0.2 inhabitants/km^2 for lowland forest and between 0.1 and 1.2 inhabitants/km^2 for upland forest (above 600 m a.s.l.). However, the empirical base for these estimates is weak, and they are largely based on extrapolation of data for modern indigenous people. Moreover, Sarayaku is located only slightly under the limit between the lowland and upland as defined for these estimates, so they can only be used as very rough estimates of the population density of the area at the time. On the other hand, Newman (1996) calculates a population density of 0.34 – 0.43 inhabitants/km^2 for a 50400 km^2 area including the present Sarayaku territory. This calculation is, however, based on population estimates from the late 17th century when, according to others (e.g., Denevan, 1976; Dobyns, 1966), the population would already have been decimated by diseases and other impacts. Therefore, the pre-contact population density may alternatively be calculated by projecting backwards in time, using this estimate of population density from the late 17th century in combination with estimates of depopulation rate.

It is not well known how the depopulation rate changed over time. On one hand, increased frequency of contact with Spanish slave-raiders and missionaries, may have led to increased incidence of disease and increased mortality. The gathering of indigenous people in missions, and the movements of indigenous people fleeing from slave-raiders and missions may also have had the same effect. On the other hand, repeated exposure to disease is likely to have led to the development of immunity, and consequently to decreased mortality. It should also be noted that data on recently contacted indigenous people in Brazil indicate that after the initial epidemiological impact, these can breed extraordinarily rapidly, doubling the

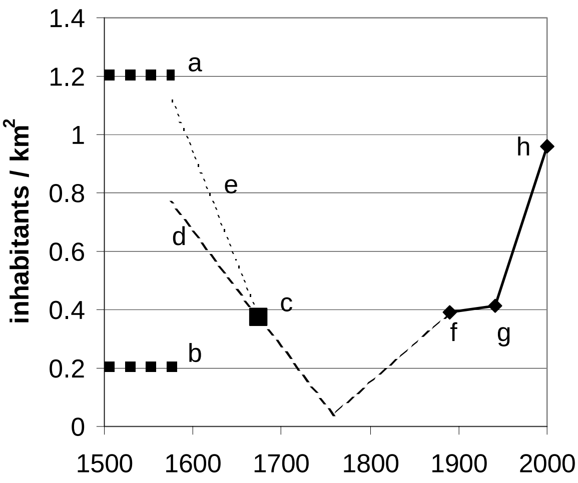

Fig. 5.2. Estimated long-term demographic changes in the study area. (a) Estimate by Denevan (1976) for drier upland forest, (b) Estimate by Denevan (1976) for lowland forest, (c) Estimate of population density in the 1670's based on Newman (1996), (d) Estimate of depopulation based on depopulation ratio suggested by Denevan (1976), (e) Estimate of depopulation based on depopulation ratio suggested by Dobyns (1966), (f) Estimate of population density based on figures provided by Magalli (1890), (g) Estimate based on figures provided by the Dominican mission (OD, 1928-1946, see Fig. 5.3), (h) Pre-census population estimate by the National Institute for Censuses and Surveys, INEC. See text for assumptions and details.

population in as little as fourteen years (Coimbra Jr, 1989, cited by Moran, 1993, pp. 94-95). On the other hand, increased incidence of disease has also led to increased internal warfare, which further has contributed to reducing populations (Cabodevilla, 1996). In any case, two different estimates of pre-contact population density will be presented here, assuming that the population decreased linearly, and based on two different estimates of depopulation rate. First, Dobyns (1966) estimated a depopulation rate of 20:1 from first contact to population nadir. Second, Denevan (1976) estimated a depopulation rate of 3.5:1 during the first 100 years of contact. While the nadir of population density with reasonable accuracy can be located to around 1760 (Taylor, 1986), the time of first contact with European pathogens is unknown, except that it did not occur before 1524, and hardly later than the mid 17th century (see Newman, 1996). However, for the following calculations, we assume that the first demographically significant impact of European pathogens occurred in 1575.

The first estimate, based on Dobyns (1966), then gives an initial population density of 0.8 inhabitants/km^2, and a minimum population of 0.04 inhabitants/km^2 in 1760. This estimate is fairly reasonable in light of the contemporary accounts of a very sparse population in the area (Chantre y Herrera, 1901, p. 132; Pierre, 1983 [1887]; Smith, 1990). The second estimate, on the other hand, based on Denevan (1976), gives an initial population density of 1.1 inhabitants/km^2, but says nothing about the population density at nadir. In sum, there is considerable uncertainty about the pre-contact population density in the area, but these backward projections provide results that are in the range between the estimates provided by Denevan (1976) (Fig. 5.2).

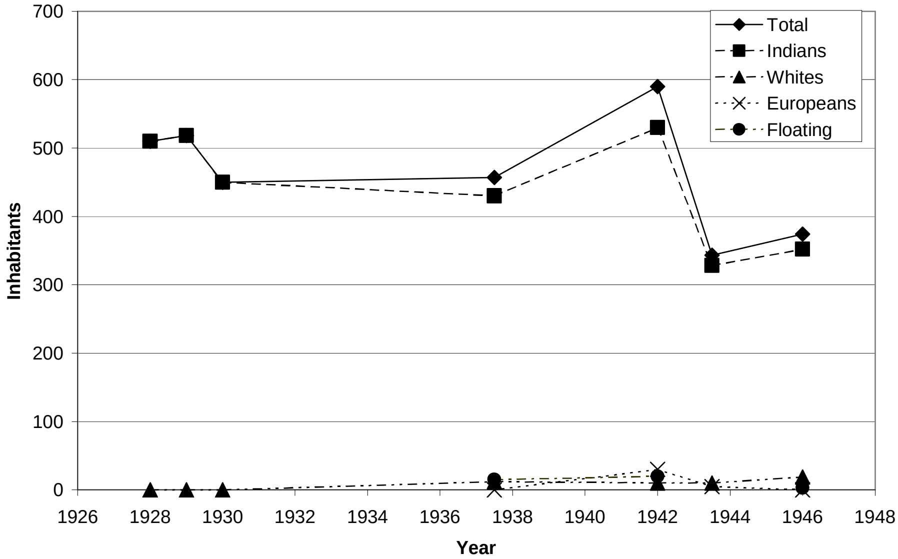

Fig. 5.3. Population figures for Sarayaku provided by the Dominican Mission, for 1928 – 1946. The differences between the years probably mostly reflect differences in the procedures, rather than true population changes. See text for details.

The first relatively reasonable population estimate for the Sarayaku community itself is from 1890 and indicates 460 inhabitants plus some 50 Achuaras and Zaparos living in the surrounding forests (Magalli, 1890, in Vargas, 1976) within the 1300 km^2 area that the Sarayaku people currently claim to be their territory, corresponding to a population density of 0.39 inhabitants/km^2.

Between 1928 and 1946 the Dominican Mission published population data, at irregular intervals, including baptisms, deaths, and population number divided into “Indians” and “whites”, and sometimes also “Europeans” and the spurious category “floating” (Fig. 5.3). In spite of consistently showing a birth surplus (when using number of baptisms as a proxy for number of births), averaging 12 per year, the population figures of these censuses actually show a population decrease from 510 to 374 from the first to the last census. The interviews with Sarayaku elders indicate that there was little emigration during this time, so this decrease is more likely due to errors in the census. Probably, the errors consist of having omitted people in those years that show low figures, rather than of having exaggerated the figures in the years with high figures. The highest figure during the period is 590 inhabitants in 1942. If we exclude the 30 “Europeans” and 20 “Floating”, who hardly were permanently settled in Sarayaku, we remain with 530 “Indians” and 10 “Whites”, totalling 540. This figure is just slightly above the figures indicated for 1928 and 1929, and probably reasonably correct. Again, assuming a territory of 1300 km^2, this gives a population density of 0.41 inhabitants/km^2, just barely higher than in 1890.

Finally, the official pre-census made in 2001 indicated 961 inhabitants of Sarayaku. The census itself indicated only 776 inhabitants. The difference is partly due to many people residing in Sarayaku being in town or somewhere else outside the community on the day of the census, but also reflects neglect on the part of some of the census data collectors, as I could confirm when revising the data sheets before they were sent in for central processing. Again, although other censuses during the preceding years indicate somewhat lower figures (Fig. 5.1.), the highest figure is probably the most accurate one. By this time, several new communities had been founded around Sarayaku, and one community had broken out and formed an enclave in the middle of Sarayaku territory. The area of Sarayaku can therefore be said to have decreased to 1000 km^2, and the corresponding population density is 0.96 km^2. The increase in population density from 1942 to 2001 corresponds to an increase rate of 1.42% per year, or a doubling time of 49 years.

In sum, although all population estimates are highly uncertain, and particularly so before the end of the 19th century, it is clear that the population decreased from the mid 16th century up to the mid 18th century, then increased again, particularly since the 1930's or 1940's (Fig. 5.2).

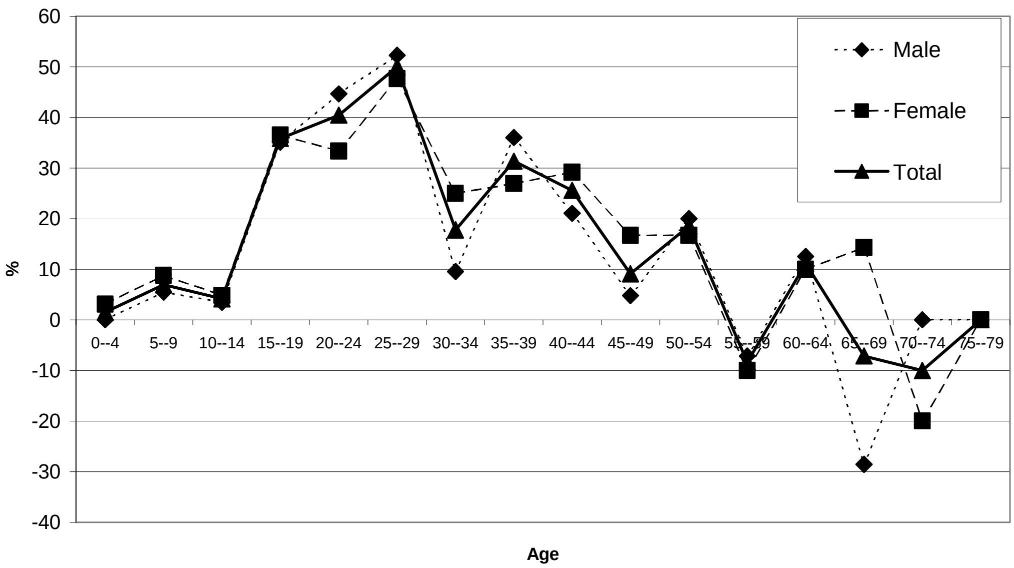

Fig. 5.4. The difference between the number of persons having their origin in Sarayaku and the number of persons currently residing in Sarayaku, according to age category. The formula used for calculating the numbers on the y-axis is: Y = 100(O – R)/R, where Y is the percentage indicated on the y-axis, O is the number of persons having their origin in Sarayaku in each age category, and R is the number of persons currently residing in Sarayaku in each age category. Positive values of Y thus roughly indicate net emigration, and negative values roughly indicate net immigration. However, with increasing age, emigration is increasingly underestimated. See text for further explanation.

Edeli et al. (1998) estimated the birth rate in Sarayaku to 3.8% and the death rate to 1.2%, giving a natural rate of increase of 2.6% per year. Sirén, Santi, Santi, Santi & Viteri (1996, unpublished) attempted to establish rates of immigration and emigration. This failed, as immigration and emigration were found to be very fluid concepts, because many young people travel back and forth in such a way that it makes it impossible to define the number of people emigrating or immigrating during a given period of time. However, the same study managed to record household members who had their origin in Sarayaku, but currently had their residence outside the community, and also those that had their origin somewhere else but resided in Sarayaku. For the young age classes, whose parents were still alive and still reside in Sarayaku, the difference between the number of people who had their origin in Sarayaku, and the number who resided in Sarayaku provided an estimate of the net emigration. This difference increased with age up to the age group 25-29 years where there were twice as many individuals who had their origin in Sarayaku than the number who at the time resided in the community (Fig. 5.4). At higher ages, the proportion decreased. This partly reflects that many emigrants come back to Sarayaku to establish a family, but also that those emigrants who stay away are not recognized anymore as members of any household in Sarayaku when their siblings establish their own families and their parents die. Except for returning emigrants, immigration was negligible, limited to a handful of people who had married Sarayaku natives.

Based on these figures, it can be estimated that 50% of the youngsters of Sarayaku emigrate from the community. Based on experiences from several years of unsystematic observation in the community, I estimate that about half of the emigrants eventually return to Sarayaku. If 25% of the children born in Sarayaku emigrate permanently before they have established a family, the net emigration rate can be estimated as 25% of the birth rate. A crude estimate of net annual population increase is then the birth rate minus death rate minus net emigration rate: 3.8% -1.2% - 0.25 $\times$ 3.8%= 1.65%, corresponding to a doubling time of 42 years. The retrospective mapping made by community members indicates an increase from 83 households in 1960 to 162 households (including the outbreak community Jatun Molino) in 2000. Fitting an exponential function to the data, gives an annual increase rate of 1.67% (Fig. 5.5), almost equal to the estimate based on birth rate, death rate and emigration. Finally, the official censuses from 1974 and onwards were analyzed, in spite of the fact that they most probably contain severe errors. Also, they do not present the data at the level of the Sarayaku community as defined by its inhabitants. Instead, for one part the data is aggregated at the level of the central hamlet of Sarayaku, and for another part at the level of the whole Sarayaku parish, which includes several communities outside Sarayaku proper (Fig. 5.6). Fitting exponential functions to the data, an annual growth rate of 1.63% results for the parish and 1.68% for the central hamlet of Sarayaku. Again, this is almost equal to the previous estimates (Table. 5.1).

There are no signs of any recent decrease in the rate of population growth. On the contrary, it appears that emigration has decreased, as the idea of emigration being the key to success in life is less common among the youngsters than it used to be. A comparison of the population pyramids based on the 1996 census

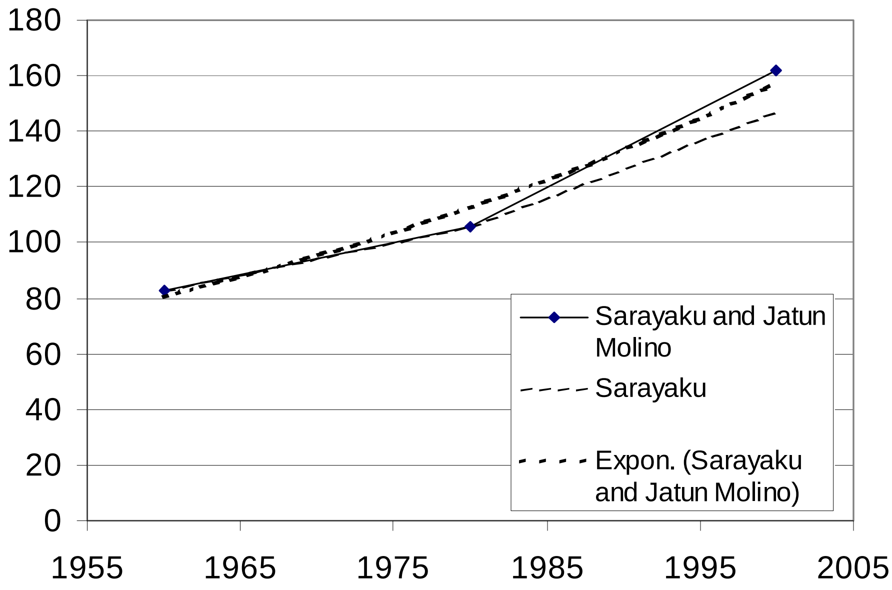

Fig. 5.5. Number of households in Sarayaku according to retrospective mapping. The exponential growth functioned fitted to the data provides an annual growth rate of 1.67% for Sarayaku and Jatun Molino together.

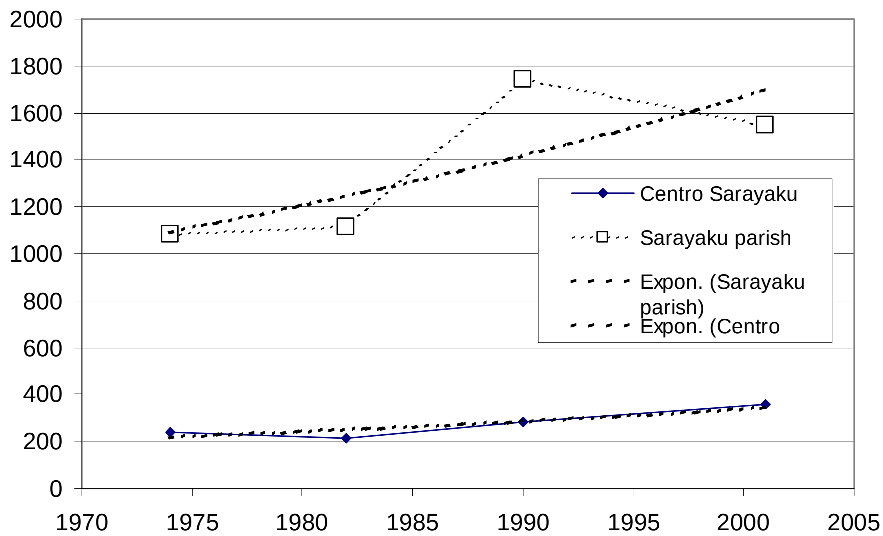

Fig. 5.6. Number of inhabitants according to official censuses. The exponential growth functions fitted to the data provide an annual growth rate of 1.68% for the Centro Sarayaku hamlet, and 1.63% for the whole Sarayaku parish (see Chapter 2.1).

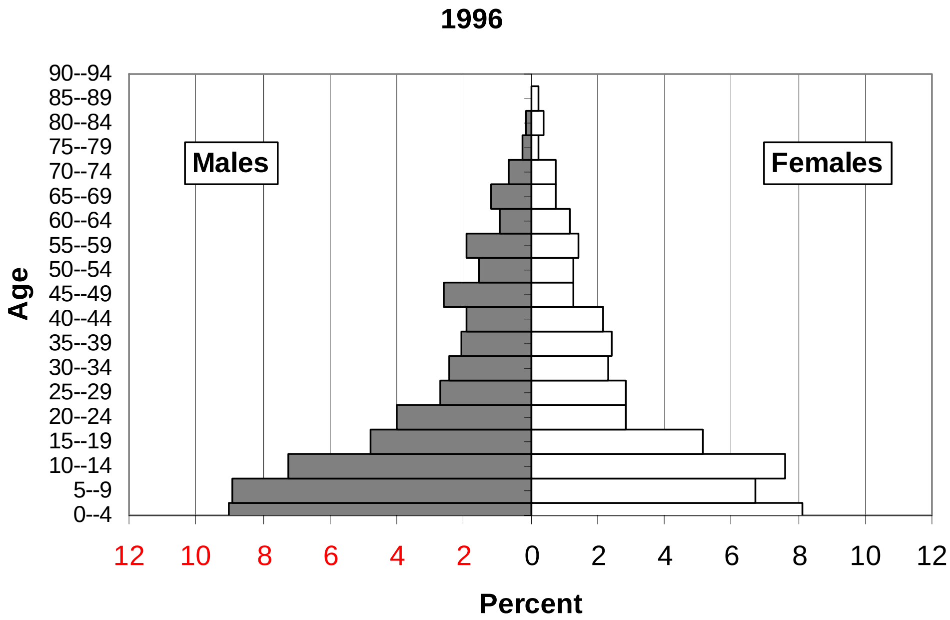

Fig. 5.7. Age pyramid of Sarayaku in 1996

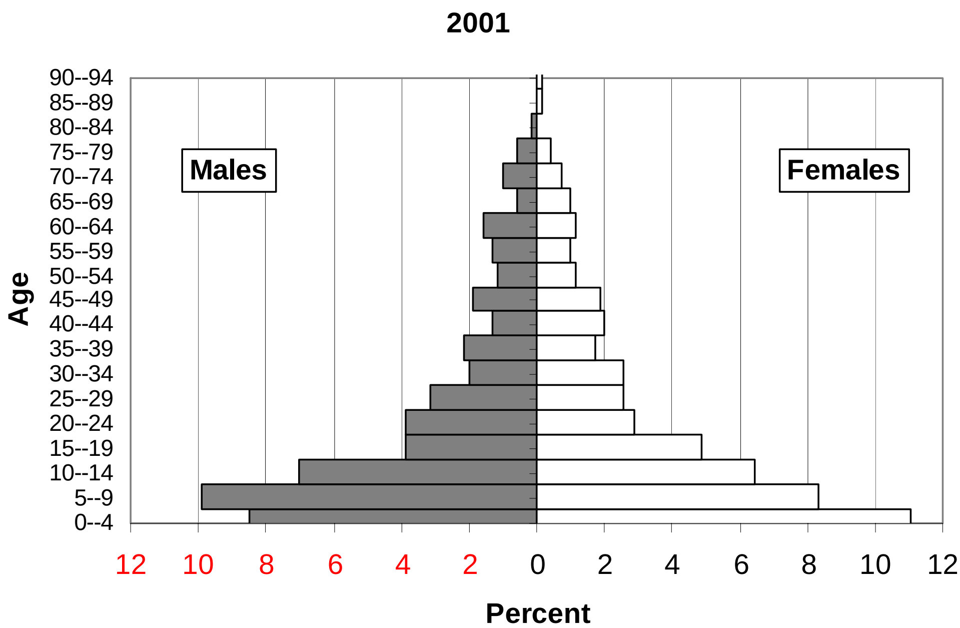

Fig. 5.8. Age pyramid of Sarayaku in 2001. The proportion of children up to nine years of age appears to have increased.

Table. 5.1. Estimates of annual rate of population growth, based on (a) fit of exponential function to population figures provided by Dominican mission and official pre-census in 2001, (b) estimates of rates of birth, death, and migration, (c) fit of exponential function to estimates of numbers of households, made by retrospective mapping, (d) fit of exponential function to official census data for the Sarayaku parish, and (e) fit of exponential function to official census data for the Centro Sarayaku hamlet. See text for details about source data and calculations.

Time period	1942 – 2001[a]	1996 - 1998[b]	1960 - 2000[c]	1974 - 2001[d]	1974 - 2001[e]
% Annual growth	1.42	1.65	1.67	1.63	1.68

(Fig. 5.7) and the 2001 official census (Fig. 5.8) suggests that the proportion of very young children has increased, as can be expected if the youngsters increasingly stay in the community and establish a family instead of emigrating at reaching adulthood.

Current population density seems to be somewhere in a similar magnitude as it was before the European contact and conquest. Birth rate is high, but the high rate of emigration keeps the net population growth down. Nevertheless, if the population continues to grow at the current rate, population density probably soon will become higher than ever before.

5.4. History: Conclusions

The major changes of the human society of the Sarayaku area and its use of natural resources are shown in Table 5.2. The first centuries after contact with European humans and pathogens were characterized by human catastrophe and ecological recovery. Since then, the impact of humans on the ecosystem has increased due to a growing population and ever more efficient technology. Meanwhile, the spatial pattern of resource use has changed, becoming more concentrated to a central area, while remote areas have experienced a decrease in direct human impact. This is particularly true for the impact on the forest cover by agricultural land use (Fig. 5.9, see also Chapter 8), but also for hunting (see Chapter 9).

Technological change has not only enabled the people to exploit existing resources more efficiently and deplete them. It has also enabled them to exploit new resources, some of them with better potential for sustainable use than the previously exploited resources. Particularly, metal tools seem to have facilitated farming on the alluvial plains, which are more productive and need shorter fallow periods than the previously used ridgetops. Shotguns, dogs, and flashlights permit hunting of a wider range of animals than blowguns alone, including highly productive species such as large rodents.

In spite of the general pattern of accelerating depletion of natural resources, there has also been an extraordinary development of the social organization of the community, implying that the prospects for the community to self-organize, in order to manage the natural resources in a coordinated way, have improved considerably. This is reflected in few recent measures taken by the community itself in order to halt the depletion of wild game, and spells hope for the future of the inhabitants of Sarayaku and for the biodiversity in the area.

Table. 5.2. Summary of the major historical changes

	- 1550	**1550-1830**	**1830-1890**
Population density	**?**	Decrease until around 1760	Increase
Settlement pattern	Dispersed	Dispersed	Increasingly nucleated part of the year
Social organization	**?**	Small autonomous groups	Ethnically mixed mission community (“reduction”). Little sense of community
Agricultural technology	Stone and wooden tools	Limited access to metal tools	Increased supply of metal tools. Stone and wooden tools abandoned
Topograhpic location of gardens	Ridgetops	Ridgetops. Towards the end of the period some alluvial plains	Ridgetops and alluvial plains
Type of forest cleared for gardens	**?**	Old-growth forest	Old-growth forest
Hunting technology	**?**	Blowgun? Bow-and-arrow?	Blowgun (and Bow-and-arrow?)
Trend in abundance of game	**?**	Increases as hunting pressure decreases	Increasing difference between central and peripheral areas
Fishing technology	**?**	Bow-and-arrow? Hook-and-line? Barbasco?	Barbasco Spears Nets? Bow-and-arrow? Hook-and-line?
Trend in abundance of fish	**?**	**?**	**?**

1890-1941	1941-1976	1976-2003	
Increase	Increase	Increase	**Population density**
Nucleated part of the year.	Nucleated part of the year.	Nucleated during school terms. Dispersed during vacations	**Settlement pattern**
Ethnic Kichwa community. Weak social cohesion. Missionaries dispute power with military/civil authorities	Increasing social cohesion. Military/civil authorities in power	Strong social cohesion. Consensus-based democracy and self-government	**Social organization**
Further increased supply of metal tools	Further increased supply of metal tools	Further increased supply of metal tools. A few chainsaws	**Agricultural technology**
Ridgetops and alluvial plains	Ridgetops and alluvial plains	Ridgetops, alluvial plains, and steep slopes	**Topograhpic location of gardens**
Old-growth forest	Old fallows or old-growth forest	Mostly fallows, with increasingly shorter rotation periods	**Type of forest cleared for gardens**
Blowgun. Perhaps a few shotguns at some point	Blowgun and shotgun	Shotgun	**Hunting technology**
Decreases. Increasing difference between central and peripheral areas	Decreases. Increasing difference between central and peripheral areas	Decreases. Increasing difference between central and peripheral areas	**Trend in abundance of game**
Barbasco Metal hooks and line Spears Nets	Barbasco, Metal hooks and line, Spears, Nets Introduction of dynamite and pesticides	Barbasco, Metal hooks and line, Spears, Nets. Decline in dynamite and pesticide fishing	**Fishing technology**
?	Slight decrease?	Decrease of large fish	**Trend in abundance of fish**

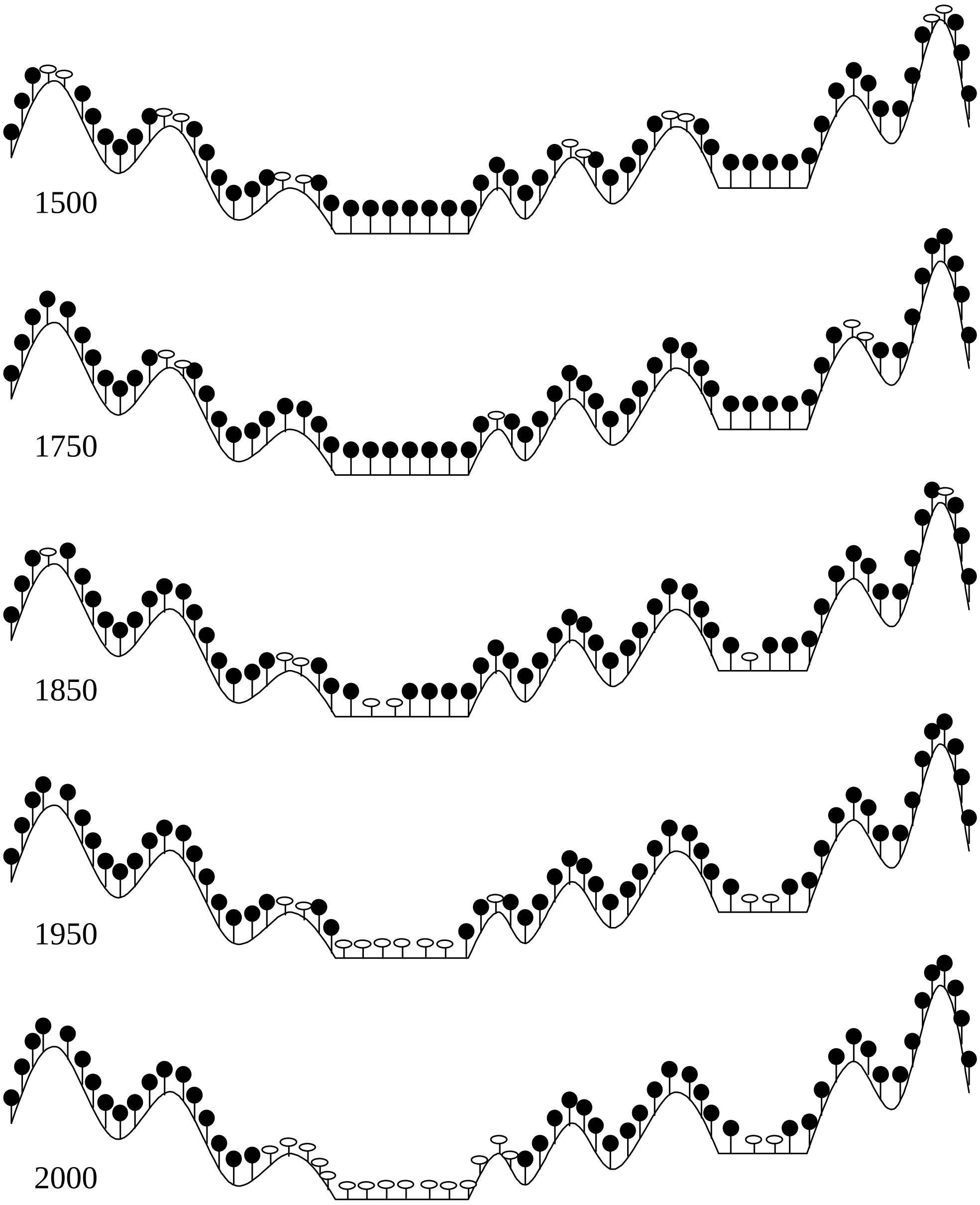

Fig. 5.9. Schematic representation of the changes over time in the spatial pattern of agricultural land use, in a north-south cross-section of the Sarayaku territory. The tall black "trees" represent old-growth forest, while the small white "trees" represent cultivated areas and fallows. The figure is not to scale, and the width of the plains is exaggerated.

Chapter 6: Local perceptions of resource depletion

The purpose of this study was to gain a deeper understanding of the perceptions the local people held about any depletion of natural resources that may be going on in the community, and the relation between such resource depletion and quality of life. This was done through semi-structured group interviews, as described in detail in Chapter 4.2. At the same time, also the local peoples' proposals in order to improve the current situation were discussed and recorded. The boxes and figures in this chapter are based on posters drawn in order to present the results back to the people in a workshop after the completion of the interviews (see Chapter 3 and 4).

6.1. Quality of life and perceived problems

Box 6.1 and Box 6.2 summarize what kind of life and community the Sarayaku people desire. In general, people expressed a desire for a life in peace and harmony, maintaining much of their current ways of living. Although several people expressed a strong desire to improve the economic conditions in the community, many also emphasized that this must not be achieved at the cost of the natural environment. There were some diverging opinions about the blessings and curses of modern infrastructure.

Box 6.1.

What does ”Living well” mean to you?

- **Work and eat!**
- **Make cassava brew and drink!**
- **Live together without getting angry at each other!**
- **Being healthy, not get sick!**
- **Study!**
- **Live without pollution!**
- **Be generous!**
- **Being free, with nobody giving you orders!**
- **Earn money!**

Box 6.2

What do you want Sarayaku to be like 20 years from now?

Uncontested views:

- **Just the way it is**
- **Airstrip and trails in good shape**
- **Good education: Having good secondary school and university, maintaining also our indigenous knowledge**
- **Good health services**
- **Forest and rivers well managed, wild animals nearby**
- **People not getting drunk too much**
- **No conflicts about land**
- **Not becoming like the mestizos**
- **Make money**
- **No petrol company, no pollution**
- **No *colonos* (settlers)**

Conflicting views:

- **New settlements!**
- **No new settlements!**

- **Have concrete houses, office, discotheque, electricity, covered space!**
- **Not become like a city!**
- **Make an ecological city with indigenous architecture!**

- **Get a road!**
- **No road!**
- **Rather a railroad!**

The main problems identified during the interviews are shown in Fig. 6.1. Strong emphasis was put on problems related to food supply, particularly the increasing difficulty of finding game meat. Discussions about diminishing hunting yields dominated the interviews, to such a point that on some occasions we explicitly had to ask people to leave that theme aside, in order to be able to discuss other issues as well. Many people also mentioned increasing difficulty in catching fish, but

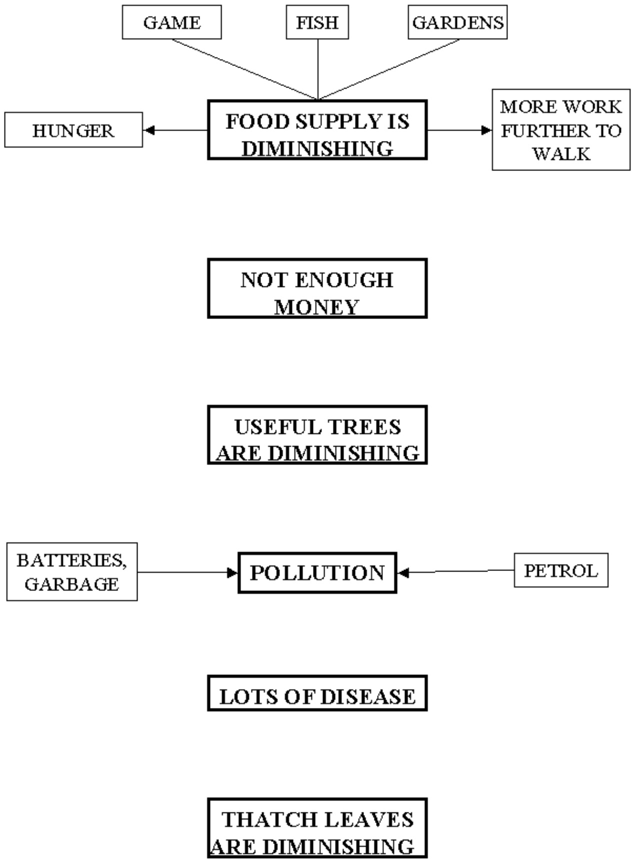

Fig. 6.1. The major problems expressed by the participants in the problem identification interviews.

there was not a consensus about this, as some claimed that the fishery was in almost as good condition as before. Decreasing agricultural productivity was also a problem mentioned by many people. In several interviews, the lack of money was also mentioned as a serious problem.

The other problems that were mentioned were considered as less serious than the ones mentioned above. One such moderate problem was the depletion of useful trees, as they are exploited for making canoes and boards. Another was pollution by batteries and other garbage, and by the oil industry. It should be noted that this problem has the character of a fear of poorly understood effects. There is no organised collection and treatment of garbage in Sarayaku, although there is increasing consumption of industrial goods. Large numbers of batteries are consumed for flashlights and radios, and some people are worried about the effects of all this garbage that is simply thrown away on the ground or in the river. On the other hand, although no oil exploitation is going on in the immediate vicinity of Sarayaku, some people fear that the pollution caused by oil exploitation in other areas already may affect the community, a fear that may not be unsubstantiated (see Chapter 13). Some people also mentioned that there is a lot of disease in the village, and that leaves for thatched roofs are becoming depleted.

6.2. Causal mechanisms and proposed solutions

Figs. 6.2 to 6.4 summarize the causes behind the major problems related to local livelihoods, as identified by the participants in the interviews. The diagrams show all explanations given, without indicating whether there was consensus or disagreement about the different causal explanations given. Most people agreed that the problem of diminishing game in the first place was caused by people killing too many animals (Fig. 6.2). However, many thought that shamans hiding or taking away the animals was a contributing factor, and a few even considered it the main cause. The increase of fallows at the expense of old-growth forest was mentioned as a contributing factor on one occasion.

The proposed solutions are summarised in Box 6.3. As can be seen, there were many proposals on how to solve the problem of too many animals getting killed. Many people thought it would be impossible to reduce hunting without providing an alternative source of food. This could be either domestic animals or domesticated wild animals. However, financial aid was considered necessary in order to be able to make the necessary investments in infrastructure. Also, several people thought that hunting pressure would be eased only when people had money to buy food in the shops. While some people argued that it would be impossible to stop people from hunting, others believed that in the future they would be able to control the harvesting of wildlife.

Within the indigenous peoples' organizations, the establishment of new settlements has often been proposed as a way to more effectively defend the land from encroachers, while also easing the pressure on natural resources around existing settlements. However, some people disagreed with this idea, claiming that the establishment of new settlements would aggravate the problem instead of solving it, as hitherto remote areas would become more accesaible to hunters.

Although many people considered the population increase to be a major factor contributing to game depletion, only one person, a teenage boy, suggested that people should have fewer children in order to solve this problem. Many others considered population increase as inevitable, as one middle-aged man put it, "only if they castrate us we will stop reproducing".

The underlying causes of diminishing fish returns were basically considered to be the same as for diminishing hunting returns. No separate diagram of the causes of fish depletion is shown, as it would look almost identical to the one illustrating game depletion (Fig. 6.2). There were, however, a few minor differences. Just as some people put the blame for game depletion on the use of destructive technology (shotguns), some also put the blame of fish depletion on the use of dynamite and the use of the native ichtiotoxic plant barbasco (*Lonchocarpus nicou*). However, while hunting with firearms is universally adopted and accepted, fishing with dynamite remains highly controversial and is far from the dominant fishing method. Barbasco is considered to cause fish depletion only when used excessively. The role of people from other communities in causing depletion was more emphasized for fish than for game, given that many fish species are migratory.

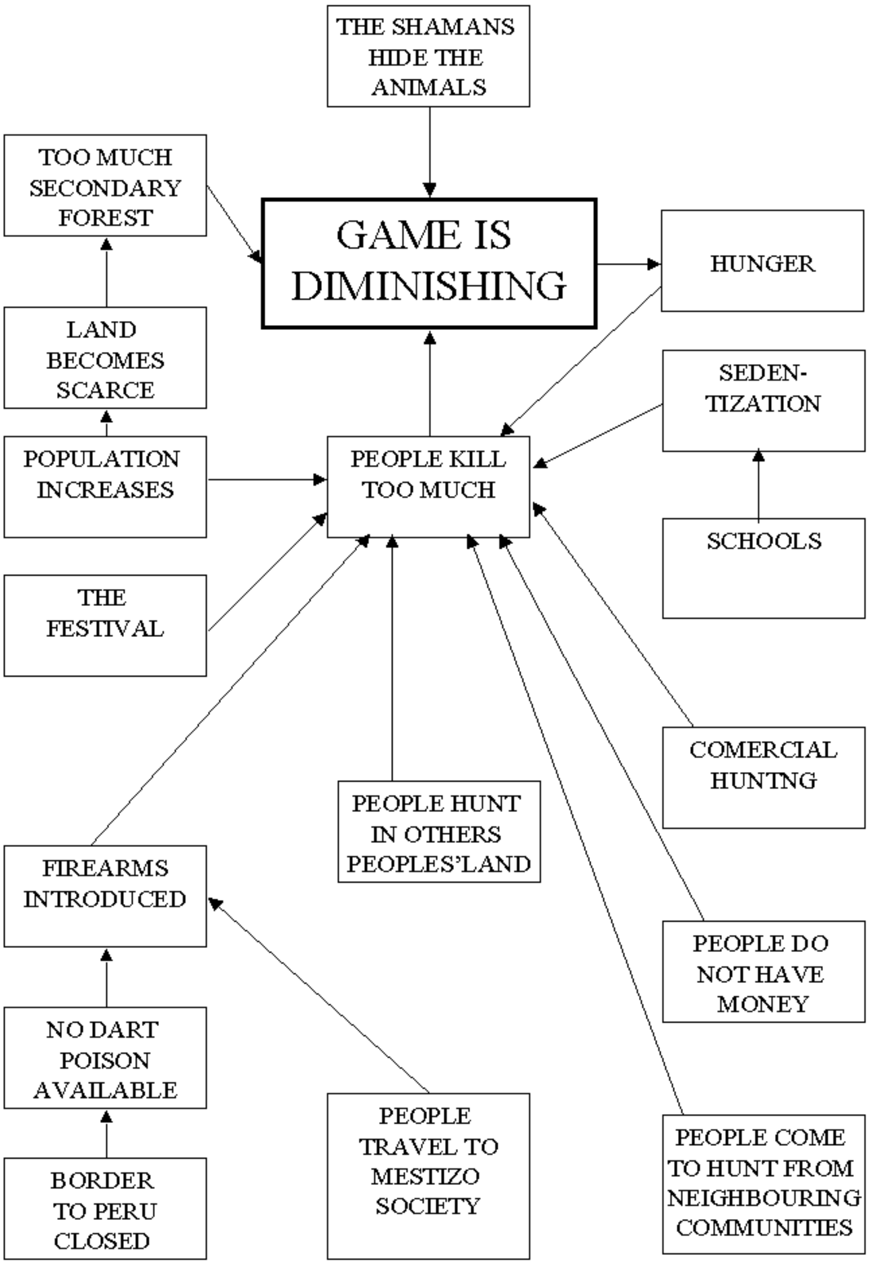

Fig. 6.2. The causes of game depletion, according to the local inhabitants

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Box 6.3.

Wild game: how to solve the problems?

- **Voluntarily refrain from killing too much: When you encounter three "carundzi" (*Penelope jacquacu*), kill only one! Do not kill pregnant animals!**
- **There should be a law establishing how much you may kill! Permit killing maximum one collared peccary per month per person!**
  - Contrasting view: Here things are not like in the "outside world"! Here we are free to do what we want!

- **Reduce the hunting for festivals!**
  - **Quit having festivals altogether!**
  - **Celebrate the festival every 2 –3 years instead of every year!**
    - Contrasting view: The festivals are good, they are part of our culture!

- **We should make money and buy food instead of hunting!**
  - Contrasting view: We must not become like the mestizos!

- **Create a reserve where hunting is prohibited!**

- **Everybody must respect the hunting grounds of others!**
  - ***Contrasting view: It is no good to exclude others, what will happen to those who do not have any own hunting grounds?***

- **Ban firearms!**

- **Make fish ponds, raise pigs, cows, chicken and forest animals! Ask for money in order to finance it!**

- **Establish new settlements in order to ease population pressure!**
  - ***Contrasting view: If we make new settlements in remote areas, there will be no remote areas left!***

- **We should not reproduce too much, have just one or two children!**

- **We should talk with each other among young people (the old people already have their habits and won't change)!**

The suggested causes of decreased agricultural productivity are shown in Fig. 6.3. Generally, pests were considered the immediate cause of these problems, although somebody also mentioned that the "abono" (Spanish for fertilizer, and referring to the substances maintaining soil fertility) was disappearing. Some people also mentioned the disappearance of the elders with supernatural powers (*paju*) related to agriculture.

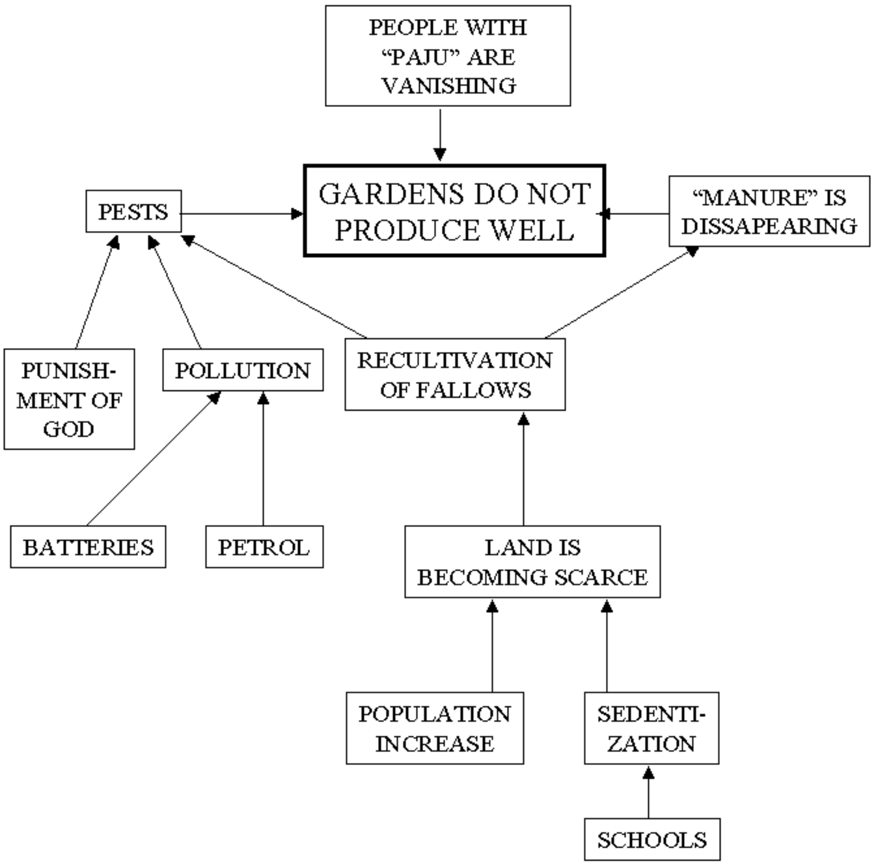


Fig. 6.3. The causes of diminishing agricultural productivity, according to local inhabitants.

Both the increase in pests and the disappearance of "abono" was considered to be influenced by the increased recultivation of fallows. According to the interviewees, in the old days people used to clear only old-growth forest in order to farm, but nowadays they often cultivate a spot that has already been cultivated up to three times before. This was considered to be an effect of the population increase and the sedentarization that, in turn, is due to the fact that everybody nowadays wants their children to go to school. This analysis was, however, not universally accepted, as one woman claimed that the pest problem was the same also in fields made in old-growth forest. Some people also speculated that punishment by God or pollution caused by oil exploitation, or by garbage such as batteries, may contribute to diminishing productivity of the soil.

When it came to proposing solutions to the diminishing agricultural productivity, there were fewer ideas than for game depletion (Box 6.4). A common proposal was to apply pesticides in order to kill the pests. Applying organic matter to each crop plant was also proposed, and there was one suggestion that agriculture should be concentrated to the riverbanks, as the soils there do not get exhausted.

Box 6.4.

Agriculture: how to solve the problems?

- **Apply pesticides!**
  - Contrasting view: We do not want pollution!

- **Apply "abono" (fertilizer, mulch)!**

- **Do not reproduce too much, have just one or two children!**

- **Use the riverbanks for permanent agriculture!**

- **Establish new settlements in order to ease population pressure!**
  - Contrasting view: If we make new settlements in remote areas, there will be no remote areas left!

Shortage of money was also considered a serious problem. The causes suggested are indicated in Fig. 6.4. This indicates that shortage of money results both from integration into national markets ("We need to buy things from mestizo society"), and from the lack of the same integration ("There is no road", "There is no market"). Some pointed out that lack of knowledge is the reason why they are not able to make money. However, in order to acquire knowledge, one needs to attend education, which also involves extra costs. Whereas some blamed the lack of money on the community members themselves for not working enough, others mean that it is the absence of external help that is the cause. At workshops and meetings during the following three years of fieldwork, we revisited these causal mechanisms and the corresponding solutions proposed, and discussed them in light of the research findings (see Chapter 3).

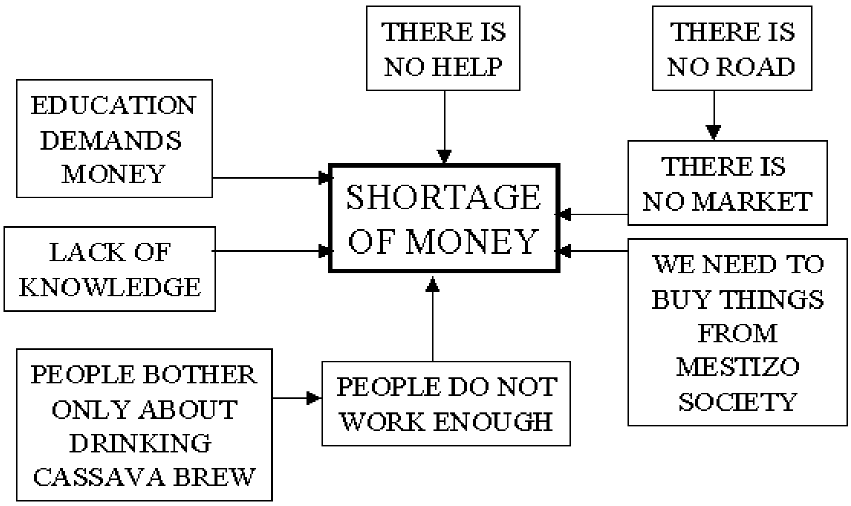


Fig.6.4. The causes of shortage of money, according to local inhabitants.

Chapter 7: Natural resources and local livelihoods

7.1. Economic activities

The economic activities in Sarayaku are mostly aimed towards consumption within the household, and to a smaller degree towards trade or exchange. Within-community exchanges of goods and services formerly mostly took the form of reciprocal giving. Nowadays monetary transactions are becoming more common. The economic activities that take up most of the time of the Sarayaku people are the ones that aim at procuring food, such as agriculture (see Chapter 8), hunting (see Chapter 9) and fishing (see Chapter 10).

Handicrafts, and construction of houses and canoes, are other important activities. The basic type of house consists of an oval thatched roof held up by poles stuck directly into the ground. A middle-sized roof is made up of some 20 000 leaves of either the small palms called *wayuri* and *uksha* (*Genoma* spp.) or *lisan* (*Cyclanthus bipartitus*, Cyclanthaceae). The poles need to be of particularly durable wood, which is heavy to carry and often has to be brought from considerable distances. Many houses also have an elevated floor made of split palm trunks, (mostly *Iriartea deltoidea*) or boards cut with a chainsaw. Some also have rooms separated by walls made of boards or split bamboo (*Bambusa guadua*).

There is a sexual division of labour. Agriculture (see Chapter 8) is mainly a female activity, although there are also particular male tasks, and males frequently "help" their wives or mothers with the female tasks. Hunting (see Chapter 9) is almost exclusively a male activity, and fishing (see Chapter 10) is mostly a male activity. Construction is mostly a male activity, pottery an exclusively female activity, making string bags and hammocks are exclusively male activities, whereas the women are in charge of cooking and making the *asua*, a fermented brew made of cassava.

Most households also have an additional "secondary" home, called *purina*, located at some distance from the main settlement, where they go during school vacations in order to enjoy better hunting and fishing. Some families who have no children in school age spend most of the year in these secondary homes and just occasionally visit the main settlement.

Most agricultural crops are exclusively for local consumption. However, some families plant tobacco (*Nicotiana tabacum*), which is sold to people from other indigenous communities throughout the region, where it is used for medicinal or ritual purposes. A government-sponsored credit programme for cattle raising in the 1980's, failed as transport costs to market made the business unprofitable. Some households, however, still have a couple of cows, a few of them up to about twenty head of cattle. The export of forest products seems to have decreased (see Chapter 5). The most prominent forest product exported from the community is the fibres of the *chili* palm (*Aphandra natalia*). This trade has actually increased in volume, and also the price has increased. Nowadays it is increasingly being cultivated, and may be considered a tree crop as well as a forest product. Handicraft, particularly pottery, is another important export item. The community recently has implemented a tourism programme, which brings in some cash income, but tourists still arrive only very occasionally. Salaries of government employees are one important source of cash. There are about thirty to thirty-five persons, mostly teachers, who receive a regular salary from the government. Of them, about twenty-five are permanent residents and members of Sarayaku, while the others are Kichwas from other communities or mestizos who only spend the school terms in Sarayaku.

Migration is an important economic and demographic factor in Sarayaku. Many young leave the community in order to find salaried work elsewhere. The men commonly work on plantations in coastal Ecuador, whereas the women often work as domestic servants in the Capital, but these are in no way the only types of job. Working in restaurants or shops, on oil company seismic crews, or environmental consultancy companies, as chauffeur, soldier, martial arts instructor, security guard, radio speaker, musician, nurse, artisan, businessman, or tourist guide, are just examples of other occupations people from Sarayaku have had outside their own community. Many of those who live in Puyo send small remittances, such as bread, rice, soap, etc. to their families in Sarayaku who, in turn, send locally produced foods to their kinfolks in town (see Edeli et al., 1998). Some who have migrated further away have even sent outboard motors to their families back home. Some of the migrants return after just a brief period, others return to settle in Sarayaku only after several years, still others emigrate forever.

Sometimes also adult married men leave their families behind for several months in order to supplement the household economy with a cash income. Many go to one particular estate near Santo Domingo in coastal Ecuador that has established a special relationship with Sarayaku, always receiving Sarayaku people who arrive there in search for a temporary job, and also employing many Sarayaku emigrants who have lived and worked there for years or decades. Just as the Sarayaku people earn much of their money outside the community, they also spend much of it outside the community, particularly in the town of Puyo where they buy clothes, salt, soap, kitchen tools, and tools used for agriculture, hunting, and fishing (Edeli et al., 1998).

The aim of this part of the thesis was to assess the importance of different types of natural resources in the local economy, and the impact of natural resource depletion on the socio-economic situation of the people in general, but particularly in terms of their nutritional status. For this purpose, two complementary approaches were used. First, the flows of food and money into and out from the households were approximately quantified by means of a limited survey of thirteen households. Second, anthropometric measurements were made, in order to use them as an indicator of nutritional status and general socio-economic conditions, as further explained below. The methods used are described in greater detail in Chapter 4.

7.2. Household livelihood study

In five of the thirteen households, there was one member who had a regular salary from the government, ranging from 40 to 130 US dollars monthly, and there was one household where one person frequently worked for the present research project as a “hamlet assistant” (see Chapter 3), and during the week of the survey charged 21 dollars for his work the preceding month. Apart from these income sources, the only monetary income recorded was at most a couple of dollars gained through selling plantains, renting a motorboat, or by winning a game of soccer or volleyball. Monetary expenditures were limited to $0.75 per household per day. Out of this, 75% was spent on imported industrial goods, and 25% on locally produced goods and services.

Most households possessed one or a few dogs, and some poultry (Table. 7.1). Given that it takes about eight months for a chicken to grow to a weight of about five pounds (2.3 kg), when it is consumed, the average holding of 12 chicken per household provides just one and a half chicken per month per household, equivalent to less than 1g of protein per capita per day. The production of eggs is of about the same magnitude, so the total contribution of poultry to the overall food consumption is small. Also, the feed given to domestic animals (cassava, maize, and household wastes) must, in most cases, be a minor fraction of the total consumption by the household. Only one of the households possessed cattle, and none of them possessed pigs.

By weight, cassava and plantains are the dominating food items (Table. 7.2, Fig. 7.1). Other crops, (see Chapter 8), constitute a minor proportion of the total production. Some domestic fruits were procured, but wild fruit was absent in the sample. The amount of fish brought to the home exceeded the amount of wild meat by a factor 2.6. Almost all food was locally produced, and imported food items such as rice, sugar, canned tuna fish, oil, and lard, represented a negligible portion of the total weight of food. In order to cross check the accuracy of the figures for wild game, we made a comparison with the data from the hunting study. The two estimates of the amount of wild game procured per household and day were almost equal: 728 g/household/day for the household livelihood study, and 698 g/household/day for the hunting study (see Chapter 9).

Most of the locally produced food items were consumed within the household, but there is also some exchange between households, particularly of wild meat and plantains (Fig. 7.2). These numbers, although only rough estimates, are in accordance with qualitative observations made during fieldwork. The data on the categories “fruit” and “other non-root crops” is very limited, but indicates that a substantial portion of these products is exchanged between households. Most exchange is in the form of gifts, whereas a smaller proportion is sold and bought.

In terms of nutrients, the foodstuffs brought in to the homes provide about 3120 kcal, 68 g protein and 25g fat per person and day (calculated for all household members, regardless of age). In terms of the contribution of energy from different classes of nutrients, carbohydrates provide 84%, proteins 9%, and lipids 7%.

Table. 7.1. Number of domestic animals held by the households in the study.

Household	A	B	C	D	E	F	G	H	I	J	K	L	M	households possessing	% households possessing	mean number possessed (possessing hh)	mean number possessed (all hh)	Median number possessed (all hh)
Household size	3	5	8	5	7	9	9	9	13	10	7	6	6					
Dogs	1	1	2	0	1	1	0	1	0	3	1	1	0	9	69	1.3	0.9	1
Poultry	0	5	0	2	8	12	15	12	32	64	7	13	16	11	85	16.9	14.3	12
Cattle	0	0	2	0	0	0	0	0	0	0	0	0	0	1	8	2.0	0.2	0
Pigs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0
Other pets	0	0	0	0	0	0	0	1	0	0	5	0	0	2	15	3.0	0.5	0

Table. 7.2. Amount of food procured per person per day in each household (g/person/day).

Household	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**Average**
Cassava	656	739	900	3223	2529	1681	1639	865	1310	1732	556	4616	1167	1552
Plantains, bananas	1627	1077	349	1392	371	1555	378	0	790	156	1130	1059	1005	724
Fish	252	0	497	2845	74	50	25	288	61	136	0	0	76	249
Wild meat	0	0	0	0	0	0	33	184	135	383	83	105	25	95
Fruits	0	0	0	0	371	0	168	0	135	45	93	30	22	78
Other root crops	0	259	45	318	0	0	84	0	109	52	0	0	205	75
Other non-root crops	0	65	0	0	0	0	25	0	2	65	0	0	65	17
Imported vegetal food	0	0	0	0	0	20	8	0	9	23	79	0	0	12
Imported animal food	0	0	3	0	0	0	0	0	4	0	0	0	0	1
Total	2535	2140	1793	7779	3345	3307	2362	1337	2555	2591	1941	5810	2565	

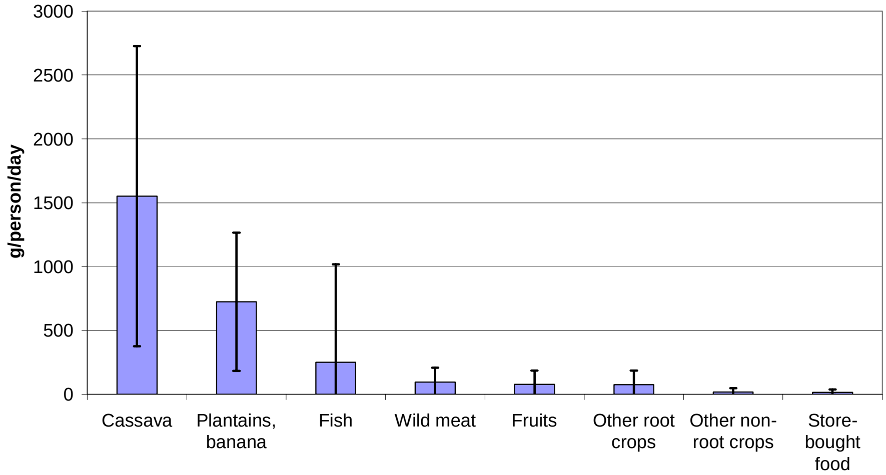


Fig. 7.1. Crude weight of different types of food products brought into the home per person and day. Error bars indicate one standard deviation based on the per capita values for each household.

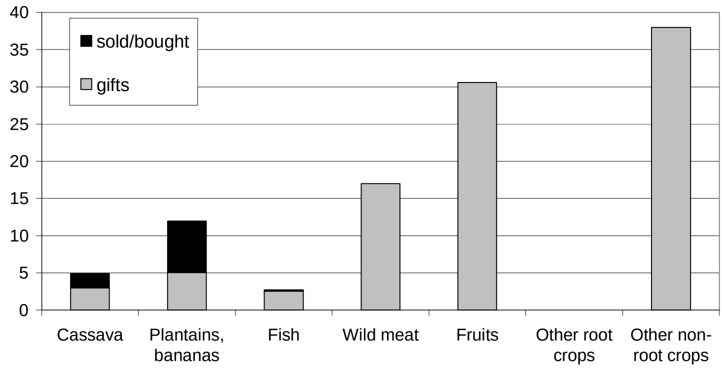


Fig. 7.2. Percent of production exchanged between households. Note that the values for “fruits”, “other root crops”, and “other non-root crops” are based on very small samples.

The staple crops cassava and plantains have a high content of carbohydrates, but very low content of protein and fat (Fig. 7.3). Cassava and plantains provide over 80% of the total energy (Fig. 7.4). Wild meat and fish, on the other hand, provide two-thirds of the protein and three-fourths of the fat. Most fat comes from fish, whereas the contribution of fat from wild meat appears to be relatively moderate, even smaller than the contribution from store-bought foods. It may be noted that whereas the contribution of imported foods in terms of protein and total energy is negligible, they actually provide a tenth of the total amount of lipids. The small amount of money that is used for buying imported food thus actually makes a quite significant contribution to improving the nutritional balance of the diet. It should be noted however, that whereas only about 18% of the households in the community have a member who earns a regular salary, the corresponding figure for the households participating in this study was 38%, so the reliance on store-bought food is probably larger in the sample than in the community as a whole.

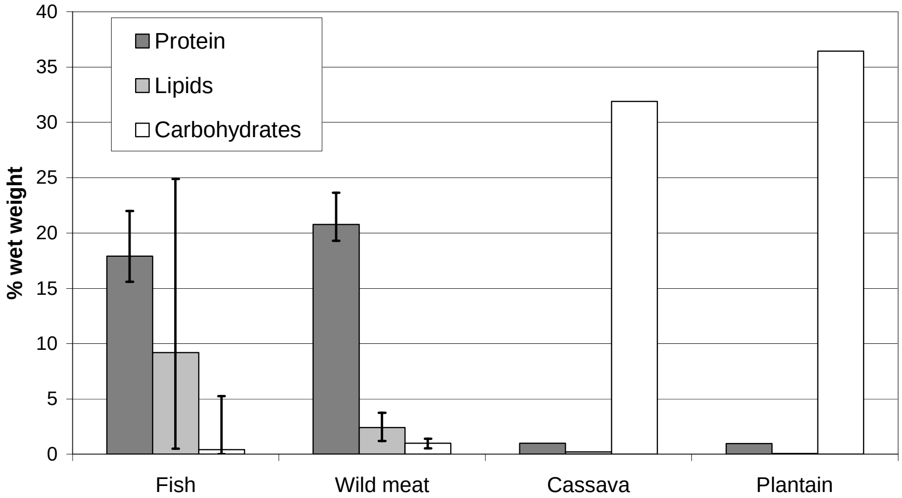


Fig. 7.3. Nutrient content of fish, wild meat, cassava and plantains, expressed as percent wet weight. Error bars show maximum and minimum values of the figures from the literature used for calculating average values of nutrient content of fish and wild meat. See Chapter 4.3.1 for details.

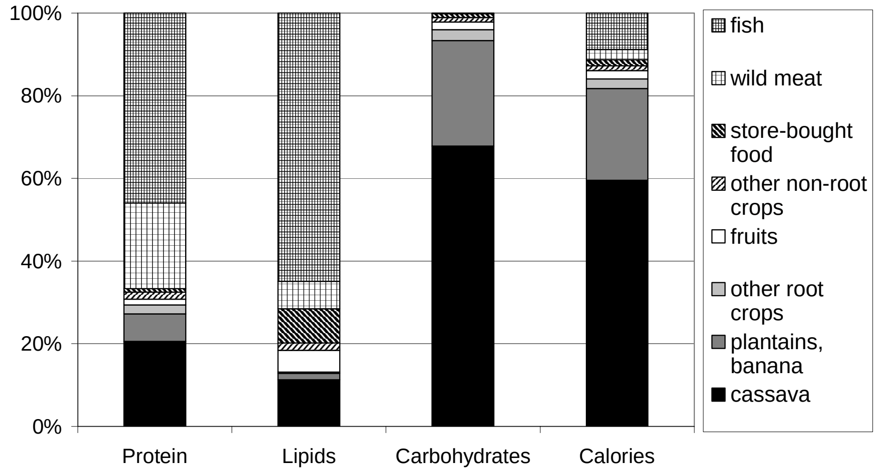


Fig. 7.4. Relative contribution of different types of food to the total amount of nutrients in the food brought into the home.

These results should be interpreted only as indicative approximations, because the sample is small and non-random, and may be affected by seasonal bias. Moreover, yields of hunting and fishing vary greatly over time. Half of the recorded amount of fish actually came from one single event of barbasco fishing (see Chapter 10). This single event represents a fourth of the protein and a third of the fat indicated in Fig. 7.4. However, such large catches of fish are in no way exceptional. On the contrary, they are even more common from August to January, when the fish arrive from downriver. It should also be noted that the figures for imported food represent only four purchases, of vegetable oil, lard, sugar, and canned tuna, respectively.

7.2. Using anthropometric measurements as nutritional and socio-economic indicators

Anthropometry is a series of standardized techniques to measure the body and its parts. It is a practical field method to assess nutritional status on community level. Nutritional status depends not only on food intake, but also on other factors such as disease and parasite infestation. As all these factors depend on general socio-economic conditions, anthropometric measurements may also be considered a general socio-economic indicator (Siqueira, 1997). In anthropometric studies of indigenous Amazonian peoples, the weight-for-height of adults usually indicates good nutritional status. However, height-for-age of children suggests that *stunting* (see Chapter 4.3.2) is common, and consequently, also adults are short. Only in a few groups was a high prevalence of thinness, or *wasting* (see Chapter 4.3.2) found among children (Dufour, 1992). Whereas the short stature of Amazonian indigenous people usually is considered an effect of nutritional stress in combination with disease (e.g., Dufour, 1994), some authors have pointed out that short stature may be a genetic adaptation to the tropical rainforest environment, and that high food intake leading to tall stature is not necessarily always healthy (Stinson, 1990; Holmes, 1995).

Therefore, simple comparison with a population with practically unlimited access to food, such as the commonly used reference population (Frisancho, 1990, see Chapter 4.3.2), may be only partly relevant in order to understand the factors affecting the nutritional status and well-being of Amazonian indigenous people. Comparison between indigenous Amazonian populations, similar in genetic constitution, but different in environmental or socio-economic conditions, or between the same population before and after environmental or socio-economic change, may provide more interesting results. In the Peruvian Amazon, the establishment of a large permanent settlement among the Machiguenga, previously living in small temporary settlements, led to depletion of wild food resources. Consequently, a drastic decrease in body weight, as well as a slight decrease in stature, was observed over an eight-year period (Baksh, 1995).

The Sarayaku people themselves have stated that they have a problem of increasing difficulty to procure food (see Chapter 6). Therefore, the purpose of this study was to provide further insight into the nature of the problem, rather than to determine whether a nutritional problem existed or not. Particularly, the household economy study aimed at explaining this shortage in nutritional terms, and to identify the relative contribution of different sources of food, in terms of the nutrients they provide. The purpose of the anthropometric study is to assess whether the suggested resource crisis is so serious that it affects body size and composition of the population. A recent serious deterioration in food supply would cause wasting among adults and increase the incidence of stunting among the young. In addition to using the standard reference population from the United States (Frisancho, 1990), comparison is also made with anthropometric data from the mixed Kichwa-Achuar community of Conambo, collected in 1993 and kindly provided by Patton (Orr et al., 2001). Conambo is located 75 kilometers east of Sarayaku, in an ecologically similar site, although at somewhat lower altitude. At the time, Conambo had 185 inhabitants, about a fifth of the population size of Sarayaku. There were large uninhabited areas to the north of the community and, consequently, wildlife was, and still is, considered to be abundant in comparison with Sarayaku. The hypothesis was that the difference in wildlife abundance would have caused a corresponding difference in nutritional status, being better in Conambo than in Sarayaku.

7.4. Anthropometrical study

Height-For-Age data indicate that the people were very short in comparison with the reference population. The average stature of adult males was 160 cm, and for adult women it was 147 cm. The prevalence of stunting (z-score < -2), increased during childhood and adolescence, and the majority of adults were stunted according to this definition. However, there was little difference in height between the Sarayaku and the Conambo populations (Fig 7.5 a, b).

Body Mass Index was near the mean of the U.S. reference population. For young children it was slightly above the mean, and then decreased with age, perhaps reflecting increasing obesity with age in the reference population as much as any change with age in the study population. Only one individual, a young girl, had a Body Mass Index z-score lower than –2. Again, there was little difference between the Sarayaku and the Conambo populations (Fig. 7.5 c, d).

Also, the upper arm muscle area of the Sarayaku population was similar to the U.S. reference population, particularly for females, whereas for males it was slightly lower, particularly for the older age categories. A curious difference between the Sarayaku and Conambo populations seems to be that the Sarayaku population had higher Upper arm Muscle Area in early childhood, but this difference disappears, or is even reversed, in adulthood (Fig. 7.5 e, f).

7.5. Discussion and conclusion

These data from the household livelihood study, although very limited, are in agreement with the general impression that most food produced is consumed within the household, that governmental salaries are an important source of money, that other income is unevenly distributed over time, and that money mostly is used in order to purchase imported goods, whereas there is little internal trading of locally produced goods. It also shows that, in spite of the increasing integration into the monetary economy, exchange in the form of gifts is still an important part of the economy of Sarayaku.

The energy content of the procured food of 3120 kcal/day/person, is approximately the required intake for physically active adult men[21]. Three-fourths

[21] Based on average weights of 59 kg for adult men, and 50 kg for women.

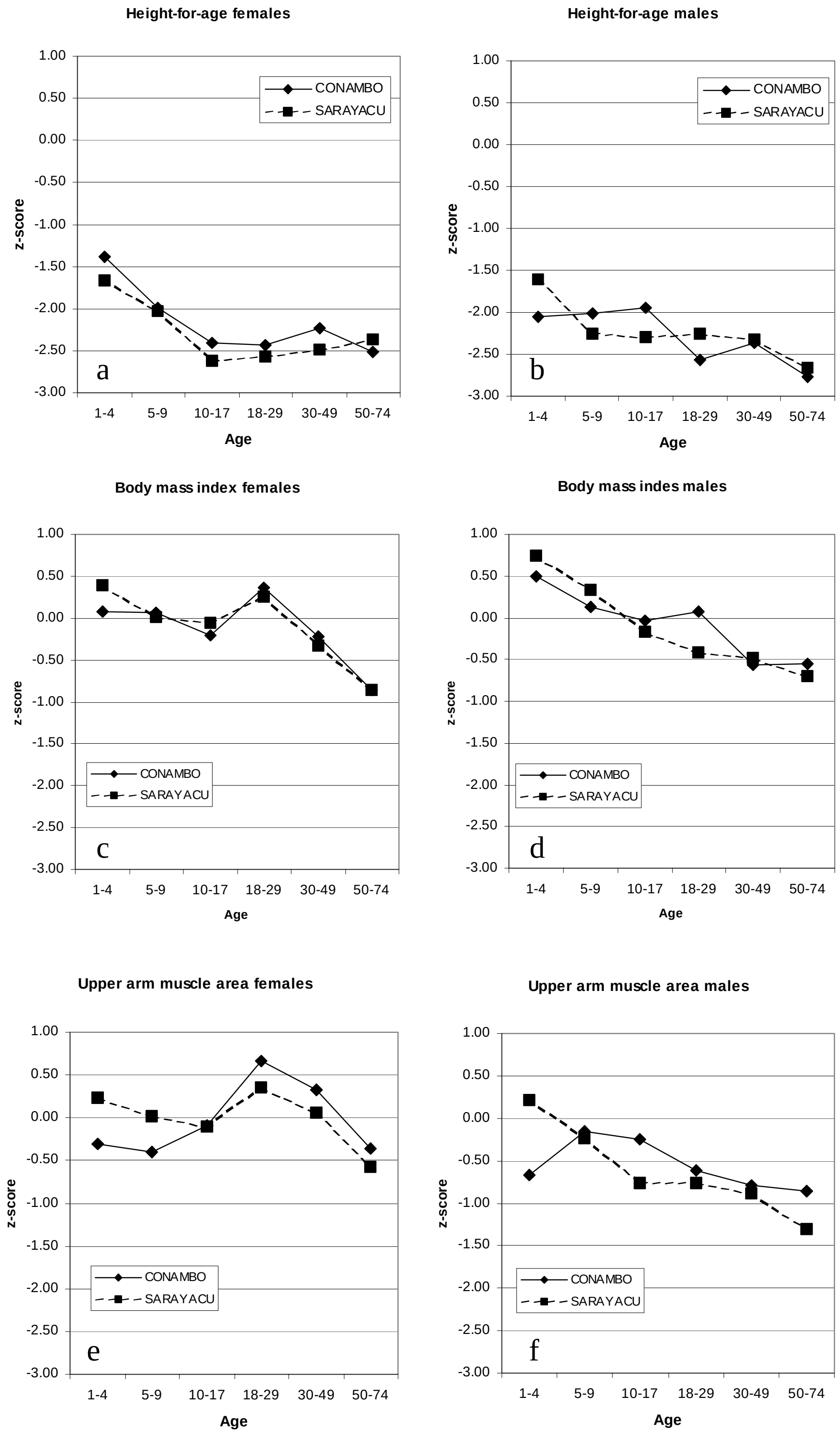


Fig. 7.5. Comparison of anthropometric measurements between the Sarayaku and Conambo populations for females (left column) and males (right column). Upper row: Height for age, middle row: Body mass index, Bottom row: Upper arm muscle area.

of the population is made up of women and children whose energy requirements are considerably smaller (FAO/WHO/UNU, 1985). Thus, the energy content in the foodstuffs brought into the household contains a surplus of energy, but it should be noted that much of the carbohydrate-rich foodstuffs such as cassava and plantains is not directly consumed by humans as it is either lost in the process of making cassava or plantain brew, thrown away, and/or fed to domestic animals.

The estimated 68g protein per person and day is significantly above the required intake for all age categories and sexes, including adolescents and lactating women (FAO/WHO/UNU, 1985; Antonsson-Ogle 1996). Nutrient requirements may, however, also be affected by parasite infestation. In a study of the Aguaruna of the Peruvian Amazon, Berlin & Markell (1977) found that 93% of the population were infested with Hookworm (*Necator americanus*). In order to withstand the loss of blood that the hookworms cause by sucking blood from the inside of the intestine, an increased intake of protein, as well as iron, may be required (Berlin & Markell, 1977) so the protein surplus in the diet may be smaller than it seems to be at first sight. The 25g of lipids per person and day is considerably below the recommended levels for all age classes. The percentage of energy derived from lipids, 7%, is also very low. It is recommended that dietary fat should supply at least 15-20% of the energy intake, the higher figure applying to women in reproductive age and children (Torún et al., 1981; FAO, 1994).

As these figures are based on the amount of foodstuffs brought to the home, for the food actually ingested the percentage of energy derived from carbohydrates must be somewhat lower, and the percentages of energy derived from proteins and lipids somewhat higher. Nevertheless, even when taking these errors into account, the level of protein calories is quite normal, whereas the level of fat calories is very low.

All these figures are averages between several households and over time. It cannot be ruled out that the individual consumption of nutrients may sometimes be substantially lower. The data from the hunting study (Chapter 10) indicate that there is considerable variation in game harvest between hamlets, the Shiwakucha and Sarayakillu hamlets harvesting two or three times as much wild game, by weight, as the other hamlets. This does not necessarily mean that the other hamlets are worse off, as they may compensate this difference by relying more on fish (particularly Chundayaku) or cash income (particularly Centro Sarayaku), but the data available do not permit any firm conclusions regarding this matter.

In comparison with studies of other indigenous people, the data from Sarayaku indicate an energy intake higher than for the Tukano, but lower than the Aguaruna and the Achuar. Protein intake seems to be higher than for the Tukano, but is somewhat lower than for the Aguaruna and the Achuar (Table. 7.3). The only sign of malnutrition revealed by the anthropometric measurements is that stature is very short when compared with the U.S. reference population. In comparison with the Conambo population, genetically similar and inhabiting a similar ecosystem, there is no sign that the current resource crisis in Sarayaku would have caused any deterioration in nutritional status. In comparison with other Amazonian peoples (see Dufour, 1992) the stature of the Sarayaku people is also near average.

Table. 7.3. Comparison of daily per capita energy and protein in the diet of different Amazonian indigenous peoples. The figures for the Sarayaku and the Achuar represent food brought to the home, whereas the figures for the Tukano and the Aguaruna represent actual food intake. Sources: (a) Dufour (1983), (b) Descola (1994), (c) Berlin & Markell (1977).

	Sarayaku	Tukano (a)	Achuar (b)	Aguaruna (c)
Energy (kcal)	3120	2542	3408	3356
Protein (g)	68	50	105	109

The possibility that the results are affected by seasonal bias must be taken into account. Particularly, the supply of fish is affected by seasonal changes (see Chapter 10), but although almost all the data for the household economy study were collected outside the fish season, the amount of fish procured was high. The largest source of seasonal variation is, however, the difference between school terms and vacations. During vacations, people disperse out to their secondary homes or purinas and eat more wild meat and fish. Consequently, school vacations are considered a period when people get sturdier, so anthropometric measurements may also show seasonal variation. Most anthropometric measurements for this study were made a few weeks after most people had returned from their vacations in the purinas, and one may speculate that they may have been in better nutritional condition than average. However, a comparison with those measurements made at the end of the school term in December, revealed no such seasonal effect. Another significant souce of error may be the estimates of fat content of fish and wild game. These were calculated as averages of the figures available in the literature, including a very limited number of species. It should be noted that the fat content of fish varies considerably both between species and between seasons (Junk, 1985), so the averages calculated based on figures from the literature may differ significantly from the actual fat content of the fish consumed in Sarayaku.

The current crisis of wild food resources does not seem to have resulted in any measurable deterioration of nutritional status. This does not, however, mean that depletion of wild game and other resources is unimportant for the nutritional status and health of the Sarayaku people and other Amazonian indigenous peoples. According to the Organization of Indigenous Peoples of Pastaza, the incidence of severe malnutrition among their member communities is highest in the communities affected by colonization and land loss, and lowest in the communities near the Peruvian border, far away from urban centres, where population density is low (Ortíz, 2001). In communities not far from Sarayaku, but closer to the colonization front and with smaller hunting territories, it is not uncommon to observe children with clear signs of malnutrition, such as thin limbs and swollen bellies, or reddish hair and apathic appearance. However, the situation in Sarayaku has yet not deteriorated to that point.

In order to better understand the role of different food sources in the nutrition of the Sarayaku people, however, it would be necessary to follow a larger sample of households over at least a full year. Also, there is a need for species-specific data on the nutrient content of the multitude of species of wildlife and fish that form part of the diet of Amazonian indigenous people, and to understand its seasonal variations.

Nevertheless, this limited study shows that similar to other indigenous people in the Amazonia, the role of agriculture in Sarayaku is, in nutritional terms, mainly to provide bulk energy in the form of carbohydrates. Fish and wild meat provide protein and fat, and increase the overall energy density of the diet. Probably they are also important sources of vitamins of minerals, although this study has not covered those aspects. Whereas protein is relatively abundant, fat is in short supply. Particularly fish seems to be an important source of fat. The data also suggest that the main importance of store-bought food may be to provide supplementary fat to the diet.

Chapter 8: Agricultural land use

8.1. Sustainability of shifting cultivation

Similar to many other peoples in tropical forests (Beckerman, 1987; Clay, 1988), the people of Sarayaku practice shifting cultivation, that is, they clear the forest in order to farm for a few years until nutrients in the soil are exhausted and/or weed infestation becomes too severe, and then they fallow the land, letting the forest grow back again. Fallowing the land and allowing the forest to grow up restores soil fertility and reduces populations of pests, pathogens and weeds over time. The growing forest also builds up biomass that can be burned in order to further reduce pests, pathogens and weeds, as well as further improve soil fertility. Therefore, the resource base for shifting cultivation consists not only of the soil, but also of the forest biomass (Nye & Greenland, 1960; McGrath, 1987)

At low population densities, only a minute proportion of the forest is cleared for farming each year. There is little competition for land and fallows are left to grow for such a long time that they become basically indistinguishable from the primary forest (e.g., Descola, 1994). Many Amazonian peoples used to be quite mobile, changing village site every few years, and soil exhaustion has been suggested as one reason, among many, for these movements (Hames, 1983; Gross, 1983;), although this view has been contested (e.g. Chagnon, 1997, pp. 71-91). Whatever the prime reason for the village movements, these movements in combination with the low population density assured that shifting cultivation in the Amazonian rainforest until quite recently was widely scattered in space, and of a low intensity in terms of the period of cultivation in relation to the period of fallow.

The overall ecological impact of such shifting cultivation systems was small, and they have even been called “models of sustainable agroecosystems” (Dufour, 1990, p. 652). Shifting cultivation is, however, not only practiced by Amazonian indigenous peoples. It is practiced all over the tropics, and has previously been practiced also in temperate regions, such as Europe. As populations have increased, shifting cultivators have often reduced the extent of primary forest and gradually decreased the length of the fallow period, which has led to decreased productivity (Boserup, 1965). Thus, the apparent sustainability observed in shifting cultivation systems of Amazonian indigenous people may depend more on low population densities than any inherent sustainability in the shifting cultivation system itself. Also, among Amazonian indigenous people, population growth and settlement in permanent villages has led to scarcity of good land to farm and expansion of secondary forest in various parts of the Amazon (e.g., Behrens, 1994; see also Coomes et al., 2000). The Sarayaku people consider such land scarcity to be a serious problem in the community (see Chapter 6).

Shifting cultivators have even been considered the main cause of tropical deforestation worldwide (e.g., Amelung & Diehl, 1992). Most of this deforestation, however, is caused by population growth due to migratory movements, often in connection with infrastructure development or governmental resettlement schemes, and less caused by the natural population increase of the native populations (Geist & Lambin, 2001).

Although the shifting cultivation of indigenous Amazonian peoples is not the main cause of deforestation today, it may nevertheless be a factor that is growing in importance, and that may be aggravated by socio-economic changes involving greater production for the market. An example is the Shuar people further south in the Ecuadorian Amazon, who have been important agents of deforestation as they have cleared land for cattle and cash crops (Rudel & Horowitz, 1996; Rudel, et al., 2002).

There are several ways by which local farmers can adapt to an increasing scarcity of land to farm. One way is to reduce fallow periods, which may accentuate problems with soil exhaustion and weed infestation, while avoiding deforestation of old-growth forest. Another way is to expand farming into the primary forest, causing deforestation but avoiding problems with soil exhaustion and increasing weed infestation. A third way is to intensify land use by increasing input of labour and technology (e.g., pest and weed control, fertilizing, irrigation) in order to increase the output per unit of land. Such land use intensification has even led to increased tree cover and decreased erosion in Tanzania (Tiffen et al., 1994) and Java (Sayer, 1995). However, farmers have little incentive for this kind of land use intensification until forest resources are used up, so that they face severe land shortage (Boserup, 1965). Land scarcity may lead to competition for land between farmers. When deciding upon whether or not to clear a particular piece of land at a particular time, the farmer then has to take into account the risk that, if he does not clear it now, somebody else may do so. Such competition may lead to a further shortening of fallow periods. To avoid such competition, farmer communities may privatize land or otherwise change the local institutions governing control and access to land (Boserup, 1965; Angelsen, 1997; see also Chapter 8).

Sarayaku today is characterized by a nuclearized settlement pattern and dependence on services such as schools, church, shops and airstrip. Transport within the area is basically limited to the rivers, and an extensive network of trails. This situation is particularly suitable for the partial equilibrium approach to the study of land use, i.e. the application of spatial economic models that take the centre as given and assumes that a transport network already is in place. Combining spatial economic models with forest rotation models, Angelsen (1997) shows that the optimal fallow length increases with increasing distance from the centre. However, also site characteristics such as soil type influence fallow length.

8.2. Production systems in Sarayaku

The Sarayaku people practice shifting cultivation in a way that is quite typical for the indigenous people of western Amazonia (e.g Johnson, 1983; Denevan et al., 1984; Salick, 1989). Shifting cultivation is, however, just the main component in a diverse agricultural system. Other components are cattle, poultry, the *chili* palm (*Aphandra natalia*), fish ponds, and home gardens with a variety of fruit trees and other useful plants. Land management practices are influenced by topography and soil. Particularly, plains (*pamba*) are managed differently from ridges or hills (*urku*). The ridgetops have been farmed for at least one and a half millennia, whereas the farming on plains seems to have started only two centuries ago (see Chapter 5). Steep slopes are considered less suitable for farming.

Small creeks are subject to frequent flooding following heavy rains, but the water also recedes fairly rapidly, permitting the soil to dry, such that severe crop damage rarely results. On the other hand, also the Bobonaza river occasionally floods the surrounding plains. Two such large floods have occurred since 1990. On such occasions, the water may leave several decimeters of sediment in some places, and it may take several days until the soil dries up, whereby severe crop damage results. Households that have a field on a low-lying plain therefore usually also have a field on a hill, as an insurance against flood damage.

Local people classify soils on hills into two major types; black soil (*yanaallpa*) and red soil (*pukaallpa*), of which the black soil is considered more fertile. Soils on plains often have a coarser structure and are referred to simply as plain soils (*pambaallpa*). On the lower-lying plains, sedimentation processes during floods create small patches of clayey soils (*turu*), unsuitable for cultivation, and other patches of sandy soils (*tiuallpa*), highly appreciated for farming cassava, maize, papaya and groundnuts. There are also stony soils (*rumiallpa*), considered less suitable for farming.

Fields (*chagra*) are small, averaging 0.20 ha, and may be just ten metres wide when planted along the riverside. Making a field involves first clearing the underbrush, and felling the trees. Then the branches and twigs are cut in pieces and gathered in piles. After drying in the sun for a few days, the piles are set on fire, and to some extent the fire also spreads to the leaves and other debris left on the ground. Sometimes, however, people do not burn the debris, but instead just cut the branches and twigs into very small pieces, so as to facilitate planting and speed up decomposition. This is done on favourable sites such as sandy soils and sometimes when clearing old-growth forest, and when one is in a hurry to get the crops planted.

Similar to several researchers (e.g., Jordan, 1987; McGrath, 1987), the Sarayaku people recognize the role of the decomposing forest biomass in improving soil fertility. Nevertheless, they generally consider roots and fallen leaves to be enough to fulfill this role. Stems, branches and twigs are considered as obstacles to planting, and all that is not too big, or too far from the edge, is simply thrown out of the field area.

Clearing and planting for fields takes place any time of the year. However, the “dry” season in July-August (see Chapter 2.2) is preferred for several reasons. The debris dries up faster which facilitates burning, and the weeds do not grow much, permitting the crops to get an advantage over the weeds. The risk that seeds and seedlings get killed by heavy rain is also reduced during the dry season. The increased availability of labour in the household during the school vacations in July-August is an additional reason why many people make fields during this time of the year.

The most important crops, in order, are sweet cassava (*Manihot esculenta*), plantain (*Musa* spp.), and maize (*Zea mays*). Sarayaku high school students Aranda

& Machoa (1993) recorded no less than 54 different varieties of cassava. There are two major types of plantain, each one further divided into several varieties; the *palanda* which has larger fruits and a richer taste, and the *guinia*, which has the advantage that it is more tolerant, growing also on poor soils, and able to survive and carry fruit even when surrounded by high regrowth. There are also two major types of maize. One is the traditional runasara, particularly suitable as a food crop because the ears dry slowly and asynchronously, allowing a prolonged period of harvesting of green ears. The other type is the fairly recently introduced morocho (see Chapter 5), which provides higher yields and dries fast and quite synchronously, facilitating a one-time harvest in order to store the maize as poultry feed.

Cassava is planted in almost all fields, typically intercropped with a wide range of other crops (see Garí, 2001). On plains, plantains are almost always planted, often also maize, and on sandy soils often also groundnuts (*Arachis hypogaea*) and papaya (*Carica papaya*). Plantains are also planted on hills with black soil. On hill fields on red soils, however, only the guinia type of plantain is planted, mostly along the low-lying edges. On red soils on hills often also pineapple (*Ananas comosus*) or barbasco (*Lonchocarpus nicou*) is planted. Spots where debris piles have been burned are planted with particularly demanding crops, such as beans (*Phaseolus* spp.), tomatoes (*Lycopersicon esculentum*), native onion (*Allium* sp.), chili pepper (*Capsicum* sp.), and various starchy root crops such as cocoyam (*Xanthosoma* spp.), yam (*Dioscorea trifida*), taro (*Colocasia esculenta*) and sweet potato (*Ipomoea batatas*). A characteristic of the system is not only the habit to plant multiple crops with different length of time until harvest, but also that harvesting is usually continuous, only groundnuts and maize being harvested within a fairly short time span. After harvesting cassava, unless plantains are casting too much shadow, the same stem is planted again, so to provide a second harvest of cassava.

Therefore, fields typically show a succession where one stage gradually transforms into the next. A common succession on plains is the maize-cassava-plantain succession, maize being harvested after three months, cassava harvested from about nine months up to a year and a half, when the plantains start to be harvested. At this point, weeding activities become limited to occasional above-ground slashing with machete. This stage of the crop succession is locally called *palandapurun*, literally meaning “plantain fallow”. After the plantains have given a second harvest the field is usually abandoned and returned to fallow. As variations of this basic theme, maize may be omitted or, on sandy soils, groundnuts may substitute or complement the maize. On hills, particularly red soils, common successions are cassava-pineapple or cassava-barbasco. Pineapples or barbasco are slow-growing and tolerant of competition. The first pineapples are ready for harvest together with the second harvest of cassava, and continue to give fruit after regrowth invades the field. Barbasco is ready for harvest after a minimum of 2-3 years. Although some weeding of the barbasco sometimes is done after the last cassava harvest, eventually regrowth takes over, and the barbasco continues to grow as an understory plant, and when harvested often stands under 15 meters tall secondary forest. All these different paths of succession have in common that after about two and a half years, the field becomes fallow. With a few exceptions, there is little variation in the length of the cropping period. On the other hand, there is considerable variation in the length of the fallow period.

Useful trees, wild species as well as cultivars, are often favoured when clearing for a field (cf. Denevan et al., 1984; Unruh, 1990). Particularly seedlings and saplings are protected, but sometimes also large trees, in spite of the shadow they cast on the crops. Important fruit tree crops are the *chunda* palm (*Bactris gasipaes*), a multi-stem palm with nutritious fruits, and the *kila* of the cacao family (*Theobroma bicolor*). The tropical cedar (*Cedrela odorata*), used for making canoes, is actively managed in the fields. Other tree species have more resistant wood, but the tropical cedar is the easiest one to manage, because large quantities of seedlings grow up once the ground is cleared around a large tree. Many people in Sarayaku relate that this kind of fallow management has increased in importance over the last couple of generations.

Recently, some households have experimented with planting rice on the plains. However, as there is no functioning husking machine, and no tradition of manual husking, the rice has so far only been used as poultry feed.

Among domestic animals, poultry is most important. Poultry are kept in rustic poultry houses during nighttime and walk around loose during daytime: They are fed on maize and kitchen waste and also eat worms, insects, and leaves. Disease outbreaks sometimes reduce poultry stocks. Predators such as small felines (*Leopardus* spp.) and opossums (*Didelphis marsupialis*) also take a significant toll. Protecting the poultry by enclosing them within poultry netting is considered impractical because of the large cost, and because the poultry do not grow well if enclosed in a limited space where they rapidly deplete the supply of worms and other wild food.

A few families have cattle pasture with introduced grass species. The cattle are tied with a rope to a tree and, in most cases, changed to another tree once or twice a day. Useful tree species, such as timber trees, have often been left to stand in the pastures, such that the degree of tree cover is fairly high. The pasture area increased drastically in the mid-1980's due to governmental incentives, and declined almost as sharply during the 1990's due to the lack of profitability (see Chapter 5). A few households raise pigs, most of them keeping them loose. This causes sanitary problems and sometimes crop damage, and therefore pig raising is not very widespread. Cattle as well as pigs are primarily raised for export to urban markets. and the meat is only occasionally sold locally.

Another type of production system that is new and increasing is fishponds. A few people have had fishponds for quite some time, foremost to keep fresh fish that have been caught alive. Others have recently built fishponds in order to produce fish for consumption, some of them with the help of NGO money. Some have used the Tilapia (*Tilapia* sp.), an introduced species, but others experiment with native Amazonian species such as *gamitana* (*Piaractus brachypomus*) and *uputaza* (*Cichlidae* spp.) The fish is usually fed on kitchen garbage, termites, and leaves. The experiences have been mixed, but in spite of some frustrations, more fishponds are being constructed.

Plantations of *chili* palm (*Aphandra natalia*) are a type of land cover that has gradually been increasing since the mid-1970's, as a response to the market demand for the fibres of the leaf bases of this palm and perhaps also to a decline of the wild stands due to unsustainable exploitation. Most plantations have been established simply by removing all other vegetation, so as to enhance the growth of the *chili* palms (cf. Borgtoft-Pedersen & Balslev, 1992), similar to the management of açai (*Euterpe oleracea*) palms in the Amazon estuary (cf. Brondizio et al. 1994). Others have been planted near houses, using the seeds of the fleshy and well-tasting fruit. It is necessary to weed during the about fifteen years it takes until the fibre can start to be harvested. By then, the canopy closes and weed growth is naturally suppressed. The total area of *chili* palm plantations is small, the largest mature holding is just 0.6 hectares, but it is a significant source of income for those families who possess them. All households also possess a small home garden with fruit trees, medicinal plants, bananas, spices, etc., which tends to grow in size and height with the age of the settlement at the site.

The purpose of the following study was to quantify the impact of farming on the land cover in Sarayaku, in order to understand the mechanisms of change and the ways the people adapt to the currently felt resource scarcity. Of particular interest was to assess the extent to which people adapt by shortening fallow periods, by expanding into forests previously not used for farming, or by switching to more intensive production systems. Also, the chapter explores how land use varies in space.

Specifically, the study aimed at answering the following questions:

- How large is the total area of agricultural land (cropping and fallow land) within the study area?
- How does land use depend on site characteristics, particularly soil, topography, and distance to settlements?
- What is the rate of expansion of cropping and fallow land, and the corresponding rate of decrease in the area of the old forest?
- To what extent are farmers adapting to land scarcity by clearing increasingly younger forests for farming?

For this study, I used two complementary methods for studying the dynamics of land use. The first method is based on analysis of interpretation of remotely sensed data. The other is based on direct analysis of field data, where each land use plot measured in the field functions as one data point. These methods were described in detail in Chapter 4.4.

8.3. Land use dynamics

According to the remote sensing study, the total field area in 2001 was 199 ha, or 0.16% of the study area (Table. 8.1). On the other hand, the field plot data analysis gives a total of only 94 hectares of maize and cassava fields in the study area

Table 8.1. Areal extent, in ha, of field, young fallow (under 20 years of age), and forest (including fallows older than 20 years) in 1987 and 2001, according to the remote sensing analysis. Overall, no major change in land use can be detected. Note, however, the increase in young fallow area in the Jatun Molino community, founded in 1983. Note also the similarity between the garden area per household in Sarayaku and Jatun Molino, respectively.

	1987			2001			Change from 1987 to 2001			Area per household 2001		
	Total	**Sarayaku**	**Jatun Molino**	**Total**	**Sarayaku**	**Jatun Molino**	**Total**	**Sarayaku**	**Jatun Molino**	**Total**	**Sarayaku**	**Jatun Molino**
Fields	213 0.17%	196	17	199 0.16%	180	19	-15 -6.8%	-16 -8.3%	2 9.3%	1.3	1.3	1.3
Young fallow (< 20 years)	2866 2.26%	2784	82	2736 2.16%	2597	139	-130 -4.6%	-188 -6.7%	57 69.7%	18.1	19.1	9.3
Forest	123663 97.57%			123808 97.68%			145 0.1%					

Table 8.2. Areal extent, in ha, of cultivated fields (cassava, maize, and plantain) of the five randomly selected households, and the corresponding estimates of the total extent of such fields within the study area.

	Household							
	1	**2**	**3**	**4**	**5**	**Average**	**Total in the study area**	**95% confidence interval**
Cassava/maize fields	0.86	0.30	0.55	0.71	0.72	0.63	**94**	+/- 29
Plantain fields	0.21	0.03	0.16	0.15	0.70	0.25	**38**	+/- 34
Sum	1.08	0.32	0.71	0.85	1.43	0.88	**132**	+/- 54
Household members	*6*	*3*	*7*	*2*	*10*	*5.60*		

(Table. 8.2). Because fields are high contrast objects, they may show up on the image even if they occupy only part of a pixel, and therefore remote sensing tends to overestimate their size (Fig. 4.14; see also Wilkie, 1994). The analysis of the field plot data for the random household sample also provides an estimate of 38 hectares of plantain fields. The sample was too small for any reliable estimates of the total area of pasture and fibra palm plantations. In any case, however, these areas are small in comparison with the areas of maize, cassava, and plantain fields.

The remote sensing study indicates that fallows younger than 20 years covered 2.2% of the study area in 2001 (Table. 8.1). According to the analysis of the field data, 65% of the fallows were younger than 20 years, whereas the rest were between 20 and 65 years old (Fig. 8.1). Based on this, the area of fallows between 20 and 65 years old can be estimated to 1.3% of the study area, and the total fallow area to around 3.4%. This figure does not include the very old "fallows" that are spread out on ridgetops all over the study area, remnants of the previous settlement pattern and agricultural techniques that gradually were abandoned during the 19th and early 20th centuries (see Chapter 5). Some of these old "fallows" are still recognized as such, but others have become indistinguishable from old-growth forest.

Farming is concentrated to the areas in the vicinity of the hamlets (Figs. 4.13 and 8.2). Of the area classified as "young fallow", 59% were within a 5 km radius from the central plaza of the community. The alluvial plain of the Bobonaza River has a particularly high percentage of young fallows (Fig 8.3). Near the hamlets, 70-90% of the land on this plain is either young fallow or field. The proportion of fields and young fallows decreases with distance from the hamlets. Outside the Bobonaza plain, the decrease in the proportion fields and young fallows with distance is even steeper (Fig. 8.4).

The comparison of the images from 1987 and 2001 shows no significant differences in overall land use, but there was an increase of secondary forest in the area surrounding the outbreak community Jatun Molino, founded in 1983 (Table. 8.1, see also Fig. 8.3). The most significant land cover change during the period was the appearance of 340 hectares of natural secondary forest that had grown up on areas where a storm had felled the forest sometime between 1987 and 1992 (Fig. 4.11), an area equal to 12% of the area of anthropogenic young fallows.

The field plot data analysis also provides an estimate of the annual expansion of cultivated area into old-growth forest. The average "lifespan" of fields was approximately two and a half years, indicating that the annual clearing rate is 40% of the total crop area, i.e., 0.4×132 ha = 53 ha. The field data also indicates that, since the 1980's, 32% of the clearings have been made in old-growth forest. Taking into account the Jatun Molino community, which represents approximately 10% of the total population in the study area, and still may clear mostly old-growth forest, it seems reasonable to increase this figure to 35%. The area of old-growth forest that annually is converted to field and fallow is then 0.35×53 ha = 18.5 ha or, in relation to the total area of old-growth forest in the study area, a conversion rate of old-growth forest equal to 0.015% per year. This may be a slight underestimate, because clearing for a field in old-growth forest also involves a heavy impact on the forest at the margins of the fields because of the impact of

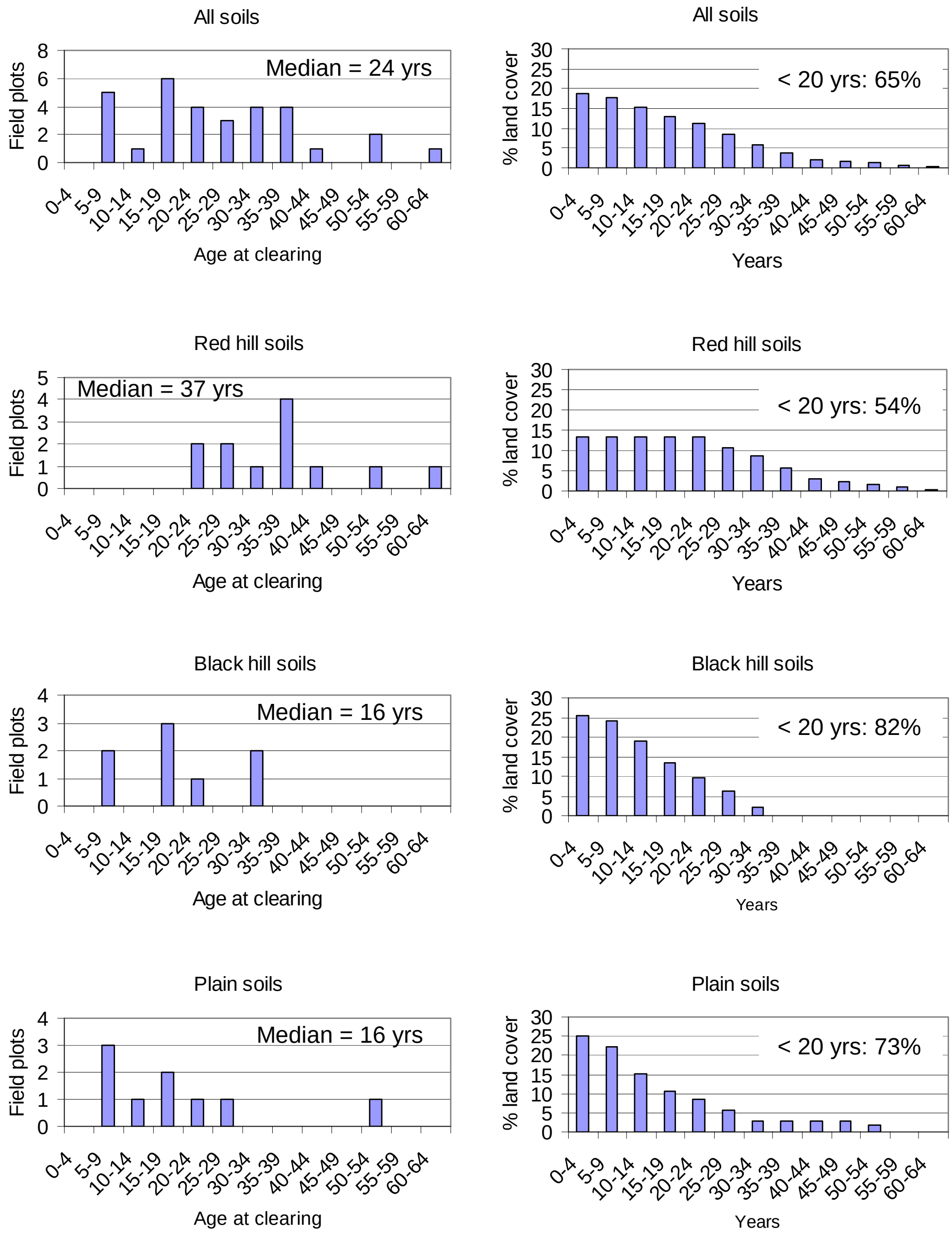


Fig. 8.1. Age of fallows at the time of the last clearing (left column), and the age distribution of fallows in the landscape, calculated according to the formula presented in Chapter 4.4.2 (right column). On red hill soils, fallows are left to grow to an older age than on black hill and plain soils, before they are cut down again.

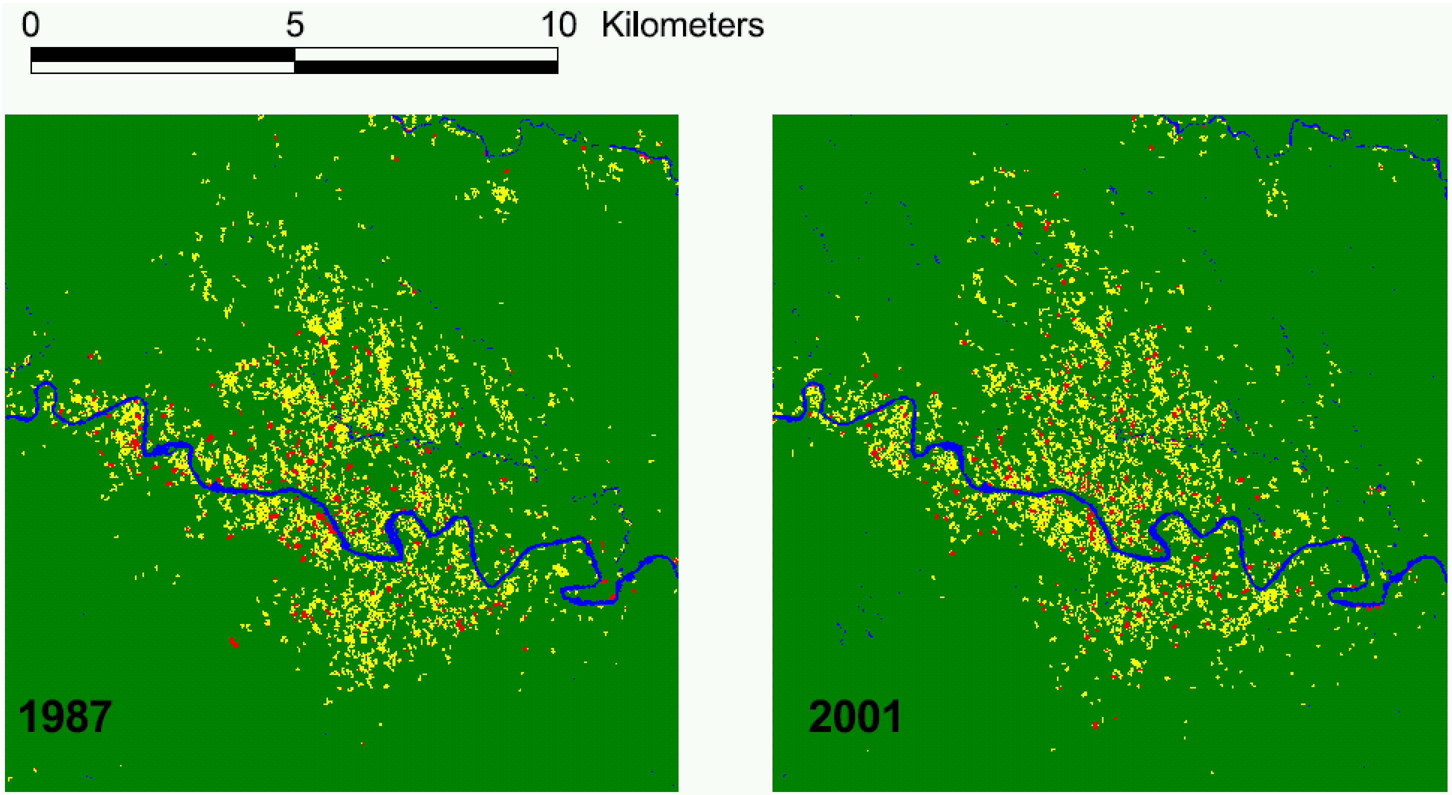


Fig. 8.2. Land use classification of the area surrounding the hamlets, 1987 (left) and 2001 (right). Red: fields. Yellow: young fallow. Green: Forest. Blue: Water, beaches, and deep shade. See Fig. 2.4 for location of hamlets. See Chapter 4.4.1.4 and Fig. 4.12 for definitions of land use classes.

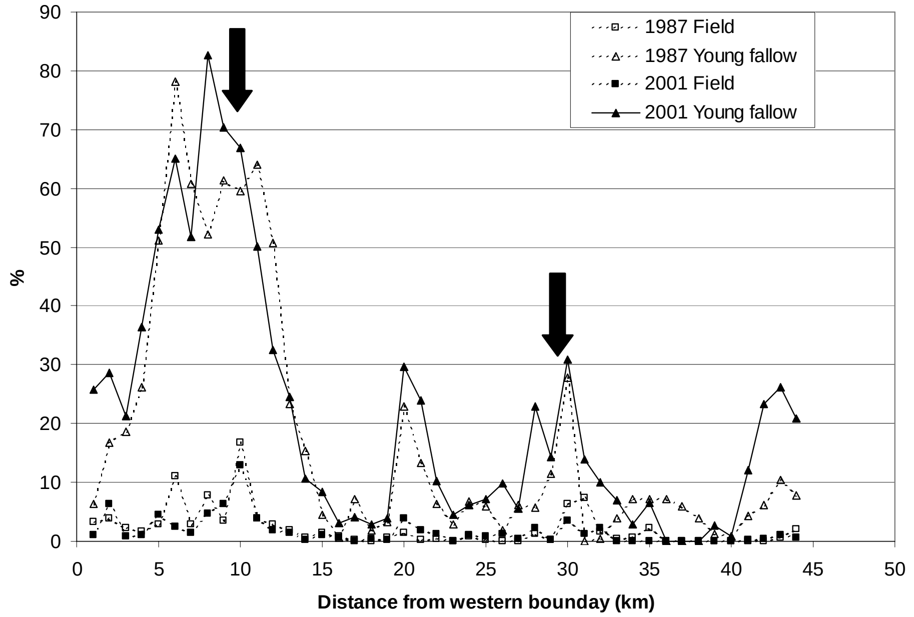


Fig. 8.3. Percentage of fields and fallows on the alluvial plain of the Bobonaza river. The black arrows indicate the locations of the village centres of Sarayaku and Jatun Molino, respectively. Based on remote sensing analysis. The values for the fallow class are corrected for classification errors (see Chapter 4.4.1.5).

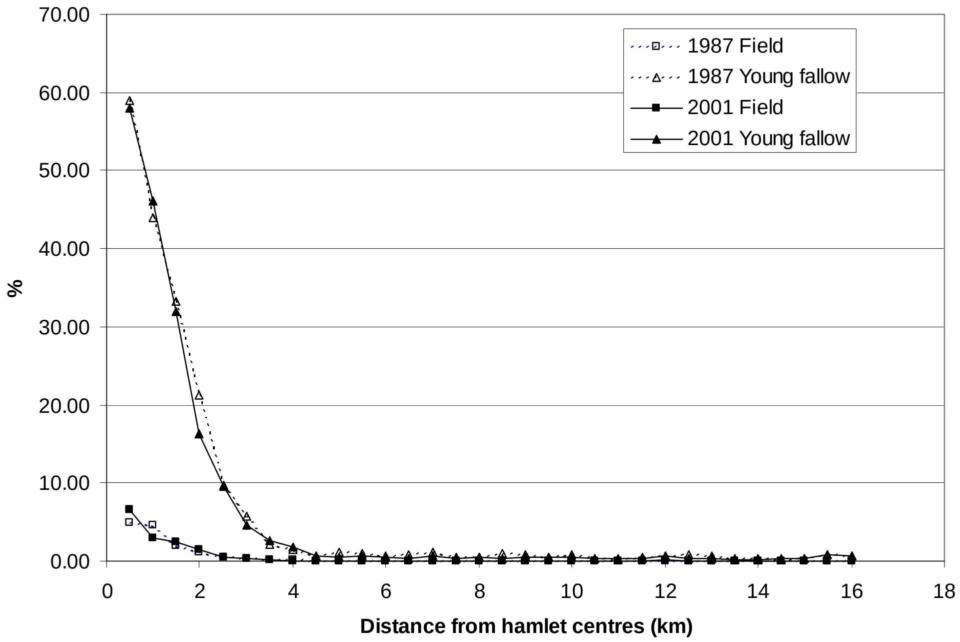


Fig. 8.4. Percentage of fields and fallows outside the major alluvial plains (those of the Bobonaza, Rutunu, and Jatunkapawari rivers, see Fig. 2.3), according to the distance to hamlet centres (schools). Based on remote sensing analysis. The values for the fallow class are corrected for classification errors (see Chapter 4.4.1.5).

falling trees. The annual rate of expansion of the intervened area (fields and fallows), on the other hand, is about 0.5% per year.

It is reasonable to assume that the area of old-growth forest cleared annually has been fairly constant during the fourteen years between the dates of acquisition of the two satellite images. This implies that the intervened area (fields and fallows) actually may have increased by 7% (14 × 0.5%), or 297 ha, a change not detected by the remote sensing analysis.

Another change that has occurred is that most of the many pastures that were established in the mid 1980’s have been abandoned and have been invaded by regrowth. However, by means of remote sensing it was not possible to distinguish pasture from old-growth forest, and even less so for secondary forest on abandoned pastures. Based on interviews (see Chapters 4 and 5) and a limited number of field measurements of pastures, however, I estimate that about 150 hectares of pasture have transformed into secondary forest since the 1980’s. This figure is based on the assumption that, by 1987, half of the households had established pastures of about 3 hectares each.

The field plot data analysis also indicates that the proportion of clearings for fields made in old-growth forest decreased from the 1930’s up to the 1980’s, when it seems to have more or less stabilized (Fig. 8.5, see also Chapter 5). Meanwhile, the distance to fields cleared in old-growth forest has increased (Fig. 8.6). This reflects the expansion of the fallows and the resulting shortage of old-growth forest. During fieldwork, people sometimes showed us fields that recently had been made by clearing old-growth forest quite close to settlements. However, these were usually on steep slopes or stony soil considered unsuitable for cultivation, and had therefore previously been left intact.

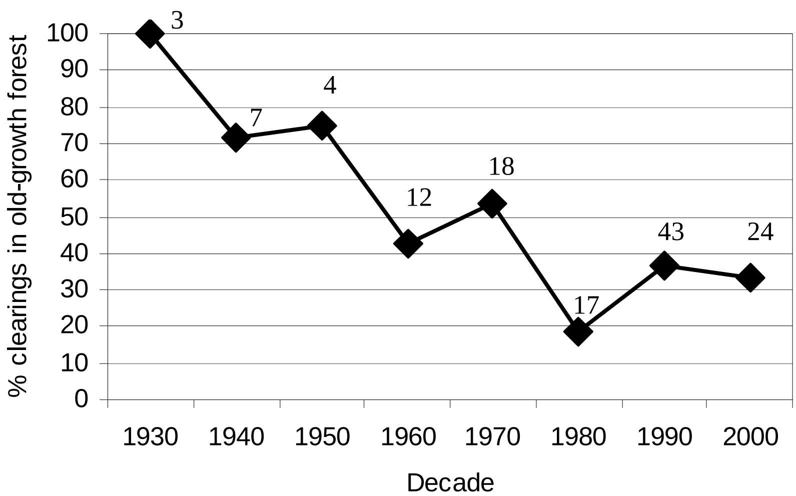


Fig. 8.5. Change over time in the proportion of the gardens that are made by clearing old-growth forest. In the 1930’s, fields were almost exclusively made by clearing old-growth forest, but nowadays most fields are made by clearing fallows. The numbers above the markers indicate the number of field plots used for calculating each percentage.

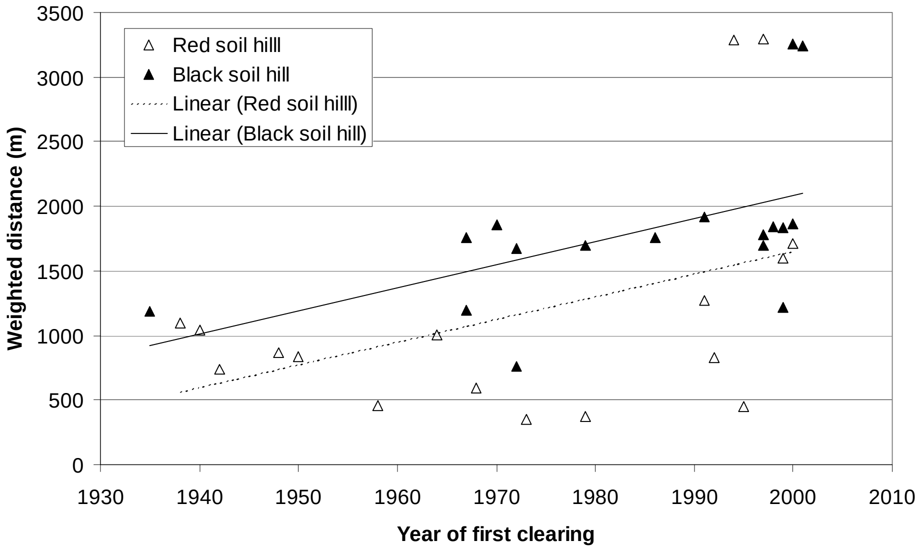


Fig. 8.6. The change over time in the distance from hamlet centres (schools) to clearings of old-growth forest. Each data point represents one field plot. With time, the Sarayaku people had to go further and further away in order to clear old-growth forest. At a given distance, old-growth forest on black hill soils tends to get cleared before old-growth forest on red hill soils. The weighted distance was calculated to account for the improved facility of transport provided by river access. Based on the author's experience, it was estimated that river transport is approximately three times easier than land transport. Therefore, the weighted distance is, whatever is the shortest, either the distance in a straight line from each plot to a school, or the distance from the plot to the Bobonaza River plus 0.3 times the distance in a straight line from that point to a school. Filled triangles and the unbroken regression line represent black soils on hill (Spearman rank correlation coefficient r_s= 0.64). Open triangles and the dotted regression line represent red soils on hill (r_s = 0.32). Confidence intervals were not calculated because the plots are not fully independent of each other. Only garden plots that are accessed directly from the permanent hamlets are included in the analysis, excluding gardens accessed from the secondary homes ("purinas"). Clearings on plains are excluded from the analysis because all plains are located near hamlet centres or secondary homes.

The remote sensing analysis indicates that the ratio of field area to total intervened area (fields plus young fallows) decreases with distance from settlement for areas outside the major alluvial plains, i.e. mostly hill areas (Fig. 8.7). On the alluvial plain of the Bobonaza river, on the other hand, this ratio changes little with distance from settlement (Fig. 8.8). In accordance with this, the field plot data analysis indicates that the fallow length increases markedly with distance to settlements for hill soils, but less so for plain soils (Fig. 8.9). Also the soil type and topography affected fallow length, fallow periods on red hill soils being longer than on black hill soils and plains (Figs. 8.1, 8.9).

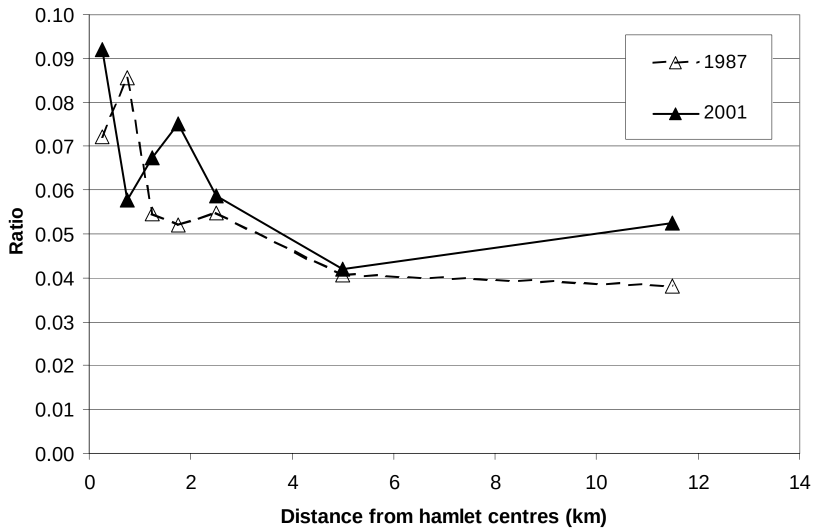


Fig. 8.7. Ratio of field/(field + young fallow) outside major alluvial plains, in relation to the distance from hamlet centres (schools) in 1987 and 2001, based on remote sensing analysis. The intensity of farming decreases with distance. Land use classes of the classified images were tabulated according to 500 m buffers around schools. The buffers were then aggregated into larger areas, each one including a minimum of 100 ha of young fallow and garden. The values used for the fallow class were corrected for classification errors (see Chapter 4.4.1.5).

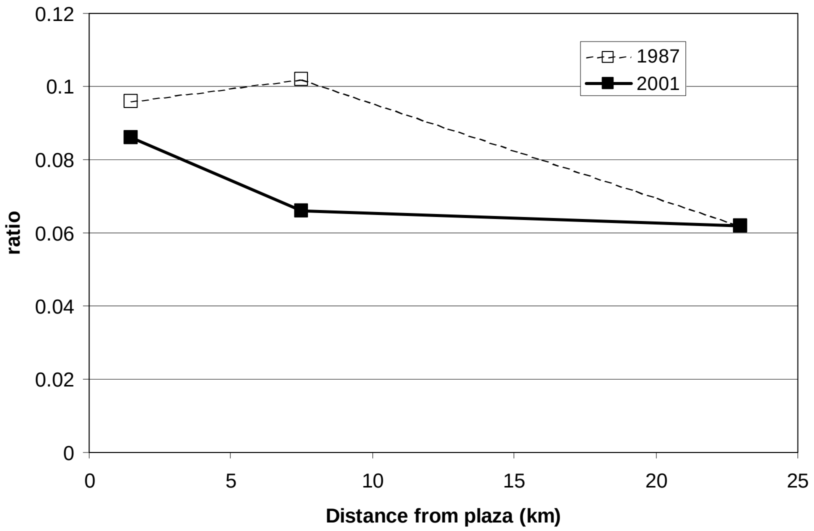


Fig. 8.8. Ratio of field/(field + young fallow) on the alluvial plain of the Bobonaza river, in relation to the distance from the central plaza of Sarayaku, in 1987 and 2001, based on remote sensing analysis. There is little change in intensity of farming with distance, and the apparent slight decrease may be due to confusion between fallows and natural secondary forest. Land use classes of the classified images were tabulated according to 500 m buffers around schools. The buffers were then aggregated into larger areas, each one including a minimum of 100 ha of young fallow and garden. The values used for the young fallow class were corrected for classification errors (see Chapter 4.4.1.5).

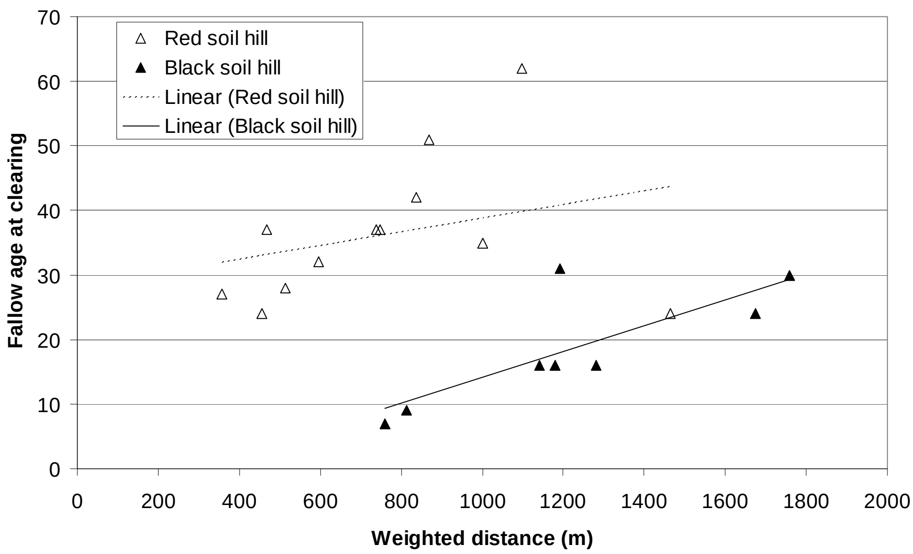


Fig. 8.9. Age of fallows at the time of the last clearing, in relation to weighted distance from hamlet centres (schools), for red hill soils (open triangles, broken regression line, $r_s = 0.30$) and black hill soils (filled triangles, unbroken regression line, $r_s = 0.77$). Each data point represents one field plot. Fallow periods increase with distance, and tend to be longer on red hill soils than on black hill soils. The weighted distance was calculated in order to take into account the improved facility of transport provided by river access (see Fig. 8.6 legend). Only garden plots that are accessed directly from the permanent hamlets are included in the analysis, excluding gardens accessed from the secondary homes ("purinas", see Chapter 2.1). Clearings on plains are excluded from the analysis because all plains are located near hamlet centres or secondary homes.

8.4. Implications for sustainability

Fields and fallows occupy just a few percent of the study area, but their area is increasing. However, the expansion rate of the intervened area, 0.4% per year, is considerably lower than the rate of population increase, which is estimated to 1.6% per year (see Chapter 5).

The proportion of fields cleared in old-growth forest has, since the 1930's, decreased to about a third (from 100% to 32%), while the population has roughly tripled over the same time (see Chapter 5). If we assume that the total area cleared per year per capita has been constant, this would imply that the absolute rate (in hectares per year) of secondary forest expansion has been fairly constant ever since the 1930's. Moreover, if we divide the present total area of fallow by the age of the Sarayaku community (~180 years), we get an average annual expansion of 25 hectares, just slightly above the estimated current 18.5 ha per year. Again, this latter figure is probably an underestimate, as it does not take into account the impact of falling trees on the forest surrounding the fields. Nevertheless, the data indicates, that the absolute rate of old-growth forest clearing has changed little since the establishment of the community, except for a brief increase in the mid 1980's when many people established cattle pastures (see Chapter 5). As the rate of expansion of cultivated land is far below the rate of population growth, the major strategy to adapt to land scarcity seems to have been to decrease the length of the fallow period.

Distance to settlement is important in determining land use. Basically all land near the hamlets is used for farming. On the other hand, beyond four or five kilometers from the hamlets hardly any land is farmed, except for a narrow rim along the major rivers. Soil characteristics and topography also influence land use, and the preference for farming on black soils is notable. Forests on stony soils or steep land may be temporally protected by the unsuitability of such sites for farming, but when the distance to better sites becomes too long, even stony and steep sites are farmed. Although the current deforestation rate is not alarming, it should be noted that almost all land seems to be farmable and in the long run few spots of forest are protected by their physical characteristics alone,

Currently, the problem of land use change is not so much a problem of deforestation as such. More importantly, it is a problem of resource scarcity for the Sarayaku people. This scarcity obliges them to farm at increasingly larger distances from their homes, to increasingly rely on clearing fallows instead of old-growth forest, and to shorten fallow periods. Longer distances to fields, decreased soil fertility and increased weed infestation cause increased workload and decreased yields.

People adapt to such increased hardships in different ways. There has been some technological innovation and intensification in the production systems in Sarayaku during recent years. This has been oriented towards animal production such as poultry and fish in order to substitute for wild game and fish, to fallow management for timber and fruits (cf. Raintree & Warner, 1986; Unruh, 1990), or cash cropping such as the *chili* palm plantations. None of these innovations do, however, provide any substantial amount of food energy, and therefore probably have little effect on the area needed for cultivation.

Resource scarcity may also cause changes in local institutions regarding control and access to resources. Absence or insufficiency of institutions that regulate the use of communally owned land may speed up agricultural expansion or shorten fallow periods beyond the social optimum (Rudel, 1995; Angelsen, 1997; Lopez,1992 quoted by Baland & Platteau, 1996, p. 285). The Sarayaku community has adapted to increasing competition for land by adopting firmer rules regulating the rights to land for farming (see Chapters 5, 6, and 11). However, there is still some competition for land that may lead to a race to clear an area of forest or fallow before somebody else does. It may be possible to strengthen rules further, encouraging permanent agriculture on alluvial plains and/or discouraging the type of competition for land that leads to shortened fallow periods or expansion into old-growth forest.

Another way to adapt to land scarcity is community fission or relocation. During the last half century, two community fissions have occurred, as small segments of the community have established new communities downstream of Sarayaku. The direct cause of the last fission was social conflict resulting from the activities of Protestant missionaries (see Chapter 5). But whatever the direct cause, such fissions reduce competition about land for cultivation, and conflicts over resources may also be an underlying cause of conflict. The current land scarcity is ultimately an effect of sedentarization and nuclearization of settlement, and with a dispersed settlement pattern, land scarcity would be relieved. Given the current demand for services such as schools, shops and airstrip, a return to the dispersed settlement pattern of the past (see Chapter 5) is not an option. Continued fissions of the community may, however, occur in the future. This would facilitate access to primary forest, and thus alleviate land scarcity while also causing primary forest loss. While some people in Sarayaku have nurtured plans to bud off new communities in order to alleviate resource scarcity, others have opposed such plans because of the negative impact that would have on wildlife populations in areas hitherto protected by their remoteness (see Chapter 6).

All over the tropics, communities similar to Sarayaku have often temporarily relieved their economic hardships by cashing in natural resources, particularly timber or minerals (e.g. Turner, 1999). Similar processes are found in Canelos, further up the Bobonaza river as well, where timber and oil companies are operating. The road network is expanding, and may cause drastic socio-economic and environmental change. Although such changes are driven by external forces, the local communities do have some power to influence decisions (see Chapters 2 and 13).

Increasing scarcity of land to farm is a serious socio-economic problem for the Sarayaku people. In the long run, it would be necessary to improve agricultural productivity without compromising sustainability. There are no easy solutions. Permanent cultivation of the alluvial plains may be technically possible, as shown by a few examples of continuous plantain cultivation, during several decades, on the fertile alluvial plain of the Bobonaza river. Perhaps improved technology for weed control, or improved river transport, could make this type of agriculture more attractive, reducing pressure on less fertile soils. Technological improvement may, however, also increase deforestation, depending on the particular circumstances and the type of technology (Angelsen & Kaimowitz, 2001). Increased access to salaried off-farm employment could also lead to increased consumption of imported foods, reducing the need for land to farm (cf. Kaimowitz & Angelsen, 1998, pp. 15-35). On a limited scale, this is already happening (see Chapter 7). On the other hand, the gradual reduction of the area of old-growth forest may as such be considered an environmental problem. This process is, however, happening at a very slow rate. The role of the Sarayaku people as political actors (see Chapters 2, 5, and 13) may, in current times, be more important for the future of the trees than their direct physical impact on them using axes and machetes.

8.5. Comparison of the methods

In order for the image analysis to give fairly accurate results, two steps were of crucial importance. First, the "equal area normalization" was used in order to correct for differences in illumination due to topography. Whereas this worked quite satisfactorily, it could be further improved by taking into account the different amount of atmospheric scattering for light at different wavelengths, in order to avoid the overcompensation of topographic shade effects in the visible bands, which introduced some spectral variation not related to the properties of the vegetation (Figs. 4.6, 4.7, 4.8). Second, within-image and between-image radiometric rectification was made based on the selection of old-growth forest areas as reference areas, which were assumed to have equal spectral properties at both dates of image acquisition, and all over the study area. Whereas this proved useful for this study, applying the same method to other places requires good knowledge of local ecosystems, as well as careful assessment of phenological phenomena or climatic variations that may affect the validity of such an assumption.

Both remote sensing and field plot data analysis can be used to estimate the amount of cultivated land, but the field plot data analysis seems to provide a more reliable estimate. Whereas the remote sensing method well distinguishes cultivated areas with a high percentage of bare soil from the surrounding vegetation, it fails to do so for cultivated land with a dense vegetation cover, most notably the plantain fallows. Moreover, remote sensing tends to overestimate the size of fields, because fields are high contrast objects, so that mixed pixels of fields and other land use classes tend to get classified as fields (Fig. 4.14). With more households in the random sample, the field plot data analysis would provide even better estimates, and could also have been used to estimate the areas of fibra palm, barbasco, pasture, and even regrowth on pasture.

The remote sensing method was used in order to estimate the total amount of young fallows (under 20 years of age). The field plot data analysis method, on the other hand, provided an estimate of the age distribution of fallows (Fig. 8.1). Combining both methods, it was possible to estimate the total area of fallows up to 65 years of age.

Unfortunately, in the sample of ground-truthed fallows used for these calculations, there were few fallows older than fifteen years. Little priority was given to the collection of such data because, in other parts of the Amazon, secondary succession generally has been shown to become indistinguishable from old-growth forest already around fifteen years of age (Lucas et al., 1993, 2002; Moran et al., 1994; Steininger, 1996, 2000). Given the problems with topographic shade and haze, I did not expect to be able to distinguish secondary succession even up to that age. Nevertheless, in this aspect the analysis was more successful than expected, and it could be further improved by ground-truthing more fallows between fifteen and thirty years of age.

This study focused on fallow age, but satellite sensors record spectral properties, not age as such. Spectral properties of the fallows depend on their botanical structure, which, in turn, depends not only on age, but also on soil characteristics and previous land use. The general impression during fieldwork was that fallows on hills with black soil, and on plains, regrow more rapidly and develop a denser canopy than those on hills with red soil. The field data was, however, insufficient to make a thorough assessment of how this affected spectral properties.

The remote sensing method did allow an assessment of how the proportions of different land use classes varied according to broadly defined geographical properties, such as distance to settlements and location within or outside the major alluvial plains (Figs. 8.3, 8.4, 8.7, 8.8). However, it was limited to two snapshots in time, 1987 and 2001, and could not account for particular site-specific characteristics such as soil type and topographic location. The field plot data analysis, on the other hand, provided data for seven decades of land use dynamics, and shows how site-specific characteristics such as soil type, topographic location and distance to settlement affects land use in terms of year of first clearing and fallow length (Figs. 8.1, 8.5, 8.6, 8.9).

The field plot data analysis method could potentially be improved by increasing the size of the random sample of households, and by refining the sampling strategy. Even when the household sample is randomized, their land use plots are not, because households choose sites to clear for fields in a non-random way. Particularly, they tend to make new fields close to old ones, thus providing considerable spatial autocorrelation. Random sampling of secondary forests was not attempted in this study, and would be quite difficult. It is quite straightforward for somebody to show all his/her cultivated areas during a few days, but showing all his/her fallows would be a formidable task. Random sampling in space is in principle possible, but to identify the owners of each randomly selected plot in order to record land use history would then be extremely laborious.

In summary, the remote sensing method and the field plot data analysis method complement each other, and the same field data can be used for both. Therefore, little, if any, extra fieldwork is needed in order to complement remote sensing with field plot data analysis, and I would recommend that fieldwork from the beginning of a study is planned in order to provide data for both methods of analysis.

Chapter 9: Hunting[22]

9.1. Introduction

Wild game is an important source of food for the Sarayaku people (see Chapter 7), and they consider game depletion to be a serious problem that affects the quality of their diet and their general well-being (see Chapter 6). This problem is not unique for Sarayaku, as wild game is an important source of food and income for millions of people in tropical rainforest regions around the world (Redford, 1992). On the other hand, game species perform important functions as herbivores, seed predators, and seed dispersers, and the absence of these animals could lead to significant ecological chain effects (e.g., Redford, 1992; Fragoso & Huffman, 2000; Roldán & Simonetti, 2001). For these reasons it is problematic that game populations in tropical rainforests are being overharvested (Redford, 1992; Robinson & Bennett, 2000).

The purpose of this chapter is to describe in some greater detail the characteristics of the wild game resource in Sarayaku, and its role in the livelihoods of the Sarayaku households (see also Chapter 7), and to assess the impact of hunting on game populations as well as how this impact in turn affects household economies. A descriptive part, covering hunting technology, hunting methods, and local zootaxonomy, is followed by the results of an empirical study and a model analysis.

9.2. Hunting in Sarayaku: General description

9.2.1. Weapons

Today the dominant hunting weapon is the shotgun. There are two common types, both of them manufactured in Ecuador; the muzzle-loader and the single tube cartridge-loaded ones (usually caliber 16). The muzzle-loaded shotguns are somewhat more expensive, have less power to kill large animals, and take quite some time to load, so that they basically give you only one chance to hit the target. Nevertheless, they are quite popular because the cost per shot is very low compared with the cartridges, and because they tend to last longer. The cartridge-loaded shotguns are cheaper, more effective for killing large game, and permit rapid reloading. The drawbacks are the high cost of the cartridges, and that the cartridge-loaded shotguns often need to be replaced about every year. Many households have both types of shotgun. Very few people have imported caliber 12 cartridge-loaded single-tube shotguns of better quality. The difference in cost per shot between cartridge-loaded and muzzle-loaded shotguns leads to slightly different hunting strategies. With a muzzle-loaded gun a wider range of species are hunted, including many small species that would not be worth the cost of a cartridge. The blowgun, which was a commonly used hunting weapon up until the

[22] This chapter is largely based on Sirén, A., P. Hambäck & J. Machoa (in press). Including spatial heterogeneity and animal dispersal when evaluating hunting: A model analysis and an empirical assessment in an Amazonian community. *Conservation Biology*. Blackwell Publishing Ltd.

1970's, is today mostly used for playful competition and as a training tool for children who hunt small birds around their homes. Occasionally, animals may be killed with spears, machetes, stones or even hands. In the 1980's some people bought '22 mm rifles, but these were expensive, and proved quite useless in the rainforest environment where you seldom get the time to aim very carefully and where the limited visibility limits the benefit acquired by the longer firing range of the rifle.

9.2.2. Hunting methods

It is not possible to classify hunting methods in any clear-cut way, because most subsistence activities are multi-purpose. What initially may have been thought of as a fishing trip may rapidly become a hunting trip if a game animal appears. A hunting trip primarily intended to hunt one particular species may end up in hunting another one. Nevertheless, for the purpose of this study, a typology of four major classes of hunting methods was elaborated (see also Chapter 4.5): Walking, waiting, canoeing, and dawning, and these are further described below.

9.2.2.1. Walking

Walking through the forest in daytime in order to hunt animals spotted on the way. All species can be encountered this way. Often all you need to do when you have spotted an animal is to react fast and shoot it. In order to shoot canopy-living birds and primates it is often necessary to wait for one to descend to a branch within reach of the shotgun. Large primates, particularly Wooly Monkey (*Lagothrix lagotricha*) are hard to kill and require that you hit them in the face or chest. Hunting Wooly Monkey is considered particularly exciting. You usually localize a troop by their typical sounds, then quietly approach them, carefully hiding beneath the understorey in order to avoid discovery. You carefully observe if a big one would descend to a branch within firing range and you shoot only when you can see its face. After the first shot the monkeys escape and you follow them running through the underbrush and may be able to get another one if you are lucky. When two or more people hunt wooly monkeys together, they spread out so that when one shoots the first shot, the other one may stand in the path of the fleeing ones. Tapirs (*Tapirus terrestris*) have so thick skin that they are difficult to kill with a shotgun unless you hit them exactly on a soft spot right behind the forelegs. Often hunters carry a 5mm homemade lead slug that they drop into the gun tube if they spot a tapir, in order to increase the impact of the shot. The foreign caliber 12 shotguns are significantly more powerful and extend the firing range basically all the way up to the treetops.

Hunting of white-lipped peccaries (*Tayassu pecari*) is distinct in that you usually first find the trails they leave when roaming around in large herds. Then (sometimes the next day) you search following the trail and may kill several individuals once you find the herd.

The use of a hunting dog greatly increases the chance to hunt some ground-living mammals. Collared peccaries (*Tayassu tajacu*), large and medium-sized rodents (*Agouti paca*, *Dasyprocta fuliginosa* and *Myoprocta* spp.) and armadillos

(*Dasypus* spp.) hide in burrows when chased by a dog. Collared peccaries can usually be shot in the burrow, by closing the entrance with poles to cage them in, and then frightening them back towards the poles by inserting a long palm frond with human urine on the tip. Sometimes up to three collared peccaries may enter the same burrow. Rodents and armadillos need to be dug out, which may take several hours, some times just to discover that the animal has escaped through another entrance. When chased by a dog, deer (*Mazama* spp.), paca (*A. paca*), and tapir (*T. terrestris*) often run to the nearest body of water where they can be killed, although the paca often escapes by diving. A particular type of tapir hunting is when one person searches through an area with a dog, and two others wait in a canoe in a river nearby with a spear, ready to spear the tapir if it would come swimming down the river. Some dogs are also good for hunting the Nocturnal Curassow (*Nothocrax urumutum*), a bird which they make ascend from the ground to a low branch where it can be shot. On the other hand, dogs often scare away birds and primates. Hunting with or without a dog therefore represents different strategies aimed at different species. Sometimes hunters also follow small creeks at night, searching with a torchlight for pacas (*A. paca*) and caymans (*Cayman crocodilus* and *Paleosuchus trigonatus*).

9.2.2.2. Canoeing

Travelling the river with canoe in the night searching the riversides with a torchlight for pacas (*A. paca*) and caymans (*C. crocodilus* and *P. trigonatus*).

9.2.2.3. Waiting

Large rodents (*A. paca* and *D. fuliginosa*) often enter fields to eat manioc and may do considerable damage. The way they chew on the manioc is distinctive, so that the species can easily be identified. As they follow a well-defined time table, hunters know when to wait for them. *A. paca* is active during the darkest hours of the night, so hunters take advantage of the nights when the moon rises early or sets late, so that there is only a couple of hours or less of complete darkness, and wait by its trail with a gun and a torchlight. Often they put an extra bait on the trail, such as some maniocs or plantains. Hunters also often wait for *A. paca*, *D. fuliginosa* and armadillos (*Dasypus* spp.) at fruit trees, mostly in secondary forest near the village but also in primary forest, often constructing an elevated platform nearby so that the animals should not smell the scent of the hunter. Deer and tapir are also waited for sometimes, but this is less common, and occurs mostly in the primary forest, after having encountered footprints where the animal has been eating fallen fruit.

9.2.2.4. "Dawning"

Waiting at the tree where a bird spends the night, in order to shoot it at dawn. This is particularly used for *N. urumutum*, which from August to February often sings all night until about an hour before dawn. While it is still dark you go out to listen and follow the song of the bird until you reach the tree. You wait nearby until dawn sets in, when the bird usually descends to a lower branch in a nearby tree and can be shot. Also *M. salvini* can be hunted in the same way. *Tinnamus* spp., on the other hand sing at dusk and at dawn, but not at night, so you need to listen carefully at dusk in order to know where to go to wait at dawn.

9.2.3. Preferences

Some species are clearly preferred above others. In the first place, preferences are determined by size, meaning that very small animals are not hunted at all, and medium-sized ones are hunted mostly when large ones are absent. There are, however, other preferences of culinary or cultural character. Particularly wooly monkey (*L. lagotricha*), nocturnal curassow (*N. urumutum*), Salvin's curassow (*M. salvini*) and collared peccary (*T. tajacu*) are considered delicacies, the kind of meat you want to offer when you invite people to your house. Of the other primates, howler monkey (*A. seniculus*) is also appreciated, while saki monkey (*Pithecia* spp.) and capuchin monkey (*Cebus* spp.) are considered meat of lower quality. The rodents *A. paca* and *D. fuliginosa* are also considered very good meat, while the capybara (*Hydrochaeris hydrochaeris*) is considered inferior meat. It is not very common and actively hunted only because it sometimes damages plantain plants. White-lipped peccary (*T. pecari*) is also appreciated, although shamans and people undergoing shamanistic treatment avoid it. Deer (*Mazama* spp.) is considered to be of slightly lower quality, although they are nevertheless preferred game species for their sheer size. The edentates are not much appreciated, although armadillos (Dasypoidae spp.) are commonly eaten anyway. Sloths may be eaten, while most people would not eat anteaters. That an animal is considered inferior meat does not mean that it is protected from hunting. It just means that it is not hunted if the hunter perceives he has got a chance to find better alternatives. Even if the hunter himself does not eat a particular kind of animal, he may kill it anyway in order to give it away to somebody less choosy.

9.3. Ethnozootaxonomy

The study of hunting was based on the locally used zootaxonomy. José Machoa and Cesar Santi assisted in making an initial list of commonly hunted species. With time, some further refinements of the list were made, according to information provided by various hunters. Finally, the locally used taxa were "translated" to scientific names, based on Durning (1987), Ortíz & Carrion (1991), Tirira (1996), and Emmons & Feer (1999).

In the locally used zoological taxonomy, there are often two or more "varieties" of the same animal "kind". In daily speech usually only the "kind" of animal is referred to, unless one specifically wants to specify which "variety" one refers to. When one "variety" is much more common than the other one, the more common one often bears the epithet "alli", meaning "proper", while the less common variety (or varieties) bears some other epithet describing its distinguishing characteristics. For example, *Cebus albifrons* is usually referred to simply as *machin*, but is also called *alli machin* in order to distinguish it from the much less common *Cebus apella*, which is called *yanamachin* because of its different colour ("yana" = black). Not all people know all varieties or how to differentiate between them, and the elders often know best. The different "varieties" in some cases seem to correspond to different species, in other cases they are known to be different morphological forms of the same species. In some cases, people assure that the different varieties do not interbreed, in other cases they are not sure.

For several of the more uncommon "varieties", I never got an opportunity to see one with my own eyes. Also, I never quite learned to distinguish the subtle differences between different varieties of some of the common game animals such as *P. jacquacu* or *P. tajacu*. The following description of the different varieties and, in some cases, identification of the varieties to species according to scientific taxonomy, is therefore largely based on José Machoa's knowledge of the local fauna and on additional information he collected from other hunters. Species identification based on second hand sources is of course risky. However, the descriptions provided for some of the more uncommon "varieties" were so strikingly similar to species described in the literature, although not necessarily from this particular geographical region, that we find it worthwhile to present this information here in order to stimulate further research on the taxonomy and biogeography of Amazonian fauna. The taxonomy and biogeography of Amazonian fauna still is somewhat confused, and there are considerable discrepancies between different authors (cf. Tirira, 1996; Emmons & Feer, 1999; Eisenberg & Redford, 1999). The information presented here hopefully may contribute to solving some of the remaining puzzles regarding the distribution of different species, and it can not be ruled out that some of the locally known "varieties" in the future will prove to be species yet not recognized as such. For example, the equatorial saki monkey (*Pithecia aequatorialis*) was described by science as late as in 1987 (Hershkowitz, 1987), but the Sarayaku people knew long before about the existence of this rare variety of the monkey they call *sipuru* (see below).

The tapir (*Tapirus terrestris*) is called *wagra* and is known in two varieties. The *jatun wagra* ("large wagra") is distinguished from the *shinluwagra* ("wagra of the shinlu palm") by its larger size and its white eartips. The *shinluwagra* is also considered to be more aggressive.

The collared peccary (*Tayassu tajacu*) is called *lumukuchi* and is known in two varieties: *alli lumukuchi* and *chinchalumukuchi* ("lumukuchi of the *chincha* palm"). About a fifth of the hunting kills reported by hunters were *chinchalumucuchi*. The chinchalumucuchi is distinguished by more white in the fur and a more visible white collar around the neck, as well as larger herds (8 – 15 as compared with up to six for *alli lumucuchi*). *Chinchalumucuchi* is also considered more aggressive.

The white-lipped peccary (*Tayassu pecari*) is called *wangana* and is known in two varieties, *jatun wangana* and *ichilla wangana*, meaning "big" and "small" wangana, respectively. *Jatun wangana* is bigger and almost completely black, while the *ichilla wangana* has a slightly reddish colour and whitish throat. In our study, *jatun wangana* was more frequently reported to have been hunted, but in many cases hunters did not report variety.

The *lumucha* (*Agouti paca*) is known in two varieties, *alli lumucha* and *yana* ("black") *lumucha*. *Alli lumucha* has a light reddish colour, while *yana lumucha* is darker. *Yana lumucha* is also considered to be bigger and to be more common in primary forest while *alli lumucha* is considered to be associated with fields and secondary forest. Our data, however, shows no significant differences in weight or habitat.

Punchana (*Dasyprocta fuliginosa*) is also known in two varieties: *Yana punchana* ("black") and *ruyak punchana* ("white"). *Yana punchana* is slightly bigger and almost all black, while *ruyak punchana* has more white in the fur. *Yana punchana* is considered to be more susceptible to hunting with dogs.

Chancha (*Myoprocta* spp.) exists in two varieties. *Alli chancha* has yellow-greenish fur, while *puka chancha* ("red") is more reddish. According to Eisenberg & Redford (1999), as well as Emmons & Feer (1999), only *M. pratti* is present in the Ecuadorian Amazon, but according to Tirira (1996) both *M. exilis* (apparently *alli chancha*), and *M. acouchy* (apparently *puka chancha*) are present in the region.

The squirrels (*Sciurus* spp.) are called *ardilla* (a Spanish term that has replaced the older term *waywashu*), and exist in three varieties. The most common one, *alli ardilla* ("proper squirrel"), corresponds to *S. spadiceus*, whereas the *ramusardilla* (squirrel of the *Ramus* palm, Arecaeae sp.) has white belly, corresponding to *S. igniventris*. The third, and most rarely killed variety, *kunambuardilla* (squirrel of the *kunambu* palm, *Attalea butyracea*), is distinguished by its reddish tail and lives exclusively in areas where the kunambu palm is present, as it prefers to eat its fruit. This does not seem to correspond to any species described in the literature.

The wooly monkey (*Lagothrix lagotricha*) is locally called *kushillu* and is known in two varieties: *Pukakushillu* ("red kushillu") and *ushpakushillu* ("Gray kushillu"). *Pukakushillu* is reddish light brown and slightly smaller than the *ushpakushillu*, which is light brown on the back and black on the abdomen. According to our data, the pucakushillu seems to be slightly more common than the ushpakushillu. The two varieties usually travel in different groups. This phenomenon has also been observed in other areas, which has led to speculations that there may be more than one species (Emmons & Feer, 1999).

The night monkey (*Aoutus* spp.) is called *tutakushillu*. The most common variety, *alli tutakushillu* is *A. vociferans*, but also another variety is known, the *jurijuritutakushillu*. This may be *A. lemurinus*, although the closest occurrence of this species described in the literature is on the subtropical Andean slopes.

The saki monkey (*Pithecia* spp.) is called *sipuru* and is known in two varieties. The most common one is referred to as *alli sipuru* (*P. monachus*), but on rare occasions also another variety known as *pukawapusipuru* ("red throat sipuru") or *jumbiwapusipuru* ("sweaty throat sipuru") is killed. The *pukawapusipuru* has a reddish light brown spot on the chest, indicating that it corresponds to *P. aequatorialis*. It lives in bigger groups than the *alli sipuru*, about 7 to 12 individuals. Out of sixteen reported kills of *sipuru* in this study, only one was reported as *pukawapusipuru*.

There are three varieties of sloth, *indillama*. The *ishtirillasindillama* ("star sloth") is *Bradypus variegatus* and the *jatun indillama* ("large sloth") seems to correspond to *Choloepus didactylus*. The *taraputuindillama* (“sloth of the *taraputu* palm, *Iriartea deltoidea*”) is probably *Choloepus hoffmani*.

The nine-banded armadillo, *armalillu* (*Dasypus novemcinctus*) is known in two varieties, *alli armalillu* (“proper armadillo”) and *purunarmalillu* (“armadillo of the secondary forest”), not to be confused with the *sima* (*Dasypus kappleri*). The *purunarmalillu* is smaller and has bigger litters, 4 – 6 as compared with the 2 – 4 of *alli armalillu*. The *purunarmalillu* is considered to be more associated with secondary forests, but this is not supported by our data, that includes eight *alli armalillu* hunted in secondary forest and four in primary forest, as compared with five *purunarmalillu* hunted in secondary forest and five in primary forest.

The *tijun* (*Nasua nasua*) is also known in two varieties, *alli tijun* and *jurijuritijun*. The jurijuritijun is just slightly smaller and has a darker colour, big canines and is aggressive against dogs. This description appears to be similar to *Nasuella olivaceae*, although this species in the literature is described only from the subtropical Andean slopes. Except for certain individuals, both varieties live in large groups.

The bird *munditi* (*Nothocrax urumutum*) is known in two varieties, *jatun munditi* (“large”) and *idzi munditi* (“small”). jatun munditi is bigger and lives in groups of three of more. Similarly, there are two varieties of *karundzi* (*Penelope jacquacu*), *jatun karundzi* (“large”) and *ichilla karundzi* (“small”).

There are three known varieties of land turtle, the *alli tsahuata*, *chinchatsahuata*, and *pukahuiña*. These are very distinct in size and appearance, but are just different morphological forms of the same species, *Geochelone denticulate* (pers. comm. Iván Jácome).

9.4. Evaluation of the status of game and the impact of hunting

This study aimed at assessing the extent of overharvest of wild game, both in terms of the range of species that were overharvested, and the spatial extent of any such overharvesting. Also, it aimed at assessing the socio-economic impact of game depletion, in terms of reduced harvest and increased hunting effort. As there were no appropriate standard methods available, this implied a considerable effort of method development, involving both a field study and the development of a computer model in order to facilitate interpretation of the field data. In brief, field data were collected by means of a form provided to hunters (Fig. 4.17) who volunteered to report all their hunting activities. They reported not only their hunting kills, but also their hunting effort, by drawing, on a map of the study area, the trajectories they had walked while hunting. The map was divided into 148 areas, which permitted collecting the data with a fairly high level of spatial detail. According to the intensity of hunting in each area, these were clumped together into seven hunting intensity zones. The status of each species was evaluated based on the variation in harvest between these hunting intensity zones. In order to facilitate the interpretation of the field data, particularly to assess the potential impact of animal dispersal on the observed patterns, a computer model was constructed. These methods are described in detail in Chapter 4.5.

9.4.1. Annual harvest of different species

Hunting kills were reported for about 70 species, and the total annual harvest of game made up a weight of about 35 metric tons. The most frequently hunted animals are medium-sized birds and medium to large sized rodents (Table. 9.1). In terms of weight, mammals, particularly ungulates and rodents, are important (Table. 9.2). The heavy reliance on ungulates and large rodents and the fairly modest contribution of primates (7%) is common in modern Amazonian societies and stands in contrast to the heavier reliance on primates that still is common in societies with lower population density and where blowguns have still not been completely replaced by shotguns (Mena et al., 2000; Yost & Kelley, 1983**)**

9.4.2. Seasonal variation

Seasonal variations in hunting patterns are largely governed by three factors: Weather, school vacations and the annual community festival. During rainy weather hunting in nearby fields and secondary forests increases, and people do not make long hunting trips. During school vacations people spread out to spend vacations in their *purinas* (secondary homes, see Chapter 2) in order to enjoy better hunting and fishing. For the community festival, special festival hunters go out to the most remote forest areas in order to hunt "good meat". The seasonal variation in hunted weight is shown in Fig. 9.1. The hunted weight is larger during the months of school vacations than other months, but the amount hunted during February, the month of the community festival, is fairly small when compared with the other months.

Table 9.1 (opposite page). Animals reported as hunted, ordered according to the number hunted annually. The ten most important game animals in terms of annual weight hunted are marked with bold text. Weights according to Mena (2000), Peres (2000), and our own field data. The entries in the list are according to the animal "kinds" according to the local ethnozootaxonomy. Some of these "kinds" of animals are locally known in different "varieties" which, in some cases, correspond to different species, and in other cases different morphological forms of the same species (see notes below, and section 9.3).

1, Tinnamus *spp: Six unidentified varieties, some of them possibly belonging to the genus* Crypturellus*; 2,* Ramphastos *spp: Three varieties, of which two unidentified. 50% of the reported kills were for* R. tucanus*, and for 21% the variety was not reported; 3,* Sciurus *spp: Three varieties. 45% of reported hunting kills were* S. spadiceus*, 15%* S. igniventris*, 6% unidentified variety (*kunambuardilla*), and for the remaining 34% the variety was not reported; 4.* Myoprocta *spp: Two varieties. 34% of reported hunting kills were* M. exilis*, 26%* M. acouchy*, and for 40% the variety was not reported; 5,* Pteroglossis *spp: Two varieties. 42% of reported hunting kills* P. flavirostris*, 11%* P. pluricinctus*, and for 47% the variety was not reported; 6.* Columbidae *spp.: Various varieties, hunting kills not reported to the level of varieties. 7.* Psarocolius *spp. Six varieties, most of them unidentified; 8,* Bassaricyon alleni *&* Potos flavus*: 39%* B. alleni*, 39%, 21%* P. flavus*, and for 39% the variety was not reported; 9,* Cebus *spp.:* C. albifrons *81%,* C. Apella *3% (one reported kill), for 17% the variety was not reported; 10, Unidentified birds: Five kinds; 11,* Choloepus *spp.:* C. didactylus *42%,* C. Hoffmanni *8% (one reported kill), not reported to variety level 50%; 12, Unidentified parrots (Psittacidae): Four kinds; 13,* Nasua *&* Nasuella*: 47% Alli Tijun* (Nasua nasua)*, 24% jurijuritijun, perhaps* Nasuella olivaceae*, 29% not reported to variety level; 14.* Pithecia *spp: 63%* P. monachus*, 6*% P. aequotarialis *(one reported kill), 31% not reported to variety level.*

Species		No. / year	No. in sample	weight (kg)	kg/year	% of annual weight
Tinnamus spp.[1]	**Bird**	**1427**	**269**	**0.99**	**1413**	**4.0**
Penelope jacquacu	Bird	995	211	1.16	1155	3.3
Ramphastos spp. [2]	Bird	980	243	0.59	578	1.7
Sciurus spp. [3]	Rodent	848	155	0.64	542	1.6
Agouti paca	**Rodent**	**713**	**129**	**7.87**	**5613**	**16.1**
Nothocrax urumutum	Bird	672	133	1.71	1148	3.3
Dasyprocta fuliginosa	**Rodent**	**544**	**96**	**3.96**	**2156**	**6.2**
Myoprocta spp. [4]	Rodent	543	93	0.88	478	1.4
Odontopbrus erythrops	Bird	482	95	0.53	255	0.7
Pteroglossus spp. [5]	Bird	467	83	0.38	177	0.5
Saguinus fuscicollis	Primate	443	93	0.40	177	0.5
Columbidae spp. [6]	Bird	327	53	0.25	82	0.2
Psophia crepitans	Bird	286	64	1.05	301	0.9
Psarocolius spp. [7]	Bird	273	48	0.53	145	0.4
Lagothrix lagotricha	**Primate**	**200**	**114**	**5.79**	**1161**	**3.3**
Dasypus novemcinctus	Edentate	193	33	4.43	857	2.5
Aoutus vociferans	Primate	177	36	0.89	157	0.5
Bassaricyon alleni & Potos flavus[18]	Carnivora	163	33	2.28	371	1.1
Pecari tajacu	**Ungulate**	**156**	**80**	**20.43**	**3185**	**9.1**
Ortalis motmot	Bird	155	27	0.47	73	0.2
Mazama americana	**Ungulate**	**150**	**75**	**20.23**	**3031**	**8.7**
Cebus spp. [9]	Primate	134	65	2.88	387	1.1
Cacicus cela	Bird	124	24	0.53	66	0.2
Caiman crocodilus	**Reptile**	**110**	**51**	**12.49**	**1368**	**3.9**
Unidentified birds[10]	Bird	100	19	0.25	25	0.1
Geochelone denticulata	Reptile	99	21	5.15	511	1.5
Mazama gouazoubira	**Ungulate**	**95**	**46**	**18.00**	**1708**	**4.9**
Choloepus spp. [11]	Edentate	90	16	4.15	373	1.1
Unidentified Psittacidae spp. [12]	Bird	82	15	0.47	38	0.1
Nasua nasua & Nasuella olivaceae[13]	Carnivora	78	17	3.05	238	0.7
Dasypus kappleri	Edentate	72	12	7.65	554	1.6
Amazonia farinosa	Bird	66	12	0.67	44	0.1
Alouatta seniculus	Primate	66	36	7.02	464	1.3
Pithecia spp. [14]	Primate	62	16	2.46	152	0.4
Ara macao	Bird	56	10	1.04	58	0.2
Paleosuchus trigonatus	Reptile	49	23	5.15	254	0.7
Tayassu pecari	**Ungulate**	**48**	**27**	**32.00**	**1541**	**4.4**
Crypturellus undulatus	Bird	44	11	0.53	23	0.1
Pionus menstruus	Bird	43	9	0.53	23	0.1
Mitu salvini	Bird	39	22	3.06	121	0.3
Pipile pipile	Bird	35	9	1.30	45	0.1
Tupinambis teguixin	Reptile	34	4	1.00	34	0.1
Sylvilagus brasiliensis	Rodent	29	5	1.02	29	0.1
Tapirus terrestris	**Ungulate**	**24**	**12**	**125.80**	**3035**	**8.7**
Microstur mirandallei	Bird	21	6	2.00	43	0.1
Ara severa	Bird	21	3	0.53	11	0.0
Aramides cajanea	Bird	17	3	0.53	9	0.0
Myrmecophaga tridactyla	Edentate	16	2	27.00	424	1.2
Saimiri sciureus	Primate	12	2	0.69	8	0.0
Ara chloroptera	Bird	12	6	1.04	12	0.0
Ateles belzebuth	Primate	8	4	6.80	55	0.2
Podocnemis unifilis	Reptile	6	1	3.78	23	0.1
Bradypus variegatus	Edentate	5	1	4.15	22	0.1
Hydrochaeris hydrochaeris	Rodent	5	1	33.71	174	0.5
Total		11897	2674		34929	100

Table 9.2. Annual harvest of major taxonomic groups in terms of number and weight.

	Number / year	Weight (kg / year)	% weight / year
Mammals	4875	26893	77.0
Ungulates	*473*	*12500*	*35.8*
Rodents	*2682*	*8992*	*25.7*
Primates	*1102*	*2562*	*7.3*
Edentates	*377*	*2230*	*6.4*
Carnivores	*241*	*609*	*1.7*
Birds	6725	5845	16.7
Reptiles	298	2190	6.3
Sum	11897	34929	100.0

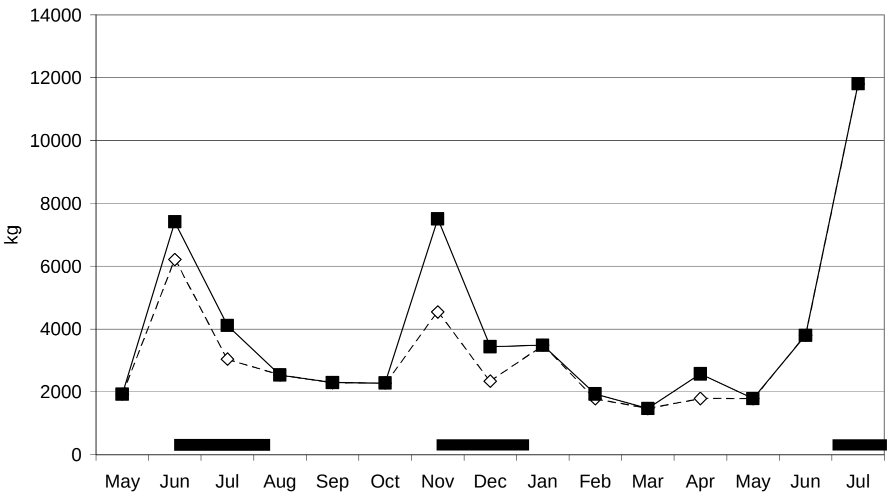


Fig. 9.1. Seasonal variation in monthly weight of game harvest from May 1999 to July 2000. The broad black lines indicate the timing of school vacations, which were from mid-June to early August 1999, from mid-November 1999 to early January 2000, and in July 2000. Community festival was held in February 2000. Game harvests are higher during school vacations, whereas the community festival, held in February, does not seem to imply any increase in game harvest. The broken line represents weights when tapirs are excluded. The estimates for the first and the last month are based on smaller samples than for the other months.

The festival, although often blamed as a prime driver of game depletion, actually makes up only 3.3% of total annual game harvest by weight. For most species, the impact of the festival hunting is negligible when compared with the impact of the hunting during the rest of the year (Fig. 9.2). However, for eleven species the festival hunting constitutes more than 10% of the annual harvest. Several of these species are known to be severely overexploited *(L. lagotricha*, *M. salvini* and *P. pipile*, see below), and two of them *(P. aequatorialis* and *C. apella*) are extremely rare and the hunting kills reported from the festival hunting were the only hunting kills reported for them at all during the study period.

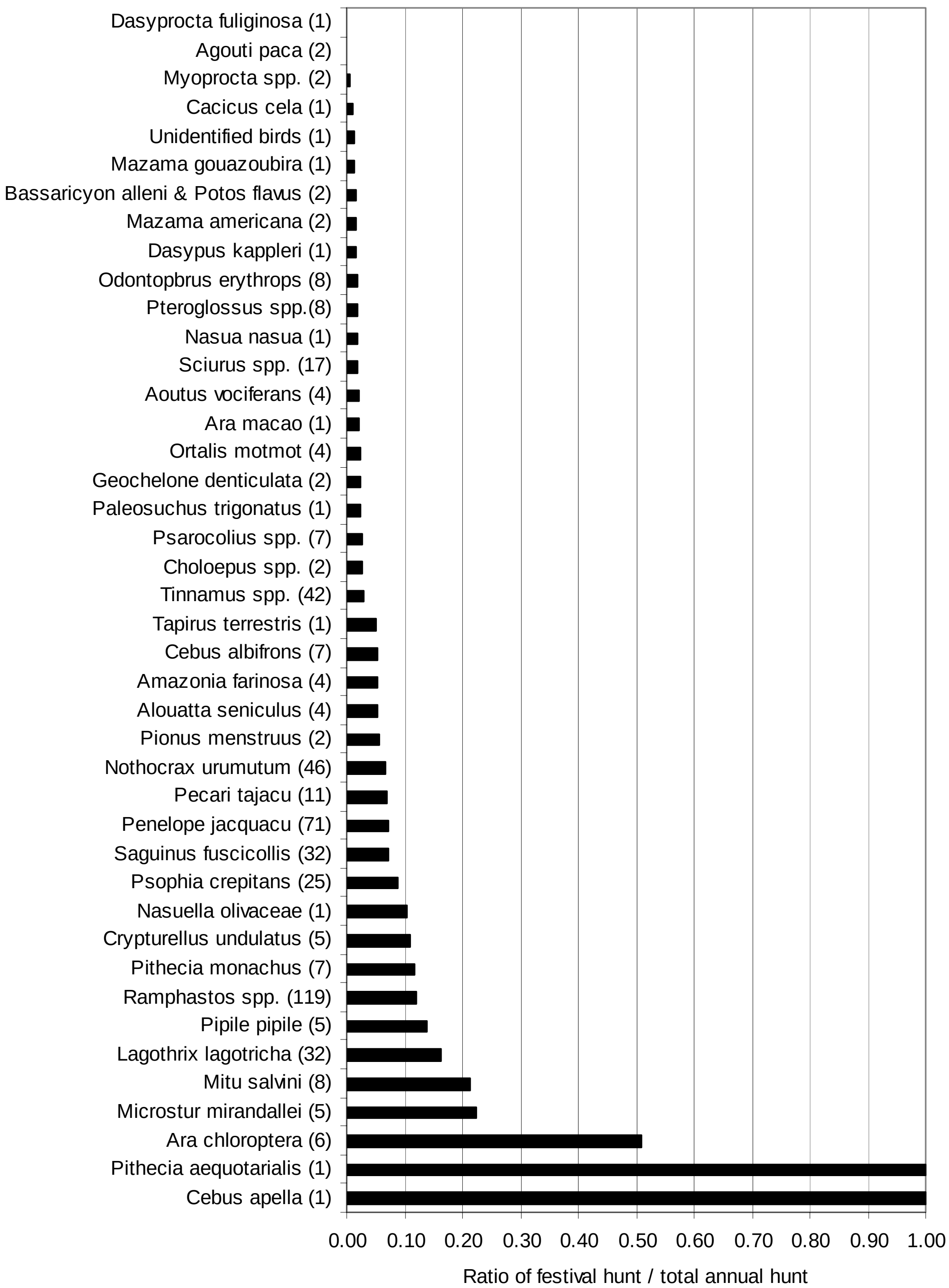


Fig. 9.2. Animal harvest during hunting for the community festival in year 2000, in comparison with the total annual harvest. Numbers in parentheses show absolute number harvested of each species during festival hunting. For most species, the harvest during festival hunting is small compared with the total annual harvest.

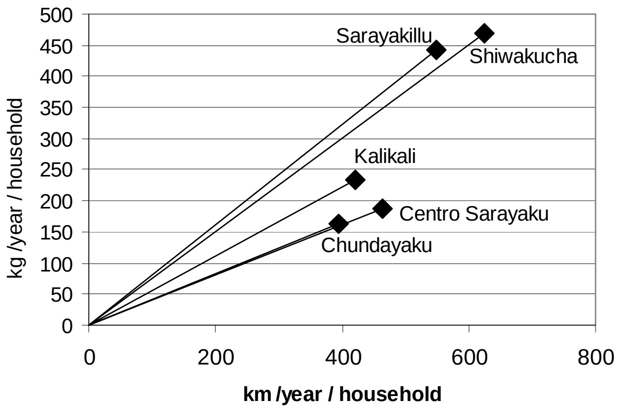


Fig. 9.3. Variation between hamlets in hunting effort and annual hunted weight. The lines represent catch per unit of effort (kg/km). The steeper the slope, the higher the catch per unit of effort.

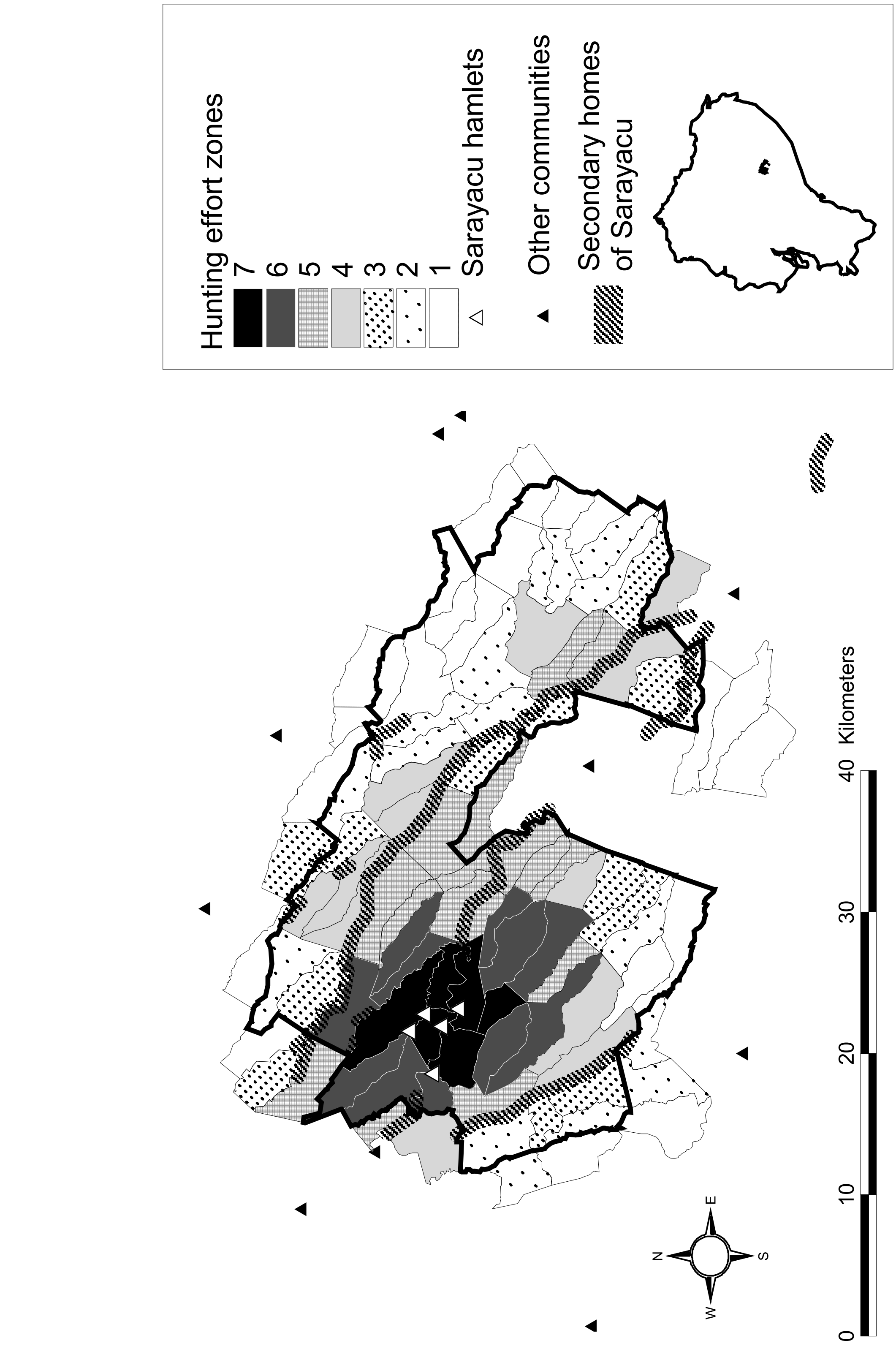
9.4.3. Variation between hamlets

There was considerable variation in game harvest between the hamlets. The annual game harvests per household for the Shiwakucha and Sarayakillu hamlets were two or three times higher than for the other hamlets (Fig. 9. 3). This was partly because the households in Shiwakucha and Sarayakillu spend more effort on hunting. But the catch per unit of effort, in terms of hunted weight per kilometer walked, was also higher for these hamlets, reflecting the fact that, in comparison with the other hamlets, they hunted more in the remote areas where animal populations are strong.

9.4.4. Spatial variation

Hunting effort was 37 times higher in the central area (zone 7) than in the most remote area (zone 1), and the distribution of hunting in space approximately followed a Gaussian distribution (Figs. 9.4 and 9.5). The harvest in kilograms per year per square kilometer increases from zone 1 (lowest hunting effort) to zone 3, then changes little up to zone 6, before it sharply peaks in zone 7 where hunting effort is highest (Fig. 9.6). Overall catch per unit of effort, in terms of harvested weight per kilometer walked, on the other hand, is highest in zones 1 and 2, and then decreases gradually to just a sixth of the maximum level in zone 7 (Fig. 9.6). This difference reflects both a decrease in the number of hunting kills per kilometre walked, and a decrease in the average weight of the animals hunted as large animal species, in particular, are hunted out near the village. Except for zone 7, the human impact on the vegetation cover was negligible (Table. 9.3), and it was therefore fairly reasonable to assume that the area, for most species, was homogenous in terms of habitat quality.

Fig. 9.4 (opposite page). Settlements, areas used for data collection, and hunting effort zones. The darker the shading the greater the hunting effort. The heavy black line delimits the area we assumed to be hunted exclusively by people from Sarayaku. For the areas outside this line, we assumed that hunters from Sarayaku hunted only half the area, whereas hunters from other communities hunted the other half (Map source data: Instituto Geográfico Militar 1:50,000, ESRI ArcWorld Supplement).


Hunting effort zones
7
6
5
4
3
2
1
Sarayacu hamlets
Other communities
Secondary homes of Sarayacu
N
E
S
W
0
10
20
30
40
Kilometers

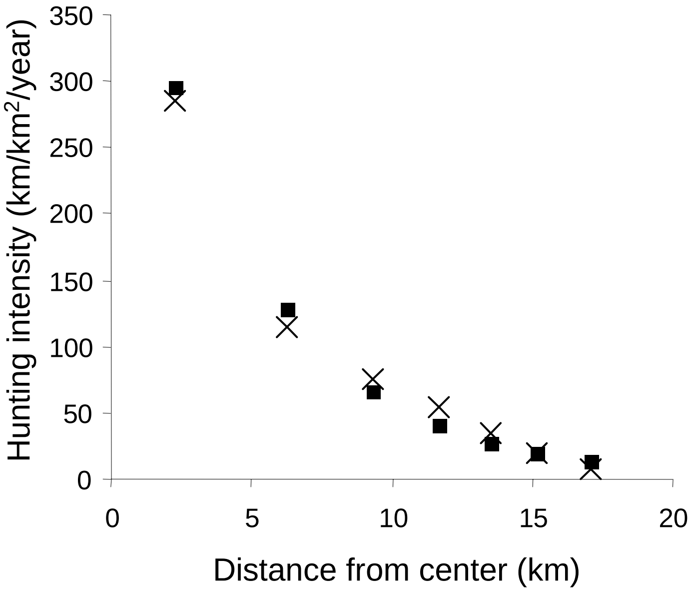


Fig. 9.5. Spatial distribution of hunting intensity. The distance on the x-axis represents the mean distance of each hunting effort zone to the central plaza of Sarayaku if the hunting effort zones were organized as concentric rings (compare with Fig. 9.4 for true spatial organization of hunting effort zones). Crosses indicate empirically found intensity values, and the squares indicate values predicted by a normal distribution of the same total hunting effort.

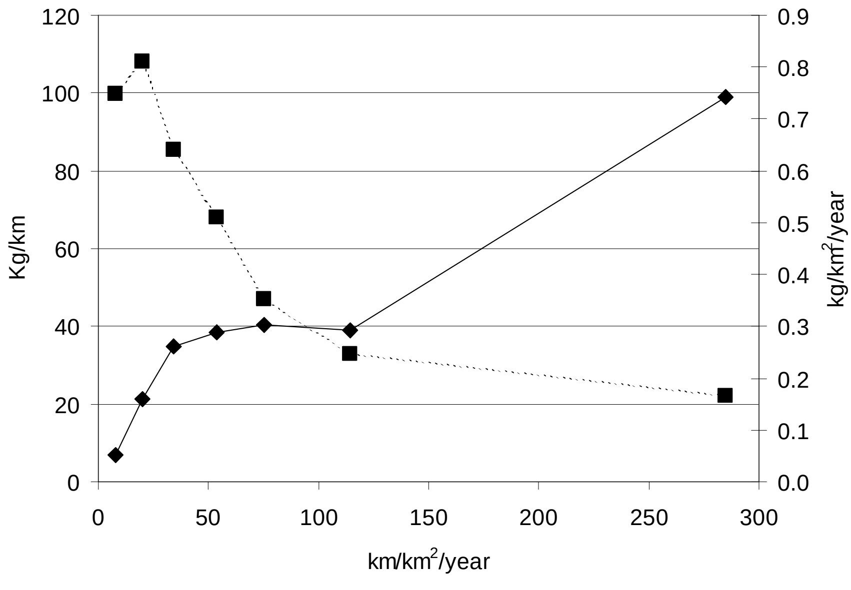


Fig. 9.6. Annual harvested weight per unit area (continuous line, right y-axis) and catch per unit effort (dashed line, left y-axis), for all species together, as functions of hunting effort in the seven zones, from zone 1 (far left) to zone 7 (far right).

Table. 9.3. Hunting effort and proportions of different types of vegetation for each hunting effort zone, according to remote sensing analysis (see Chapter 4.4.1. for classification procedure).

Zone[a]	Hunting effort (km/km^2/ year)	Area (km^2)	Forest [b] (%)	Young [c] fallow (%)	Fields (%)
1	8	222	99.9	0.1	0.0
2	20	161	99.8	0.2	0.0
3	34	143	99.0	0.9	0.1
4	54	148	99.0	0.9	0.0
5	75	156	98.0	1.8	0.1
6	114	136	96.9	3.0	0.2
7	285	63	74.6	23.5	1.9
Total	61	1028	97.7	2.2	0.2

[a] Zones pictured in Fig. 9.4.
[b] Mostly old-growth forest, but also small areas of natural secondary forest and fallows older than 20 years.
[c] Fallows younger than 20 years.

For twelve selected game species (Table. 9.4), preferred by hunters for their size and taste, we examined the harvest rate as a function of hunting effort and the catch per unit of effort (CPUE) as a function of hunting effort. A decreasing harvest rate with an increasing hunting effort indicates local overharvest. On the other hand, decreasing CPUE with increasing hunting effort indicates that hunting reduces population densities, and when this decrease is substantial, it may indicate local overharvesting. Based on this analysis, we grouped the species into four groups, according to their level of overharvesting:

Group 1 (*L. lagotricha*) was the most overharvested (Fig. 9.7 a-b). There was a negative correlation between harvest and hunting effort and a negative correlation between CPUE and hunting effort.

Group 2 species (*T. tajacu*, *T. terrestris*, *M. salvini*, *N. urumutum*, and *M. gouazoubira*) (Fig. 9.7 c-l) showed signs of overharvesting, but to a smaller degree than group 1 species. Similar to group 1, there was a negative correlation between CPUE and hunting effort, but there was no correlation between harvest rate and hunting effort. Instead, there was a peak in harvest rate at an intermediate hunting effort. The sharp decrease in CPUE values therefore occurred at higher hunting efforts for the group 2 species than for the group 1 species, indicating that populations in zones of low hunting intensity may be less reduced by hunting.

Table. 9.4. Annual harvest and biological characteristics of the species studied.

Species	Annual harvest (% of total weight)	Average weight (kg)[a]	Annual harvest (No.)	Annual harvest / MSY[b]	Hunting methods (% of hunting kills) Walk[c]	Canoe[c]	Wait[c]	Dawn[c]	By Chance[d]	Max. finite rate of increase (λ_{max})[e]	Home range (km²)[e]
Agouti paca (rodent)	16.1	7.9	713	0.52	37	2	59	0	2	1.95[5]	0.015-0.034[13]
Tayassu tajacu (ungulate)	9.1	20.4	156	0.06	100	0	0	0	0	3.49[5]	1.6-2.4[14]
Tapirus terrestris (ungulate)	8.7	125.8	24	0.78	90	10	0	0	0	1.22[5]	16.4[19], 5.9 / 39[20], ~25[f]
Mazama americana (ungulate)	8.7	20.2	150	0.20	77	11	8	0	5	1.49[5]	ND[g]
Dasyprocta fuliginosa (rodent)	6.2	4.0	544	0.05	43	0	55	0	2	3.00[5]	ND[g]
Mazama gouazoubira (ungulate)	4.9	18.0	95	0.07	93	0	5	0	3	1.63[5]	0.25-0.34[15]
Tayassu pecari (ungulate)	4.4	32.0	48	0.05	100	0	0	0	0	2.32[5]	21.8-109.6[12], nomadic/migratory[10]
Lagothrix lagotricha (primate)	3.3	5.8	200	0.78	99	0	0	0	1	1.15[5]	7.6[9], >8.6[7], 1.7[8], 3.5[2], 7.4[3], 3.5-4.5[4]
Nothocrax urumutum (bird)	3.3	1.7	672	ND	64	0	0	36	0	ND[g]	ND[g]
Alouatta seniculus (primate)	1.3	7.0	66	0.16	96	0	0	0	4	1.17[5]	up to 1.8[21], 0.22[1]
Mitu salvini (bird)	0.3	3.1	39	ND	72	0	0	22	6	1.46[11]	1.5[18]
Ateles belzebuth (primate)	0.2	6.8	8	0.04	100	0	0	0	0	1.08[5]	2.8[22]

[a] Based on Refs 16, 17 and our own data
[b] Annual harvest divided by maximum sustainable yield according to Ref 5
[c] See Chapter 9.2.2.
[d] Hunts of animals encountered when not carrying a shotgun. In some cases animals were killed with a harpoon or machete, in other cases, the hunter ran to a nearby house to get a shotgun.
[e] 1, Gaulin and Gaulin quoted by Ref 7; 2, Soini 1986 quoted by Ref 9; 3, Defler quoted by Ref 6; 4, Nishimura 1990 quoted by Ref 6; 5, Robinson and Redford 1991; 6, Strier 1992; 7, Peres 1994 quoted by Ref 9; 8, Stevenson 1994 quoted by Ref 9; 9, Defler 1996; 10, Peres 1996; 11, Bezago and Bodmer 1998; 12, Fragoso 1998; 13, Beck-King et al. 1999; 14, Judas and Henry 1999; 15, Barrientos-Segundo and Maffei 2000; 16, Mena 2000; 17, Peres 2000; 18, Santamaria and Franco 2000; 19, Herrera and Taber 2001; 20, Medici et al. 2001; 21, Palacios and Rodriguez 2001; 22, Suarez 2002
[f] Based on observations of a tagged free-ranging semi-wild tapir in our study area
[g] no data

Group 3 species (*M. americana*, *T. pecari*, and *A. seniculus*) show ambiguous results from the analysis. Similar to groups 1 and 2, CPUE and hunting effort were negatively correlated for *M. americana* (Fig. 9.7m), but there was also a positive correlation between harvest rate and effort (Fig. 9.7n). *T. pecari* and *A. seniculus* showed no correlation for either regression (Fig. 9.7o-r). The lack of correlation between CPUE and hunting effort may mean that species are not being overharvested, whereas the lack of correlation between harvest rate and hunting effort may indicate overharvesting. However, hunters often killed several individuals of these species at the same time, so the results are sensitive to single hunting events.

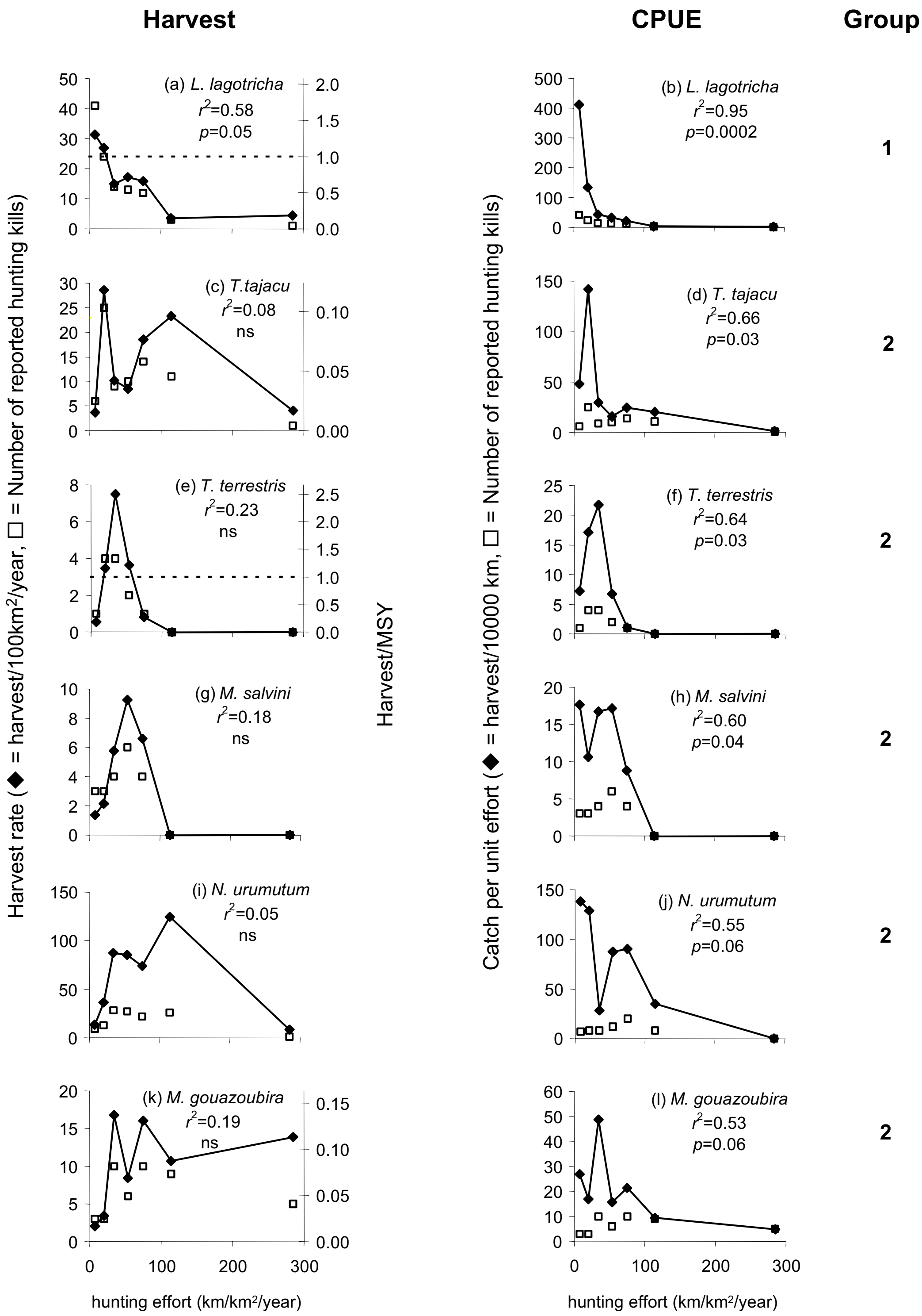
Group 4 species (*A. paca*, *D. fuliginosa*, and *A. belzebuth*, Fig. 9.7s-y) showed no indications of overharvesting. Harvest rate and hunting effort were positively correlated, and there was no correlation between CPUE and hunting effort.

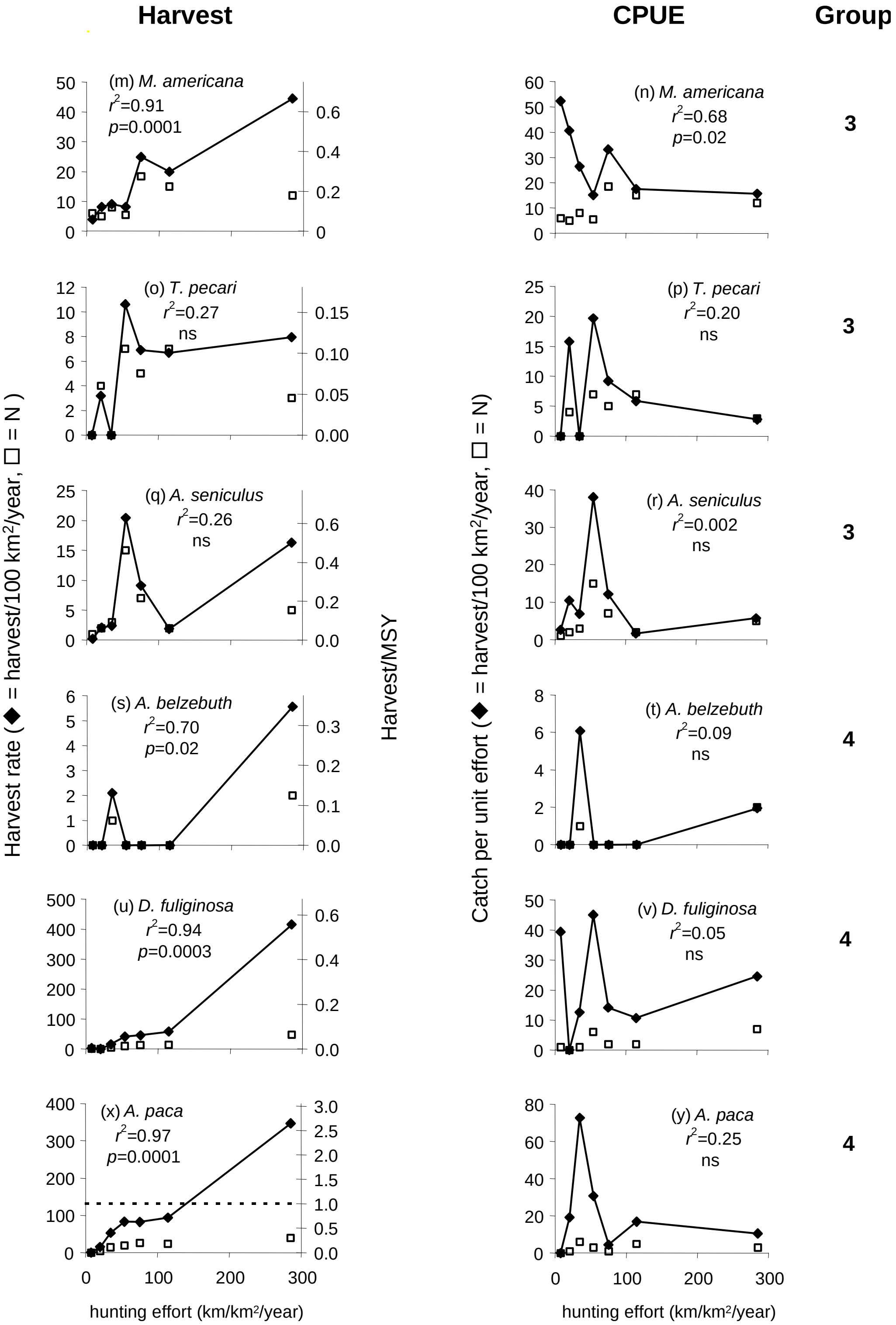
For those species showing signs of overharvesting (groups 1 and 2), we visually examined where each species was overharvested using the criterion that CPUE should be considerably < 60% of the maximum CPUE (see Robinson & Redford, 1991). According to this criterion, all group 2 species are overharvested in zones 6 and 7 and in some cases also in zones 4 and 5 (*T. tajacu* and *T. terrestris*), whereas *L. lagotricha* is overharvested in zones 2-7. Because the maximum CPUE may underestimate the carrying capacity, this criterion provides only minimum estimates of the spatial extent of overharvest.

9.4.5. Spatial interaction model

In the model analysis, we related the total harvest for the area to the maximum total harvest at a given dispersal and reproduction rate, because the maximum total harvest occurs at different hunting efforts for different dispersal and reproduction rates. For all scenarios, the maximum harvest occurred at an intermediate effort and we examined three hunting scenarios in relation to the peak harvest (Fig. 9.8): good management (90% of maximum harvest, Fig. 9.9a-d); moderate overharvesting (80% of maximum harvest, Fig. 9.9e-h); and severe overharvesting (20% of maximum harvest, Fig.9.9j-m). The reasons for selecting a harvest level less than maximum harvest to represent good management was because (a) this way total hunting effort is reduced, which *per se* is desirable for hunters, and (b) the maximum harvest is rather unstable, as a small increase in hunting effort would lead to a considerable reduction in harvest (Fig. 9.8).

Figure 9.7 (next pages). Harvest rate (graphs on the left) and catch per unit effort (CPUE, graphs on the right) as a function of local hunting effort for 12 game species hunted in the village of Sarayaku. Each graph shows mean values for the seven hunting zones where a higher value on the x-axis indicates a higher hunting effort. The right y-axis in the graphs on left shows values on harvest/maximum sustainable yield as calculated from Robinson and Redford (1991). Species are divided into 4 groups depending on the shape in the relation between variables. Group 1 species show a negative relation for both harvest rate and CPUE in relation to hunting effort. Group 2 species show a negative relation only between CPUE and hunting effort. Group 3 species showed ambiguous results. Group 4 species showed only a positive relation between harvest rate and hunting effort.


Harvest
CPUE
Group
(a) L. lagotricha
r2=0.58
p=0.05
(b) L. lagotricha
r2=0.95
p=0.0002
1
(c) T.tajacu
r2=0.08
ns
(d) T. tajacu
r2=0.66
p=0.03
2
(e) T. terrestris
r2=0.23
ns
(f) T. terrestris
r2=0.64
p=0.03
2
(g) M. salvini
r2=0.18
ns
(h) M. salvini
r2=0.60
p=0.04
2
(i) N. urumutum
r2=0.05
ns
(j) N. urumutum
r2=0.55
p=0.06
2
(k) M. gouazoubira
r2=0.19
ns
(l) M. gouazoubira
r2=0.53
p=0.06
2
Harvest rate (◆ = harvest/100km2/year, □ = Number of reported hunting kills)
Harvest/MSY
Catch per unit effort (◆ = harvest/10000 km, □ = Number of reported hunting kills)
hunting effort (km/km2/year)
hunting effort (km/km2/year)



Harvest
CPUE
Group
(m) M. americana
r^2=0.91
p=0.0001
(n) M. americana
r^2=0.68
p=0.02
3
(o) T. pecari
r^2=0.27
ns
(p) T. pecari
r^2=0.20
ns
3
(q) A. seniculus
r^2=0.26
ns
(r) A. seniculus
r^2=0.002
ns
3
(s) A. belzebuth
r^2=0.70
p=0.02
(t) A. belzebuth
r^2=0.09
ns
4
(u) D. fuliginosa
r^2=0.94
p=0.0003
(v) D. fuliginosa
r^2=0.05
ns
4
(x) A. paca
r^2=0.97
p=0.0001
(y) A. paca
r^2=0.25
ns
4
Harvest rate (◆ = harvest/100 km²/year, □ = N)
Harvest/MSY
Catch per unit effort (◆ = harvest/100 km²/year, □ = N)
hunting effort (km/km²/year)
hunting effort (km/km²/year)

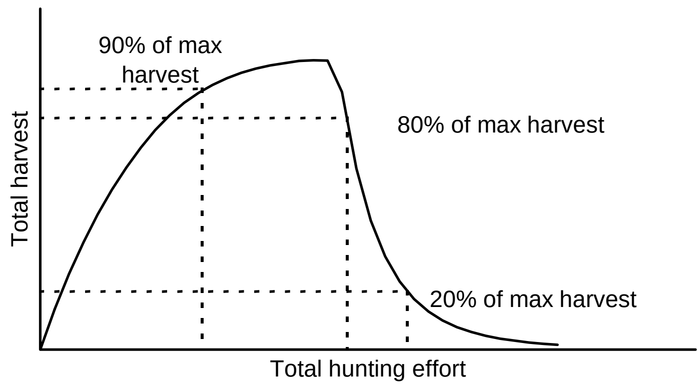


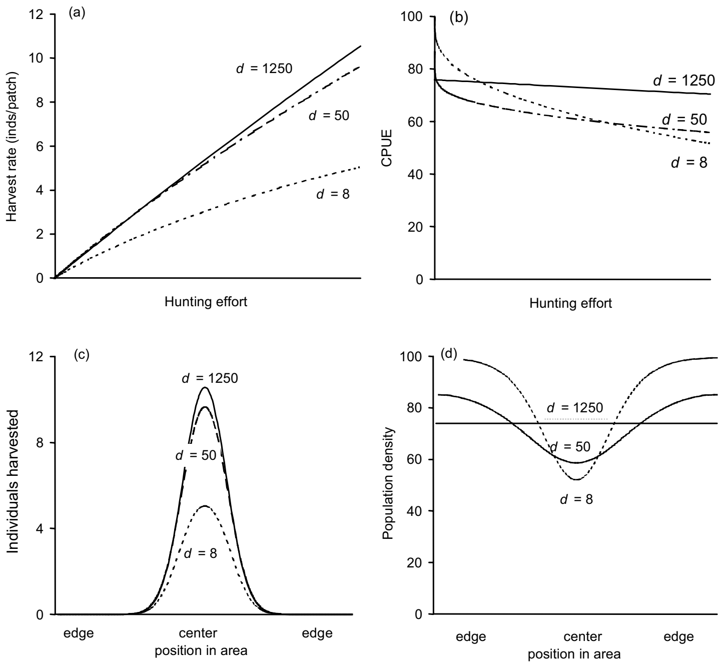
Figure 9.8. The distribution of total harvest in relation to hunting effort in simulations. The simulations used total hunting efforts corresponding to 90, 80 and 20 percent of maximum harvest, for each dispersal and reproductive rate, representing good management, moderate overharvesting, and severe overharvesting.

The analysis showed that the harvest and CPUE within each patch depend predictably on animal dispersal and reproduction rates. When a species with a low dispersal rate was overharvested, harvest rate was highest at very low hunting effort, and there was a sharp decrease in CPUE from the minimum hunting effort to slightly higher efforts (Fig. 9.9j-k, dotted lines). This occurred because individuals were exterminated in the heavily hunted areas around the village and most animals therefore were killed far from the village (Fig. 9.9l-m, dotted lines). For a well-managed population, in contrast, the harvest diagram almost linearly increases and CPUE is only slightly decreasing (Fig. 9.9a-b, dotted lines).

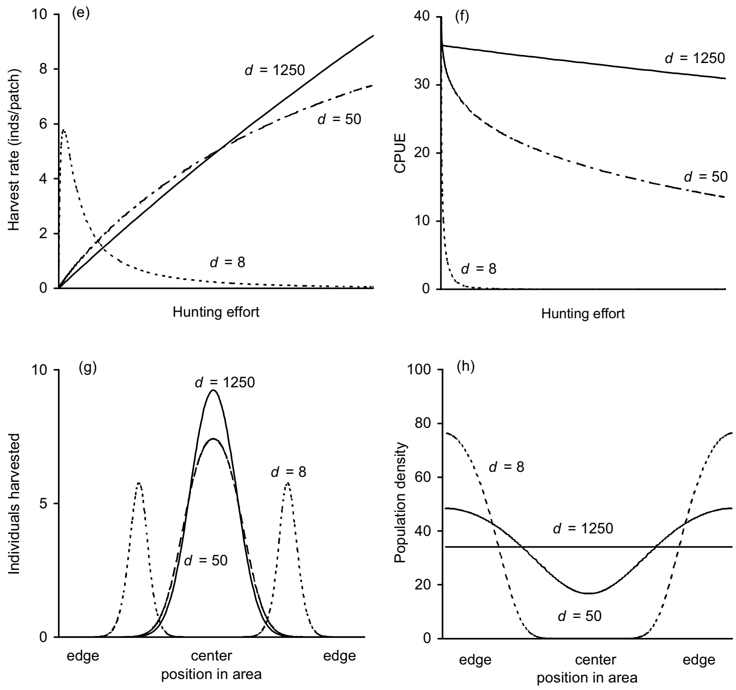
On the other hand, when a species with high dispersal rate was overharvested the pattern of harvest and CPUE in relation to the local hunting effort (Fig. 9.9j-k, solid lines) was almost indistinguishable from the pattern for a well-managed population (Fig. 9.9a-b, solid lines). In these cases, there was always an almost linear relation between the local hunting effort and the local harvest rate, and therefore almost no relation between hunting effort and CPUE. This occurred because animals redistribute themselves much faster than depletion occurs in the heavily hunted area. At intermediate dispersal rates (Fig. 9.9, hatched lines), the differences between a well managed and an overexploited population were discernible, although less apparent than at low dispersal rates.

Figure 9.9 (opposite page). Model output of local harvest rates and CPUE in relation to local hunting intensity, and of the distribution of harvested individuals and the population density of animals for good management (90% of maximum harvest), moderate overharvesting (80% of maximum) and severe overharvesting (20% of maximum) at three dispersal rates (d = 8, 50 & 1250).

Good management



Moderate overharvesting



Severe overharvesting

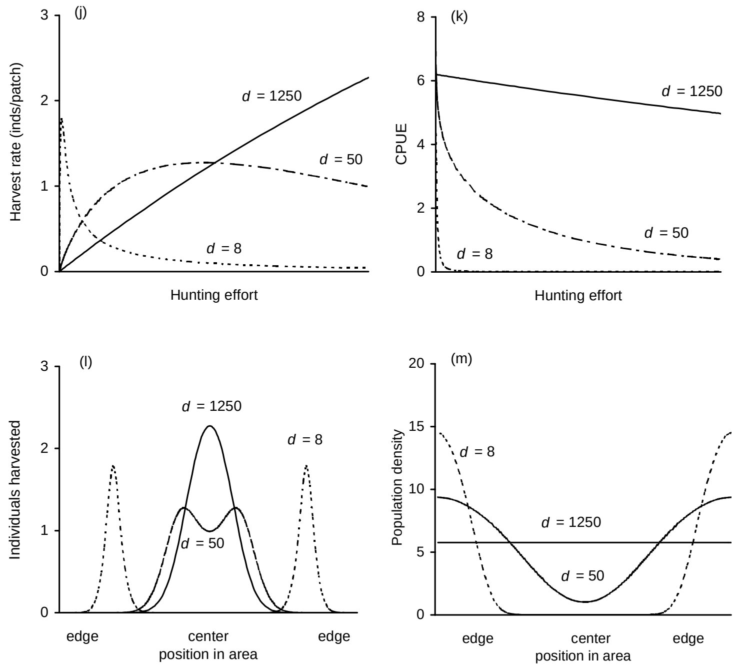


Fig. 9.9. (cont.)

The effect of varying the animal reproductive rate had consequences similar to varying the dispersal rate (Fig. 9.10). A high reproductive rate had the same consequence on the relation between local hunting intensity and harvest as a low dispersal rate, and a very low reproductive rate had roughly the same consequences as a high dispersal rate. These results should be understood in relation to the fact that we related the total harvest to the maximum harvest for a given dispersal and reproductive rate.

9.4.6. Model results compared with field data results

The model analysis showed how dispersal reduced differences in population densities, moved the peak of local harvest rates toward higher hunting efforts and, therefore, affected the correlation between effort and harvest rate from positive for animals with high dispersal rate to negative for animals with low dispersal rate. This caused CPUE at high dispersal rates to become constant across different levels of hunting effort, similar to the pattern that, for species with low dispersal rate, indicates no overharvesting. Also, it shows that low reproductive rates can cause effects similar to those for high dispersal rates. To use the spatial pattern of harvest and CPUE to assess game depletion, one must take into account the rates of both reproduction and dispersal of a species.

Most of our study species have home ranges small enough so that movements within these would not contribute to dispersal of a magnitude corresponding to a species with high dispersal rate in the computer simulation (Table. 9.4). This

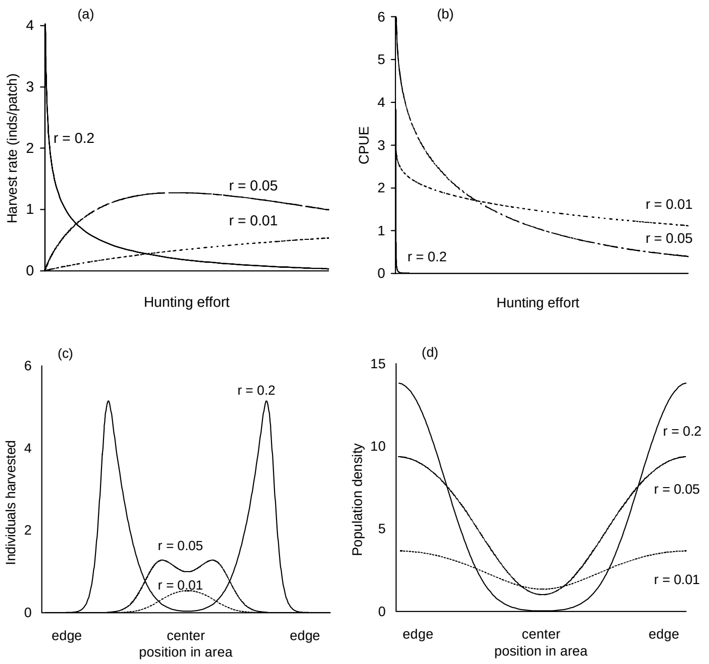


Figure 9.10. Consequences of varying the reproductive rate (r) at severe overharvesting (total harvest = 20% of maximum harvest, d=8) on the relation between hunting effort, and harvest and catch per unit effort (CPUE), respectively, and on the distribution of live animals.

suggests that the dispersal mainly consists of young individuals that leave their maternal home range. Consequently, high dispersal rates occur only for animals with high reproductive rates, and it is therefore unlikely that species would have both a low reproductive rate and a high dispersal rate. Most of our study species have fairly low reproductive rates (Table. 9.4), meaning that only a small proportion of the population would be dispersing at any given time. It is therefore unlikely that high hunting intensity in the centre of the area would depress population densities across the entire area as it would for a severely overharvested highly mobile species in the computer simulation (Fig. 9.4 j-m, solid lines). This supports our initial conclusions, with a few exceptions.

The most important exception is *T. pecari*, which is seen only occasionally in Sarayaku nowadays. Although the spatial pattern of harvest and CPUE suggest that this species is not overharvested, its high dispersal rate may have obscured the effects of intensive hunting. Also, *T. terrestris* has a home range large enough to span two or three hunting intensity zones, and the use of spatial pattern of harvest rate and CPUE as indicators probably underestimated the extent of overharvesting. Finally, the classification of *A. belzebuth* into group 4, representing species showing no signs of overharvesting, is a puzzle, given that a similar species, *L. lagotricha*, is severely overharvested. We believe that *A. belzebuth*, being a highly social species, actually increased its dispersal rate when its population density got so low that dispersing individuals had a hard time finding groups to join. The observed increase in harvest rate with increase in hunting effort therefore probably was a result of high dispersal rate. Thus, contrary to the initial conclusion, this species actually may be critically overharvested.

9.4.7. Status of other species

The analysis presented above was limited to twelve species that were particularly preferred by hunters, and for which the assumption of homogeneous habitat quality was fairly well satisfied. The caymans (*Caiman crocodilus* and *Paleosuchus trigonatus*) show considerably higher CPUE in the zones of low hunting effort. This may indicate that they are overharvested closer to the village, but it may also have to do with differences in habitat quality, particularly the existence of numerous lakes in the zones of low hunting intensity (see Chapter 2.2).

The method is also useful in order to assess the status of less preferred species. As hunting effort decreases and the preferred species become more abundant, however, the CPUE for these species increasingly underestimates population density, as the focus of hunters shifts away from the less preferred species. For most of the less preferred species, harvest rate as well as CPUE are highest near the village, in zone 7, and decreases to zero in the remoter zones of low hunting effort, indicating that the populations in the remoter areas are hardly affected by hunting at all. However, other less preferred species show CPUE values that are highest in the zones of low or intermediate hunting effort, and that are very low in the zones of high hunting effort, and harvest rates that peak in zones of intermediate hunting effort. Such species are *Penelope jacquacu*, *Pipile pipile*, and *Cebus albifrons*, and this indicates that, in spite of not belonging the most preferred game species, hunting has severely reduced their populations in a large area surrounding the village. On the other hand, *Aoutus vociferans* and *Saimiri sciureus* were exclusively hunted in the zones of intermediate hunting effort, indicating that they are already hunted out near the village, but that they are nearly unaffected in the remotest areas where hunters concentrate on larger prey.

9.5. Methodological insights

We have shown how the status of hunted animal species in Amazonia can be assessed based on knowledge of animal dispersal rates and the spatial distribution of harvest rates and CPUE. The effects of animal dispersal have previously been documented in predator-prey systems (e.g., Holt, 1984; Oksanen, 1990) but have received less attention in the hunting literature. The inclusion of spatial structure and dispersal therefore provides a complement to earlier methods when evaluating the sustainability of hunting. For instance, Robinson and Redford’s (1991) method may be more powerful if contrasting heavily hunted and less hunted areas on a relatively small spatial scale, as in our study. Our analysis showed that their method failed to identify any species in our study area as overharvested (Table. 9.4), but at the finer spatial scale (the seven zones of hunting effort) it did identify overharvested zones for some species (Fig. 9.4a, e, x).

Similarly, our method may also be combined successfully with Bodmer’s (Robinson & Bodmer, 1999) method. By performing line transect inventory and CPUE measurements in the same area it would be possible to establish a rough conversion factor from CPUE to population density. CPUE values could then be converted into population density estimates for comparison with estimated carrying capacities or for calculating production. Furthermore, the two methods, our's and Bodmer's, complement each other because line-transect inventories are more feasible in areas with high animal densities than in heavily hunted areas with low densities (Bodmer et al., 2000). On the other hand, calculating CPUE is most feasible where hunting effort is fairly high but becomes problematic in areas with low hunting effort because of a small sample size.

One problem with our method is that our indicators probably underestimated the spatial extent of overharvesting. The first indicator, a decreasing harvest rate with an increasing hunting effort, may underestimate because animal dispersal moves the peak of harvest rates toward higher hunting efforts, changing the correlation between local hunting effort and harvest rate from negative to positive. The second indicator, a low CPUE, may underestimate the spatial extent of overharvesting because animal dispersal smoothes out differences in animal density and the area with maximum CPUE may also have reduced populations. However, these problems would be reduced through improved knowledge of animal dispersal rates. Appropriate field methods for observing dispersal are available (e.g., Campbell & Sussman, 1994; Fragoso, 1998), and such data should be collected in a way that allows for quantitative expressions on dispersal rates (Turchin, 1998).

A second problem is that the usefulness of CPUE as a proxy for population density depends on the selection of a proper unit of effort (Salthaug & Godø, 2001; Marchal et al., 2002). The CPUE estimates in this study could be improved by refining the classification of hunting methods. It would for instance be recommendable to collect information on the use of dogs because hunters used dogs in zones close to the village but less so in remote areas. This may be one reason why CPUE estimates were high for *L. lagotricha* in zone 1 and why maximum CPUE for *T. terrestris* and *T. tajacu* was not found in zone 1 but in zones of slightly higher hunting effort. Similarly, it would be recommendable to collect information on hunting methods such as digging out animals from burrows, or on the differences in walking speed between wide trails near the village and almost invisible trails in remoter areas.

Finally, our method assumes steady state, and therefore has reduced validity when change is rapid. Until the rate of change can be verified by repeated observation, our method must be complemented with an assessment of past changes in hunting effort. Our assessment, based on ethnographic sources, interviews, censuses, and retrospective mapping, is that hunting effort in our study area is increasing but at a fairly moderate rate (see Chapter 5).

The main practical use of our method might be for identifying suitable locations for no-take areas. Such areas may be the most viable option for wildlife managers in tropical forests. Community members suggested that the establishment of no-take areas may be a strategy with potential for success (see Chapter 6). The management of such areas can be based on traditional arrangements of hunting rights and existing social structures (see Chapters 2 and 11), whereas banning hunting of certain endangered species may be less socially feasible. In the design of no-take areas, we suggest that a first step would be the identification of a limited number of target species, to reduce the complications of multispecies management. We further argue that these species should show clear indications of being overharvested but remain important sources of game meat. Moreover, no-take areas should probably be established where animal densities are reduced but still high enough to have a potential for recovery within a reasonable time span. Unless a fairly quick recovery can be observed, the motivation on part of the hunters to maintain and comply with hunting restrictions is likely to deteriorate. To adopt these criteria for the present study, we suggest that three potential target species within the following zones have the most certain potential for fairly rapid improvement; *L. lagotricha* in zones 5 and 6, *T. terrestris* in zone 4, and *T. tajacu* in zones 2 to 5. In the final decision about where to allocate no-take areas one would also have to account for the cost of enforcement and the short-term cost for hunters in the form of lost hunting opportunities. Our method provides a fairly low-cost alternative to assess the status of tropical forest game species, with high spatial resolution. It can therefore provide information on which to base decisions aimed at improving the sustainability of hunting in tropical forests.

9.6. Implications for sustainability

Game depletion is not a new problem to the people of the Sarayaku area, but has increased particularly during recent decades (see Chapter 5). The elders of today may have experienced an untypical golden age of hunting, because in the early 20th century population numbers still were low after the epidemics of the 16th to 19th century, and then they got access to modern weapons, which facilitated hunting. Today, the combined effect of population increase and modern hunting weapons have resulted in depletion of game resources. *Ateles belzebuth* and *Cebus apella* have always been rare, but are now rarer than ever and should be considered highly endangered species in the Sarayaku area. *Pithecia aequatorialis* and *Pipile pipile* also have reduced populations, but as they are not highly preferred game species they will probably survive in remote parts of the community territory as long as there are other more highly valued game species present. *T. pecari* has made a remarkable return as a major game species after nine years absence, perhaps due to disease outbreak (cf. Fragoso, 1997), but it is still not considered a permanent component of the local fauna, and must be considered threatened. *L. lagotricha*, *M. salvini* and *T. terrestris* maintain strong populations only far away from the village. Given their low reproduction rate, they must be considered threatened.

Although not at risk for biological extinction, several other species are overhunted in the sense that their population densities have been depressed, particularly near the village, so that hunters have to spend unnecessarily much time and physical effort in order to acquire the game meat they need to feed their families. Such species are *N. urumutum*, *P. jacquacu*, *T. tajacu*, and possibly *M. americana* and *M. gouazoubira*. Other species, such as *A. paca*, *D. fuliginosa*, *Dasypus* spp., and most smaller game species, are very lightly exploited over most of the area and it would probably be possible to increase harvests without putting sustainability at risk. Hunting is likely to continue as a major source of food for Sarayaku for a long time to come, but hunting progressively smaller and smaller game, having to walk further and further away, would be very unlucky both from economic and from ecological points of view. Rational management of large game species has a potential to provide more meat than today and at a lower cost in terms of time and effort spent. Fortunately, the remarkable social development the community has undergone the last few decades has also involved decisions that constitute small steps on the way towards rational management of the wild fauna (see Chapters 5 and 13).

Chapter 10: Fishing

10.1. Amazon fisheries and the problem of scale

Fish is a crucially important food resource in Sarayaku, providing an estimated two-thirds of the total dietary fat and almost half of the dietary protein of the people (see Chapter 7). According to the local people, the fish resources are declining (see Chapter 6). Unfortunately it was not possible to make any assessment of the status of fisheries, or the impact of fishing on the resource base, within the time and resources available for producing this thesis. This was particularly because there was a problem with the geographical scale of the study. Many Amazonian fishes are migratory, particularly some large catfish species can migrate several hundreds, or even thousands, of kilometers (Junk, 1984; Lowe-McConnel, 1986; Agudelo-Córdoba et al., 2000). For a limited area such as the Sarayaku territory, the status of the fish stocks may bear little relation to the local harvest of fish. Therefore, a study of the interactions between human society and fish populations may have to be carried out on a larger geographical scale. To complicate things more, current knowledge about the migrations of Amazonian fish, as well as other aspects of their ecology, is insufficient. The few studies made have mostly focused on the Amazon river itself and its larger tributaries (e.g., Goulding, 1980), whereas very little is known about the fish in smaller tributaries near the Andes, such as the Bobonaza.

The Sarayaku people recognize a season of ascending fish, which usually starts in September, after the end of the dry season (see Chapter 2). During this time, a wide variety of fish species arrive along the Bobonaza in pulses from downriver, ascending every time the river rises after heavy rains. Among these are several species of large catfish (e.g., *Brachyplatystoma juruense*, *Pseudoplatystoma fasciatum*, *Pseudoplatystoma tigrinum*, *Paulicea lutkeni*) as well as smaller catfish (e.g., *Pimelodus* spp. and *Calophysus macropterus*) and other fish, such as, for example, *Prochilodus nigricans*. In the month of March, approximately, the fish start to descend again, the females now getting ready to spawn.

Parts of the populations of smaller fish species, such as *Pimelodus* spp. and *Prochilodus nigricans*, however, remain in the Sarayaku area when the others descend. Other species are considered entirely stationary, particularly Cichlids, Erythrinids, and the smaller Characids and Loricariids (armoured catfishes).

10.2. Sarayaku fisheries

The Sarayaku people use various fishing methods to catch a wide variety of species. One important method is use of the poisonous root of the barbasco plant (*Lonchocarpus nicou*). This is done in all types of running water, from minute forest streams, where just a few pieces of barbasco are enough to provide a meal while camping out in the forest, to the Bobonaza River itself, where over fifty kilograms of barbasco may be used in large communal fishing events and yield a ton or so of fish in just a day.

Many fish are also caught with hook and line, from half-decimeter long cichlids to large catfishes. Cast nets are used to catch *Prochilodus nigricans*. Nets are also used to trap fish that enter the mouths of small tributaries when the Bobonaza itself swells and gets turbid due to heavy rain in the headwaters, and to stretch across small creeks fished with barbasco. Sometimes nets are just left in the river to catch fish, but this is relatively impractical because of the large amount of debris transported by the river which gets stuck in the nets. Nets of synthetic fibres have recently largely replaced those of palm fibres, which tend to decay rapidly.

In the clear waters of the upper Rutunu River, the smaller Loricariids (armoured catfishes) are caught by diving, either just searching for the fish with the hands, or with the help of a harpoon and/or a diving mask. Fishing with dynamite was introduced in Sarayaku in the 1960's, but is nowadays considered destructive and is no longer commonly practiced. Fishing with pesticides is considered a criminal offence in the community, because of its catastrophic effects on all aquatic life. Nevertheless, on rare occasions, creeks that suddenly become void of aquatic life give rise to suspicions of pesticide fishing.

10.3. Anthropogenic influences

Inland fisheries worldwide are generally severely affected by overfishing, habitat degradation, and pollution. River fisheries, however, tend to be more resilient than lake fisheries, and seldom collapse by overfishing alone, although they may collapse through a combination of overfishing and habitat degradadation. Fisheries of the Amazon river system are in a remarkably good shape when compared with other river fisheries in the world. However, also in the Amazon, stocks of commercially valuable fish species are being depleted, particularly near major cities. Some habitats are degraded by dam construction and deforestation of floodplains, and locally there are severe pollution problems related to mining and oil exploitation (McClain, 1999).

The most obvious threat to fish resources in Sarayaku may be overfishing. Overfishing of small rivers in the Amazon basin may have occurred already in the distant past, because of the widespread use of fish poisons among indigenous peoples. On the other hand, overfishing of the large rivers is a recent phenomenon, driven by an increased demand for fish in the growing Amazonian cities, and by improvements in fishing technology (Goulding, 1983). The Bobonaza river, being relatively small, is still used, almost exclusively, for subsistence fishing by ten or so indigenous communities with a total of a few thousand inhabitants, as well as some non-indigenous settlers in the headwaters, and some militaries at the Montalvo base. Downriver, on the other hand, increasing commercial fishing in the Marañon river takes a heavy toll on fish populations. Around Iquitos, commercial fishing with freezer boats took off in the 1970's (Coomes, 1995), and by 1999, the annual harvest of fish by the commercial fleet in Iquitos exceeded 23000 tons[23]. Commercial fishing is said to be an important income source even as far up the

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23 http://www.siamazonia.org.pe/Bases%20de%20datos/Estadísticas/Extracción.htm (2003-11-30)

Pastaza river as in Andoas, on the Peruvian side of the border, only 60 km downriver from the mouth of the Bobonaza river[24]. Given the migratory habits of many important fish species, it cannot be ruled out that commercial fishing in the Pastaza and Marañon rivers in Peru affects the Sarayaku fisheries.

Habitat degradation is another potential threat to the fish resource. The bulk of the food of most fish species in the upper Amazon is of terrestrial origin (Saul, 1975), and many fish species spend important stages of their life cycle in the seasonally flooded varzéa forests (Goulding, 1980). Deforestation of riparian habitats may therefore affect fish populations. The Sarayaku territory itself has not suffered extensive deforestation (see Chapter 8). However, again, the impact of habitat alteration on fish populations must be studied on a larger spatial scale, ranging from the headwaters of the Bobonaza river down to the Pastaza, and perhaps even the Marañon and beyond.

Hydroelectric dams change the flooding regime of rivers, which may affect fish populations negatively (Junk, 1984). There is one hydroelectric dam on the Andean slopes of the Pastaza River, and another is scheduled for construction soon. These dams may affect the flooding regime of the Pastaza and indirectly affect fisheries of its tributaries, particularly the Bobonaza.

Finally, pollution is serious threat (see Chapter 13). Elsewhere in the Amazon, oil exploitation has increased salinity in the water to the point that it inhibits fish reproduction (Snedaker, 1977 [OEA, 1987, Ch. 12]). It has also caused pollution of water with hydrocarbons and heavy metals (Kimerling, 1993; Jochnick et al., 1994) and led to increased rates of cancer and other diseases among the affected populations (SanSebastián et al, 2001a, b, 2002; Hurtig & SanSebastián, 2002). Although no oil exploitation is taking place in Sarayaku yet, the migratory fish consumed by the Sarayaku people may contain environmental pollutants, as oil exploitation in the Peruvian part of the Pastaza river basin has caused elevated levels of hydrocarbons and mercury in water and sediment near the Ecuadorian border (MEM, 1998).

Similarly, the urban waste that pollutes the Pastaza river in its headwaters in the Andean highlands may affect the fish consumed by the Sarayaku people. Particularly, several of the creeks in the southern part of the Sarayaku territory are not part of the Bobonaza river basin, and discharge directly into the Pastaza river via the Jatunkapawari. The fish in these creeks, even if they migrate only short distances, may be affected by pollution originating in the cities of the highlands.

Gold mining in other parts of the Amazon has led to massive mercury pollution with potentially severe health consequences (e.g., Maurice-Bourgoin & Quiroga, 2002). Gold has been exploited in the Sarayaku area in the past (see Chapter 5), and any rise in gold prices may potentially lead to new interest in gold mining in the area. As a matter of fact, in 1992 a company was granted a mining concession that included part of the Sarayaku territory although, in the end, the company did not initiate any activities in the area.

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[24] Personal communication by Tito Machoa, a Sarayaku merchant who went to Andoas on a business trip in 1998.

The use of agrochemicals is another potential threat to fisheries (Goulding, 1980). Cash-cropping with heavy use of agrochemicals is common in settler areas along the roads in the upper part of the Bobonaza basin. The effects of these agrochemicals on the fishes are unknown.

10.4. Trends in resource base status

Most people in Sarayaku agree that fish abundance has decreased during recent decades, in particular large fish (see Chapters 5 and 6). Particularly, *Brachyplatystoma filamentosum*, *Colossoma macroporum* and *Piaractus brachypomus* have become extremely rare. These species are intensively exploited in commercial fisheries elsewhere in the Amazon (Goulding, 1980; Aguelo-Córdoba et al., 2000), and this may be a contributory reason to the observed decline in Sarayaku. On the other hand, small fish have been less affected. Actually, a barbasco fishing event in the Bobonaza River in 2001 yielded enormous quantities of small fish, particularly *Pimelodus* sp., and, according to some elders, more than they had ever seen before. This is consistent with observations from other river systems that increasing fishing pressure initially does not affect the total harvests very much, but the mean size of caught fish decreases, and large species tend to disappear first (Welcomme, 1999).

On the other hand, there are also indications of depletion of stocks of small stationary species. Particularly, small rivers and creeks near permanent settlements are considered to be depleted of fish. An exploratory study made by a Sarayaku secondary school student for his graduation thesis provides further support for this view, indicating that fish catches were twice as large in the Jatun Sarayaku River than in the Sarayakillu River (Malaver, 2001). Both rivers are ecologically similar and have similarly sized catchment areas (see Fig. 2.3). The most significant difference between the two rivers is that some forty households reside permanently along the Sarayakillu, while the Jatun Sarayaku is situated three kilometers walk away from any permanent settlements, and therefore subject to much less fishing pressure.

10.5. Potential for improved management

On the central Amazonian floodplain, local communities have been able to self-organize around the management of floodplain lake fisheries (McGrath et al., 1993). However, management of riverine fisheries is much more complicated because of the lack of clear boundaries of the ecosystem. Moreover, because of the migratory nature of many species, particularly large catfish, management may need to be carried out on a large spatial scale, for some species even demanding international cooperation (Ruffino & Barthem, 1996). However, as other fish species are stationary (Cichlids, Erythrinids, and the smaller Characids and Loricariids) or appear to migrate only over short distances (e.g., *Brycon melanopterus*), these may be possible to manage on a smaller spatial scale.

10.6. An agenda for research

In order to secure the future of the wild stocks of fish as a food source for the Sarayaku people, one important step on the way is to gain a deeper understanding of the interactions between human society and fish populations. Management guidelines could then be drawn up based on such knowledge. An agenda for research with that purpose would include three important areas: (1) Migratory patterns of different fish species, (2) The role of fish in human nutrition, health, and economy, and (3) Impact of human activities on fish populations.

Understanding the migratory patterns of the different fish species is a prerequisite to define relevant study areas for more detailed studies of different species, and also to suggest suitable spatial scales of management. In the first place, this would be done by interviewing local fishermen living along the Bobonaza and Pastaza rivers (cf. Valbo-Jørgensen, 2000). Then, local communities could become involved in reporting fish catches, similar to the way the Sarayaku people got involved in reporting their hunting activities (see Chapters 4 and 9). In view of the results of these studies, finally, an assessment would be made about the potential usefulness of methods such as mark and recapture or radio-tracking.

Understanding the role of fish in human nutrition, health, and economy is important in order to be able to draw up socially feasible management guidelines, and to facilitate a constructive dialogue in cases of conflicts between fisheries and other interests. The nutritional content of Amazonian fish is poorly known (see Chapter 7), so one component of research should be to analyze the nutrient content of different fish species at different times of the year. Similarly, the content of harmful pollutants, such as heavy metals and hydrocarbons, in the different fish species in different parts of the basin also needs to be mapped. Fish catches should be quantified based on reporting by fishermen. The economic importance of commercial fishing should also be quantified, both at aggregate level as well as at household level.

Finally, the research should also aim at a deeper understanding of how human activities affect fish populations. Building up a system for local monitoring of fishing effort and fishing yield would be of central importance in this. Even in the absence of detailed ecological knowledge, such data can be used in order to assess the status of fisheries, based on the catch per unit of effort or on the size distribution of the fish caught (Welcomme, 1999). Also, habitat degradation should be monitored using remote sensing, and sources of pollution should be surveyed.

Achieving this will require that a highly skilled interdisciplinary research team works intensively in the area over several years. Such an input is imperative, because at stake is the most biologically diverse river system of the world, and the food supply not only of the Sarayaku people but also many others.

Chapter 11: Explaining natural resource depletion

11.1. Theories about the causes of natural resource depletion

The previous chapters have shown how important resources such as wild game, fish, and old growth forest have decreased in abundance in Sarayaku. Obviously, population growth and improved technology have been important factors involved in creating the current situation of scarcity of wild game and ever more distant primary forest, a process also affected by the increasingly sedentary settlement pattern (see Chapter 5). Such explanations alone are, however, insufficient in order to understand the reasons for resource depletion and, particularly, in order to find a way forward towards a solution of the problems. The impact of people on natural resources is the effect of decisions made by a large number of individuals. The available options for individual actors, and the incentives for making different choices, are affected by demographic and technological change, but they are also affected by many other, often interrelated, variables (Kaimowitz & Angelsen, 1998, pp. 8-11; Ostrom, 1999).

When many individuals withdraw resource units from the same resource pool, the result is often that the resource pool gets depleted. For the collective of resource users, it may be beneficial to refrain from resource use in order to conserve the resource and obtain future benefits. However, for each individual there is little incentive to refrain from withdrawing resource units, because he has to bear the whole cost himself, whereas he must share the future benefits with the other resource users. Thus, the egoistic behaviour of each individual leads to collective ruin, a phenomenon known as a *tragedy of the commons* (Hardin, 1968; Tisdell, 1993; pp. 9-11). In economic terms, the resource gets dissipated to the level where the average value of resource withdrawal equals the wage rate. In game theory, this situation, where every player maximizes his/her own payoff given the behaviour of other players, is referred to as *Nash equilibrium* (Ostrom et al., 1994, p. 54). In contrast, local resource users in many cases actually have avoided such a "tragedy of the commons", as they have organized in order to manage common property resources such as irrigation systems, fisheries, forests, and groundwater basins, in a coordinated manner (e.g., Ostrom et al., 1994). The likelihood that resource users manage to self-organize around such management of common pool resources[25] strongly depends on the attributes of the resource itself, as well as the attributes of the people who use the resource (Box 11.1).

Similarly, it has been shown that there are some characteristics of such local institutions for common pool resource management that increase the likelihood for them to endure. Such characteristics have therefore been called *design principles* (Box 11.2).

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[25] Whereas the term *common property resource* refers to a particular property regime, the term *common pool resource* (CPR) refers to particular characteristics of a resource, namely high subtractability and difficulty to exclude potential users (Ostrom et al., 1993). The two terms are, however, often used synonymously.

Box 11.1. Attributes of a resource and its appropriators that are conducive to an increased likelihood that self-governing associations will form.

Attributes of the resource:

R1. Feasible improvement: Resource conditions are not at a point of deterioriation such that it is useless to organize, or so underutilized that little advantage results from organizing.

R2. Indicators: Reliable and valid indicators of the conditions of the resource system are frequently available at a relatively low cost

R3. Predictability: The flow of resource units is relatively predictable.

R4. Spatial extent: The resource system is sufficiently small, given the transportation and communication technology in use, that appropriators can develop accurate knowledge of external boundaries and internal microenvironments.

Attributes of the appropriators:

A1. Salience: Appropriators are dependent on the resource system for a major portion of their livelihood or other variables of importance to them.

A2. Common understanding: Appropriators have a shared image of how the resource system operates (attributes R1, 2, 3, and 4 above) and how their actions affect each other and the resource system.

A3. Discount rate: Appropriators use a sufficiently low discount rate in relation to future benefits to be achieved from the resource.

A4. Distribution of interests: Appropriators with higher economic and political assets are similarly affected by a lack of coordinated patterns of appropriation and use.

A5. Trust: Appropriators trust one another to keep promises and relate to one another with reciprocity.

A6. Autonomy: Appropriators are able to determine access and harvesting rules without external authorities countermanding them.

A7. Prior organizational experience: Appropriators have learned at least minimal skills of organization through participation in other local associations or learning about ways that neighbouring groups have organized.

Source: Ostrom (1998)

Box 11.2. Design principles illustrated by long-enduring CPR institutions

1. Clearly defined boundaries: Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.

2. Congruence between appropriation and provision rules and local conditions: Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money.

3. Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules

4. Monitoring: Monitors, who actively audit CPR conditions and appropriate behavior, are accountable to the appropriators or are the appropriators

5. Graduated sanctions: Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both.

6. Conflict-resolution mechanisms: Appropiators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

7. Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

For CPRs that are parts of larger systems:

8. Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are orgnized in multiple layers of nested enterprises.

Source: Ostrom (1990, p. 90)

One should not, however, uncritically accept the “tragedy of the commons” and the lack of institutions for common pool resource management as the only explanation of any observed degradation of natural resources, because there are also several alternative explanations. Particularly, people who are unaware of the impact of present resource withdrawal on the resource stock, and the potential for future resource withdrawal, do not perceive any dilemma between pursuing individual benefits and avoiding collective ruin (Moxnes, 2000; Burke, 2001). Among the reasons for such unawareness may be magical or fatalistic beliefs that do not recognize any causal link between withdrawal of resources by humans, and the depletion of the resource stock (Baland & Platteau, 1996; Krech, 1999; Burke, 2001), but even in the absence of such beliefs, people tend to have difficulties to understand the dynamic nature of living natural resources (Moxnes, 2000).

The decrease of an initially large stock of a resource (such as the timber in a primary forest, or an animal population not previously subject to hunting) is not always a “tragedy of the commons” either, because it may not even constitute a depletion of the resource in the sense that the stock is reduced to such a level that the potential for future withdrawal is compromised. The social optimum may not be to leave the resource untouched, but rather to maintain the resource stock at such a level that the net long-term benefit is maximized.

The net long-term benefit, in turn, is not only the value of the harvest minus the cost of harvesting the resource. Also the rate at which people discount future benefits must be taken into account. If this discount rate is higher than the maximum rate of growth of the resource, it may even at social optimum be economically rational to drive the resource to extinction (Clark, 1990, pp. 1-8). Although future generations may not agree with the decisions of the present generation, this is a matter of coordination between generations, not of coordination among the presently living resource appropriators, and is therefore not covered by the theory about common pool resource management versus the tragedy of the commons.

The social optimum may also change with time. Particularly, as population grows, so does the need for food, and therefore also the need for cultivated land. The socially optimal proportion of cultivated land in the landscape may therefore increase. Deforestation driven by population growth may therefore not always constitute a tragedy of the commons. Instead, it may represent a transition of a social optimum at a low population density to a different social optimum at a high population density. Again, ultimately population growth may constitute a tragedy of the commons in itself, as the decision to breed may be beneficial to the individual, but the aggregate effect of these individual decisions may be detrimental to the collective (Hardin, 1968).

The social optimum is a useful analytical concept (e.g. Tisdell, 1993, pp. 9-11; see also Clark, 1990, pp. 39-44) but it is seldom possible to quantify it for a real life situation. An alternative way to approach the question of the causes of natural resource depletion is to ask how resource withdrawal is affected by socio-economic variables at the level of households, regions, and nations. During the 1990’s there has been a boom of such studies of the causes of tropical deforestation. These studies indicate that price levels, wage rate and employment, technology and property regime are important factors influencing deforestation rates (Kaimowitz & Angelsen, 1998). For hunting in tropical forests, Shively (1997) showed that resource-poor households are those that hunt most, while Godoy et al. (1995) and Wilkie & Godoy (2001) suggest that an increase in income from an initially low level may increase harvesting of wildlife, but that a further increase in income may cause it to decrease.

These different ways of explaining natural resource depletion are not necessarily mutually exclusive. The different mechanisms cannot always be separated from each other, and may instead interact with each other. Different theoretical approaches complement each other by providing different perspectives on the same problem.

11.2. Local institutions governing access to natural resources in Sarayaku

The task to describe the institutions that govern access to natural resources in Sarayaku is difficult, because there are few explicit rules. Local institutions are norm-based more than rule-based, rooted in a shared sense of what is right to do and what is wrong to do (cf. Campbell et al., 2001).

In order to have the right to harvest natural resources within the Sarayaku territory at all, one must be a member of the community. Membership is not formally defined. Most commonly, one becomes member by being born to parents who are members of the Sarayaku, and by growing up in the community. For those who have no pedigree from Sarayaku, normally the only way of becoming a member is by marriage, or by being raised as a child in a Sarayaku household, as has occurred with some orphans from outside the community.

In terms of the spatial extension of the Sarayaku territory, boundaries are not absolutely clear. The boundaries between communities have mostly been defined by custom, but some have also been defined by explicit agreements between communities. However, in Sarayaku people frequently complain that the other communities do not keep such agreements. The land titles granted by the government in 1992 do not coincide well with traditional boundaries or the agreements about boundaries made between communities, neither with current patterns of resource use, and therefore constitute an additional source of conflict.

Within the Sarayaku territory, each community member has the right to exploit resources within a limited area. These rights are inherited or acquired by marriage, but must also be continuously upheld.

The establishment of a field leads to ownership not only of the field, but also of the fallow that grows up when the field is no longer weeded. The owner therefore has the right to fruit, timber, and other resources in the fallow. This principle of ownership of fallows emerged at different times in different parts of the community, as old-growth forest near the community grew scarce, particularly during the 20th century (see Chapter 5).

Fields and fallows are generally viewed as something resembling private property. In general, such land is acquired by inheritance, but on rare occasions, land is also given away, and it can also be borrowed. Old-growth forest, on the other hand, is considered to have no owner. Instead, each community member has use right to a particular portion of the primary forest, defined by inheritance and continuous occupation. These use rights overlap each other, such that for any particular point in the primary forest, several families hold use rights. Typically, these use rights have a fan-like shape extending from the house out into the forest. Many households have two separate such areas of use rights, one that extends from their permanent home in the village, and another one extending from their *purina* (secondary home, see Chapter 2) (Fig. 11.1). Within such areas, holders of use rights may hunt, fish, cut timber or make fields. In a similar manner, having a house along a river establishes a use right to a stretch of that river. Also these use rights overlap each other, extending several kilometers beyond the immediate

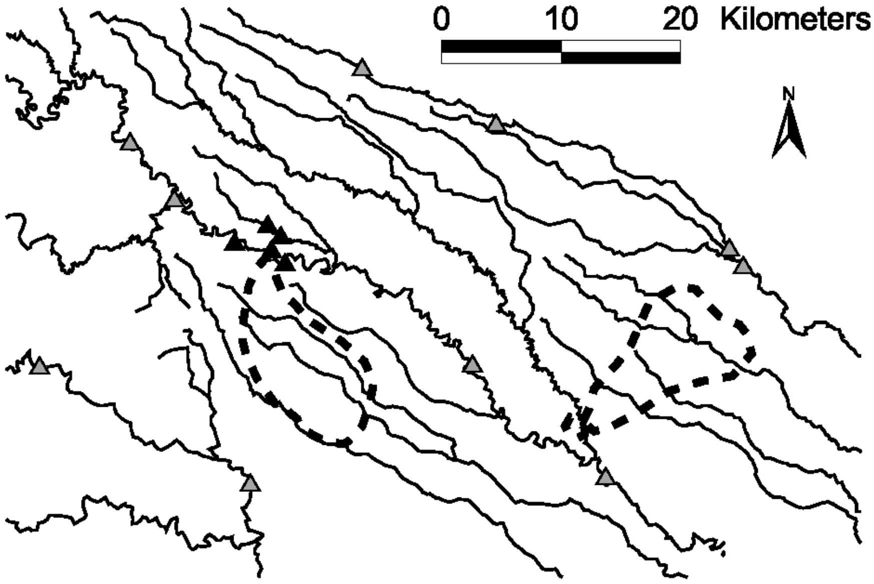

Fig. 11.1.An example of the approximate extension of the use rights, to forest resources, of one household. One fan-shaped area extends from their house in the village, and another one from their secondary home

vicinity of each house. All use rights and property rights weaken with time, unless they are actively upheld. Community members who have been absent from the community for a long period may not be able to return unless they have left some relative in charge of upholding their rights to their housegrounds and fallows. Inheritance of all these rights previously used to pass from father to son. Nowadays, however, use rights are inherited basically equally by sons and daughters, sons-in-law, and daughters-in-law, although those men that hold use rights based on continuous occupation, and inheritance from father to son during several generations, are considered to have stronger rights when it comes to decision-making. Occasional hunting and fishing in connection with journeys is also allowed anywhere regardless of whether the person in question holds use rights to the particular place.

There is some confusion and discrepancies regarding the principles of access and control to natural resources. Whereas some people claim that it is old tradition to stay to the lands one has inherited and respect the lands of others, other people claim that the indigenous people traditionally have held all land in common, and that private property is a notion imported from the mestizo society. These discrepancies, however, could be resolved in a workshop that the Government Council of the community arranged in order to incorporate the customary system of land rights into written rules, and where I was asked to act as a facilitator for some of the discussions. All participants could agree with the idea that the same piece of land may simultaneously be the property of a particular household, a group of households, and the community at large, and that any change in land use requires a consensus among all three levels.

It is important to understand how local institutions are norm-based rather than rule-based. Some young intellectuals have, for a long time, argued for the adoption of local "laws" regulating natural resource use as well as trade with liquor and many other community concerns. However, such changes have not been possible to bring about rapidly. For example, in 1992 the community held a five-day workshop in order to discuss common concerns and formulate new statutes of the community as well as regulations regarding natural resources and other areas. After four days of discussions, a plenary was held on the last day, and the people unanimously adopted a large set of regulations, including limiting barbasco fishing (see Chapter 10) of the Bobonaza river to once a year, and totally banning liquor. Soon after the workshop ended, the river dried up, providing good conditions for barbasco fishing, and during the following weeks, the people repeatedly fished the Bobonaza river with barbasco. Similarly, the *kurakas* (see Chapter 2) continued to offer liquor to the participants of communal work parties, according to long held custom. In this case, rules did not rule, custom ruled. This does not mean that local institutions are static. On the contrary, as will be further discussed below, important changes have taken place and are continuing to take place. A pronouncement by a General Assembly of the community is, however, not in itself enough to bring about such change. It must be accompanied by a change in the views held in common about what is right to do and what is wrong, and therefore the issue must have been exhaustively treated in previous discussions.

11.3. Conflicts and dilemmas

11.3.1. Agriculture

Conflicts over land to farm have increased strongly during the last couple of decades. Often they occur among relatives. Given that a fallow may be left for several decades before being farmed again, the original owner may by that time be dead, leaving several children and grandchildren who all can claim inherited rights. The absence of permanent landmarks, and past loans of land add to the confusion. When somebody discovers that somebody else is encroaching on his/her land, starting to make a field, the response is often to make another field beside it. Although the "encroacher" is allowed to finish his/her field, the other field is a clear signal that any further encroachment will not be tolerated. Other times, an oral complaint may be enough to make the "encroacher" desist from continuing to make the field. More and more frequently, however, the affected party denounces the encroacher to the the teniente político or the Government Council of the community (see Chapter 2.4), and the matter is resolved in a meeting with both conflicting parties, teniente político, and the Government Council. Recently, there have also been a couple of cases where people have claimed ownership rights to old-growth forest adjacent to their fallows. This has, however, been explicitly rejected by the members of the Government Council, who claim that the old-growth forest is free for anybody who holds use rights to the area.

The expansion of secondary forest, leading to decreasing cover of primary forest, can hardly be viewed as a "tragedy of the commons". Although many people lament the ever-increasing distance to old-growth forest, the need for land to farm is considered superior to the need for old-growth forest, as is reflected by the position of the Government Council. On the other hand, it seems that the unclear situation regarding ownership of fallows in some cases causes a race to clear a potentially disputed fallow before somebody else does. This may shorten fallow periods to below the social optimum (cf. Angelsen, 1997, p. 97).

11.3.2. Timber

Timber for canoes and house construction is also getting scarcer near the hamlets and the major rivers. Given that there are no exclusive property rights to timber in the primary forest, this may indeed be a matter of a tragedy of the commons. Some timber trees also grow in fallows, and there is increasingly an active management of these trees, but also complaints about theft of timber trees from fallows.

11.3.3. Thatch leaves

Leaves for thatched roofs are harvested from a number of different species, such as *lisan* (*Cyclanthus bipartitus*, Cyclanthaceae), *uksha* (*Geonoma* spp.), and *wayuri* (*Geonoma* sp.). A medium-size house requires some 20 000 leaves, so considerable amounts of leaves are harvested. *lisan* is abundant in fallows on alluvial plains, but the *uksha* and *wayuri* are restricted to old-growth forest. Particularly the leaves of the *wayuri* are priced for their durability. This palm, however, grows only in very limited areas, particularly in one place downstream of the community of Teresa Mama, and another minor one at the lower stretches of the Rutunu river. Particularly the first place has been providing *wayuri* leaves for the whole Sarayaku community since before the time that Teresa Mama became a separate community, while the Rutunu site mostly has served the families who have their secondary homes nearby. The *wayuri* leaves are considered to be increasingly scarce, in spite of the existence of customary rules regarding harvest. The *wayuri* is a small palm, its trunk rarely exceeding three meters in height, and each palm carries about ten to fifteen leaves. The trunk can easily be bent down with one hand, so as to cut off the leaves with the other hand. In order not to kill the tree, you are supposed to leave at least four leaves. Thus, the same tree can be harvested over and over again, although after harvesting of leaves, the new leaves become smaller and therefore less useful for thatch. Similarly, when harvesting *uksha*, people leave at least three leaves. Violations of these harvest rules are relatively uncommon, with the exception of an oil company crew that cut down a large number of trees when making seismic prospection in the area in the 1970’s (see Chapter 5). The reasons for the relative success of this CPR management system may be the following:

- Very tender leaves are less useful for thatch, so the incentives to take all leaves are small.
- The resource is stationary, facilitating monitoring. As the trunk of the dead tree would leave visible evidence, any violation could be detected even a long time afterwards.
- Harvest is carried out intensively by a small number of people during a limited period of time, in connection with house construction. The transport of the

leaves by foot and in a canoe is a very visible activity, so in case of infringement there would be little doubt about whom to blame.

It should be noted, however, that a couple of hundred kilometers to the northeast, the Huaorani people have no such rules regulating the harvest of leaves from *Geonoma macrostachys*, and cut down the whole tree in order to harvest the leaves (Svenning & Macía, 2002). Perhaps the Sarayaku people have had an experience of resource scarcity, which the Huaorani have not, leading to the emergence of commonly agreed harvesting rules. However, even this system of CPR management, while successful in terms of the degree compliance, does not necessarily guarantee sustainability of resource use. Repeated harvesting of leaves may affect the viability of the plant, and its ability to propagate. Therefore, even if the trees are not directly killed, the harvesting may gradually deplete the resource base, a process that may not be obvious at first sight (cf. Hall & Bawa, 1993; Murali et al. 1996).

A few people have also brought *wayuri* seeds and sown them close to the Sarayaku community. The palm takes about thirty years to grow to harvestable size, and the trees that were planted first are just about to be ready to harvest. Recently, the Teresa Mama community has started to charge a fee from people from Sarayaku who come to harvest *wayuri* leaves. Although initially some Sarayaku people considered this unfair, it was finally accepted as a legitimate way for the Teresa Mama community to improve its economy based on the management of their local natural resources.

11.3.4. Hunting

As the hunting territories of individual households overlap each other, any piece of forest in Sarayaku is open for hunting by several households. This, in combination with the mobile nature of the wildlife resource, creates a situation similar to open access. Although some individuals claim they attempt to preserve wildlife on “their” land, they also complain that their attempts are frustrated because of the hunting performed by their neighbours. The depletion of wild game can therefore be regarded as a tragedy of the commons. Solving the problem of game depletion would require management over a spatial scale that accounts for the movements of animals (see Chapter 9), and would therefore require cooperation between the several hunters who share use rights to the same area.

On two occasions, I discussed with groups of community members the attributes that are conducive to the emergence of self-organizing around common property resource management according to Ostrom (1998) (Box. 11.1). The people agreed with each other that the resource (wild animals) as well as the appropriators (the Sarayaku people) had most of these attributes. But a few of the attributes were lacking: They said that the Sarayaku territory is so large that nobody knows all of it (R4), that their knowledge about how the resource system operates may not be enough (A1) and, particularly, they stressed that they lacked trust in each other (A5).

Recently, a few measures have been taken in order to preserve the wildlife. The community has decided to celebrate the community festival every second year, instead of every year, as has been the custom since the 19th century. This measure is unlikely to have much effect on the major game species, but may be an important measure in order to protect some other, very vulnerable, species (see Chapter 9.4.2). Also, the community has decided not to permit export of wild meat from the community, except for small remittances to relatives in town. Again, this is not a measure that will contribute much to halt game depletion. However, given the increasing market for bushmeat, it is an important measure in order to prevent the depletion of wild game from accelerating further due to commercial hunting, such as is happening in the tropical forests of central Africa, where there lately has been a catastrophic decline of several large game species (e.g. Walsh et al., 2003). After the conclusion of the fieldwork, the community has also assigned a reserve area, where all hunting is prohibited (see Chapter 13.3.3).

11.3.5. Fisheries

Fisheries are particularly interesting in terms of common property resource management in the Amazon, because of the migratory habits of many fish species, and because of the characteristics of the technique of fishing with the poisonous barbasco roots (see Chapter 10).

Many fish species, particularly large catfish, migrate long distances. These resources are therefore not only shared among many communities, but also among different countries, such as Ecuador, Peru and Brasil. In this case, there is no coordination among users in different countries, and we have a tragedy of the commons. This is a dilemma in the long term, about maintaining a breeding stock.

In the short term, there is also another type of dilemma when the fish arrives in pulses from downriver; to fish with hook and line, in order to get a continuous provision of fresh fish, or to fish with barbasco, to get a large amount of fish at once. The dilemma is that if one community decides to fish only with hook and line, the fish rapidly continues travelling upriver where the next community would fish with barbasco. Meanwhile the neighbouring community downriver may also fish with barbasco, diminishing the amount of fish that continues upstream. This is a dilemma in the short term, about how to share the fish currently available.

There is, however, an additional related dilemma, the provision of barbasco. Fishing the Bobonaza or Rutunu River with barbasco demands cooperation between a large number of people in order to gather enough barbasco. Digging up the barbasco roots is quite hard work, and while the individual bears the cost of this, the collective enjoys the benefits. Previously, the people who provided the barbasco did not accept that others came to catch fish. This, however, has changed during the last couple of decades. When somebody is going to fish the Bobonaza with barbasco, hundreds of other people may also show up in order to catch the fish. The provision of barbasco is, however, no problem, as some social status is awarded to those who provide it.

Another aspect of CPR management of fisheries is the handling of fishing techniques that are considered destructive, particularly dynamite and pesticides. In Sarayaku, there is strong opposition against using pesticide for fishing, and dynamite fishing is also not well regarded. Therefore, dynamite fishing is uncommon, and only on rare occasions suspicions do arise about somebody having fished with pesticides (see Chapter 10). Reportedly, fishing with dynamite and pesticides is more common in some other communities in the region.

11.4. Unawareness of the impact of human withdrawal of natural resources

The awareness of the impact of hunting on the resource stock is a relatively recent phenomenon in Sarayaku. Hunting luck has always been unpredictable, and the wild animals have been believed to live hidden inside the ridges. Shamans have been considered to have the ability not only to hide away animals inside the hills, but also to let the animals out from the hills when they wish. Scarcity of wild game has therefore been blamed on shamans hiding away the animals because of pure envy. This kind of belief is still common, and some people mean that, as the powerful shamans are dying off, and few youngsters enter the shaman profession, there is nobody left with the ability to let out the animals the old shamans locked up in the hills. Some people of the older generation explicitly rejected the idea to regulate hunting in order to conserve wildlife populations, claiming that wildlife populations were not decimated by hunting, but just hidden away inside the ridges by envious shamans. Others, while pointing out the harmful impact of firearms on wildlife populations, were more concerned about animals getting scared away by the sound and smell of gunshots, than by the resource withdrawal as such.

Nevertheless, most people are nowadays quite aware of the impact of hunting on the resource stock. This research project, with its many components of training events and participatory research (see Chapter 3), may have contributed to increase the awareness even more.

11.5. Conclusions

Natural resource depletion in Sarayaku can, to some extent, be explained as a “tragedy of the commons”, particularly the depletion of wild game and fish. However, the “tragedy of the commons” is an appropriate explanation only when the resource users are aware of their impact on the resource base (Moxnes, 2000; Burke, 2001), and this has not always been the case for all the resource users in Sarayaku. On the other hand, the loss of old-growth forest cannot be explained as a tragedy of the commons, because the need for land to farm is considered a higher priority than the preservation of old-growth forest.

Comparing the relatively successful common property management of the *wayuri* and *uksha* palms (*Genoma* spp.) with the hitherto obvious tragedy of the commons of wild game, it seems that CPR management of the *wayuri* is favoured by the resource being immobile, the possibility to harvest without killing, and the visibility of harvest activities. This contrasts with the wild game which is mobile, has to be killed in order to harvest, and which, at least to some extent, is possible to harvest without anybody else knowing it.

The relative success in getting individuals to provide barbasco for collective fishing suggests that collective action is facilitated if the individual sacrifice is publicly visible, such that the provider gets moral recognition. On the other hand, refraining from hunting or fishing in order to increase the stock available for others is harder, as the individual sacrifice is not visible to others. In other words, collective action is easier than collective inaction.

Common property resource management has not been very prominent in Sarayaku. Local institutions are largely norm-based. Infringements may lead to conflicts with neighbours, but rarely to formal sanctions. This is, however, changing as rule-based institutions are gaining more acceptance and as a new generation of community leaders make efforts to enforce the rules agreed upon at community assemblies.

Chapter 12: Economic experiments as learning tools for local resource users

12.1. Background

In order to understand which factors influence the extent to which resource users are able to solve CPR dilemmas, researchers have not only conducted field research on real situations, but also conducted experiments in the laboratory (see Ostrom et al., 1993 for a review). For such economic experiments, researchers typically create conditions that closely match the conditions specified in a theoretical model. By inducing value, usually cash rewards, the laboratory situation leads laboratory subjects to perceive and act on payoffs that have the same mathematical properties as the payoffs in the linked mathematical model.

Most economic experiments have been carried out with college students as subjects. A recent development in the field of experimental economics is, however, to instead perform the experiments in rural societies and with real resource users (Cardenas, 2000; Henrich et al., submitted). Apart from providing data about how the social context of people influence their economic behaviour, such economic experiments have also been appreciated by the participating subjects, because participating in the experiments has been a learning experience relevant to problems they face in real life (J.-C. Cardenas, pers. comm.). Thus, experimental economics can connect to the field of participatory research. When local resource users are actively involved in a participatory research process, this greatly increases the chances that the research findings actually are used in order to improve the situation on the ground (Hamilton, 1995; Shanley & Gaia, 2002; see Chapter 3). The purpose of the first experiment presented here was to expose local hunters to a situation similar to the real CPR dilemma of hunting wild animals, thus learning about their own behaviour in relation to the wildlife resource and other resource users. The purpose of the second experiment was to explore how an increased income may affect how much people hunt.

12.2. Managing wildlife in the lab

12.2.1. Introduction

Depletion of wild animals in real life is a slow process that occurs on a large spatial scale. The following experiment was designed with the hope that exposing resource users to a similar problem condensed in time and space may stimulate reflection over the corresponding process in real life. The aim was to construct a game that was neither too easy nor too difficult, so that successful management would be a realistic, but not easily achieved, goal. This chapter presents the model, the rules, and the results of the game played three times with different subjects. It also briefly explores the individual strategies that lead to the aggregate results. Finally, it discusses the pros and cons of economic experiments as participatory research tools, and outlines some future directions.

12.2.2. Methods

12.2.2.1. The model

The basic idea of the model is that each player for each round of the game has a limited number of "units of effort" which must be allocated[26] either in hunting wild animals or in raising domestic animals. In order to facilitate participation in the experiment for local hunters, many of whom seldom read, write or make mathematical calculations in daily life, all functions of the model were made stepwise and presented in table form. However, the stepwise functions were based on the following continuous equations:

The rate of return to effort allocated in raising domestic animals is fixed:

$$H_d=E_d \times A \qquad (A=2) \qquad (1)$$

where H_d is harvest of domestic animals and E_d is effort allocated to raising domestic animals, and A is a constant. On the other hand, the rate of return to effort allocated in hunting increases linearly with the size of the population of wild animals:

$$H_w=E_w \times N \times B \qquad (B=0.002, \{0 \leq E_w \leq 400\}) \qquad (2)$$

Where H_w is harvest of wild animals, E_w is effort invested in hunting, N is the size of the population of wild animals, and B is a constant. The number of wild animals, in turn, is determined by a logistic growth function

$$\Delta N/\Delta T=C \times N \times \qquad (1-(N/K)^{\theta}) - H_w \quad (C=0.19237, K= 10000, \theta=5) \qquad (3)$$

where T is time, K is carrying capacity, θ is an exponent used in order make maximum sustainable yield occur at 0.7K (in the stepwise function, when N is between 6751 and 7250), as is reasonable for large tropical rainforest mammals (Robinson & Redford, 1991), and C is a constant. This formula introduces time-dependence (see Herr et al., 1997) into the model. The use of a time-dependent model complicates the analysis, but it is a more realistic representation of the dynamics of wildlife in real life than the more commonly used time-independent models, where the resource is restocked to its original size after each round of play (e.g., Cardenas, 2000, 2003). The use of a logistic growth equation is more realistic than time-dependent models with a fixed replenishment rate (e.g., Messick et al., 1983).

Combining equations (1) and (2), one can see that at N=1000, $H_w= H_d$, that is, hunting and raising of domestic animals are equally profitable. (In the stepwise functions this occurs when N is between 751 and 1250.) At lower N, breeding of domestic animals is more profitable, and at higher N, hunting is more profitable.

Calibration of the model involved testing different values of the constants A, B and C, the maximum value of hunting effort (E_w), and of the initial value of N, as well as different numbers of total rounds. This was first done with simulated players in the computer, then with the hamlet assistants (see Chapter 3) as participants.

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[26] In the jargon of economics, the "units of effort" to be "allocated" would be called "tokens" to be "invested".

Because it was difficult to know how many people would show up in the morning to participate in the game, different versions of the game were prepared for seven up to ten people. The number of “units of effort” per player and round varied according to the number of participants, so that it totalled about 400 units of effort per round. The game started at N = 3000 and was played 40 rounds. Also, in order to remove incentives to deplete the resource in the end of the game, subjects received payment for another ten rounds, as if the level of resource would have been kept stable for these rounds, and dividing the resulting harvest equally among the players.

12.2.2.2. Subjects

The experiment was run three times in different hamlets. From each hamlet, households were randomly ordered in a list, and the respective hamlet assistant (see Chapter 3), got in charge of inviting each household to send one subject to participate, and to continue down the list until ten persons had accepted to participate in the experiment. (In reality, many who had accepted the invitation often did not show up, whereas others who had not been invited did show up.) The hamlet assistants had a sheet with the invitation written in Spanish, which they explained in the local language (Box 12.1).

Box 12.1: Invitation to participate in a didactic game about hunting

- The objective is to learn about hunting
- There will be prizes for all participants, about $1.80 - $5.50 each
- In order to participate one should:
    - Hunt at least once a year
    - Be acquainted with numbers and know how to sum
- Seven to ten persons can participate in the game
- The game starts at seven o’clock in the morning and finishes at noon. After the game a light lunch will be served.

12.2.2.3. Framing and rules

Because of the limited literacy of many of the players, instructions were given only orally in the local language. The players were told that they were going to play, that they were in another world where there were only two types of animals, equal in all respects except that one is wild and one is domestic. They received a sheet showing the relations between wild animal population size (N), production ($\Delta N/\Delta T$), and harvest per unit of effort (H_w/E_w), and the basic characteristics of the underlying model were explained. They also received a payoff table that directly showed the relation between units of effort invested in hunting (E_w) and total harvest (H_w+H_d) at different population sizes (N).

Box 12.2. Information given to participants after each round

Game 1 (Shiwakucha)

- Total harvest of domestic animals (H_d)
- Total harvest of wild animals (H_w)
- Gross increment of wild animal population, harvest not taken into account ($\Delta N/\Delta T+H_w$)
- Net increment of wild animal population, harvest taken into account ($\Delta N/\Delta T$)
- Wild animal population size after harvest (N)

Game 2 (Centro Sarayaku)

- Number of players investing different levels of units of effort in hunting (E_w) (0-4, 5-8, 9-12, 13-17, or 18-22)
- Wild animal population size after harvest (N)

Game 3 (Kalikali)

- Wild animal population size after harvest (N)

Each round of the game was framed as one year, and each unit of effort was framed as one day of hunting each month during that year.

Each player was randomly assigned a secret ID number in order to allow players to remain anonymous. They were informed that after the game they would be given 20 sucres for each animal harvested, in a closed envelope with their ID number on it, and they got a conversion table for converting number of animals to sucres or dollars. (At the time, Ecuador was in the process of abolishing the national currency and replacing it with the US dollar, so payments actually were made in dollars at the rate 25000 sucres per dollar.) They received a decision form where they should fill in their allocations and number of harvested animals for each round and calculate their accumulated harvests.

The players were explicitly told not to try to assign their units of effort as if it were in real life, that instead they should think only in terms of the game, and remember that they were going to get real cash rewards at the end of the game. They were prohibited to reveal their ID number and to show their game cards and decision forms to other players. However, they were explicitly told that they were allowed to talk freely about anything, and even were allowed to reveal to others what they wrote on their game cards and decision forms, as long as they did not actually show them.

For each round, an assistant handed out a game card to each player where they should fill out their respective ID number and the number of units of effort invested in hunting, and then return it to the assistant. Because of an untimely deterioration of a laptop computer battery, all calculations were made on a hand calculator. After making the calculations based on the numbers indicated on the game cards, I gave some feedback information to the players. This information was slightly different in each game (Box. 12.2), in order to explore whether the information provided to the players had any effect on the outcome. The real game started after first having played five practice rounds, where I had gone around revising the decision form of each player after each round in order to check that they understood how to fill it out.

12.2.3. Results

12.2.3.1. Benchmarks

In order to maximize the group profit (MAX), players should invest zero units of effort in hunting in the initial rounds, in order to raise the number of wild animals (N) to 6751 as soon as possible and then keep it there for the rest of the game (Fig. 12.1d, e, f, broken line). On the other hand, if all players play selfishly (SELF), they allocate all their units of effort in hunting until as long as N > 1250, and invest zero effort in hunting when N gets lower than this threshold level. Such selfish behaviour would cause an oscillation of N around 1250 (Fig. 12.1d, e, f, thin line).

12.2.3.2. Shiwakucha (Game 1)

The players started out with a total hunting effort that just barely caused the wild animal population (N) to decrease, but then gradually increased hunting effort, such that wild animal population size (N) after fifteen rounds had reached the point where allocation of effort units to hunting and to domestic animals gave equal returns. In spite of the low returns, the participants did not decrease hunting effort significantly for several rounds. Instead, they kept allocating much of their effort units to hunting even when this gave the same, or even lower, return as allocating effort units in domestic animals. Although they slightly decreased hunting effort in the end, this was not enough and too late to provide any benefit (Fig. 12.1 a, d). The total harvest was even lower than the SELF benchmark, with small differences between players (Fig. 12.2).

12.2.3.3. Centro Sarayaku (Game 2)

The players started with a total hunting effort low enough to allow the wild animal population size (N) to increase. Then, the total hunting effort slowly increased and this, in combination with the increasing N led to rapidly increasing returns. However, total hunting effort did not increase to such a high level that N would start to decrease. Instead, N continued to increase to higher than the optimal level before it decreased again and then oscillated around the optimal size. The total accumulated harvest was very near the MAX benchmark (Fig. 12.1 b, e). There were large differences between the players, however, three of them harvesting even more than the MAX benchmark, and one receiving just barely more than the SELF benchmark (Fig. 12.2).

12.2.3.4. Kalikali (Game 3)

In the first round, total hunting effort was just barely above the equilibrium effort level, but then rapidly increased. As a result, wild animal population size (N)

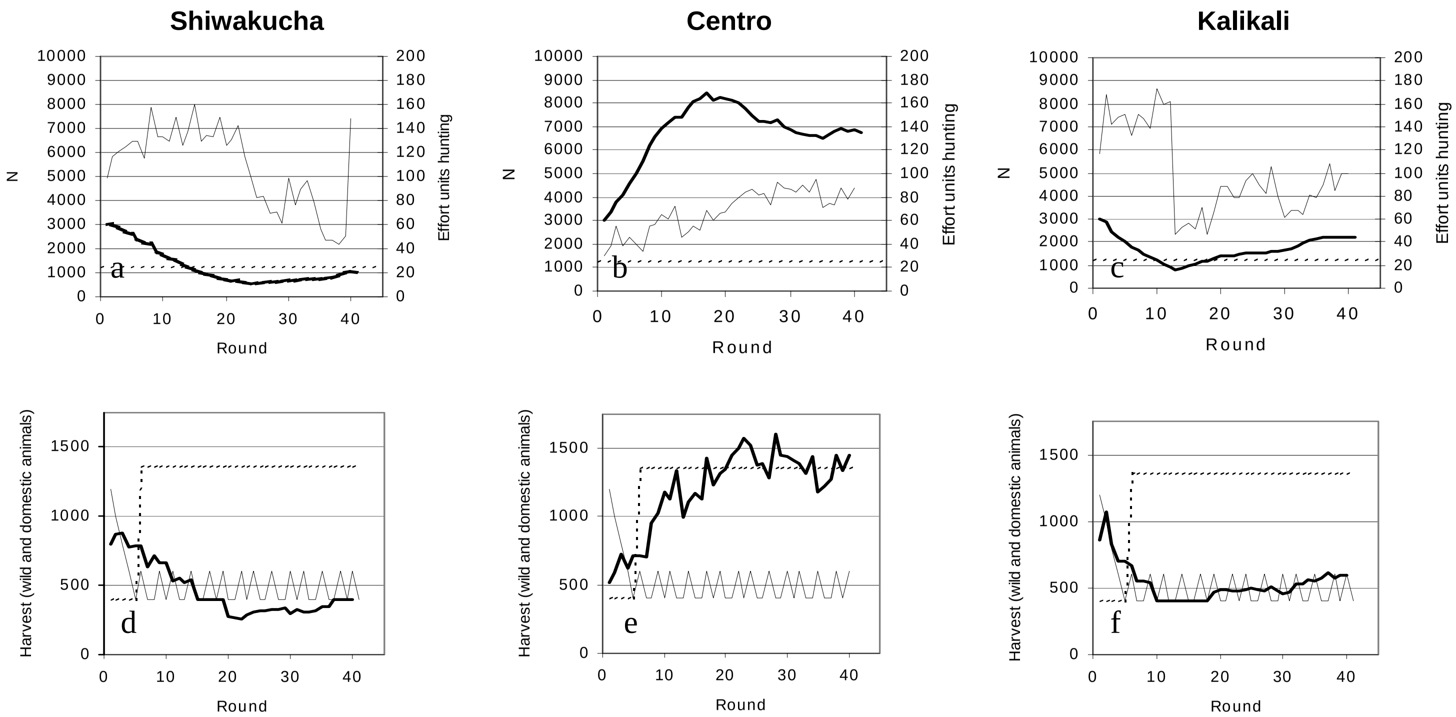

Fig. 12.1. Results of the three games played in Shiwakucha (left), Centro Sarayaku (middle) and Kalikali (right).Top row: Changes in effort units allocated to hunting (thin line), changes in the size of the resource pool (thick line), and the level at which allocation of effort units in hunting and in domestic animals were equally profitable (broken line). Bottom row: Changes in harvest (thick line) in comparison with MAX benchmark (broken line), and with SELF benchmark (thin line). See text for explanations.

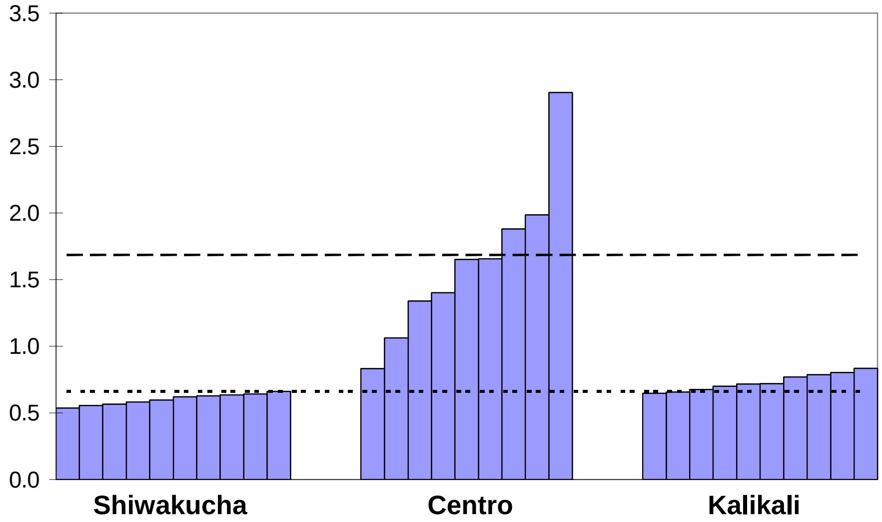

Fig. 12.2. Total individual payoff in the three games, expressed in equivalents of the daily wage rate for unskilled labour in the community at the time. Broken line = MAX benchmark. Dashed line = SELF benchmark.

decreased very rapidly, and after just eight rounds it was down to the level where investment in hunting gave the same return as allocation of effort units in domestic animals. During four more rounds, the players played high hunting effort, so that wild animal population size (N) continued decreasing. At this point, an overambitious assistant (a substitute for José Machoa, who suddenly had fallen ill) gave a hint to a few of the players that they should play low hunting effort in order to gain more profit in the end. At this point, hunting effort drastically decreased as some, but not all, players started to play very low hunting effort. However, the total hunting effort still was so high that it permitted only a very slow recovery of N (Fig. 12.1 c, f). The total accumulated harvest ended up just barely above the SELF benchmark level, with little differences between individual players (Fig. 12.2).

12.3.4. Other observations

An important question is how much the players actually understood of the game. Misunderstanding could occur at two levels. First, a player may not understand how the immediate payoff in each round depends on the effort units he indicates on his game card. This kind of misunderstanding would lead to arbitrary allocations of effort units, and would require that better feedback be given to the players about the payoff at each round. Second, a player may not understand how present withdrawal of resource units affects the potential future withdrawals. This kind of misunderstanding may be an important factor influencing how individuals behave both in economic experiments and in real life situations of natural resource depletion (Moxnes, 1998, 2000).

By revising the decisions forms, I found that most players had filled them in fairly well. Although there were sometimes minor errors in reading the payoff table, and some errors in calculating accumulated profits, undoubtedly most players had understood the relation between the effort units they indicated on the game cards and the payoff they received. Some, however, had either not filled out the decision form at all, or had done so extremely poorly. These were one player in game 1 (Shiwakucha), two in game 2 (Centro Sarayaku) and six in game 3 (Kalikali), where some of the players were not entirely sober. On the average, the players who did not fill out their decisions forms well allocated slightly less effort to hunting than other players. One person from game 2 (Centro Sarayaku) afterwards said that he had allocated effort units to hunting according to how he would have done in real life. Thus, the way the game was framed, in combination with some lack of understanding by some of the players of the relation between the effort units indicated on the game card and the immediate payoff, may have had some influence on how the game was played.

There may also have been some misunderstanding of how present withdrawal of resource units affected the future possibilities to withdraw resource units. The data do not permit any firm conclusions on this point. However, the fact that aggregate level of effort units allocated to hunting drastically decreased in game 3 (Kalikali) when the players got hints that this may increase their payoffs in the long run, indicates that this type of misunderstanding may have had a role. In game 1 (Shiwakucha) there was also a curious time-lag between depletion of the resource pool and a reaction in terms of a decrease in effort units allocated to hunting. Curiously, several players continued to make high allocations of effort units to hunting for several rounds even when N had decreased to under 750, the level at which allocation of effort units in domestic animals actually was more profitable (Fig. 12.1 a, c). Their decision forms, correctly filled out, indicate this was not due to any misunderstanding of how their immediate returns were affected by their allocations of the efforts.

In spite of having been explicitly told that they were allowed to talk about the game, the players rarely got involved in conversations about the game and common strategies. Although they constantly were talking to each other, the conversations almost exclusively consisted of jokes and laughter. In game 1 (Shiwakucha) and game 3 (Kalikali), occasionally some player remarked that it would be better to allocate less effort units to hunting. Such suggestions sometimes did result in some reduction in overall allocation of effort units to hunting, but many of the players just continued as before, and any substantial debate about common strategies never emerged. Very rarely were there any complaints about others playing too high hunting effort and the players never tried to find out how much effort units others allocated to hunting. It is notable that in game 2, the players got some information on individual allocation of effort units after each round (see Box 12.2). This clearly indicated that one person was consistently free-riding by allocating very high numbers of effort units to hunting. Nevertheless, there were no complaints about this behaviour, and no attempt to find out who the free-rider was.

After each game, there was a short discussion. However, explaining, training rounds, and the game itself, took about four hours, and by the end people had little energy left for discussions. Nevertheless, some commented that they had discovered too late that by depleting the resource they lost potential profit in the long run. One of the participants in game 2 (Centro), a man quite involved in community affairs, commented that he consistently had allocated few effort units in hunting in order to let the resource pool grow. We did not have possibility to have a final workshop that originally was planned in order to present all results back to the players and discuss them. However, we later learned that some of the players had discussed the experiment afterwards with each other, comparing the outcomes of the different games. This indicates that the experiment did stimulate reflection about management of common pool resources, which was the primary purpose of the whole exercise.

12.3.5. Discussion

Two of the games resembled the SELF benchmark scenario, players failing to cooperate in order to increase group profit. However, the oscillation around N=1250 predicted in the SELF benchmark scenario did not occur. On the other hand, one game resulted in a relatively successful CPR management, providing almost the maximum group profit, although unevenly distributed (Fig. 12.2). This indicates that, as was the purpose, the game provided a CPR situation that was difficult, but far from impossible, to solve. In both “failed” games, the number of effort units allocated to hunting tended to increase all the way until the resource was depleted up to the point where allocation of effort units in hunting provided equal, or even less, return than allocation of effort units in domestic animal breeding (Fig. 12.1 d, f). Given that community members previously had indicated lack of trust as an important obstacle for CPR management in the community, this seems consistent with the results of Messick et al. (1983) where low-trust subjects in a situation of overexploitation of a CPR resource increased their harvests over time.

This exploratory study does not permit any firm conclusions about the factors that influence whether players manage to self-organize in order to successfully manage the CPR of the game. However, the lack of communication between players was striking. The same lack of communication had also been observed during the pre-test with the hamlet assistants. When asked afterwards why they had not discussed with each other during the game, they replied that the secrecy observed with the game cards and decision forms had made them feel that communication was prohibited. In order to avoid this kind of misunderstanding, the participants in the present experiments got very explicit instructions that they were allowed to communicate with each other. Nevertheless, they did not take this opportunity. In other experiments, subjects are typically prohibited from communicating during part of the game, and when allowed to communicate, subjects become more cooperative (Ostrom et al., 1993, Ch. 7; Cardenas, 2003). If the absence of communication during the game reflects a similar absence of communication about the wildlife resources in the real world, this may be one reason why hunters have not been able to self-organize around management of these resources in the community. An interesting continuation of the work may therefore be to do the same experiment again in order to test for the difference between games where the players are only allowed to communicate, and games where they are actively encouraged to communicate.

The lack of communication may be related to values and habits from real life that the players bring in to the lab. Hunting is surrounded by secrecy, as people who go for a hunt take great care to sneak out of the community without anybody taking notice of them. In a similar parallel to real life, once the "free-rider" in game 2 (Centro Sarayaku) who made the biggest profit of all players, had left the site of the game, he made no secret about having made this significant profit, equivalent to three daily wages. On the contrary, he invited a number of friends, including several of the people who had participated in the same game, to use up the money partying at the local store, similar to the way a hunter may share the booty of a good hunt.

It cannot be ruled out that the observed depletion of the resource pool in the experiment was a result of unawareness about the nature of the dynamics of the resource pool itself, rather than of a lack or coordination or "tragedy of the commons". As a way to isolate these from each other, to enable comparison, the experiment could be made with one of the players acting as a social planner, making all the decisions on how to allocate effort units.

Several improvements can be made to the game. It would be important to provide the players with direct feedback on how their allocation of effort results in amount of harvest, and monetary profit. Also, making the underlying model continuous instead of stepwise would facilitate mathematical analysis. It would be important to provide more space for discussing the game with the players afterwards, as such discussions provide many insights both to the players and to the researchers (Cardenas, 2000, 2003). This requires that the game is speeded up in order to leave more time for discussions.

Being time-dependent, the model mimics the dynamics of the wildlife resource better than the more commonly used time-independent models. Nevertheless, there are several factors that this model does not account for. On the ecological side, such factors are, for example, multi-species interactions, year-to-year variation, spatial heterogeneity, stochasticity. On the economic side, the model is unrealistic in that it does not take into account discounting, and assumes a linear utility function. In real life, not only would hunters discount the future (rather eat a piece of meat today than an equal piece of meat after twenty years), they would also assign much greater utility to the first pound of meat hunted each day than to the five hundredth. In the logic of a market economy it may make sense to make losses during five years in order to make profit during the subsequent forty-five years, but in a subsistence economy it makes no make sense to starve during five years in order to guzzle during the subsequent forty-five years.

Including all these factors in the model would, however, make it far too complicated. Perhaps most important is that the players themselves consider the model relevant to problems in real life. A further development may be to involve local resource users in building the model itself, as this also would be quite a learning experience in itself (see Lynam et al., 2002; D'Aquino, 2002) and this may increase the likelihood that they apply their experiences from the game to solve real life problems of wildlife management.

One limitation on the use of this type of economic experiment is that it requires an exogenous source of money. When this is available, however, the experiences from these experiments in Sarayaku indicate that economic experiments have a potential to be an efficient tool for local resource users to learn about the management of common pool resources.

12.3. Effects of income on wildlife harvest

12.3.1. Introduction

Many people in the community considered lack of money to be the main reason behind game depletion. Therefore, they argued that the only way to solve the problem would be to increase peoples' monetary income. If they just had money, they said, instead of hunting they would buy chicken netting in order to raise poultry, or eat store-bought food produced elsewhere, such as rice and canned food. Some others, however, put forward the view that people with money were the ones that always have good guns and plenty of ammunition and can hunt as much as they like. Those who have money, they said, always have plenty of food, but they are also the ones who are exterminating the game, whereas the ones who do not have money to buy ammunition suffer hunger. It seemed as if the majority held the view that an increased income would lead to less wildlife harvest. But this argument may have been biased by (1) a wish to demonstrate environmental consciousness, and (2) a desire to put forward the case for more development funds to the community.

These questions connect to an ongoing discussion among researchers about the relation between income level and game depletion. Many tropical forest communities are currently undergoing profound socio-economic changes, which alter the way they use forest resources (e.g., Sierra et al., 1999), and one question that has caught the attention of researchers is how changes in income level affect how much people hunt. Shively (1997) showed that resource-poor households on Palawan, the Philippines, are those that hunt the most. On the other hand, Godoy et al. (1995) and Wilkie & Godoy (2001) suggest that an increase in income from an initially low level may increase wildlife harvest, as the extra income enables hunters to invest in improved hunting technology, but that a larger increase in income may cause wildlife harvest to decrease, as bushmeat is replaced by other food sources, i.e. shift from a necessity to an inferior good. Isolating the role of income is, however, complicated by the fact that income level may be correlated to market access, and market access in itself often leads to increased commercial hunting (e.g., Sierra et al., 1999).

The question has important policy implications. If income increases lead to a decrease in hunting, each extra dollar of income would yield a double benefit. Apart from the benefit of the income increase as such, there would also be the benefit of reducing hunting pressure, which in the long term would lead to stronger wildlife populations, which would be an additional benefit for wildlife-dependent communities. On the other hand, if an income increase leads to increased hunting, this may exacerbate depletion of wildlife resources and, in the long term, deprive local people of an important food source, thus reducing the net benefit of the income increase. In the first case, an income increase alone would improve the local economy as well as protect biodiversity. In the second case, any measure that increases income would need to be accompanied by specific measures in order to protect wildlife resources.

As the effect an income increase has on wildlife harvest depends on the initial circumstances (Godoy et al., 1995; Wilkie & Godoy, 2001) it is difficult to predict the direction of this effect at a particular place and time. Household surveys that permit regression analysis between income level and wildlife harvest, similar to Wilkie & Godoy (2001), are one option, but it is impractical if there is little between-household variation in income, if income is unevenly distributed in time, or if much of it is earned during migratory work outside the community in question. Another way to find out is to ask the people how they would spend an extra income. However, answers to hypothetical questions are prone to various kinds of biases (Tisdell, 1993, p. 102), and real incentives may be needed in order to get true answers (Bohm, 1994). In this section, we will present a method that uses real incentives in order to avoid biased answers to the question of what people would do if they got an extra income. Would they invest the money in hunting equipment, or would they use the money to shift to alternative food sources?

12.3.2. Methods

As the people of the community by themselves had formulated two opposing hypotheses, this provided a good opportunity to use a participatory research approach, employing a method that also would allow the local people to rapidly get feedback on research results and reflect upon the implications. For the purpose, we coordinated with the Sarayaku Government Council in order to make an experiment in the form of a lottery at a community assembly, where the people gather in order to discuss various issues of common concern.

At the lottery, a first prize and a second prize were to be drawn. However, for each prize, there were different alternatives, and in order to participate in the lottery, everybody had to choose which alternative he/she preferred if they won the first or second prize. The first prize was either a muzzle-loaded shotgun or 30 meters of chicken netting. Both these prizes were worth 420 000 sucres (about 20 USD) in the nearest town, corresponding to 7 daily wages for non-skilled labour in the community. For the second prize there were four alternatives out of which two were hunting ammunition (shotgun cartridges or gunpowder and shots) and two were food items: (rice and canned tuna fish or a rooster and two eggs). All four alternatives were worth 42 000 sucres (about 2 USD) according to local prices, corresponding to 0.7 daily wages. All prizes were exhibited in front of the assembly. We explained that we would not judge or condemn anybody for his/her choices, and that the lottery was just a way to find out more about the interactions between monetary income and hunting. Then we gave one ticket to every adult person at the assembly, and recorded their respective choices of prize items on a slip that remained with us. There we also indicated age, sex, and whether the person earned a steady salary or not. (Fig. 12.3).

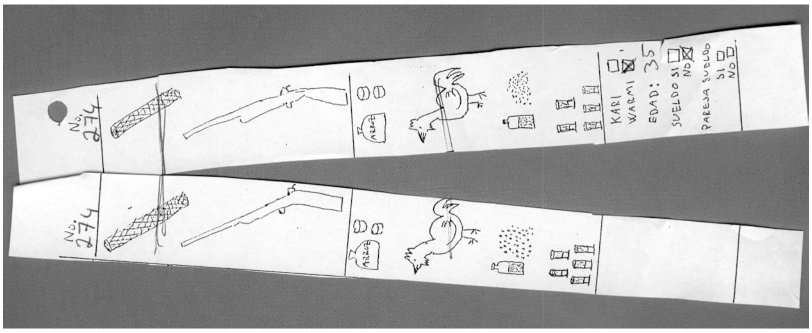

Fig. 12.3. The lottery ticket used.

About half of the adult population, 208 persons, were present, probably a quite representative sample. When everybody had received a ticket, we made a preliminary bulk count of peoples' preferences, and presented the result to the audience. Then we drew the winners, and one woman in her 50's won the second prize, according to her choice she got the rooster and the eggs, while a man in his 50's won the first prize of his choice, the shotgun. The remaining prize items were kept for future needs.

12.3.3. Results

For the first prize, about two-thirds of the people preferred the shotgun over the chicken netting. For the second prize, the preferences were quite evenly divided between ammunition and food (Fig. 12.4, Table. 12.1). While these were the principal results of the experiment, we also made some further analyses regarding the difference in preference between different groups of people within the community.

Of particular interest for the research question is also whether there are any differences in preferences between people with and without a steady salary. The people who had a steady salary showed preferences different from the rest, as they to a larger degree chose the chicken netting rather than the shotgun, and the food items rather than the ammunition (Fig. 12.5, Table. 12.1).

Splitting the results in age classes, there was a clear dividing line around an age of 30 years. A vast majority of the young people preferred the shotgun over the chicken netting. Among old people on the other hand, preferences were fairly evenly divided between the two alternatives. For the second prize, however, preferences were fairly evenly divided between ammunition and food among young as well as among old people (Fig. 12.6, Table. 12.1).

Splitting the results according to sex, the great majority of men preferred the shotgun over the chicken netting. The women were not far behind. For the second prize again, there was only a slight difference between men and women. A slight majority of the men preferred the ammunition, whereas a slight majority of women preferred the food items (Fig. 12.7, Table. 12.1).

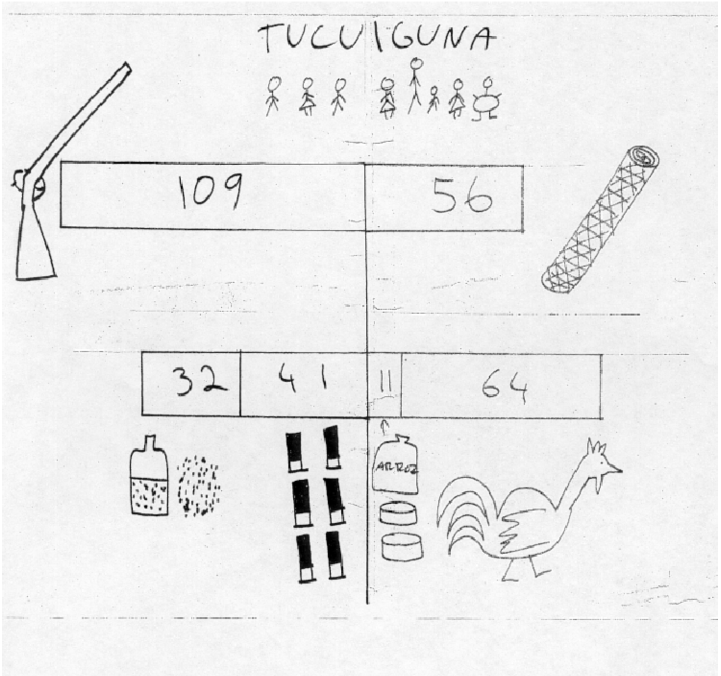

Fig. 12.4. Overall results of the experiment. Figures 12.4 – 12.7 are scanned from posters drawn in order to present the results at workshops in the community.

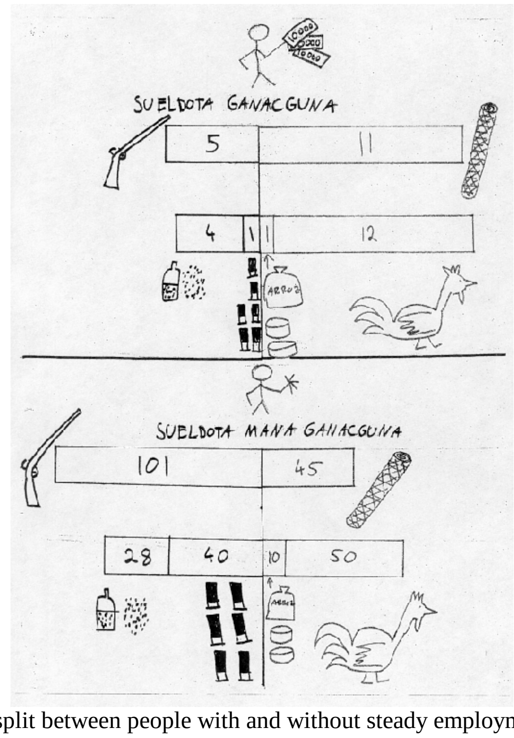

Fig. 12.5. Results split between people with and without steady employment, respectively.

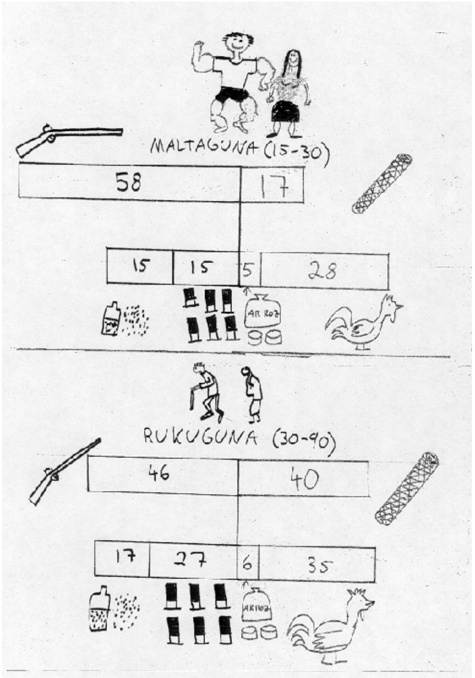

Fig. 12.6. Results split according to age.

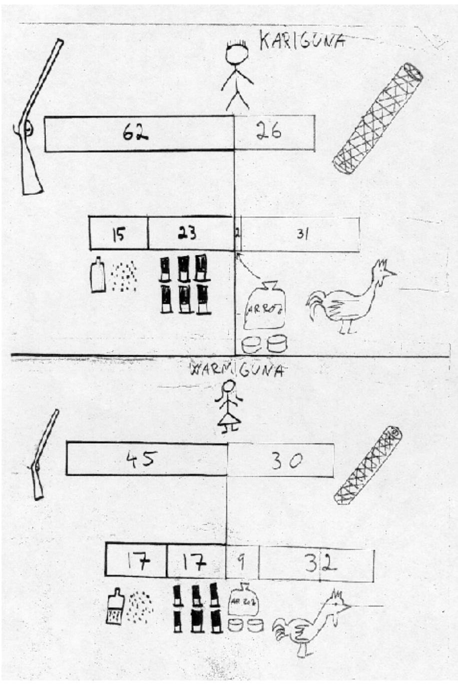

Fig. 12.7. Results split according to sex.

*Table 12.1. Summary of the results. As additional information, results of non-parametrical statistical analysis are provided. The pooled results and the results for each single category (men, women, young, old, salary, no salary) were tested with binomial test, examining if the frequencies differed from those expected if choices were made randomly. Opposing categories (men vs. women, young vs. old, salary vs. no salary) were tested against each other with a G-test. For the second prize, the sum of gunpowder/shots and cartridges is tested against the sum of rice/tuna fish and rooster/eggs. The sign * indicates significance at p<0.05. The sign ** indicates significance at p<0.05 also when p-values are adjusted according to a sequential Bonferroni test.*

		First prize		Second prize	
		% choosing hunting equipment	G-test	% choosing hunting equipment	G-test
Pooled		66**		49	
Split according to income	Steady salary	31	*	28	*
	No steady salary	69**		53	
Split according to age	Young	76**	**	48	ns
	Old	53		52	
Split according to sex	Men	70**	ns	54	ns
	Women	60		45	

12.3.4. Participatory interpretation of the results

During the following two weeks, we arranged workshops in each of the five hamlets that constitute the community, in order to present and discuss the results in more detail. For that purpose, we elaborated bar diagrams with pictures, understandable also for illiterate people (Figs. 12.4 -12.7). The results caused much laughter and comments that the idea that money would solve the problem of game depletion had been just empty words.

That most women had preferred the shotgun was somewhat surprising to us, as hunting with firearms is an exclusively male occupation, whereas women often are in charge of taking care of the poultry. However, people considered it quite natural that women wanted shotguns for their husbands and sons so that they could bring home meat.

That the young were more prone to prefer hunting equipment was also considered natural, as they are the most active hunters. This result contrasted with some statements previously made by youngsters that the old people were the ones to blame, and that the young were more conscious about the problem of game depletion (see Box 6.3).

People did not consider the income level as such to be the main reason why people with a steady salary preferred the chicken netting and food items to the hunting equipment. Instead, most of them said this was because these people have a job to take care of, and therefore do not have much time to go hunting, so they prefer to buy food or raise poultry.

12.3.5. Discussion

The subjects of the experiment faced the choice between on one side hunting equipment, and on the other side alternative foods or material for producing alternative foods. Most of them chose hunting equipment. This seems to refute the hypothesis that an increased income automatically leads to less wildlife harvest. However, the same hypothesis seems to be supported by the fact that those who earned a steady salary showed less preference for the hunting equipment. But again, the community members themselves did not so much attribute this effect to the income as such, but rather to the employment that reduces the time available for hunting, an aspect not taken into account in previous studies (Godoy et al., 1995; Shively, 1997; Wilkie & Godoy, 2001).

The limited number of alternatives available to the subjects does not, of course, reflect the multitude of choices available in real life. If a slightly different set of alternative prizes had been offered, the results of the experiment may have been different. Although both were food items, and the monetary value was the same, much more people chose the rooster/eggs than the rice/canned tuna. This shows how sensitive this type of study is to the exact choice of items offered as prizes. The difference in preferences between the rooster/eggs and the rice/canned tuna may reflect different pricing mechanisms. All other prize items are industrial goods, sold in stores at prices set by market mechanisms. Poultry, on the other hand, is locally produced, and traded directly between producer and consumer at prices that are set annually at community assemblies. At the time of this experiment, Ecuador had suffered severe inflation such that the general price level had more than doubled over less than a year, but the community had not yet had an assembly in order to adjust prices on locally produced and traded goods accordingly. Because the mechanism of price setting for the rooster/eggs was different than for the other items offered as second prize, it may not be correct to consider them all to have equal monetary value. The perceived value of the rooster/eggs may therefore have been considerably higher than the official price, and this may explain why so many people chose the rooster/eggs.

On the other hand, the monetary value of the different items at stake might not have been a very important consideration. We gained this insight as a side effect of a miscalculation of the time that we needed to hand out the tickets at the assembly, which forced us to train some assistants on the spot. We did not manage to make clear to each of these that on each ticket the preferences should be indicated both for the first prize and the second prize. Thus, almost half of the participants indicated only one choice, either a first prize or a second prize. Interestingly, 40% of those indicated only a second prize, although the first prizes, in monetary terms, were worth ten times more. This may seem irrational, but it probably reflects that people consider the direct use value of the items, and not their monetary value in exchanges. For example, those who already have enough guns at home may have more use of ammunition than of an additional gun.

The results of this experiment indicate that an increase in income in the community hardly would imply an easing of the pressure on wildlife resources. On the other hand, employment may do so. However, an aspect not taken into account in this experiment was that although people with steady employment may hunt less than others, they may instead buy bushmeat from others. Therefore, it remains to explore whether increased employment really would cause a decrease in total hunting pressure.

Local communities are key actors in determining how forest resources are used and protected, and are the first to suffer if resources are depleted (Shanley, 1999). The method used for this study is particularly useful in that it permits the local resource users themselves to fully grasp the research design and participate in the interpretation of the results.

Chapter 13: Threats, opportunities, and recent developments

13.1. Introduction

During thousands of years, the most significant types of natural resource use in the Sarayaku area, in terms of their importance for human society as well as their ecological impact, have been subsistence agriculture, fishing and hunting. Consequently, these activities have been the focus of this thesis. In order to draw up future scenarios it is necessary, but not sufficient, to take into account current trends in these types of resource use. One cannot exclude the possibility that other types of natural resource use, such as cash cropping or extraction of oil and timber, in the near future may take over as main components in the local economy or as major causes of environmental change. Such developments have already been seen in similar communities not far away. Therefore, the effects such activities may have for the people and the environment in Sarayaku will here be briefly discussed.

This chapter will also briefly discuss some important events that have happened in Sarayaku after the completion of fieldwork in late 2001. Such events are particularly Sarayaku's struggle against the oil company CGC, the creation of a wildlife reserve, and the implementation of a university programme in Sarayaku in order to educate teachers.

13.2. Potential agents of change

13.2.1. Oil

Various foreign oil companies have searched for oil in the Ecuadorian Amazon ever since the 1920's (Galarza-Zavala, 1981). In 1967, finally, the consortium Texaco-Gulf found a rich oilfield near Lago Agrio in the northern Ecuadorian Amazon, and in 1972 a pipeline to the coast was completed in order to exploit the oil (Kimerling, 1993).

Initially, the most obvious impact of the oil exploitation resulted as a consequence of the construction of roads along the pipeline and to the oil wells. Thousands of colonists settled along the roads, cutting down the forest and dispossessing the indigenous peoples from the land where they had made their living. With time, however, the routine release of untreated wastes, as well as accidental oil spills, also created a problem of severe pollution with hydrocarbons and heavy metals (Kimerling, 1993; Jochnick et al., 1994). For the affected people, this has implied increased incidences of cancer, spontaneous abortion, fungal skin disease, diarrhea, gastritis, pains in head and ears, and irritation of eyes, nose and throat (SanSebastián et al., 2001a, b, 2002; Hurtig & SanSebastián, 2002).

ChevronTexaco is currently facing a lawsuit by people affected by the pollution[27]. Meanwhile, the government hopes to increase oil production. An

[27] http://www.amazonwatch.org/newsroom/view_news.php?id=750 (2004-03-02)

additional pipeline has been constructed amid protests by local inhabitants as well as international environmentalist organizations, and started operating in 2002.

The oil frontier has been pushed towards the south, and since 1994, an oil field has been in production in Villano, only 30 km north of Sarayaku. Although the company praises itself for its management of environmental, social and health issues (e.g. Vacas et al., 2003), other observers note that the project has not brought tangible benefits to the local people (Korovkin, 2002). No independent assessment has been made regarding possible pollution caused by the project, but some local inhabitants complain about dead watercourses[28].

One hundred and fifty kilometers downriver from Sarayaku, oil is exploited on the Peruvian side of the border, and elevated levels of heavy metals and hydrocarbons have been found in the environment (Ministerio de Energía y Minas, 1998), so migratory fish caught by Sarayaku people may already be affected by oil-related pollution.

The impact of the oil industry has led to various protests on the part of the indigenous people in the Amazon (e.g. Gerlach, 2003). Sabin (1998), however, points out that in spite of the negative impacts the oil industry have had on indigenous people, they have themselves commonly worked on seismic crews. According to Sabin (1998), indigenous communities and federations rarely have opposed oil activities as such, but instead have "questioned the terms of industrial activities more than industry itself" (p. 155) and "sought to readjust the distribution of costs and benefits" (p. 153).

13.2.2. Timber

In tropical forests worldwide, logging is a major cause of degradation of tropical rainforests. Not only does the felling of the trees have a direct impact on the forest. The logging roads also connect the land to regional markets, making it profitable to clear the forest in order to plant cash crops. When indigenous people do not have legal land titles, or when their land rights are not effectively enforced, encroachment by settlers often follows (e.g., Watson, 1996).

Logging in the Amazon has affected the indigenous people in different ways. In some cases loggers subdue indigenous people by the force of firearms, killing those that pose resistance. In other cases, loggers strike deals with indigenous communities. However, such deals are often exploitative, involving cash payments, goods, or services of a value representing a minimal fraction of the wood extracted. Such deals also tend to favour a limited number of powerful individuals in the communities, and sometimes set different indigenous communities or peoples against each other (Watson, 1996; Turner, 1999). Nevertheless, logging does not necessarily have to be contrary to the interests of the indigenous people. Where indigenous people control their own land, there are also some cases where they have been able to negotiate fair prices for the timber, and have avoided the benefits becoming concentrated to a few leaders (Turner, 1999; Zimmerman et al., 2001).

[28] Personal communication by Pedro Santi, Huitoc; Jose Dahua, Pandanuque, on video filmed by Cristina Gualinga Cuji and Acción Ecológica.

The benefits acquired through timber sales may, however, have a cost in the form of decreased abundance of wild game and other non-timber forest products (Shanley & Gaia, 2002).

Timber extraction is already an important component of the local economy in the Canelos community, located where the road from the town of Puyo meets the Bobonaza river (figs. 2.2 and 2.8). The timber is cut into thick boards and transported by horse and, sometimes, canoe, to the road. If, and when, the road reaches the vicinity of Sarayaku, the community will have to deal with the question about whether it should get involved in timber sales at all and, if so, how, where and how much to cut.

13.2.3. Roads

Worldwide, the construction of roads in tropical rainforest areas generally leads to increased deforestation (Kaimowitz & Angelsen, 1998). As the indigenous people in Pastaza have legal titles to their land, however, large-scale colonization by outsiders may be avoided even if roads are built. Even so, road access may lead to increased market integration, and this, in turn, may lead to more cash cropping and deforestation, as has happened in other parts of the Amazon (Henrich, 1997; Rudel et al., 2002).

The government of Ecuador has long had plans to build a road from Canelos, passing Sarayaku, to the military base in Montalvo and on to the Peruvian border. This road even exists on the official maps of the country. After the peace treaty with Peru in 1998, there may be fewer strategic reasons to build this road than before. On the other hand, the Canelos road is gradually being pushed downriver, as the community actively lobbies the municipal authorities to get road access also for some distant hamlets. This has already considerably facilitated river transport from Sarayaku to Puyo, as there is no need anymore to pass a few difficult rapids.

At the current rate, counting from 1995, when the road reached Canelos proper, it would take 60 years for the road to reach Sarayaku. The municipality most probably will continue to extend this road if the people want it, and if there is money to do it. Although other indigenous communities in Pastaza desire to get a road connection in order to be able to commercialize cash crops (Korovkin, 2002), many people in Sarayaku are skeptical (see Chapter 6), having observed that road access had brought little economic progress to Canelos, but on the other hand significant social impacts. If oil is to be exploited in the area, however, road construction may be inevitable. Although there is one nearby case of oil exploitation without constructing a road (Korovkin, 2002), that is an exception, and the indigenous communities will not hold the decision-making power in that matter.

13.3. Recent developments

13.3.1. Oil company strategies and indigenous communities

13.3.1.1. Sarayaku vs. CGC

In 1996, the Ecuadorian government granted a 2500 km^2 concession, called "Block 23", to the Argentine company CGC for oil exploration. About half of this area was Sarayaku territory, and the rest belonged to various smaller Kichwa, Shuar and Achuar communities, primarily along the Bobonaza and Copataza rivers (Fig. 2.3). This was the start of what would become a bitter conflict between Sarayaku and the CGC, which still continues. This conflict, as such, was not meant to be the focus of my research. However, any discussion about the relation between the Sarayaku people and the environment would not be complete without mentioning the oil industry.

My perspective on this problem is not, and could not be, the one of a "detached observer" (see Chapter 3). The relation established with the community, which was a prerequisite in order to be able to finalize my research, demanded absolute loyalty with the community and its democratic structures of local government. Thus, when the general assembly of the community, in 2000, prohibited any contact with the oil company, this applied to my person as much as to anybody else. Interviewing oil company representatives or requesting any documents from the oil company was therefore out of the question. Nevertheless, my observations provide some insights into the relations between oil companies and indigenous people in the Ecuadorian Amazon that complement previous analyses (e.g., Sabin, 1998; Mendez et al., 1998; Korovkin, 2002).

Most of the communities within the concession belonged to the OPIP (Organization of Indigenous Peoples of Pastaza). Initially, CGC attempted to establish a dialogue with the OPIP in order to reach an agreement about the seismic explorations. Those contacts did not, however, proceed rapidly forward, so CGC changed tactics and started to approach Sarayaku directly. At the time, some individuals of OPIP had received allowances from the oil company ARCO when participating in a joint Environmental Commission that was supposed to participate in the environmental management and monitoring of ARCO's operations in Block 10, north of the Block 23 (see Mendez et al., 1998; Korovkin, 2002), and reportedly CGC had donated some funds to the OPIP. This had caused resentment among many people in Sarayaku. In their view, a few OPIP leaders lived a comfortable life in town paid by the oil companies, while none of these benefits reached the communities.

Therefore, when CGC approached Sarayaku directly, establishing a direct contact with the company, without intermediaries, was seen by some community members as an opportunity for a little revolt against the OPIP leadership. Others in Sarayaku, however, firmly opposed any contact with the CGC. Whereas some people happily traveled between Sarayaku and Puyo in chartered airplanes paid by CGC, others refused to do so. When CGC sent an airplane load of school supplies as a "gift" to Sarayaku, a group of youngsters immediately set it all on fire. Because of this resistance, CGC representatives were not able to enter Sarayaku directly. However, CGC employed a Sarayaku native, who recently had returned to live in the town of Puyo after several years in the U.S., as a community liaison officer. Being a community member, he could move around freely in the community, frequently bringing “gifts” such as sacks of rice, live poultry, and alike. The president of Sarayaku at the time (1997 – 1999) frequently made use of the free air flights provided by CGC and, according to Sarayaku informants, he also was provided lodging and food in the best hotels of Puyo. CGC also offered him a personal contract for construction of a system of running water in the community. Whereas some people in the community considered that he had sold himself to the oil company, others supported him because they needed running water.

In May 2000, a CGC representative, in charge of Block 23, finally entered Sarayaku and talked at a community assembly. He proposed the signing of a contract that would imply that Sarayaku gave its consent to the oil exploration as well as 20 years of exploitation. In exchange, CGC would provide community support to a value of 60 000 dollars yearly during the exploration phase, and a total of 80 000 dollars during the 20 years of production. The money would be for all communities within the concession, but would be administrated by Sarayaku[29]. Many people loudly supported the signing of the contract. Others, however, particularly the women and elderly, opposed it. There was also considerable confusion, as some, even educated community leaders, misunderstood the meaning of the contract, believing that that CGC asked nothing in return for the money it offered. The CGC representative argued that signing the contract was Sarayaku’s last chance to rise up from poverty. If the community chose not to sign the contract, he said, CGC would not enter by force and just return to Argentina continuing to be “friends” with Sarayaku. The meeting ended amid chaos, and the contract was not signed. A couple of weeks later, Sarayaku had another community assembly and analyzed the events more thoroughly. Following that, a delegation from Sarayaku called CGC to a meeting in Puyo. The message was this time clear and unmistakable. Sarayaku did not want any oil exploration in its territory, and there was nothing more to discuss. From now on, Sarayaku refused all attempts to dialogue by CGC. Instead, the community turned to the Ecuadorian government, proposing that Sarayaku should become a protected area, excluded from oil operations in perpetuity.[30]

Having failed to get Sarayaku’s consent, CGC now changed strategy, starting to approach the other communities within the concession. The company arranged a number of courses and gatherings for the people of these communities, and employed community leaders as well paid motorboat drivers at these events. Some communities got seriously divided over the issue, but those leaders who supported CGC retained power. CGC created a so-called “Coordination Committee”, composed of community leaders assigned the double roles of being paid employees of CGC while also claiming to represent their communities, and making

[29] Letter from Ricardo Nicolás, representative of CGC, to Mario Santi, president of Sarayaku, dated May 23, 2000, copy in the possession of the author

[30] At the time I was not in Ecuador. Several people who had been present at the meetings narrated the happenings to me at my arrival to Sarayaku a few weeks later.

pronouncements in the mass media in their name. Members of the Coordination Committee, and some other leaders of nearby communities, sometimes came to the outer hamlets of the Sarayaku community to gather small groups of people, hand out gifts, slander the Sarayaku leaders of being corrupt, and talk about the supposed benefits the oil exploration could bring to the community.

CGC claimed that only a small portion of the people in Sarayaku opposed the oil operations. Although the previous president of Sarayaku had terminated his mandate in 1999 according to the normal procedure in the community (see Chapter 2), CGC continued to deal with him, making him sign various contracts in the name of the community, including contracts for running water and solar energy. CGC also appointed him as Sarayaku's "representative" in the Coordination Committee. After disregarding several warnings, he finally became an outcast, expelled from Sarayaku, and living permanently in a hostel in town, apparently at the expense of CGC. On one occasion, CGC employees handed out medicines to inhabitants of Sarayaku, asking them to present their ID cards and sign a paper as a receipt. Afterwards, this paper was manipulated and transformed into a petition directed to the CGC, confirming that three out of the five hamlets in Sarayaku conformed a separate organization, called "Independent Hamlets of Sarayaku", represented by two named CGC employees, one of which was the previsously expelled Sarayaku ex-president. The petition also asked for the seismic exploration works to be initiated as soon as possible.[31]

In late 2002, CGC finally initiated seismic work in block 23, starting in communities where they had gained the support of the leaders[32]. Meanwhile, however, Sarayaku organized surveillance of its borders, and when the seismic crews reached Sarayaku territory, they were expelled. After two months of repeated clashes with CGC employees, military and private armed guards, the military got the order to withdraw, and the subcontractor of CGC decided to pull out for good, so that CGC was forced to suspend the activities. During that time, Sarayaku members had been subjected to torture, an attempt of murder, and a rape threat. As normal subsistence activities had been abandoned, many people suffered malnutrition and faced heavy work in order to catch up with the agricultural duties they had neglected.

CGC considered Sarayaku's active resistance to be "criminal" and "terrorist" acts, and and intended to resume activities as soon as another subcontractor could be found, and the government guaranteed "security" (see El Comercio, 17-Mar-2003)[33]. The Ecuadorian Minister of Energy and Mines has publicly announced that he will send soldiers to the Sarayaku territory in order to allow the CGC to continue the seismic operations (see El Universo, 10-Oct-2003)[34].

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[31] Copy in the posession of the author

[32] I left Ecuador in January 2002. My main sources regarding posterior events are email messages from various Sarayaku members.

[33]http://www.elcomercio.com/noticias.asp?noid=54947 (accessed 4-Mar-2004)

[34]http://www.eluniverso.com/core/eluniverso.asp?edicion=1&page=noticia&id=12&tab=1&contid=FA7ACF534DB344F7A92ADC6AE13C8132 (accessed 2-Mar-2004)

Sarayaku, on the other hand, claimed that the community was just defending its constitutional rights. In 1998, a new constitution was adopted in Ecuador, which significantly strengthened the indigenous peoples' rights (see Gerlach, 2003, pp. 77-78).

CGC, employees, on the other hand, reported several Sarayaku members to the police, accusing them of attempted murder, theft and vandalism, which resulted several arrest warrants against several members of Sarayacu, including a few community leaders, accused of being the "intellectual authors" of the alleged crimes. Sarayaku protested emphatically, considering these to constitute political persecution. A few days before the president of Sarayaku would meet the Inter-American Commission of Human Rights in Washington, D. C., in order to complain about the non-compliance on part of the Ecuadorian Government, however, a public prosecutor decided to drop some of the arrest warrants, because of the lack of any evidence that the alleged crime had even occurred. Later, all the arrest warrants were definitively cancelled on similar grounds (see El Comercio, 13-Feb-2004[35]; El Universo, 5-Mar-2004[36]).

In its continued attempts to discredit the leadership of Sarayaku, CGC started to broadcast a daily one-hour programme over a local radio station, where members of the "Coordination Committee" were able to slander, insult, and threaten Sarayaku members in general, and the community leaders in particular. However, when Sarayaku finally approached the director of the radio, threatening legal action, the programme was immediately stopped. Sarayaku leaders received several anonymous death threats over the telephone, and at one point a local radio station broadcasted faked condolences of three Sarayaku leaders, supposedly killed in a traffic accident.

During much of this struggle, Sarayaku leaders complained that the community was alone. Although a couple of communities on the outskirts of the concession supported Sarayaku, other communities sided with the oil company against Sarayaku, even closing off river transport (see El Universo, 3-Mar-2003[37]), so that the only way to get to town was by airplane, which was very expensive. The indigenous peoples federations such as the OPIP, CONFENIAE, and CONAIE, did not side with the oil company but did not provide much support to Sarayaku either. The version that dominated in the mass media was that there was no opposition to oil activities as such in the Block 23, and that many communities even welcomed the CGC. An illustrative example is an article in El Comercio (7-Dec-2001[38]),

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[35]http://www.elcomercio.com/noticias.asp?noid=85868&hl=true&f=2/13/2004 (accessed 6-Mar-2004)

[36]http://www.eluniverso.com/core/eluniverso.asp?edicion=1&page=noticia&id=12&tab=1&contid=AFA85672C19D4FE9952AA1DEF9B1B3A9 (accessed 6-Mar-2004)

[37]http://www.eluniverso.com/core/eluniverso.asp?edicion=1&page=noticia&id=12&tab=1&contid=A0FA657D8C504B6196B52D5C295A89BE (accessed 6-Mar-2004)

[38]http://www.elcomercio.com/noticias.asp?noid=8258&hl=true&f=12/7/2001 (accessed 4-Mar-2004)

titled “Petrol: Amazonian indians seek participation”, which narrates how a large number of delegates from different indigenous communities gathered in Pakayaku (see Fig. 2.3) in order to discuss a proposal for the “current and future petrol exploitation” in the Pastaza province. While demanding participation in the economic benefits, and measures to limit the environmental damage, the participants of the gathering apparently expressed no opposition to oil exploitation as such. What the article does not mention, however, is that the Sarayaku people boycotted the gathering in question, refusing to let their presence give legitimacy to an event that had been financed and orchestrated by CGC itself.

Although Sarayaku sent email messages to a wide range of international environmental and human rights organizations asking for support, they rarely received any reply. Only when the community members started to confront the seismic crews out in the jungle, did Sarayaku became frequent frontpage news in Ecuadorian newspapers. Gradually, support for Sarayaku built up within Ecuador as well as internationally.

Before that, however, Quito-based Centro de Derechos Economicos y Sociales (CDES), and Washington-based Center for Justice and International Law (CEJIL) started to provide legal assistance to Sarayaku. In November 2002, Sarayaku filed a complaint to the *Defensor del Pueblo* (Ombudsman for constitutional rights), who a week later pronounced that the CGC and the Minister of Energy and Mines had violated articles 84 and 88 of the Ecuadorian Constitution, as well as Art. 28 of the Environmental Management Law, Art. 15-2 of the Convention 169 of the ILO, and Principle 10 of the Río Declaration on Environment and Development, by not having duly consulted the affected communities before initiating the oil prospection activities. In April 2003, Sarayaku presented a petition to the Inter-American Commission of Human Rights. In response to that, the Commission ordered the Ecuadorian Government to implement cautionary measures, in order to protect the “physical, psychological and moral integrity” of the people of Sarayaku, and particularly the community leaders, as well as to protect the “special relation the community has with its territory” The Ecuadorian Government, however, has explicitly pronounced in the press that it will disregard this legal ordinance (see El Expreso, 19-Jan-2004), and did not even show up to a meeting called by the Commision on March 3rd, 2004, in order to treat the issue (see El Universo, 5-Mar-2003[39])**.** In December 2003, men and women from Sarayaku who were on the way to a peaceful anti-oil manifestation in the town of Puyo, got physically assaulted by a mob of people in the Canelos community (see Figs. 2.2, 2.8), as an explicit retaliation for their opposition against the CGC Company (see Rigzone, 5-Dec-2003)[40].

The issue continues unresolved, as the government has announced that it will send military to Sarayaku in order to make way for the oil exploration, while Sarayaku, on the other hand, is preparing to defend its land. Whatever the final

[39]http://www.eluniverso.com/core/eluniverso.asp?page=noticia&id=12&tab=1&contid=4CCB04EF2A154D16BD47F0B06CBF091E&EUID=" (accessed 7-Mar-2004)

[40] http://www.rigzone.com/news/article.asp?a_id=9806 (accessed 4-Mar-2004)

outcome will be, it will constitute a milestone in the history of Sarayaku, that will have caused lasting changes in the relations among the Sarayaku people, with neighbouring communities, and with the surrounding national and international society.

13.3.1.2. Insights provided by the case of Block 23

The case of Block 23 provides some important insights that challenge the view of Sabin (1998) on the way indigenous people in the Ecuadorian Amazon relate to oil companies. The conclusion that indigenous people "questioned the terms of industrial activity more than industry itself", seems to be premature, for a number of reasons:

First, one must ask the question of whether the indigenous people have had any choice at all. In the case of Block 23, CGC made extraordinary efforts in order to achieve consent to the oil activities from Sarayaku representatives. When the company could not get this consent, however, they did not accept this result, and proceeded to attempt to appoint "representatives" of Sarayaku themselves, even recurring to outright fraud. Finally, having failed also in this strategy, it proceeded to initiate seismic works anyway, backed by military and private guards. Although Sarayaku opted for confronting the seismic crews, as well as the private guards and military, in the forest, this must be considered exceptional. To judge from the Sarayaku case, the choice of indigenous communities is between, on one hand, accepting oil activities *per se*, and negotiating in order to receive a larger share of the economic benefits and reducing the negative impacts or, on the other, to confront better fed, better equipped, and better armed seismic crews, private guards, and military in the forest. It is not surprising that few communities have chosen the latter alternative.

Second, the position of indigenous peoples regarding oil activities cannot be understood without taking into account the internal politics of the communities and their federations. Not only did the CGC co-opt local leaders and create patron-client relations where certain indigenous leaders took on the lucrative role of intermediaries between CGC and the communities (cf. Korovkin, 2002; Turner, 1999). CGC also attempted to distance community members from those leaders that did not accept to get co-opted, and promoted persons of its own choice as leaders. The study of Sabin (1998), based on academic publications, newspaper and magazine articles, and a limited number of interviews with leaders of indigenous federations, makes no attempt to analyze the mechanisms by which certain indigenous persons acquire and maintain their status as leaders. In the case that any of these leaders to any extent derive their power by serving as intermediaries in a patron-client relation between oil companies and indigenous communities, their views on the oil industry may primarily represent their own personal interests, and should not be taken as representative of indigenous people in general. It should here also be noted that many of the grassroot people in Sarayaku considered the dialogue between the oil company ARCO and OPIP (see Mendez et al. 1998) to be little more than a strategy of ARCO to buy the conscience of the OPIP leaders, thus destroying the organization, and leaving the grassroot communities alone to fend for themselves. Ironically, at one point this strengthened the support in Sarayaku for the idea to strike a deal directly with the CGC, as some argued that otherwise only the OPIP leadership would reap the benefits from oil development that seemed inevitable.

The question of who actually speaks for the indigenous people is therefore not straightforward. And it is complicated even more by the fact that the oil companies actively strive to make the mass media serve their purposes. This is evident from a leaked document regarding the program of community relations of the oil company Burlington Resources, which operates a concession adjacent to block 23, and also has a 25% share in the block 23. One of the activities planned in order to overcome the resistance posed by the communities within the block 24, was to:

> "Cooperate with local media in order to make radio reports and written reports that contribute to change the adverse positions and stimulate a spirit of cooperation in order to carry out the project."[41]

Of course, the oil companies also have the financial muscle to do this well. Local radio stations frequently reported from communities where the people expressed their gratitude for solar panels or other things provided by CGC. One well-known radio journalist in Puyo even accompanied and participated actively in the Coordination Committee of CGC on its PR tours in the communities. On the other hand, journalists would not enter Sarayaku, unless the community provided the transport, which was exceedingly costly, given that a chartered aircraft was the only feasible way of traveling. As the case of Sarayaku was almost unknown internationally, the community received hardly any financial support. And because of the lack of funds it could not make their case known by bringing journalists to the community. The war of information was very unequal.

In this particular case, though, several factors combined to make it possible for Sarayaku to fend off the oil company, at least temporarily. As late as 1998, a new constitution had been adopted in the country, which considerably strengthened the rights of the indigenous people. Not least, the new constitution recognized the right of indigenous people to

> "…Be consulted regarding plans and programs of prospection and exploitation of non-renewable resources in their lands..."(Art. 84:5)[42].

This may not have made much difference, however, unless Sarayaku also managed to get in touch with a couple of NGOs, national and international, that provided first class legal assistance, and even managed to bring the case up to the Inter-American Commission on Human Rights. Moreover, at the height of the

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[41] "Programa de relaciones comunitarias para el bloque 24 durante el periodo de fuerza mayor". Annex to letter "Referencia: Respuesta a la Nota Oficial No. 622 PEP-2000, Programa de Relaciones Comunitarias del Bloque 24 para el Año 2001", signed by "Michael J. Frampton, Jefe de Proyectos del bloque 24, Gerente de Relaciones Comunitarias, Seguridad , Salud y Medio Ambiente, Burlington Resources Ecuador Limited". Copy in the possession of the author. Translation by the author.

[42] http://www.georgetown.edu/pdba/Constitutions/Ecuador/ecuador98.html (accessed 2-Mar-2004). Translation by the author.

conflict, there was a change in government in Ecuador. The new president had won the election largely thanks to a coalition with the national indigenous movement, and two indigenous leaders became appointed as ministers. Only a few months later, the alliance broke apart, but at the most critical time Sarayaku had allies near the centre of power in the country. Sarayaku leaders also gradually made enormous leaps forward in their capacity to manage information. They learned how to make press releases and how to distribute them to media. Just a couple of years before, the telephone system in Puyo had been improved, facilitating the use of Internet, and the Sarayaku people learned how to use it in order to distribute information internationally. This way, although the communication from Sarayaku to Puyo had to go via a two-way radio, the information from Puyo to the world was spread instantly.

In sum, the Sarayaku people had to make extraordinary efforts in order to make their voice heard, and they had to make extraordinary sacrifices as well as take extraordinary risks in order to expel the seismic crews. Nevertheless, their relative success in making their case known was also a result of a number of favourable circumstances, that had not been present previously for any other similar community facing a similar problem. Had it not been for the efforts of the Sarayaku people, in combination with the exceptionally favourable circumstances, all that would have remained documented for history would have been that the communities in the Block 23 reached an agreement with the CGC regarding the oil activities, in full accordance with the theories of Sabin (1998). The conclusion that indigenous people usually have not opposed the oil industry as such (Sabin, 1998) is, if not wrong, at least meaningless. Who knows how many of them may have wanted to oppose the oil industry, or even attempted to?

13.3.2. Improved education

During recent years, Sarayaku has struggled in order to improve the quality of education in the community. Since 1996, a brigade of students from the University of Lleida (Catalunia, Spain) has each year come to Sarayaku to give a three-week training course for the teachers. Beginning in 2003, these activities expanded, as the University of Lleida together with the University of Cuenca, Ecuador, initiated a four-year university programme in “Indigenous Education” in Sarayaku. The purpose is not only to improve the level of knowledge in basic subjects such as mathematics, Spanish, English, etc., but also to improve the teachers’ capacity to adapt the education to the particular situation and needs of the community. Reportedly, the experiences so far are encouraging. Hopefully, an increased level of education will facilitate for Sarayaku to reach whatever goals the community sets, whether these goals are to improve the economic conditions, to protect the environment, or others.

13.3.3. Wildlife reserve

During fieldwork, the question of how to reverse the trend of declining wildlife resources was repeatedly discussed. Many of the proposals initially put forward by the people (see Chapter 6) did not, however, appear feasible when discussed more thoroughly. Banning shotguns, for example, was deemed socially unacceptable, and to some extent counterproductive, as it would significantly complicate the hunting of *Dasyprocta fuliginosa* and *Agouti paca*, species that are significant sources of meat and that are not overhunted. On the other hand, the proposal to ban the annual community festival would be insufficient, given that the animal harvest during festival hunting, for most species, was found to constitute only a small fraction of the annual harvest (see Chapter 9).

One proposal that seemed to be socially acceptable as well as ecologically efficient seemed to be the creation of wildlife reserves, or no-take areas, where hunting would be prohibited. It seemed that groups of twenty to thirty households, living in the same hamlet, or sharing the same area of *purinas* (secondary homes, see Chapter 2), not only would be an appropriate group size in order to facilitate social control and avoid rule-breaking, but also that the overlapping areas of use rights of such a group could be combined to make up a reserve area large enough to effectively protect most major game species, given the range of their movements (see Chapters 9 and 11), while still leaving a considerable area where the people could continue to hunt. To achieve this, however, funding for guards to patrol the reserve would be necessary. Moreover, to reduce the time people spend on hunting, and to avoid potential problems with non-compliance of reserve regulations, it would be helpful to provide an alternative source of food as well as an alternative occupation (see Chapters 6 and 12). A project that combined the creation and patrolling of no-take areas with subsidies of production of alternative food therefore seemed to be a feasible strategy.

After discussing this concrete proposal with the Sarayaku Government Council, and then at a general assembly of the community, the inhabitants of the Chundayaku hamlet gathered in order to discuss the designation of a reserve area on the hunting grounds they held in common. They agreed to prohibit hunting beyond the alluvial plain of the Jatunkapawari River, but this prohibition would only become effective when funding for surveillance and for the construction of infrastructure for fish culture and poultry breeding was acquired. I wrote a proposal in close coordination with José Machoa who had participated in the meetings with the Chundayaku hamlet. After fieldwork was completed, this proposal led to a visit to Sarayaku of two representatives of the European Association of Zoos and Aquariums (EAZA). They met with the Sarayaku Government Council, and with the members of the Chundayaku hamlet, and José Machoa gave a presentation of the results of the programme for self-monitoring of hunting that the community had been carrying out during the preceding two years (see Chapter 9). Finally, this led to funding being provided by a German private foundation, mediated by a German zoo, and the project took off in August 2003. According to José Machoa, who now works as a project coordinator, the work is proceeding satisfactorily. Hunting has ceased inside the reserve, and several households have already constructed fishponds. Other hamlets, seeing the experience in Chundayaku, are now interested in following their example.

Chapter 14: Conclusions

14.1 Answers to the research questions

The research presented in the previous chapters provided some answers to the initial research questions, which may be summarized as follows:

14.1.1. How does human exploitation of natural resources affect the resource base?

The populations of several animal species are severely reduced by hunting, particularly those species that are large, slow-breeding, and have conspicuous behaviour, and particularly in the vicinity of the village (see Chapter 9). The human impact on animal populations has been significantly increasing during the last century (see Chapter 5).

The overall human impact on the forest cover is small. Fields, and fallows younger than 65 years old, cover only 3.4% of the Sarayaku territory, concentrated around the village and the major rivers. This area is increasing, but only with an estimated rate of 18.5 hectares per year, corresponding to an annual deforestation rate of 0.015% per year (see Chapters 5 and 8).

14.1.2. How does the status of the resource base affect local livelihoods?

The yields from hunting near the village, in terms of hunted weight per unit of effort, are just a sixth of the yield in the most remote parts of the community territory. Hunters need to spend more time searching for animals than they would if the game were managed in a coordinated way (Chapter 9). The contribution of wild meat to the diet is important, because the bulk food in Sarayaku is cassava and plantains, which have very low contents of protein and fat. Any decrease in nutritional status due to the depletion of wild game could not be established. However, it seems likely that a further decline of the populations of game animals could have such effects, whereas an increased availability of wild game may improve nutritional status (Chapter 7).

Local inhabitants claim that the increased reliance on clearing fallows for fields, and the shortening of fallowing periods, leads to an increased workload with weeding, and decreased production due to decreasing soil fertility (Chapter 6). This phenomenon was not studied in detail. However, it was found that people also make clearings in primary forest at an ever-increasing distance from the village. This increases the time and effort needed in order to travel to the fields and, particularly, to transport the products to the home (Chapter 8).

14.1.3. How do the characteristics of the specific human society under study affect the way people exploit natural resources?

The depletion of game animals has been caused by the combined effect of human population increase, improved hunting technology and a spatial concentration of hunting effort, due to an increasingly sedentary and nucleated settlement pattern (Chapter 5). It remains to explore in greater detail how these factors interact with each other, and the relative importance of each of them. It should be noted that while the spatial concentration of hunting has created an area around the village that is basically void of the must vulnerable animal species, it has also created areas with very low hunting pressure in remote corners of the community territory, which serve as refuges for vulnerable species (Chapter 9).

Population increase, technological improvement and nucleated sedentary settlement do not inevitably lead to game depletion, as game populations potentially can be managed in a coordinated way in order to maximize long-term collective benefit. However, there has been a lack of awareness of the impact of hunting on the resource base, and despite of the growth of this awareness, community members have been unable to coordinate their hunting behaviour, producing a “tragedy of the commons”. Increased income level may be a factor that worsens the situation, as people may use the money to acquire more, or better, hunting equipment. This may lead to a spiral of ever decreasing animal populations, and a resulting increased need for costly hunting equipment. On the other hand, an increased level of employment may potentially reduce the hunting pressure, as people get less time for hunting, and may switch to other food sources (Chapter 12).

The increase in the area of fields and fallows is basically a result of population increase. The area of fields and fallow has, however, increased at a slower pace than the population increase, as the proportion of fields made by clearing old-growth forest has decreased during the 20th century. A cattle project in the 1980’s may have caused a small jump in deforestation rate, but as most pastures were abandoned in the 1990’s this caused little lasting effect.

To a limited extent, unclear ownership may lead to competition that further decreases fallow length. This problem may be reduced by adapting local institutions regarding rights of control and access to land. However, to some extent, the shortening of fallow periods and the expansion of fallows at the cost of old-growth forest, are inevitable consequences of population growth. The only way to avoid shortening of fallow periods is to expand more into old-growth forest, and the only way to avoid expansion into old-growth forest is to shorten fallow periods. Although one may envisage technical solutions, such as more intensive farming on the alluvial plains, this is not a realistic option in the short term.

14.2 Reflections on research approach and methodology

The focus of this thesis was a complex problem, at the interface of human society and nature, and in a specific social and geographical context. Scientific theory was a means to understand the problem, and the research was not intended to test any theory as an end in itself. The complexity of the problem required the use of a number of complementary theories and methods. Thus this thesis covers a wide range of themes, each one of which well could have deserved a thesis of its own, such as history, local livelihoods and nutrition, agricultural land use, hunting, fishing, common pool resource management, and experimental economics. Putting all this into one single thesis of course has its costs. Reading all relevant literature in so many and diverse fields of science would be a formidable task, so my knowledge is probably incomplete in some of these fields. In some of them, I actually had no previous experience, and did not realize their importance until I was well into fieldwork, and had to learn rapidly by self-study and aided by helpful colleagues. Entering unknown terrain in this manner is of course a risky business if one is afraid of making mistakes. That risk, however, was far outweighed by the benefits. My initial research efforts led to dialogue with highly qualified researchers in almost every field of science that I had entered. Their constructive critique and suggestions helped my research proceed forward. I believe the data presented in this thesis still deserve even deeper analysis, and I would welcome more critique and suggestions by ecologists, geographers, historians, economists, political scientists, nutritionists, and others. My belief is that progress of knowledge is best achieved through a free interchange of ideas, and I explicitly reject the tendency, which I have found to be common in academia, to rather keep quiet than take the risk of getting criticized.

The wide and multi-disciplinary approach that I have used was necessary, given the complexity of the problem of natural resource use and depletion in the community studied. A study limited to one discipline, such as ecology, geography, demography, political science, history, or nutrition, would only have provided a very partial understanding, insufficient in order to grasp the challenges to be met and the possibilities to improve the situation.

In order to answer the research questions about how human activities affect the resource base, and how the status of the resource base affects local livelihoods, it was necessary to collect quantitative data on material things, such as the number of animals killed, the extension of fields and fallows, the amount of food items brought to the homes, and human population size. Such data collection was largely based on observations made by the local people. The aggregated observations made by a whole community, during their present and previous daily life and subsistence activities, surpasses, by several magnitudes, the amount of observations a single researcher can make during a few years of fieldwork. And as long as the local people feel that it is in their interest that the research proceeds successfully, there is little reason to believe that the observations made, and information provided, by them would be of less quality than observations made directly by the researcher.

Such quantitative studies alone are, however, insufficient in order to answer the third research question, on how the characteristics of the human society affects the way people exploit natural resources. Whether natural resources are depleted or managed sustainably depends on human decisions. The reasons behind human decisions are largely intangible, and could only be understood by participant observation and dialogue. Much such dialogue was carried out in an informal manner, in connection with the collection of quantitative data. The economic experiments brought attention to the people some aspects of their own behaviour, fuelling further reflection and bringing the dialogue forward. The workshops where preliminary research results were presented, and the issues of natural resource use and management discussed, were also important forums for reflection.

Unfortunately, due to lack of time, it was not possible to hold a workshop about the economic experiment "wildlife management in the lab" (Chapter 12.2), neither was it possible to return to Ecuador and Sarayaku, after analyzing the data of the agricultural land use study (Chapter 8), in order to present the results. So that is a task that still remains for me to complete.

This problem-driven and broad approach is not incompatible with development of theory and methods in specific disciplines. Such development is only somewhat unpredictable. The hunting study involved considerable development of theory and method, not because it was a goal in itself, but because it became necessary in order to answer the research questions regarding hunting, without having to spend every day of fieldwork doing line transect inventory of game animals. The study of agricultural land use involved considerable methods development, because of the difficulties related to topographic shade, haze, the small size of fields, and the small magnitude of change, which made it hard to detect. A researcher primarily interested in developing general theory of land use change may have chosen a study area with flatter topography, a more marked dry season with less haze, larger fields, and more rapid change, in order to make things easier. For me, changing the study area due to such considerations was not an option, so I had to confront the challenges.

In no way, however, do I wish to dismiss the contribution and importance of discipline-based, theory-driven science in the overall research process. On the contrary, I would not have been able to perform this study without the support of experts in the various disciplines covered in the thesis (see "Acknowledgements"). I believe such close interaction between problem-driven and theory-driven research brings both forward.

14.3 Implications for development

Current development actions for indigenous people in the Amazon tend to focus on production of goods and services for the market (e.g., Smith & Wray, 1996). My research indicates that significant development benefits also can be reached by improving the management of wild resources consumed locally, particularly wild game. An improved management of wild game could lead, in the long run, to increased consumption of meat, and improved nutritional status. It could also lead to a decrease in the time used for hunting, which would leave more time for other economic activities, for example the production of goods and services for the market that is exactly the focus of most development actions. The preservation of wildlife, furthermore, may also be seen as a marketable service in itself, for tourism purposes, or for the "existence value" of wildlife (see Carneiro da Cunha & Almeida, 2000, p. 325), which may translate into financial support from international NGOs or similar sources (see Chapter 13).

Because of their importance in the nutrition of local people, the impact of any development action on the use of wild game and fish resources should be assessed in advance. In the absence of active management of such resources, the long-term benefits of increased monetary incomes may be significantly reduced as people use the money to acquire, for example, better shotguns and more ammunition. Such an “arms race” may lead to increased availability of wild meat only during a short transition period, until animal populations reach a new equilibrium at a lower density than before. On the other hand, when the monetary income is tied to employment, people may have less time to hunt, which may permit animal populations to increase, thus producing an extra benefit in addition to the employment as such (see Chapter 12.3). Most readers of this thesis, as well as most indigenous Amazonians, probably agree that money is a good thing to have. The point I want to make here is that, for communities such as Sarayaku, money is even better when combined with employment and with management of wild game or any similarly important common pool resource.

There are currently two competing systems of authority in indigenous communities in the region. One is consensus-based grassroot democracy. The other is clientelism, where certain individuals derive their authority from a position as intermediaries between their communities and economically powerful external actors. In order to improve the living conditions in the communities, it is of crucial importance to support the local democracy and combat corruption and clientelism.

14.4. Implications for conservation

This thesis contributes to the growing body of knowledge showing that subsistence hunting is depleting the fauna of the Amazon rainforest (see Chapter 9). Recognizing this basic fact should not be confused with any moral condemnation of indigenous and rural peoples as “villains” (cf. Sponsel, 1992, p. 244). Those who depend on hunting for their subsistence are the ones who are most directly affected by the consequences of wildlife depletion. Scientists who deny the existence of this problem (cf. Schwartzman et al., 2000a, b) will not contribute to its solution, thus missing a wonderful opportunity to benefit local communities while also conserving biodiversity.

The ecological impact of human activities in Sarayaku is increasing due to population growth, in accordance with the arguments of Terborgh (2000). In spite of high birth rates, however, emigration keeps population growth down (Chapter 5). The deforestation rate is very low (Chapter 8). Nevertheless, population growth is, in the long run, of course not sustainable.

The impact of the Sarayaku people on the environment is not, however, limited to the direct physical impact of their shotguns, axes, and machetes. Through political action, and by physically keeping out encroachers, they have protected their territory from colonization and they have even kept oil companies at bay (see Chapters 5 and 13). Doing so, the community has repeatedly come into conflict with the national government. In light of this, the belief that governments are the only hope for long-term protection of the environment in the Amazon (cf. Terborgh, 2000) does not seem to be justified.

Sweeping generalizations about indigenous people should, however, be avoided, because they are internally diverse and continuously changing. The Sarayaku people have rules for how to harvest palm leaves used for thatch, in order to avoid resource depletion, whereas the nearby Huaorani people do not (see Chapter

11.3.3). Although Sarayaku as a community opposed oil development, some other nearby communities did not, and also a few individuals in Sarayaku sided with the oil company (see Chapter 13.3.1). Dynamite fishing used to be common in Sarayaku, but is no longer, although it continues to be common in other nearby Kichwa communities (see Chapter 10). Indigenous people are not free from the "arrogance, ignorance, myopia, greed, and destruction" that Sponsel (1992, p. 243) ascribes to "western" exploiters. But neither are they fated to "be busily selling off their natural patrimony" (Terborgh, 2000, p. 1359) as soon as they get the means to it.

Similar to any other people, the ways of production of Amazonian indigenous people have ecological impacts, and increasing population densities and improved technology are increasing these impacts. At the same time, these people are individuals with capacity to reflect, adapt, organize, and act in order to bring about change. Sometimes they manage to act in a coordinated way for the common good, other times they fail. The environment is one out of many items on their agenda, and they often face trade-offs. In these senses they differ little from, say, Japanese or Swedes.

14.5. Future scenarios

The future of Sarayaku will be shaped by decisions made by the Sarayaku people, as well as by the developments in the country and the world. Predicting the future is impossible, but one can draw plausible scenarios. The following three scenarios are simplified, but not implausible. Even if the assumptions for any of the scenarios would be fulfilled, the future will most probably hold other surprises. The point here is not to make predictions. It is to show that there are various possible paths to take, and which one to take is a matter of decision for human stakeholders, not a matter of prediction by scientists.

14.5.1. Current trends continue

This scenario is based on the assumptions that (1) the Sarayaku people continue to behave as they did during 1999-2001, and (2) no major changes are imposed by outside forces. This means that the old-growth forest continues to slowly decrease in extent, as the area of fallows increases. Moreover, fallow periods also continue to get shorter and shorter. Decreasing soil fertility, increasing weed infestation, and increasing distance to fields, force people to work more in order to produce enough food to feed themselves. In a similar manner, an increasing population leads to increased hunting pressure and continued depletion of wildlife. Hunters are forced to go further and further away in order to hunt, and turn to smaller and smaller species, as the large species are hunted out. The total game harvest decreases. The gradual depletion of fisheries also continues, leading to smaller size of the fish caught, greater effort on part of fishers and, finally, to a decrease in fish catch. The decrease in harvests of wild game and fish, in turn, leads to deterioration in nutritional status.

This deterioration of natural resources and local livelihoods cannot go on forever. Community fissions may relieve the pressure on land and wildlife resources, but only temporarily. At some point, more fundamental changes would have to occur. After many decades, or even centuries, agricultural intensification in order to increase the yield per unit of land area (see Boserup, 1965) may be the only option to survive. Before that, forest and wildlife resources would be severely depleted, and the way of life that the Sarayaku people want to maintain would have been lost forever.

14.5.2. Accelerating destruction

This scenario is based on the assumptions that (1) oil is searched for, found, and exploited in Sarayaku, and (2) the current trend towards increasingly efficient self-government in Sarayaku is broken, and the current democratic organization of the community is replaced by a patron-client relationship where community leaders derive their status from the position as intermediaries between the community members and external economic interests.

Oil exploitation involves construction of pipelines and roads. Along the roads, the Sarayaku people clear the forest and plant cattle pastures or cash crops. A race to establish ownership of land results, which further speeds up deforestation. Timber merchants buy timber along the road. The timber becomes an open access resource, and the resulting competition leads to rapid depletion of the resource, which is sold at a low price, covering only the cost of the work, at the current average wage rate, of felling the timber and transporting it to the road. Populations of wild game decline, due to degradation and fragmentation of habitat. Moreover, the current ban on exporting wild meat from the community is not upheld, and people start to sell wild meat to consumers in urban and peri-urban areas, causing further depletion of wildlife resources.

Community leaders, deriving their power from their relations with oil and timber companies, do nothing in order to hinder the plundering of the community’s resources. Pollution from the oil exploitation harms aquatic life, further diminishing the availability of fish, and finally making the fish unhealthy to consume. Human health deteriorates due to malnutrition and pollution.

14.5.3. Towards sustainability

This scenario is based on the assumptions that (1) no outside economic interests impose any changes against the will of Sarayaku, (2) the community continues to increase its educational level, as well as its capacity to coordinate actions for collective benefit.

The recently established wildlife reserve of the Chundayaku hamlet becomes a success, and leads to growing wildlife populations. After initially reducing the wildlife harvest, the people soon are able to harvest as much wildlife as before, but at a closer distance. Finally, they can even increase the wildlife harvest. Seeing this success, other hamlets follow the example of Chundayaku, establishing their own wildlife reserves. External funding is necessary in the beginning, but finally the need for costly monitoring of the reserves is reduced, as social control is enough to make people refrain from hunting within reserve limits. Nevertheless, the reserves provide some cash income, from international conservation funds, as well as from tourists who come to view the abundant wildlife in the reserves. Because people need to spend less time hunting, they get more time for other economic activities. All this leads to an improved nutritional and general economic status in the community.

As the causes to the decline in fishery yields probably lie outside the community, halting this decline may need cooperation at a much larger geographical scale, perhaps including the whole watershed of the Pastaza river. In any case, even if the current decline continues, the socio-economic effects of this decline could be partly compensated for by rational management of the wild game. Fish culture may also compensate to some extent for the decline in wild fish.

As the educational level increases, particularly of women, birth rates fall. Within a few decades, the birth surplus is reduced to such a level that it is fully compensated for by emigration. As population growth ceases, there is little need to continue shortening fallow periods, or to continue expanding into old-growth forest, so also net deforestation rate approaches zero.

14.6. Conclusions

Viewed superficially, the environment in Sarayaku seems to be in top shape. But for the Sarayaku people, it is in a state of crisis, depleted of important resources. Whether resource use will continue on its slow path towards gradually increasing depletion, whether it will change towards more sustainable and productive ways of managing resources, or whether there will be an abrupt change to rapid plundering of natural resources will largely depend on a few, very interdependent, key factors:

1. Whether the community manages to maintain effective control over its territory, or if economically stronger external interests take over.
2. Whether the local democracy of Sarayaku survives and continues to develop, or if it gets corrupted, destroyed, and replaced by a system based on clientelism.
3. Whether the capacity of the community to manage common pool resources continues to increase or not.
4. Whether population growth slows down, or if the current rate of increase continues.

Substantial improvement of the situation is achievable. However, it will require hard work by the Sarayaku people. The decisions made, or not made, at national and international level, will also be important in shaping the future of Sarayaku.

Researchers may also have a role to play in situations such as the one in Sarayaku. By showing how human decisions in the past have led to the present situation, and how current decisions may affect the future, the researcher may be able to influence decisions that are made today. Ideally, this leads to wiser decisions and a brighter future.

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