Monitoring of butterflies within a landscape context

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Förord

NILS, Nationell Inventering av Landskapet i Sverige, är ett nationellt miljöövervakningsprogram som finansieras av Naturvårdsverket och Jordbruksverket. Programmets syfte är att med hjälp av ett landskapsperspektiv kartlägga den biologiska mångfalden och landskapets struktur samt att studera förändringar bland dessa över tiden.

Inom NILS genomförs i dagsläget dagfjärilsinventeringen i ängs- och betesmarker på uppdrag av Jordbruksverket. Den metodstudie som presenteras i rapporten har genomförts för att få en uppfattning om mängden dagfjärilar i ett större landskapsperspektiv. Syftet med studien har varit att analysera en ny form av inventeringsmetod som kan komplettera inventeringarna i ängs- och betesmarker. Metoden bygger på att hela landskapets vegetation har inkluderats. Resultatet av studien kan komma att användas som underlag för en komplettering av nuvarande metod för att ytterligare effektivisera arbetet NILS utför för att uppfylla de nationella miljökvallitetsmål satta av Sveriges Riksdag. Arbetet har utförts på uppdrag av NILS och i samarbete med Linköpings universitet. Studien har genomförts som ett examensarbete på 60p (ects credits) vid det internationella mastersprogrammet i applied biology, Linköpings universitet.

Sture Sundquist
Programchef NILS

Contents

Abstract

Monitoring of butterflies is most often only directed towards the grassland fauna. Species associated with other vegetation types, as well as the impact of the surrounding landscape, often become neglected. The aim with this study was, in contrast, to perform a novel landscape-based monitoring method for butterflies in diverse vegetation types and more specifically
(i) evaluate the impact of environmental variables on butterfly abundance, (ii) compare the distribution of butterflies in different vegetation types and (iii) analyse and improve the monitoring method. Eight randomly placed study sites (750 m x 750 m) located in south eastern Sweden were used. The vegetation composition inside the squares had been assessed using aerial photos. Tree cover had largest impact on butterfly abundance with a negative linear relationship between abundance and increasing tree cover. Clear-cuts were the vegetation type harbouring the overall highest abundance and diversity of butterflies. In semi-natural grasslands, where the nationally-based monitoring of butterflies in Sweden currently is being performed, only 42% of the species were found, indicating a bias directed towards only a part of the species pool. The novel kind of monitoring presented here, using a landscape context, can, if performed regularly, increase our knowledge of how structural changes at landscape level affect butterflies and thereby improve the conservation efforts.

Keywords: conservation, semi-natural grasslands, landscape perspective, *Lepidoptera*, rarefaction, vegetation type.

1 Introduction

Since the end of the Second World War, an already intensified farming in Sweden, as well as in the rest of Europe, has escalated and led to a monotonous landscape. Grasslands, wetlands and other nature types with high biodiversity have nowadays to a great amount been turned into arable fields and forest plantations (Ihse 1995). Butterflies are one group of organisms that has been negatively affected by this change in land use and all over Europe a decline in species richness has been seen (Pullin 1995, Van Swaay & Warren 1999).

How land is used affect butterflies in different ways and the loss of suitable habitat is of major concern in terms of conservation (Schneider & Fry 2005). Butterflies are known to respond fast to environmental changes compared to other taxa like birds and vascular plants (Thomas et al. 2004) and even small changes in the environment can affect butterfly diversity and abundance. It is therefore important to monitor both changes in the environment and in butterfly abundance.

Monitoring of butterflies is mostly focused on grassland habitats (e.g. Bourn & Thomas 2002, Pöyry et al. 2005, Öckinger et al. 2006, Öckinger & Smith 2006), creating a bias of information, which might also lead to a bias in conservation efforts, aimed at grassland fauna. As virtually all vegetation types in Europe contain threatened butterfly species (van Swaay et al. 2006) and as the overall landscape also outside grasslands in fact holds resources, though not generally regarded as associated to butterflies (Dennis 2004), focusing at only a certain group of butterflies creates a risk that species will disappear without any notice. With monitoring using a landscape perspective, which sometimes is preferred (Schneider & Fry 2005, Bergman et al. 2004), it is possible to reduce the bias.

As part of fulfilling the Swedish national environmental objectives “A Rich Diversity and Animal Life” and “A Varied Agricultural Landscape”, a monitoring programme named NILS (The National Inventory of Landscapes in Sweden) was launched in 2003 by the Swedish government and the Swedish Environmental Protection Agency. The programme covers terrestrial environments all over Sweden and documents landscape elements such as stone walls and solitary trees as well as different species, e.g. butterflies. By including diverse vegetation types, the surrounding landscape and by conducting inventories every fifth year, the aim is to detect how changes in nature composition at landscape level affect species and individual richness (NILS 2007). However, the butterflies in NILS are only monitored in areas which are part of the Swedish survey of semi-natural grasslands (pastures and meadows). That survey included all semi-natural grasslands in Sweden larger then 0.1 ha with considerable biological and/or cultural values. An enlargement of the present method, incorporating a wider range of land use also for butterflies, may give a better picture of the real situation. Regarding butterflies, national programmes also exist in for example Finland (Saarinen et al. 2003), the Netherlands (van Swaay et al. 1997), Switzerland (Weber et al. 2004) and in the UK (Dennis et al. 1999). However, none of the programs monitor butterflies systematically across a wide range of habitats, indicating the need for accurate data on butterfly abundance and information of its change over time.

The aim of this study was to test a novel landscape-based monitoring method for butterflies in diverse vegetation types and to analyse the importance of different landscape variables, as well as the method per se. As far as known, there are no similar monitoring schemes and hence, there is a paucity of information on what type of analyses is appropriate and what results to expect. More specifically, I wanted to (i) evaluate the impact of environmental variables on butterfly abundance, (ii) compare the distribution of butterflies in different vegetation types and (iii) analyse and improve the monitoring method.

2 Material and methods

2.1 Study site

The field work was conducted during the summer of 2006 in south eastern Sweden (Figure 1). Staff from NILS have randomly placed seven study sites (henceforward called "the NILS-squares"), each covering a landscape square of 1.1 km x 1.1 km with a smaller one covering 750 m x 750 m in the middle. The vegetation composition differed between sites, but together they constituted a representative sample of the nature in the region, with intensively-managed agricultural land in a band from west to north east and with coniferous forests in north and south. The squares are named by nearby towns and their exact location is not disclosed.

An additional square, not included in NILS, was accessed in Tinnerö, near the city of Linköping, to facilitate intensive studies regarding butterfly diversity at different number of visits during a season. Henceforth, data from Tinnerö is included only when clearly stated. Otherwise, only the seven NILS-squares were part in the analyses.

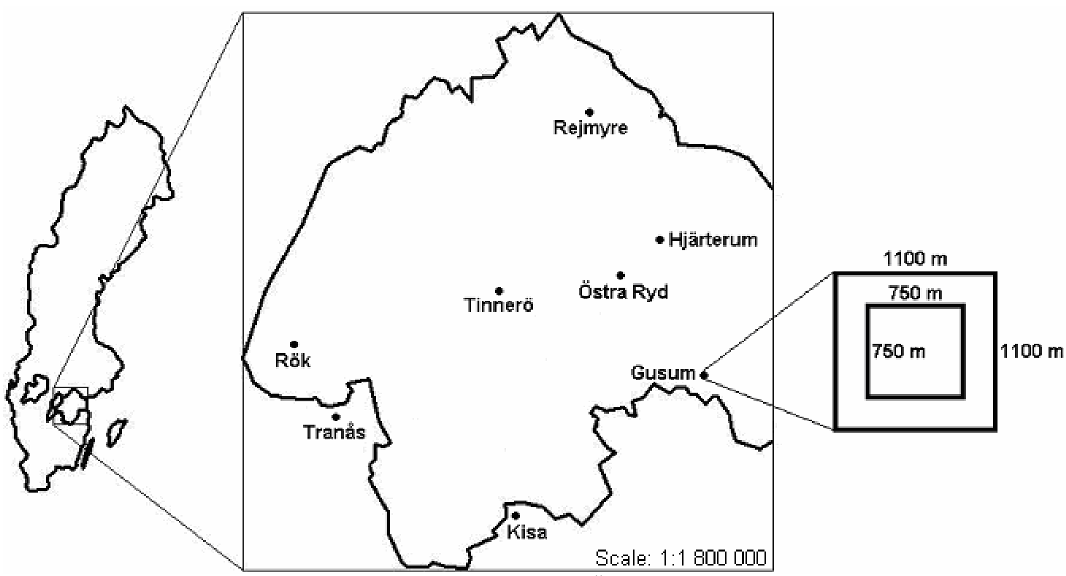

Figure 1. Location of the study sites in the county of Östergötland, SE Sweden, and illustration of a landscape square.

2.2 Quantifying landscape structure

Vegetation composition in the squares had been assessed by senior photogrammetrists at the Swedish University of Agricultural Sciences (SLU), Umeå, using colour infrared aerial photos, scale 1:30 000, taken between 2002 and 2003. Each vegetation type inside the squares has been indicated with a polygon and received a unique number and environmental description, following certain procedures and definitions (Allard et al. 2003). From the large number of variables assessed, the following were considered useful in the present study; area (m2) and the percentage of tree cover (the sum of *Picea abies*, *Pinus sylvestris* and deciduous trees) as well as the percentage of shrubs, dry, mesic, damp and wet land of each polygon.

2.3 Butterfly recordings

On the border of the inner square, all butterflies (*Lepidoptera*) and burnet moths (*Zygaenidae*) were recorded with the line transect model used by Pollard (1977); the border/transect was walked in an approximate pace of 50 m per minute and all individuals found within 5 m in front and to the sides were recorded. If not being able to identify the butterflies in flight or after being netted, they were taken to the laboratory for further identification. During time for identification, the monitoring was paused and later resumed. Double count of an individual was avoided as much as possible but could not be eliminated. Transects in polygons with arable fields and land near houses (gardens, cemeteries etc.) were excluded, as were polygons in inaccessible areas such as wet marshes or unclimbable hills.

Because *Leptidea reali* and *Leptidea sinapis* as well as *Plebeius argus* and *Plebeius idas* are hard to identify even when captured, each pair were, in this study, recorded as one single taxon (*Leptidea r/s* and *Plebeius a/i*). All nomenclature of butterfly species follows Eliasson et al. (2005).

To facilitate walking in a straight line along the border and to assign a butterfly observation to a polygon, a field map (scale 1:5000), a compass and a GPS transmitter (Garmin GPS 60) was used.

All NILS-squares were visited six times from the 8th of June to the 18th of August under predominantly sunny conditions from 17°C and above and without strong wind (≤5 on the Beaufort scale). Time for monitoring started no earlier than 9 am and ended before 5 pm (Swedish summer time, GMT+2). The intervals between the visits were 8-14 days, depending on weather. During warm periods, the intervals were in the lower range to reduce the risk of missing possible peaks in abundance.

In the additional study site, Tinnerö, the same method was used but with 12 walks and shorter intervals between visits.

3 Analyses

3.1 Impact of environment

As an initial step to analyse the association of different species to the environmental variables and the overall landscape composition, a principal component analysis (PCA) was performed using the CANOCO 4.5 software (ter Braak & Šmilauer 2002). PCA is a multivariate method based on linear assumptions (Hugh & Gauch 1982) and is preferable to use when the species data has low beta diversity (Gauch & Whittaker 1972), as in this case. The environmental variables were taken from all polygons at the sites and not only from the polygons crossed by the transect. The study sites were also included in the analysis so that a possible species association to the sites could be seen. In the calculation, species data were log-transformed to diminish the influence of a few species with high abundance.

To further evaluate the environmental variables and to test if and how they contributed to the variation in butterfly abundance, a generalized linear model, GLZ (Poisson distribution, log link function), was made using STATISTICA software version 7.0 (StatSoft Inc. 2004). Since the length of the walked transect in each polygon differed, the number of individuals found was expressed as number of individuals per 100 m transect. The variable "tree cover" consisted of the sum of "*Pinus sylvestris*", "*Picea abies*" and "deciduous trees" so these three variables were therefore excluded from the model (to evaluate their effect separately, the analysis was re-run). The output contributed to a linear regression with the variable with highest impact on butterfly abundance.

As species richness is sensitive to sampling area, a linear regression, as with butterfly abundance, was avoided. Instead, a 3D-graph with an additional third axis, with length of transect, was made for illustration.

3.2 Comparing semi-natural grasslands with other habitats

To spot potential species preferences to certain vegetation types, a compilation of the richest polygons in terms of individuals per 100 m transect and species was conducted. All polygons belonging to the three vegetation types with highest richness were selected. Comparisons were made with the findings in semi-natural grasslands part of the nationwide survey of ditto, since it is the only vegetation type where the nationally-based monitoring of butterflies in Sweden is being performed (Glimskär et al. 2006). The categorization of a polygon as semi-natural grassland was made using the database TUVA from The Swedish Board of Agriculture (2007); a semi-natural grassland (a grassland which today mostly is used as grassland and has been so for long time and with no or only a few relatively recent indications of sowing, fertilizer or ploughing) with considerable values in flora, fauna, water or cultural heritage. Categorization of the other vegetation types, clear-cuts, bogs and other grasslands, were made subjectively based on field experience.

3.3 How number of visits affects the species richness detected

As number of species found during this magnitude of visits in most cases underestimate the true species richness, the rarefaction method first proposed by Sanders (1968) (later revised by Hurlbert 1971), was used to estimate the total species richness. With the rarefaction method it is possible to compare the number of species at different localities when the sampling effort varies, in this case between the NILS-squares and the one in Tinnerö. For calculations, the internet-accessible Species Richness Estimators Eco-Tool (Russel 2006), based on the techniques described in Colwell & Coddington (1994) and Colwell et al. (2004), was used. Chao 2 was chosen as non-parametric estimator as it performs well on small samples (Colwell & Coddington 1994). The average number of found species at each visit was expressed as proportion to the estimated total species richness. An additional rarefaction curve was made based on the average value of the parameters from the line equations of each site. To estimate the proportion of butterfly species found at different sampling intensity (i.e. number of visits), records from different visits at each site were combined according to a time period scheme. For one (1) visit, the count made at each site around the first and second week of July was chosen, since the Swedish butterfly fauna for the area is at its peak during that period (Söderström 2006). For two (2) visits, the visits were divided into a first and a second half of the season and then combined into the possible combinations to get an average value. The same for three visits but with the visits divided into three parts with two visits in chronological order. For four visits, count 2, 3 and 4 was always included and combined with the other visits. Regarding five visits, when one count had to be excluded, an arbitrary estimation was made of which to exclude depending on dates and lengths of intervals.

For Tinnerö, the average of 20 random combinations of visits was taken for 2-10 visits and 12 combinations for 1, and 11 visits.

4 Results

In total, 2234 individuals belonging to 54 species were observed. Of those, 1425 individuals and 53 species were associated to the NILS-squares (6 visits to 7 squares) and 819 individuals belonging to 34 species to the Tinnerö-square (12 visits). The number of individuals in the NILS-squares varied between 384 and 88 and the species between 31 and 21. Because of bad weather in May, some early spring species were probably missed. For total information on species and abundances, see appendix.

4.1 Impact of environment

The PCA showed large differences in butterfly assemblages between sites (Figure 2).

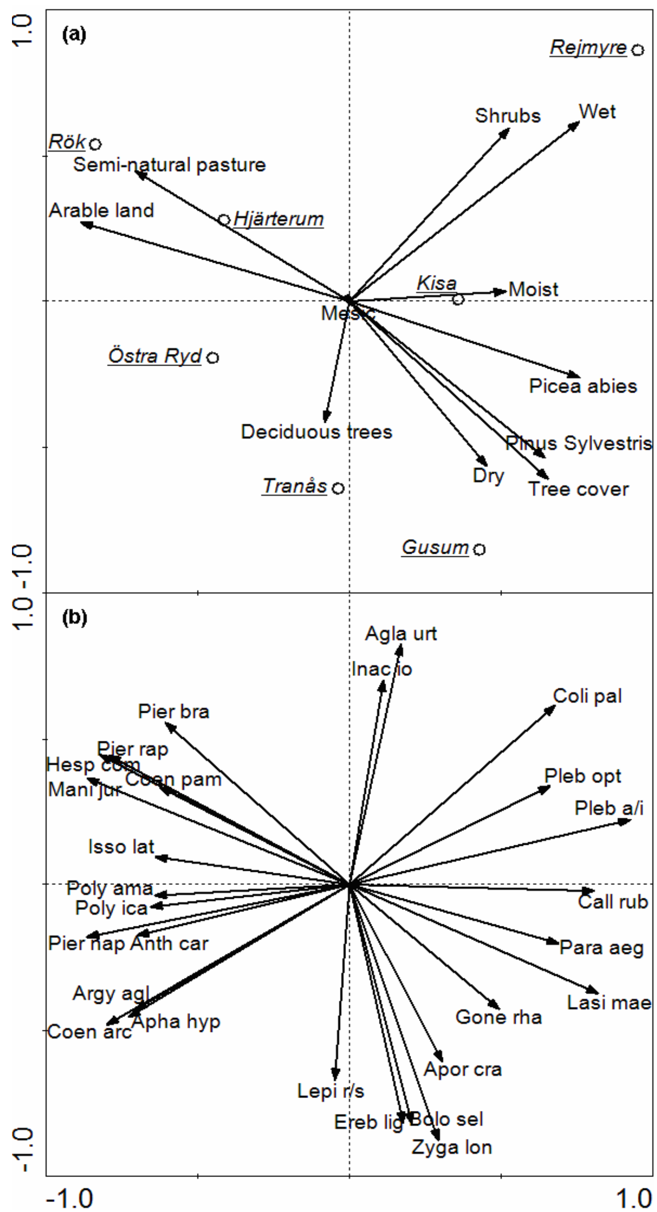

Figure 2. PCA illustrating (a) the study sites and ten associated environmental variables and (b) the butterfly species. Only the 27 species with highest impact on the model are shown. Eigenvalues for PC1 and PC2 were 0.462 and 0.195, respectively.

Table 1. The outcome of a generalized linear model (Poisson distribution, log-link function) with ind/100m as response variable from 167 polygons at seven study sites.

	Wald stat	P-value
Area	117.76	**0.00000**
Tree cover	4371.76	**0.00000**
Shrubs	25.12	**0.00000**
Dry land	622.10	**0.00000**
Mesic land	236.16	**0.00000**
Damp land	0.22	0.63670
Wet land	29.70	**0.00000**
Study sites	1964.64	**0.00000**

There was a negative linear relationship between butterfly abundance and increasing tree cover (Figure 3), with the latter accounting for about 28% of the variation in abundance. Other variables like "dry land", with the second highest Wald statistic in this analysis, showed no such linear relationship. The same analysis were also made with "tree cover" separated into "*P. abies*", "*P. sylvestris*" and "deciduous trees" (data not shown), presenting the highest Wald statistic for *P. sylvestris* (2213). The negative linear relationship with butterfly abundance was though lower than for tree cover alone (R2=0.179 and R2=0.278, respectively).

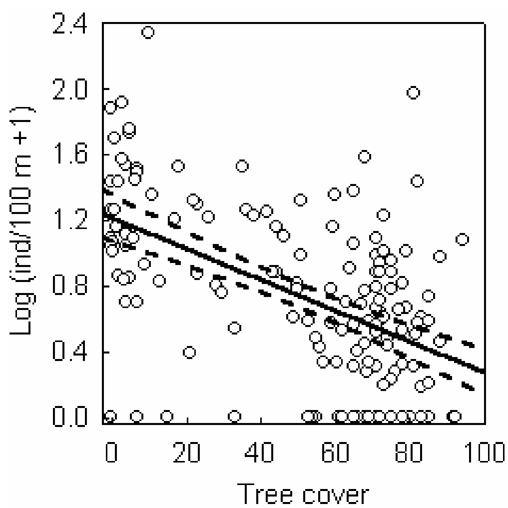

Figure 3. Abundance of butterflies versus total tree cover. Data from visited polygons in seven NILS-squares in SE Sweden. The equation of the line is y = 1.2117-0.009324x, r^2=0.278, 95% confidence interval.

The number of species increased with decreasing tree cover and, as expected, with length of transect (Figure 4). Areas with up to 50% tree cover had the highest amount of butterfly species, but the span was wide and butterflies could be seen over the whole range. Highest number of species was found from approximately 200 meters of transect.

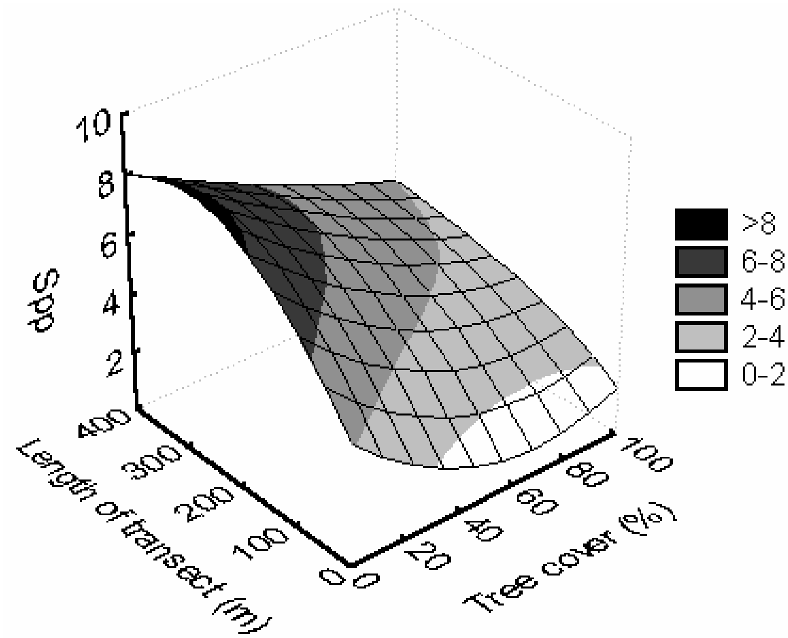

Figure 4. Butterfly species richness at different tree cover and length of transect in seven NILS-squares. (Distance Weighted Least Squares, stiffness 0.49)

4.2 Comparing semi-natural grasslands with other habitats

The vegetation types richest in butterflies, all consisted of polygons with relatively low tree cover (Table 2). Semi-natural grasslands harboured half the number of species and a good fifth of the individuals, in comparison with clear-cuts, bogs and other grasslands together. Of the vegetation types individually, clear-cuts harboured the highest abundance of butterflies and other grasslands the highest species richness. Every vegetation type had several unique species for its particular vegetation.

Table 2. Comparison of number of individuals and species found at six visits in four different vegetation types with highest abundance of butterflies. Unique species in the last column is in comparison with classified semi-natural grasslands. Data from seven NILS-squares.

	Semi-natural grasslands	Other grasslands	Clear-cuts	Bogs	Other grasslands+ clear-cuts + bogs
Spp	22	30	29	16	44
Spp of total (%)	42	57	55	30	83
Ind	128	161	327	102	590
Ind of total (%)	16	20	40	12	72
Ind/100m	30	19	33	22	26
Length of transect (m) * no. of visits	2550	5010	5970	2760	13740
N	4	8	12	6	26
Unique species	*Lasi meg* *Isso lat* *Lyca phl*	*Argy nio* *Apor cra* *Poly sem* *Lyca hip*	*Hipp sem* *Bolo sel* *Zyga vic* *Zyga fil* *Nymp ant* *Lime pop*	*Para aeg* *Lasi pet* *Coli pal* *Papi mac*	*Para aeg, Ereb lig, Lasi mae, Lasi pet, Hipp sem, Argy nio, Argy adi, Bolo sel, Meli ath, Ochl syl, Thym lin, Apor cra, Coli pal, Pleb a/i, Pleb opt, Poly sem, Lyca hip, Call rub, Zyga vic, Zyga lon, Zyga fil, Lime pop, Nymp ant, Inac io, Papi mac, Poly c-alb*

4.3 How number of visits affects the species richness detected

All study sites followed an estimated logarithmic curve without an asymptote being reached (Figure 5). In the NILS-squares, the percentage increase after each visit followed a similar pattern but the start and ending of the curves differed. The range of found species for the NILS-squares after the first, third and sixth visit was between 14 and 49%, 39 and 76% and 64 and 91%, respectively. Tinnerö followed a similar pattern but with a maximum after twelve visits with 83% of the estimated species richness detected. The average curve of all eight sites ranged between 28 and 77% for the first 6 visits. In comparison, there were minor differences between the average curve and the curves for each site.

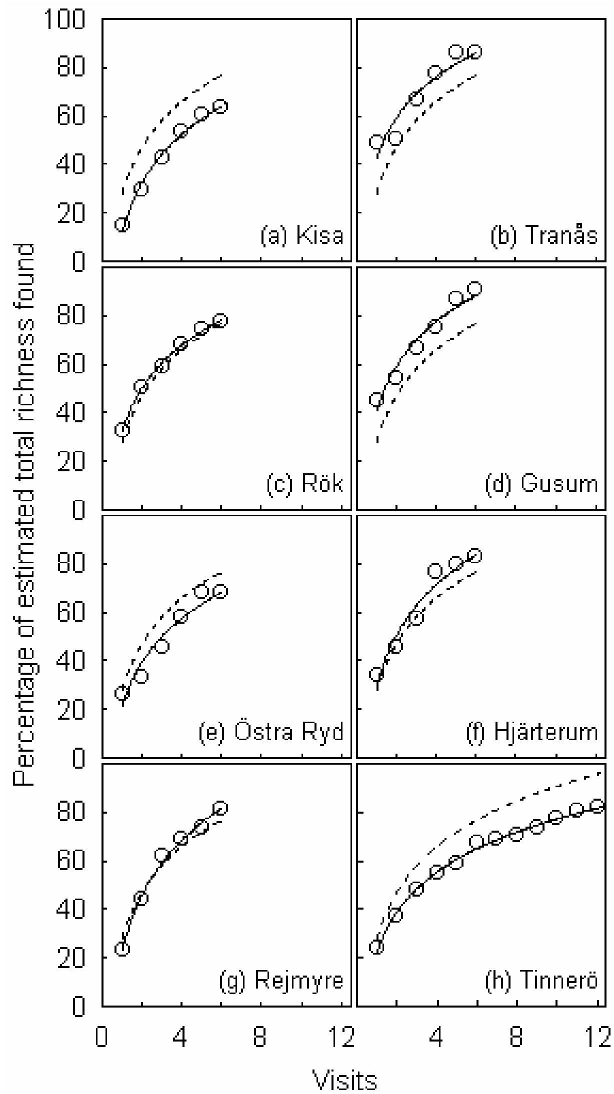

Figure 5. Percentage of estimated total species richness found at different number of visits (solid line). Number of species in the sites is based on an average value from combinations of visits (cf. Material and method 3.4.3). The dotted line is an average curve based on the line equations from all sites. yaverage=28.334+62.441*log10(x). The value on 100 % found species comes from the non-parametric estimator Chao 2.

5 Discussion

5.1 The impact of environmental variables on butterfly abundance

The results from this study highlight the fact that butterflies can be seen in diverse environments and use a large part of the landscape. Most environmental variables chosen contributed significantly to the butterfly abundance, though, both the GLZ (Table 1) and the plot of number of individuals versus tree cover (Figure 3) indicated that tree cover had larger effect on butterfly abundance than other variables. The majority of individuals were found in areas with tree cover up to approximately 50%, which is in conformity by the findings in Schneider & Gry (2005).

5.2 Comparing butterfly distribution in different vegetation types

The composition of butterfly species varied depending on landscape structure. Open, agriculturally dominated sites like Rök, Hjärterum, Östra Ryd and Tinnerö, have a composition with typical grassland species like *Maniola jurtina*, *Coenonympha pamphilus* and *Issoria lathonia*. Some of these were totally absent in the more forested sites (Kisa, Gusum, Tranås and Rejmyre), which, on the other hand, harboured species like *Pararge aegeria*, *Boloria euphrosyne*, *Callophrys rubi* and *Plebeius argus/idas* unique for that kind of vegetation. Rejmyre, the site with largest amount of bogs, harboured *Colias palaeno* and *Papilio machaon* associated to that vegetation (Söderström 2006) and they were not found in other sites. Even though butterflies can be seen in more or less every vegetation type, nationally-based monitoring of butterflies in Sweden is only made in semi-natural grasslands of considerable biological and/or cultural value, part of a nationwide survey of semi-natural grasslands. These sites cover less than 1% of the total land area in Sweden (The Swedish Board of Agriculture 2007) but consequently 100% of the area where monitoring is being performed. Semi-natural grasslands are among the most species rich habitats (Schneider & Fry 2005) but the question is if species linked to other vegetation types are also present. In this study, that was not the case. The surveyed semi-natural grasslands harboured 22 of the total 53 found species (42%) in the NILS-squares. Considerations should though be taken regarding the low number of polygons covering surveyed semi-natural grasslands, but on the other hand, that is how the regionally landscape is composed. Of the vegetation types examined, all have unique species for its particular composition. In clear-cuts, bogs and other grasslands, 26 of the species were not found in semi-natural grassland, showing the importance of including diverse environments during monitoring of butterflies. Individually, clear-cuts harboured the highest abundance of butterflies and other grasslands the highest species richness.

5.3 Method discussion

Whether it is reasonable to only do monitoring in semi-natural grasslands, or if other vegetation types should be included in a large scale monitoring of butterflies, should be given extra attention. A large part of the total butterfly diversity will never be monitored if not incorporating diverse environments, hence, using a single environmental approach can lead to unrepresentative data and a bias directed towards only a part of the species pool. Large parts of the landscape hold valuable resources for butterflies, even though the resources are regarded as completely unsuitable based on the butterflies' vegetation association, as indicated by Dennis (2004). He further describes the resource-exploitation behaviour of *Maniola jurtina* where 78% took place in so called unsuitable biotopes, emphasising the importance of the surrounding landscape for butterflies. Consequently, a broader perspective is advised to take into consideration when making conservation plans for butterflies.

The rarefaction curves can be used to evaluate the required number of visits to make at a site to find a certain percentage of the species pool. With data from several sites, an average rarefaction curve could act as a model for the whole region. To detect more than two thirds of the species at a site, which can seem acceptable, it would need four, maybe five, visits in this part of Sweden (remember though that in this study, the monitoring visits were spread to increase to probability of monitoring in several flight periods, leading to an overestimation of found species compared to performing monitoring during a narrower time period). After 12 visits, the average curve reached near 100% found species, which is in accordance with Dennis (1999). The Tinnerö site showed that above six visits, the increase in percentage found species was minor and the additional workload is perhaps not financially justified when money often is limiting in nature conservation (Pergams et al. 2004). Monitoring in diverse landscapes, incorporating more then the traditional hotspots, makes it possible to detect changes over a wider range of habitats. It also yields a higher diversity and may give a better understanding of the species association to different vegetation types. To receive a satisfying amount of data, it might though need a comparatively higher workload since species-poor habitats also are included.

When analysing species associations to environmental variables, data from aerial photography interpretation made for the original NILS survey were used. It partly became difficult analysing the data and several lessons were made. For example, when using aerial photography as a tool in ecological studies, it is of great importance that the interpretation is correct and that it covers nature elements relevant for the kind of research being performed, in this case for butterflies. It is also of great importance that the interpretation is up to date with time of field work execution since much can happen in nature during a short period of time. For example, an old-growth forest can one day have a tree cover of 90% and the other day has become a clear-cut area covering none. Of course, that sort of changes can easily be detected during field work, but earlier done tree cover estimations, area calculations etc. become affected and have to be re-done. The same type of problem emerges if only a part of a forest polygon has been cut, which generates two polygons instead of one; a cause for confusion in field, time consuming problems at the desk and a possible rejection of data in the end. With maps up to date, these obstacles and the less accurate and cost effective corrections in field will be reduced. For NILS, the regular procedure is that the sites will be interpreted one year before field work. In this study, the landscape-squares were interpreted 2002 and 2003, i.e. up to four years in advance, which could have contributed to some difficulties along the way.

Another question being raised is how high the accuracy in polygon classification must be to capture necessary nature elements for good data quality. As noted during this study, forests with high percentage tree cover have low number of individuals, but glades inside of these might sometimes attract a relative high number. Is it then the forest as a whole with the light patches included or the light patches per se that is the attractant? The polygon classification must therefore be done on a relatively fine scale based on the butterflies so this kind of biases can be reduced.

5.4 Conclusions and implications

This study has verified that monitoring of butterflies using a landscape perspective yields data with higher diversity of species compared to when only including semi-natural grasslands. Even though butterflies associated to other vegetation types occasionally can be found in semi-natural grasslands, they will never be monitored to the same extent. Butterflies belong to a taxa very sensitive to environmental changes and there is a risk that sharp declines in species will go undetected with a single environment approach, especially in times of global warming.

Numerous studies have concluded that heterogenic environments enhance the diversity of butterflies (Schneider & Fry 2001, Krauss et al. 2003, Kerr 2001, Grill et al. 2005, Ohwaki et al 2007), but also among other taxa like birds (Söderström et al. 2001), which is due to that heterogeneous environments attract species associated to different vegetation types (Schneider & Fry 2005). Clear-cuts seemed to be important for many species, as supported by Inoue (2003), probably due to the more heterogeneous environment clear-cuts often possess. Monitoring how butterflies use clear-cuts and other habitats in the forested landscape may have implications for forestry management.

In general, almost all vegetation types in Europe support threatened butterfly species (van Swaay et al. 2006). This highlights the fact that monitoring should be based within a landscape context including more species than what is presently done. Using the same squares for repeated monitoring, as in NILS every fifth year, will provide a good illustration of how changes in landscape structure affect species composition. It may then become possible to understand the effects of forestry, road buildings, an increase in coniferous forests etc. which can have implications for the conservation of butterflies. The butterfly sensitivity can also act as a tool giving early warnings of environmental changes.

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Appendix

Appendix 1. Abundance of butterflies and number of polygonsand sites where butterflies were found during monitoring ineight landscape-squares in SE Sweden.

Species	Abundance	No. of polygons with occurrences (n_{max}=1234)	No. of sites (n_{max}=8)
Aphantopus hyperantus	440	124	8
Plebejus argus/idas	295	47	3
Pieris napi	235	121	8
Coenonympha pamphilus	117	52	4
Polyommatus icarus	89	41	6
Coenonympha arcania	80	48	6
Maniola jurtina	69	47	4
Argynnis paphia	68	53	8
Gonepteryx rhamni	66	42	8
Pieris rapae	62	38	4
Lasiommata maera	59	36	6
Pararge aegeria	58	42	7
Brenthis ino	56	28	6
Argynnis aglaja	54	34	6
Aglais urticae	37	14	7
Boloria euphrosyne	35	25	7
Ochlodes sylvanus	32	17	5
Leptidea reali/sinapis	28	22	6
Inachis io	28	21	7
Polyommatus amandus	27	21	6
Thymelicus lineola	24	15	3
Melitaea athalia	23	16	6
Polyommatus semiargus	22	11	2
Erebia ligea	21	18	7
Callophrys rubi	21	10	3
Zygaena lonicerae	20	9	5
Issoria lathonia	18	13	3
Pieris brassicae	18	17	5
Hesperia comma	17	11	3
Plebejus optilete	17	9	4
Anthocharis cardamines	12	8	7
Boloria selene	11	8	2
Aporia crataegi	9	6	1
Polygonia c-album	9	8	5
Argynnis adippe	8	6	3
Colias palaeno	7	3	1
Lycaena virgaureae	7	6	4
Lycaena phlaeas	7	7	2
Zygaena filipendulae	7	4	2
Celastrina argiolus	3	3	2
Nymphalis antiopa	3	3	3
Hipparchia semele	2	2	2
Lycaena hippothoe	2	2	2
Lasiommata megera	1	1	1
Lasiommata petropolitana	1	1	1
Argynnis niobe	1	1	1
Aricia artaxerxes	1	1	1
Glaucopsyche alexis	1	1	1

Cupido minimus	1	1	1
Favonius quercus	1	1	1
Zygaena viciae	1	1	1
Vanessa atalanta	1	1	1
Papilio machaon	1	1	1
Limenitis populi	1	1	1
Total	2234		