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POLICY COMMENTARY

The incentive gap: LULUCF and the Kyoto mechanism before and after Durban

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Abstract

To-date, forest resource-based carbon accounting in land use, land use change and forestry (LULUCF) under the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol (KP), European Union (EU) and national level emission reduction schemes considers only a fraction of its potential and fails to adequately mobilize the LULUCF sector for the successful stabilization of atmospheric greenhouse gas (GHG) concentrations. Recent modifications at the 2011 COP17 meetings in Durban have partially addressed this basic problem, but leave room for improvement. The presence of an *Incentive Gap* (IG) continues to justify reform of the LULUCF carbon accounting framework. Frequently neglected in the climate change mitigation and adaptation literature, carbon accounting practices ultimately define the nuts and bolts of what counts and which resources (forest, forest-based or other) are favored and utilized. For Annex I countries in the Kyoto Mechanism, the *Incentive Gap* under forest management (FM) is significantly large: some 75% or more of potential forestry-based carbon sequestration is not effectively incentivized or mobilized for climate change mitigation and adaptation (Ellison *et al.* 2011a). In this paper, we expand our analysis of the *Incentive Gap* to incorporate the changes agreed in Durban and encompass both a wider set of countries and a larger set of omitted carbon pools. For Annex I countries, based on the first 2 years of experience in the first Commitment Period (CP1) we estimate the IG in FM at approximately 88%. Though significantly reduced in CP2, the IG remains a problem. Thus our measure of missed opportunities under the Kyoto and UNFCCC framework – despite the changes in Durban – remains important. With the exception perhaps of increased energy efficiency, few sinks or sources of reduced emissions can be mobilized as effectively and efficiently as forests. Thus, we wonder at the sheer magnitude of this underutilized resource.

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Introduction

Ellison *et al*. (2011a) identify a significant 'Incentive Gap' (IG) in the European Union (EU), Kyoto Protocol (KP), and United Nations Framework Convention on Climate Change (UNFCCC) carbon accounting and reporting frameworks for land use, land-use change, and forestry (LULUCF). Because the carbon stored in omitted carbon pools, managed forests, and harvested wood products (HWP) is not adequately accounted under current carbon accounting practices, strong incentives for increased carbon sequestration and the balanced and efficient use of forest resources are not in place. Accounting practices under the UNFCCC, KP, EU, and other national-level emission reduction schemes thus fail to adequately mobilize the LULUCF sector for climate change mitigation and adaptation. Moreover, each of these frameworks (UNFCCC, KP, EU, and national-level strategies) employs different reporting and/or accounting conventions with significant and potentially adverse impacts on how forest resources are used (Ellison *et al*., 2011a: 1063). Recent LULUCF carbon accounting reforms at the 2011 COP17/CMP7 meetings in Durban have done little to change the basic dimensions of this problem. Although some significant progress has been made, the IG remains large.

The consequences are significant: continued global warming and climate change threaten human life and that of other species on the planet. Rising temperatures and changing rainfall patterns are altering the most basic and fundamental conditions for human, animal, and plant life/survival. The International Energy Agency (IEA, 2011) recently argued little time remains for humankind to alter her behavior. If international-, regional-, and national-level strategies do not change

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within the next 5 years, there is no chance the world will keep step with the IPCC's 450 Scenario aimed at keeping temperature rise below +2 °C. And some even argue the +2 °C target is inadequate (Hansen *et al.*, 2008; 350.org). Humanity, however, is currently on a path to a +6 °C or greater rise in temperatures (IEA, 2011). Even the 2010 concessions made at COP15/CMP5 in Copenhagen are insufficient to keep global warming below +3.5 °C (Höhne *et al.*, 2011). Coupled with a recent report from the US Carbon Dioxide Information Analysis Center announcing that 2010 had witnessed the greatest annual increase (5.9%) in global greenhouse gas (GHG) emissions of all time (Boden & Blasing, 2011), all of the points listed above suggest humanity is moving in the wrong direction.

Good tools for the management of climate change mitigation and adaptation, in particular those that are natural, readily available, and comparatively inexpensive to cultivate are hard to come by. Forests represent just such a tool and exhibit distinct advantages over other climate change mitigation and adaptation resources – in particular due to their potential '*double and triple use value*'. As forests naturally bind carbon dioxide into biomass through photosynthesis, transpiration, and growth, they are among the most important sources and sinks of planetary greenhouse gases. Through deforestation, fellings, and natural decay, forests contribute approximately 15–20% of the world's GHG emissions.

Putting an end to deforestation and contributing to re- and afforestation can contribute substantially to climate change mitigation. In addition, forests are linked to natural processes of atmospheric regulation, participating importantly in the cross-continental transport of moisture vapor and thus the more even distribution and geographic diffusion of freshwater resources (Ellison *et al.*, 2012a). Further, forests cool the earth's surface and represent important biodiversity havens (CBD, 2009; Ban-Weiss *et al.*, 2011) – not to mention their larger socioeconomic importance. Forests naturally help preserve life in all its planetary forms and thus act as an important climate change adaptation agent. Despite clear and present justifications for the role of forests in the climate change mitigation and adaptation framework, insufficient progress has been made in creating an adequate support and incentive framework for the successful mobilization of forest-based resources.

Current efforts to mobilize LULUCF for the purposes of climate change mitigation and adaptation make inadequate use of this remarkable resource. This is true at two important levels. On one hand, large carbon pools are not counted in current carbon accounting practices. The potential mobilization of unmanaged forests, forest management (FM) resources, HWP, and other omitted carbon pools (peatlands, etc.) would greatly increase the pool of potential resources for climate change mitigation (and adaptation) strategies. Recent changes to LULUCF introduced at the 2011 COP17 meetings in Durban only partially modify this basic problem. Considerable unevenness likewise remains across carbon accounting and carbon-trading frameworks. This is perhaps most obvious when considering the EU case in comparison to the international UNFCCC framework. To date, the EU still prohibits trade in emission reductions produced in the LULUCF sector. Although, in the international framework, countries do possess the right to trade in the carbon sequestration potential of forest-based resources – through Removal Units (RMU's) and the CDM-based Certified Emission Reductions (CER's) – the potential range for trading is constrained by the failure to adequately incentivize all forms of forest-based carbon sequestration (net removals).

In the current study, we measure and quantify the magnitude of the current Incentive Gap (IG), both across Annex I countries and also across the larger set of non-Annex I and nonsignatory countries. In particular, we estimate the impact of the LULUCF changes introduced in Durban on Commitment Period 2 (CP2) and compare these with estimates of the IG in CP1. Quite vast carbon mitigation resources go unmobilized in the current carbon accounting and carbon-trading frameworks. Yet relatively modest changes in the UNFCCC and Kyoto carbon accounting guidelines and procedures could potentially motivate and incentivize significant change. However, we do not have a good sense of: (1) what the potential magnitude of such carbon removals might be? (2) where the largest potential pockets for additional carbon sequestration efforts lie? (is it, for example, in unmanaged forests and omitted carbon pools, in the Forest Management (FM, Art. 3.4) sector, or other omitted carbon pools?); (3) what share of potential increases in carbon sequestration lie in Annex I countries and what share lies outside the Annex I framework? and (4) what specific elements of the UNFCCC and Kyoto carbon accounting procedures in LULUCF should be changed to have the biggest impact on increased carbon sequestration?

In what follows, we first address variation in carbon accounting practices and their use in carbon-trading frameworks at the international and EU level – focusing in particular on the relative importance of Afforestation, Reforestation, and Deforestation (Art. 3.3 ARD) relative to the complementary role of Forest Management (Art. 3.4). Second, we discuss the potential role of forests in climate change mitigation and adaptation, highlighting in particular the elements of what we call the 'troika' and the relative advantages associated with balancing the competing sets of interests surrounding forest resources. Third, we discuss the outcomes of the

AWG-KP and the 2011 Durban LULUCF agreement. Fourth, we compare old and new versions of the IG based on the Durban outcome. Finally, we briefly outline the global potential that remains to be incentivized in the KP framework. The final section concludes.

LULUCF carbon accounting and the Kyoto process

As illustrated in Ellison *et al.* (2011a), the efficient, effective, and balanced use of forests and forest-based resources can be implemented through an effective reform of carbon accounting in LULUCF. To create incentives for cost-efficient climate change mitigation and adaptation and to promote the efficient and effective use of forest resources, it is necessary to include all forest-based carbon pools and emissions in one all-encompassing, unified, and coherent national land-use inventory. Thus, all previously neglected carbon pools should be combined into one national land-use inventory, collapsing distinctions such as the inauspicious division of LULUCF accounting into Art. 3.3 (Afforestation, Reforestation, and Deforestation, ARD) and Art. 3.4 (Forest Management, FM).

Further, adequate consideration of what we call the *troika* of competing but potentially compatible interests surrounding forest resources should address each of the following: (1) the promotion of standing forests (in particular for the purposes of carbon sequestration, biodiversity protection, and ecosystem promotion), (2) the traditional HWP value chain, and (3) bioenergy. The successful balancing of these competing interests and the enhancement of efficiency and effectiveness in the balanced use of forest resources require an accounting mechanism that weighs and rewards each component according to its real climate mitigation potential. LULUCF carbon accounting models that favor the interests of one member of the troika over others – in particular bioenergy over standing forests and HWP – will likely lead to inefficient outcomes.

Carbon sequestration in standing forests and HWP is not fully recognized in most accounting frameworks. The EU, for example, does not permit the inclusion of LULUCF in EU-based commitments, and carbon credits cannot be traded in the EU's ETS. Moreover, the implementation of LULUCF accounting is uneven across Parties to the KP. Although the recent conclusions of the 2011 COP17 meetings in Durban modified LULUCF carbon accounting rules, the accounting of carbon sequestration (net removals) in standing forests and HWP has only been partially modified and remains subject, in particular, to a new 3.5% of 1990 GHG emissions 'cap'. Although HWP and standing forests will now be more highly valued than was previously the case vis-à-vis bioenergy, eliminating the cap and incorporating all remaining omitted carbon pools can improve this relationship. The successful inclusion of all major terrestrial carbon pools in a revised and updated Kyoto Protocol (KP) that fully accounts for all carbon credits from both carbon sequestration (net removals) and fossil fuel substitution, and renders these fully fungible across international (and EU) carbon-trading schemes, would encourage both long-term carbon sequestration in standing forests, HWP, *and* bioenergy resource use.

The international LULUCF carbon accounting framework (UNFCCC and the Kyoto protocol)

In its early efforts at promoting climate change mitigation, the UNFCCC placed considerable emphasis on forests. Art. 4(1d) of the Convention addresses forestry and states that Signatory parties shall 'promote and cooperate in the conservation and enhancement […] of sinks', including biomass and forests. Art. 4(1a) further required the creation of national inventories and regular reporting on 'anthropogenic emissions and removals by sinks'. Early national communications to the UNFCCC addressed the extent of forest resources in Signatory party countries and were followed by regular reporting to the UNFCCC of GHG national inventories.

Through the UNFCCC's Kyoto Protocol framework, countries possess the right to trade in *Removal Units* (RMU's) generated on the basis of Afforestation, Reforestation, and Deforestation (ARD, Art. 3.3) and forestry operations, and in *Certified Emission Reductions* (CER's) generated on the basis of investments through the clean development mechanism (CDM). RMU's and CER's, for the most part, are restricted to carbon removals generated under Art. 3.3 through Af- and Reforestation efforts. Credits from carbon sequestration (net removals) under FM (Ar. 3.4) are both limited by the so-called 'cap' (for Annex I countries) and are not eligible under the framework of the CDM mechanism, which limits CER's to Afforestation and Reforestation efforts (Art. 12).

Due to this model, lands dedicated to forestry as of the base year 1990 – whether currently forested or not – are typically not eligible for credits resulting from increased forest growth and carbon sequestration efforts. Likewise, no credits can be calculated and accounted for increased forest growth from unmanaged forests. However, compared to the Art. 3.3 AR(D) market, the Art. 3.4 FM market is significantly larger. In this sense, the division of Art. 3.3 on Af-, Re-, and Deforestation (ARD) from Art. 3.4 on FM in the UNFCCC and Kyoto Protocol guidelines is perhaps the biggest single factor explaining the lack of adequate integration of forestry-based interests in the RMU/CER and Kyoto-based mechanisms.

Although the CDM market initially exhibited little positive growth, more recently it has become one of the faster growing components of the semivoluntary market. The CDM market represented 5.4% of the total market in 2010 (Ecosystem Marketplace, 2011) compared to approximately 1% of the total CDM market in 2008 (Ecosystem Marketplace, 2009: 51). RMU's remain the principal LULUCF-based mechanism, although CER's from CDM projects are on the rise.

The EU and the KP

Although the EU has repeatedly discussed the possibility of incorporating LULUCF into the EU climate change mitigation framework, for the most part LULUCF remains only a secondary appendage – successful LULUCF carbon sequestration and emissions are recorded in UNFCCC reporting, but generally not accounted for in the EU framework. In revising the EU strategy for the second Kyoto round intended to follow upon the first Commitment Period (2008–2012), the EU's 2020 Climate and Energy package did not attempt to model the impact of incorporating LULUCF in the package (see SEC(2008)85-V2: 36-7) and ultimately left LULUCF out of the policy framework. However, individual elements of the Climate and Energy package did require the European Commission to revisit that decision at a later date. Art.'s 8 and 9 of the EU's Effort Sharing Decision (406/2009/EC) and Art. 28 of the EU ETS Directive (2009/29/EC) required that the European Commission assess the possibility of incorporating LULUCF into the EU emission reduction and emission trading framework. The European Climate Change Programme (ECCP) and DG Climate Action were charged with the task of evaluating the potential role of LULUCF and initiated several public consultations (one in Fall 2010 and another in January 2011: see DG CLIMA's website: http://ec.europa.eu/clima/events/events_archives_en.htm).

There is considerable resistance within the EU toward the integration of LULUCF into the EU's climate change mitigation framework, and in particular into the EU ETS. Both the EU ETS Directive (both the previous EU ETS Directive (2003/87/EC) covering the 1st Commitment period and the newer ETS Directive (2009/29/EC) covering the 2nd Commitment period) and the EU Linking Directive (2004/101/EC), for example, allow credits from CDM and JI projects to be used in the EU ETS. But the Linking Directive explicitly excludes the potential use of CER's and ERU's from the LULUCF sector (Art. 11a, subparagraph 3b; see also Swedish EPA, 2006: 11). There is, in particular, considerable antipathy toward any weakening of the EU Emission Trading Scheme (ETS) that might result from a possible reduction in carbon prices or reduced incentives to limit emissions in the ETS sector.

Potential approaches for incorporating LULUCF in the EU framework are essentially of two types. On one hand, LULUCF could be integrated into the EU commitment strategy and used as a tool for promoting increased efforts at compensating emissions by promoting the development of carbon sequestration strategies through the use of forestry. On the other hand, the EU could integrate LULUCF into the EU's Emission Trading Scheme. However, despite generally widespread support for the incorporation of LULUCF into the EU climate policy framework, the ECCP (2010) notes several difficulties. These include problems of uncertainty in the estimates of sequestered carbon, the lack of annually based LULUCF reporting cycles, and uncertainty over whether LULUCF should be incorporated into the EU's ETS or into the commitment mechanism. The ECCP points out that incorporating LULUCF into the EU ETS could require some manipulation, as the EU ETS currently requires information about individual installations (forest owners) and would require a significant administrative apparatus. Furthermore, the current EU ETS system is based on annual compliance, whereas national forest inventories are based on longer cycles (ECCP, 2010: 8).

Tensions between the competing uses of forest-based resources are evident at the heart of the ECCP. Whereas some participants would like to see a focus on carbon sequestration in standing forests, others favor the 'use of biomass for substitution of GHG intensive material and energy use' (ECCP, 2010: 3). Some ECCP members have even argued FM should not be included when incorporating LULUCF into the EU climate strategy – in particular due to the potential impact this might have on HWP and the use of biomass for energy (ECCP, 2010: 6).

In March 2012, DG Climate Action issued a draft proposal on LULUCF GHG accounting rules that follows up on the Durban LULUCF agreement (COM (2004) 93 final). For the most part, this proposal addresses the harmonization of LULUCF accounting rules across the EU member states. Furthermore, the proposal intends to integrate and make mandatory reporting on both the activities of Cropland and Grazing land management in the general EU LULUCF approach. However, although COM(2004) 94 final sets the stage for future potential incorporation of LULUCF into the EU climate policy framework, it stops short of making explicit recommendations about how this should be done. On the other hand, from discussions it is clear that DG Climate Action is favoring a model that isolates the potential impact of LULUCF on the EU climate policy framework by setting separate LULUCF targets and retaining the current segmentation between LULUCF and the EU ETS system.

Individual Member states and Annex I signatories likewise exhibit resistance to the potential for change. Sweden, for example, like many EU member states and Annex I countries, is resistant to modifications in the existing rules that may result in higher levels of uncertainty and risk. Incrementalism, i.e., taking only small forward policy steps, is reinforced by the fact that decision making regarding Kyoto practices is conducted through an intergovernmental framework requiring consensus on the part of all participating Parties and signatories. For this reason, large changes in the Kyoto framework are difficult to pursue.

At the same time, several factors point to the potential importance of considering the model proposed herein. First, the climate challenge requires urgent and rapid action. Second, LULUCF represents a substantially undermobilized resource with significant use value. Third and finally, the current LULUCF carbon accounting strategy has the unfortunate effect of favoring the use of some forest-based resources over others. In particular, bioenergy-based resources are currently favored over other forest-based resources. Bioenergy is strongly favored in current carbon accounting practices – emissions from bioenergy combustion are considered neutral whereas the carbon sequestered in HWP or in standing forests is not consistently counted or incentivized. For carbon accounting purposes, during CP1, all harvested wood is considered immediately oxidized. Although this strategy has been favorably modified for CP2, as we argue below, these changes do not go far enough.

While this may encourage movement toward the low carbon economy, we argue this can be achieved more effectively and efficiently with improved carbon accounting practices. Moreover the consequence of not moving in this direction is the inefficient use of forest-based resources and slower progress on climate change mitigation (and adaptation). Finally, as we illustrate below, this strategy does not adequately mobilize forest growth and increases in the total forest sink.

Table 1 Cost of forest-based carbon sequestration and renewable energy (cost per $MtCO_2e$)

Ecosystems marketplace 2011	Reported volume ($MtCO_2e$)		Avg. price (US$/$tCO_2e$)	
	Historical total	2010	Historical	2010
Voluntary OTC	59	27.4	5.46	5.63
CCX	2.9	0.1	2.83	1.18
Total voluntary markets	61.9	27.6	5.36	5.60
CDM	9	1.4	4.28	4.49
NSW GGAS	3.1	1.1	12.26	*
NZ ETS	0.6	0	13.91	12.95
Total regulated markets	12.8	2.6	5.61	4.61
Total global markets	74.7	30.1	5.40	5.54
Total primary market	71.6	29	5.22	5.49
Total secondary market	3.2	1.2	9.69	7.56

EU 2030 (IEA, 2009)	CO_2 savings $MtCO_2$	Abatement cost $ per tonne CO_2
Savings from lower emitting technologies	660.0	54.20
More efficient coal plant (excl. CCS)	23.5	9.90
More efficient gas plant (excl. CCS)	–	0.00
Utilizing spare gas capacity over coal	–	0.00
Through use of CCS	158.4	61.10
CCS coal (Oxyfuel)	77.0	56.90
CCS coal (IGCC)	66.4	61.10
CCS gas	15.0	83.10
Nuclear	252.6	39.60
Renewables	225.4	70.20
Hydro conventional	16.3	32.60
Bioenergy	39.7	58.60
Wind onshore	22.4	46.00
Wind Offshore	99.6	63.00
Geothermal	7.4	27.20
Solar PV	23.0	188.40
Concentrating solar power	8.2	70.70
Tide/wave	8.8	61.50

Sources: Ecosystem Marketplace (2011: ii) and IEA (2009).
* Inadequate data.

Good tools for effective and efficient climate change mitigation *and* adaptation?

Although potential strategies for efficient and effective climate change mitigation exist, the structure of approaches and the focus on efficient strategies remain weakly articulated in the EU and most other countries. Many organizations have pointed, for example, to the potential advantage of pursuing increased energy efficiency. The *3C Initiative* in particular – a group of like-minded think tanks – points to the high potential return (economic reward) from investing in energy efficiency in building-related energy use (for more on the 3C Initiative (2009), see: http://www.combatclimatechange.org and the previous work of two affiliated organizations, McKinsey, 2008; and Vattenfall, 2006). The most distinctive feature of the 3C analysis is the recognition of 'negative abatement cost curves' associated with energy efficiency improvements, indicating substantial economic returns from investing in energy efficiency. Although not strongly supported in the EU climate policy framework, energy efficiency enjoys support from important EU-level actors. The European Climate Foundation (2010) recently published a report detailing the need for more concerted energy efficiency efforts, noting that the EU Member states would need to triple their efforts to reach 2020 climate goals for reducing energy use by 20% (see also Altmann *et al*., 2010b).

Beyond energy efficiency, forest-based climate change mitigation and adaptation scenarios represent a similarly cost-efficient and effective strategy. Although both are underutilized in the EU and global climate change mitigation playbooks, we focus herein only on the potential role of forests. There are many reasons for promoting the role of forests in climate change mitigation and adaptation. For one, forest-based carbon sequestration represents one of the cheapest forms of climate change mitigation. Compared in particular with estimates of carbon dioxide (CO_2) abatement costs resulting from the introduction of renewable energy technologies (Table 1, bottom panel), forest-based carbon sequestration is significantly less costly. Although exceedingly difficult to estimate, at its most expensive, the cost per ton of carbon dioxide equivalents (CO_2e) for carbon sequestered in forests is approximately \$7.50 (or \$12.95 in the New Zealand market) (Table 1, top panel). And many forest-based carbon markets are significantly cheaper. For renewable energy, on the other hand, the lowest CO_2 abatement cost estimates are for efficient coal plants (not viable in the longer term). Next to this, only geothermal energy is even remotely competitive.

Much can be said about the relative accuracy of the IEA cost estimates (see e.g., Altmann *et al*., 2010a: Sec. 4.2), or about the difficulties of accurately estimating the costs of afforestation initiatives (ECCP, 2008). Moreover, estimated costs can easily change based on the structure of demand or change in the underlying technologies. The IPCC *Forest* report (Nabuurs *et al*., 2007) estimates the amount of carbon sequestration that would occur at different price levels and assumes base prices for carbon sequestration that are considerably higher than those presented here. This may in part be a function of variation in price levels across countries and regions. The cost estimates provided in the Ecosystem Marketplace (2011) report also have the advantage of being based on more recent experience. All in all, however, forests represent a significant advantage over many other climate change mitigation alternatives. In pointing this out, we do not wish to suggest efforts should not be made to pursue the use of renewable energy technologies. We do, however, wish to suggest there are multiple and explicit advantages from pursuing increased forest growth and forest-based carbon sequestration. These can accommodate and complement the advantages of renewable energy technologies.

The potential for carbon sequestration in forests and soils is considerable. Forests already represent vast stores of carbon. All in all, this amount totals some 861 ± 66 Pg C, with just under half of this amount (383 ± 30 Pg C, 44%) located in the soil and the remaining amount represented by living biomass (42%), deadwood (8%), and litter (5%) (Pan *et al*., 2011: 989). How much more carbon forests could *potentially* sequester on an annual basis remains open to question. Pan *et al.* (2011) note that estimates of the *current* global annual net uptake of forests range from less than 1.0 to as much as 3.4 Pg C yr^{-1}, but provide considerably lower personal estimates at 1.1 ± 0.8 Pg C yr^{-1}. The IPCC 2007 *Forest* report likewise notes considerable variation in the estimates of the total global mitigation *potential* of standing forests. Based on variation in the international price of carbon, potential estimates range anywhere from 1.3 to 13.8 $GtCO_2e$ yr^{-1} (Nabuurs *et al*., 2007: 543). Although significantly underutilized and not effectively mobilized, forest-based carbon sequestration represents a significant global potential.

Accounting procedures that potentially contribute to slowing the rate of deforestation and forest cover loss represent significant *global public goods* and can potentially be influential in both less developed, developing, *and developed* countries. Deforestation represents one of the greatest potential threats to future global atmospheric GHG concentrations. On the other hand, total global forest density has increased, largely compensating many of the regions with declining forest cover (Rautiainen *et al*., 2011). Although the precise impact of deforestation on global emissions remains contested (Van der Werf *et al*., 2009), total emissions from deforestation, forest degradation, and peatlands represent 15% or more of global anthropogenic emissions. Previous estimates were considerably higher, reaching as much as 20% of global GHG emissions. Van der Werf *et al.* (2009) also include new emission sources in their calculations (in particular peatlands). For a large number of developing countries, deforestation and forest degradation represent the principal source of emissions (ibid.).

These points provide strong arguments for supporting the promotion of forests as a climate change mitigation and adaptation tool. Virtually any mechanism that can successfully slow or put a stop to current rates of deforestation would have a sizable and significant impact on current rates of global warming and climate change. The fact that forests provide a relatively cheap resource for achieving this goal represents a *win-win* opportunity. The advantages of promoting increased forest growth and cover can simultaneously help promote avoided or reduced deforestation.

But beyond questions of cost, forests and forest-based resources exhibit many other advantages. As argued below, forests have what one might call a '*double and/or triple use value*': forest-based resources can serve more than one purpose, can be used more than once and can likewise be used simultaneously to fulfill multiple goals at any given point in time (i.e., for climate change mitigation *and* adaptation). In this sense, forests and forest-based resources have distinct advantages over other climate change mitigation and adaptation tools and can potentially give rise to *multiplier*-type effects due to their use and reuse. The *multiplier use value* of forests is not adequately appreciated in the current literature.

Few would dispute that a more diversified use of forest-based resources based on the promotion of standing forests and HWP is less efficient. Following Nabuurs *et al.* (2008), quite a diverse range of potential forest uses can be mobilized to 'maintain or maximize forest carbon pools and carbon sequestration'. Without entering into the details of this debate, carbon accounting strategies that provide a framework for supporting *multiple forest uses* represent a meaningful alternative. To encourage a more efficient and balanced use of forest resources, a more flexible and dynamic carbon accounting framework is presumably a requirement. But the *potential* advantages of forest-based resources extend well beyond their more conventional *multifunctional use value* to include a substantial range of climate change mitigation and adaptation use values.

Forests and forest-based biomass material have *double and sometimes triple the potential use value* associated with other climate change mitigation and adaptation resources and tools. Thus, on one hand, in addition to representing invaluable long-term stores of carbon and thus a particularly inexpensive climate change mitigation resource, forests likewise have considerable climate change adaptation value. For example, forests play an invaluable and even crucial role in natural atmospheric regulation of the hydrologic cycle (Ellison *et al.*, 2012a). Forests likewise play an important role in cooling the Earth's surface (Ban-Weiss *et al.*, 2011). And forests have the potential to play an important role in biodiversity protection. However, many of the climate change mitigation and adaptation related advantages of standing forests (and even forestry) are frequently not well recognized (Ellison, 2010).

Mitigating the troika

The concept of the efficient and effective use of forest-based resources is simultaneously based on the potential uses of biomass resources. However, in addition to the traditional forest resource-based value chain, bioenergy now consumes ever-larger amounts of the forest resource value chain.

To date, a large part, about 50%, of the roundwood taken out of the forests globally is used as fuel wood (FAO, 2010). The corresponding number for Sweden is about 8%. But of the remaining industrial roundwood about 35% is eventually combusted for energy production as waste products from the refinement chain at saw and paper mills (Wikberg, 2009). Residual waste (branches, treetops, and increasingly frequently stumps) is also utilized for bioenergy production. This pattern, however, is not representative of all countries. In Hungary, for example, much of bioenergy demand is met with solid biomass (logs chipped for combustion). But even in countries like Sweden, discussions increasingly revolve around what share of treetops should be set aside for bioenergy material and how much should be used for stemwood (HWP). Increasing demand for bioenergy material is likely to place increasing pressure on potential uses for harvested biomass material.

The point we have tried to make (Ellison *et al.*, 2011a) and emphasize here again is that current climate-related strategies, in particular because of the emphasis they place on bioenergy use and their failure to incorporate adequate accounting of HWP and standing forests, are likely to place significant pressures on the traditional forest value chain. We do not wish to signal lack of support for the use of forest-based resources for bioenergy purposes. This would significantly misinterpret our goal. Rather, we argue that far more could (and presumably should) be done to ensure the following two key points: (1) that the pursuit of and support for bioenergy use does not undermine other viable and efficient uses of forest-based resources (the traditional forest value chain should not come under threat from new entrants favored by climate change mitigation), and (2) that a truly efficient and effective use of forest-based resources should be pursued. From our perspective creating a level playing field based on equal incentives for all components of the forest value chain will promote the full potential use value of forest-based resources, thereby taking advantage of their double/triple use value.

Without adequate safeguards in place, one of the important risks is that much of the traditional value chain (in particular HWP) will be threatened by the growth of the bioenergy sector. Although powerful incentives for fossil fuel substitution may have important emission reducing effects, they also have potentially far-reaching and unintended consequences for

Table 2 Change in renewable and bioenergy use, 2009/1990

Country/Region	Change in RES use, exclud. hydro (GIC 2009/1990), %	Wood and wood waste share of RES (GIC 2009), %	FM forest cover share of total land use, %	Change in wood and wood waste use (PEP 2009/1990), %	Change in wood and wood waste use (GIC 2009/1990), %
EU27	133	45	24	85	88
EU15	126	41	23	62	68
NMS10	185	76	27	192	174
Austria	79	46	3	0	83
Belgium	386	56	1	139	290
Bulgaria	231	67	3	340	329
Cyprus	1533	16	(na)	50	167
CzR	171	73	34	143	123
Denmark	237	52	14	90	164
Estonia	290	95	4	348	270
Finland	44	81	72	50	42
France	35	48	41	0	0
Germany	493	36	32	281	281
Greece	89	38	9	−11	−11
Hungary	152	77	20	117	128
Ireland	433	21	4	70	79
Italy	157	22	31	310	376
Latvia	50	80	54	156	91
Lithuania	178	86	34	189	167
Luxembourg	611	27	3	127	127
Malta	0	0	0	0	0
Netherlands	377	35	2	189	259
Poland	302	82	30	258	258
Portugal	65	52	45	13	13
Romania	233	71	28	538	522
Slovakia	270	51	1	290	273
Slovenia	70%	48	59	81	61
Spain	156	27	27	9	9
Sweden	39	54	72	67	67
UK	581	24	7	331	447

Source: Own calculations based on Eurostat online data. GIC, Gross inland consumption; PEP, Primary Energy Production (Ellison, 2011b).

standing forests (see in particular Wise *et al.* 2009), as well as for more conventional forest-based industries.

In the EU, the growth of bioenergy use for the production of heat and electricity has been significant (see Table 2). In the EU as a whole, *bioenergy use* has grown at a rate of 88% over the period from 1990 to 2009 (at 174% in the New member states (NMS) and at 68% in the EU15). EU and national-level goals for biomass energy use are significantly high. This is driven primarily by the EU's Renewable Energy Directive (2009/28/EC) and by expectations that a significant share of EU renewable energy will be generated using national-level bioenergy resources.

The 2010 EU Wood report notes that demand for biomass for energy use is likely to outstrip available supply sometime between 2015 and 2020 (Mantau *et al.*, 2010: 23), creating the conditions for significant conflict across the different components of the forest value chain. Improved FM could ameliorate at least some of these constraints (Verkerk *et al.*, 2011). At the same time, econometric projections of future forest use suggest that the bioenergy sector will place increasing strain on the European forest sink (Böttcher *et al.*, 2012). These studies, however, inexplicably neglect the potential for increased forest cover and growth outside FM. Although Art. 3.3 afforestation and reforestation is not immediately available for use in the bioenergy sector, it can help mitigate losses to the forest sink.

At a larger scale, such pressures are not yet evident. Based on data reported by Parties to the UNFCCC (Submission 2011, 7th of November), CO_2 *emissions* from biomass use have risen significantly. In the EU15, *emissions* have increased 104%, in the EU27 124%, and in the New member states 260%. For

Annex I countries, however, while CO_2 emissions from biomass have increased, fossil fuel-based CO_2 emissions have declined. At the same time, biomass CO_2 emissions as a share of forestland CO_2 emissions have decreased, whereas carbon removals in forestry have increased. Thus while the shift to biomass has contributed to reducing global fossil fuel-based emissions, thus far forest cover has not been negatively impacted. Worldwide, biomass emissions have risen some 37%. However, total biomass emissions for all Annex I countries are heavily influenced by the decline from above 60 000 Gg CO_2 to about 14 000 Gg CO_2 in Russia. This suggests that the potential to use biomass from the forest for energy generation is large and can be increased without jeopardizing the net sink.

At the country level, some parties have increased the use of biomass and some have decreased it. The largest increase can be seen among eastern European countries (i.e., Romania, Slovakia, Poland, Bulgaria), whereas the decrease was found in Russia, Kazakhstan, Ukraine, and Croatia. On average the increase in biomass use did not affect net removals on forestland. However, at country level, several parties increasing the use of biomass have also decreased net removals on forestland. And in some countries, National Forest Inventory discrepancies have emerged (Ellison *et al*., 2012b).

Beyond the threat to biomass availability and the traditional forest value chain, far more is really at stake. The double and triple use value of both the climate change mitigation and adaptation potential of forests is best promoted by a strategy that: (1) does not place the most emphasis only on bioenergy, and provides greater opportunities for the promotion of both standing forests and HWP; and (2) places a particular emphasis on the margin for increased forest growth and cover.

AWG-KP negotiations and the 2011 COP17 Durban outcome

Since 2008, the AWG-KP (the *Ad hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol) has conducted discussions on how to revise carbon accounting rules for LULUCF. Several options to replace the current rules were proposed. For the most part, these concerned carbon accounting under FM (Art. 3.4 of the KP) – in particular strategies for replacing the gross-net accounting approach and the 'cap' with an alternative rule – and whether FM should be mandatory. Up to Durban, the fallback position was to keep the rules as they are.

Several important decisions were made at the 2011 COP17 Durban meetings regarding LULUCF accounting practices (see, the advance unedited Durban LULUCF conclusions are available here: http://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/awgkp_lulucf.pdf). The first of these involves the decision to continue the Kyoto Protocol and to enter a second Commitment Period in 2013 that will end either in 2017 or 2020. The second concerns the transition to mandatory reporting under FM. The third involves the adoption of a new, revised 'cap' and the shift to 'net-net' accounting. The new 'cap', set at 3.5% of total 1990 GHG emissions (excl. LULUCF), is larger than the previous cap. Furthermore, the shift to net-net accounting means that annual growth will not be counted against zero ('gross-net' accounting), but will rather be counted against a specific, predetermined baseline (or 'reference level'). Parties may gain credits if they report removals about the baseline up to the new cap. Any FM-based removals above the 3.5% cap remain unaccounted and non-incentivized. Parties will be debited if reported removals (increased harvest) fall below the baseline.

Table 3 Kyoto LULUCF rules: pre- and post-Durban

Kyoto rules – LULUCF	Pre-Durban (CP-I: 2008–2012)	Post-Durban (CP-II: 2013–2020)	Idealized model
FM election	Voluntary	Mandatory	Mandatory
Cap	3% of 1990 emissions, 15% of actual net removals (whichever smaller, or negotiated)	3.5% 1990 emissions	No cap
Reference level/ (Accounting method)	Reference level = '0' (gross-net)	Projected, historical or reference level = '0' (net-net)	Reference level = '0' (gross-net)
HWP	Reported/not counted	Production approach (limited by 'cap')	Production approach (or stock change Approach, no limit)
IG	88%	43–66%	0%
ARD offsetting	Permitted	Not permitted	Collapse Arts. 3.3 & 3.4

The fourth new decision concerns mandatory reporting of HWP. Parties are now required to report HWP, and can register credits for HWP using the *Production Approach* (PA) as long as 'transparent and verifiable activity data' are available. Barring this, HWP may be reported on the basis of instant oxidation. However, as all Annex I countries have FAO data available to them, HWP reporting will now be conducted on the basis of the PA. This approach does not permit the accounting of imported, harvested wood products. Finally, although HWP can now be accounted, countries are still subject to the terms of the new 3.5% 'cap'. Thus, in this regard, carbon sequestration (net removals) through HWP is only partially incentivized. In fact, for most Annex I countries, this amount is likely to be minimal.

Other LULUCF changes agreed in Durban include the incorporation of at least one previously omitted carbon pool: Wetland drainage and rewetting has now been added to the category of electable activities. A new *natural disturbances* mechanism has been approved that allows Parties to withdraw from accounting emissions from land areas associated with natural disturbances when they exceed a set background level. The background level is set based on historical information on disturbances. Finally, a new mechanism has been introduced under Art. 3.4 that allows countries to trade new afforestation against deforestation.

Current LULUCF negotiations have not typically included some or even most of the recommendations raised in this study. No attempts, for example, are currently being made to collapse Arts. 3.3 and 3.4, or to include all omitted carbon pools into one all-inclusive carbon accounting framework. To date, Art. 3.3 activities have remained untouched and the focus is primarily on how to account for increases or decreases in net removals in Forest management under Art. 3.4. Likewise, although it has been suggested, few countries favor entirely removing the cap and moving to a gross-net accounting system without limitations on the total potential accounting of carbon sequestration (net removals) under FM.

Table 3 summarizes the most important pre- and post-Durban decisions and also provides an indication in column 3 of what we consider the ideal LULUCF carbon accounting framework. In this context, although Durban in many ways represents an important step forward – perhaps the two most important accomplishments from our perspective are mandatory reporting under FM and the sizeable increase in the cap that will be applied in CP2 – we generally argue much more can be done to adequately 'incentivize' the balanced and efficient use of forests and forest-based resources.

ARD, FM, and other omitted carbon pools

Art. 3.3 on Afforestation, Reforestation, and Deforestation (ARD) was essentially created to promote human-induced change in forest cover and growth. This provided a framework for promoting the climate change mitigation and adaptation potential of forests. However, the decision to exclude what is presumably the largest share of human-induced forest resources from comprehensive carbon accounting practices and thus incentivized carbon sequestration may remain one of the greatest riddles of UNFCCC and KP history. By placing an emphasis on anthropogenic or human-induced forms of change in forest growth and thus forest-related carbon sequestration, Art. 3.3 essentially excluded both natural forest growth and forest management from accounting. Art. 3.4 (FM) was created as an afterthought, primarily at the insistence of Japan (Fry, 2002). Whether intentional or not, this afterthought separated forest-managed lands from lands set aside for afforestation.

Many were initially concerned about the potential impact of including LULUCF in the Kyoto framework as it was assumed that many countries with large forest cover might take advantage of it to reduce efforts on their Kyoto Protocol emission reduction commitments. Although this concern persists (see e.g., Höhne *et al.*, 2011: 7), we argue that this problem can be addressed by improving the structure of commitments (Ellison *et al.*, 2011a). The setting of commitments should follow upon the setting of rules (not the reverse). In this way, the emission reducing potential of forests can be included in country- and international-level target setting. Furthermore, concerns about the role of '*natural disturbances*' have likewise contributed to limitations of the potential role FM can play in carbon removals. Both of these concerns have led to the development of carbon accounting practices that significantly limit the potential to mobilize carbon sequestration (net removals) in forest-based resources.

Thus the split between Arts. 3.3 and 3.4 activities had the impact of artificially hiving off the vast majority of *human-induced* change in forest cover and growth (Art. 3.4) from the category of af-, re-, and deforestation (Art. 3.3). As Art. 3.3 AR was mandatory for all Parties under the KP, many Parties did not feel the need to *elect* FM. Moreover, for some countries, the option to *voluntarily* elect and thus report 'forest management' activities represented an almost unavoidable incentive to promote within-country leakage across Arts. 3.3 and 3.4 and, under CP1, may still encourage forest degradation in Annex I countries and deforestation in Non-Annex I countries where sustainable forest management (SFM) practices are not well entrenched. For other

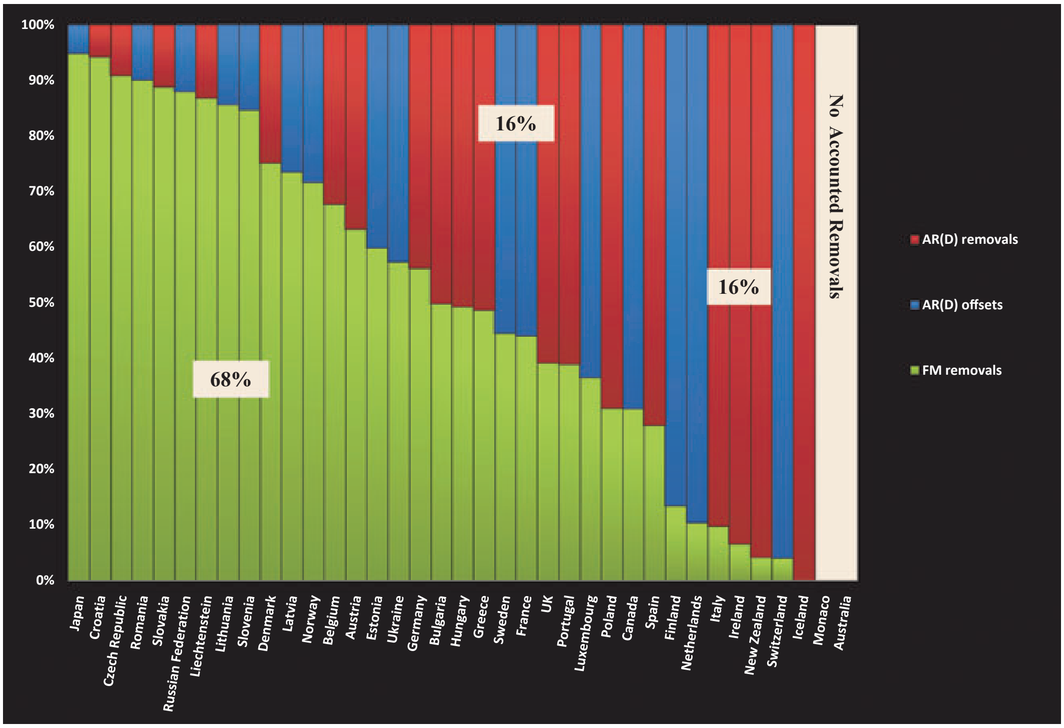

Fig. 1 *Accounted*: AR(D) net removals + AR(D) offsets from FM + FM net removals up to the cap (in% of total). *Note*: For the purposes of this illustration, any emissions under AR(D) are set to '0'. We have also estimated hypothetical offsets and removals for countries that have not elected FM under CP1. Furthermore, all nonaccounted FM net removals measured in the Incentive Gap are not included here. *Sources*: Based on 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php). Average values for the years 2008 and 2009. For parties not electing FM, data on Forest land remaining forest land reported to the UNFCCC has been used as a proxy.

countries, not electing FM represented a strategy for shielding the forestry sector from any potential negative impacts that might arise from stricter carbon accounting.

Although AR was intended to form the principal contribution to carbon sequestration in the LULUCF sector, in practice the opposite has happened. Figure 1 displays the share of AR in relation to the total accounted forestland net removals as reported under the UNFCCC. Although several countries in Europe have seen quite significant increases in forest cover, the average contribution from AR represents only approximately 16% of the total across Annex I countries. Moreover, a good share of total carbon sequestration (net removals) under Art. 3.3 is actually the result of offsets from FM (16%). The vast majority of carbon sequestration (net removals) that could hypothetically be recorded if all Annex I countries were eligible to claim them originates from the FM sector (offsets + cap), or approximately 84% (16% + 68%).

In fact, despite significant efforts in Annex I countries to pursue af- and reforestation projects, in total this amount has not been enough to completely compensate Annex I countries for the rate of deforestation. Estimated across all Annex I countries, total ARD in 2008–2009 results in a net emission of 30 $MtCO_2\ yr^{-1}$. As indicated in Fig. 1, net emissions are compensated by offsets from the forestry sector. However, even with the potential for using offsets from FM, a few countries still exhibit net emissions.

Thus for Annex I countries, the share of increased carbon sequestration (net removals) under the Forest Management cap represents the most important contribution to LULUCF-based carbon sequestration. This suggests reliance on Art. 3.3 ARD activities may be misplaced. The total increase in forest cover and growth is significantly greater under FM than under Art. 3.3. Moreover, the share of total annual active forest regeneration under FM exceeds that under Art. 3.3 by a significant factor. In Sweden, for example, averaged over the period 1990–2010, on an annual basis more than 13 times more active forest regeneration occured under FM than under Art. 3.3 (based on data from the Swedish Forestry Agency 2011; '*artificial* regeneration' is 'planting and ground sowing' and excludes *natural* regeneration). This should not suggest there is no potential outside the FM sector. Quite the opposite is presumably true. But to date, most of the increased forest cover and growth has occurred under FM, underlining that attempts to mobilize forest-based resources should not neglect this sector.

In this regard, as argued in Ellison *et al.* (2011a), merging re-, afforestation, and carbon sequestration efforts into one cohesive framework may make good sense. The principal foundation for this argument is the lack of solid theoretical grounding for the division between these two categories: as they are both powerfully linked to anthropogenic manipulation, concepts of human-induced vs. natural growth do not logically support their separation. To this argument, we add that a greater share of increased forest cover and growth in Annex I countries comes from FM.

The 2011 COP17 meetings in Durban eliminated the offset rule (transfer of net removals from FM to ARD). Thus in CP2, countries will no longer be able to compensate net emissions and/or harvesting from ARD with removals under FM. This has the interesting effect that countries will no longer be able to arbitrarily increase the use of the total amount of FM removals by utilizing these to cover deforestation in Art. 3.3 sectors. Moreover, this raises the relative importance of the Art. 3.3 ARD segment, as countries will now effectively be penalized for all deforestation in this segment and are further eligible for any and all credits (without limit) arising from increased reafforestation.

On the other hand, if the cap is eventually removed (as we recommend), this would essentially mean there is no longer any significant difference, in terms of potential carbon credits, between Art. 3.3 and 3.4. Both under CP1 and CP2 rules, there has always been an incentive to increase reafforestation under Art. 3.3 because no *cap* to the total amount of carbon credits individual countries can receive has been imposed. However, as illustrated above, this has not provided significant incentives for additional carbon sequestration efforts.

Perhaps the strongest argument in favor of eliminating the cap and collapsing Arts. 3.3 and 3.4, however, is the potential to mobilize the entire forest sink rather than only part of it. This, along with the inclusion of other currently omitted carbon pools (such as unmanaged forests) could possibly go a long way to ensuring that adequate forest biomass will be available to meet rising demand and adequate forest cover will be available to secure additional benefits from forest-based climate change mitigation and adaptation.

One area where our model may create unintended incentives should, however, be highlighted. Although FM can have potentially significant and positive impacts on all of the above-mentioned climate change mitigation and adaptation issues, FM can have negative impacts as well. In particular, concerns raised by monocultures, plantation forestry and, negative impacts on both the water supply and biodiversity, and some of

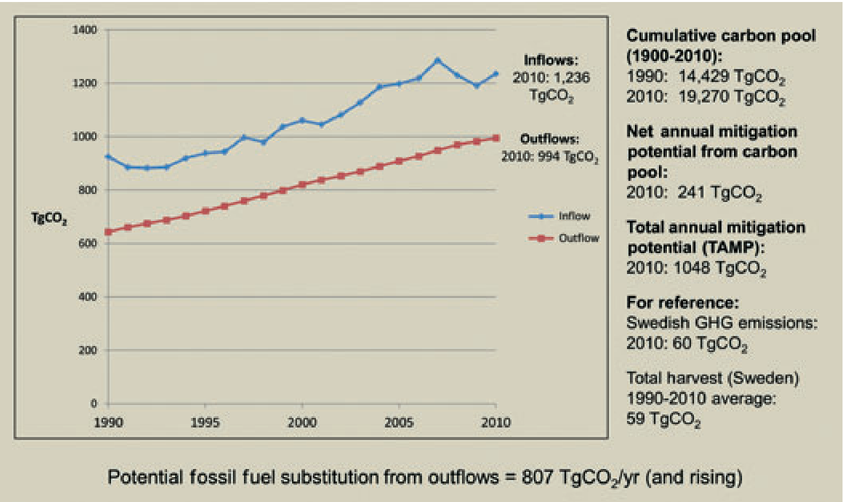

Fig. 2 HWP and Global Carbon Pool Flows. *Source*: Own calculations based on IPCC HWP guidelines and using Kim Pingoud's EXPHWP model (version 4.3). The excel spreadsheet model is available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP_Worksheet.zip. Data are from the FAO: http://faostat.fao.org/DesktopDefault.aspx?PageID=626&lang= en#ancor. Inflows were based on the annual global production of semi-finished products in the categories sawn wood, wood-based panels, and paper products. Outflows for each category (the world's total amount of discarded products per year) represent first-order estimations using half-life values, 35 years for sawn wood, 25 years for wood-based panels, and 2 years for paper.

the potentially negative impacts of forestry operations on the environment should not go unrecognized.

At the same time, there are potential ways to handle such difficulties. Where there are challenges to biodiversity from FM, one can consider a strategy that weighs the relative value of untouched/pristine and/or natural forest cover more highly than FM forest cover. This could, for example, be calculated on the basis of RMU's at a slightly higher marginal rate than for other forms of carbon sequestration. Although the impact pushes in the opposite direction, this proposed strategy is not unlike the form of 'discounting' that already occurs with estimating carbon sequestration in HWP: lost shares of carbon sequestration from harvesting, decomposition, etc., are deducted from contributions to the carbon pool.

HWP

Although HWP has long contributed to a growing carbon pool, its potential has not been adequately mobilized. Under CP1 rules, harvested biomass is considered as immediately oxidized. After Durban, under CP2 rules, a greater share of HWP can be accounted. However, several important restrictions apply. Thus we argue that HWP still has not been adequately mobilized and more could be done.

Figure 2 illustrates global inflows entering the HWP carbon pool and outflows leaving the pool. The difference (inflows–outflows) corresponds to the net change in the HWP carbon pool. Inflows are higher than outflows, thus raising the total size of the carbon pool in the long term.

The total net HWP carbon pool was calculated at approximately 19 270 $TgCO_2$ in 2010. Between 1990 and 2010, this pool increased by approximately 34%. Thus, HWP continues to sequester a considerable amount of carbon. The net annual mitigation potential from the carbon pool was equal to about 241 $TgCO_2$ (1236–1994) in 2010. Furthermore, this quantity will increase on an annual basis as long as HWP use continues to increase and longer term HWP impacts on the carbon pool are favored.

To gain some sense of the magnitudes involved, a country like Sweden emitted 60 $TgCO_2$ in 2010. Assuming 100% of outflows from the carbon pool are used as bioenergy for fossil fuel substitution, the total annual mitigation potential (TAMP), i.e., the global amount of carbon either sequestered in HWP or made available for fossil fuel substitution through bioenergy combustion (outflows from the pool), represented an amount some 17.5 times (241 + 807/60) Sweden's annual GHG emissions. Moreover, this amount does not include fossil fuel substitution resulting from choosing HWP products over high carbon intensity construction materials like cement and steel.

To gain a sense of the potential HWP magnitudes made available for carbon sequestration on an annual basis, the annual harvest in Sweden (after accounting for initial decomposition and other losses during harvest) represents approximately 59 $TgCO_2$ in total Roundwood outtake. Currently, this amount is roughly equivalent to total annual GHG emissions in Sweden. However, although some CO_2 is emitted during processing, the total amount made available for carbon sequestration is still significant. This reveals the importance of carbon accounting strategies that recognize the total amount of carbon sequestered in HWP. Not counting this quantity will reduce incentives for taking advantage of the HWP carbon pool.

It is difficult to estimate potential change in the production of HWP and thus future potential amounts of carbon sequestration and fossil fuel substitution that might occur as a result of adequate carbon accounting practices and improved incentives. Although some attempts have been made to estimate future demand for HWP and bioenergy, these are typically based on existing demand structures and do not incorporate modified incentives. Nor do we necessarily know how these incentives might get translated into practice at the national level.

The above data suggest HWP represents a potentially important climate change mitigation resource. Moreover, the data above support the concept of double and triple use value: without HWP, TAMP is reduced by the annual net gain to the carbon pool (241 $TgCO_2$).

On the surface, the changes in the Durban COP17 LULUCF agreement appear to recognize this potential. The requirement of reporting HWP based on the Production Approach will make it possible for countries to further mobilize the carbon sequestered in HWP. At the same time, the new Durban regulations also impose important constraints. The new 3.5% cap will also be applied to potential HWP carbon credits as well. Thus, although the new regulation could potentially provide more powerful incentives for carbon sequestration in HWP, these incentives will be restricted by the 3.5% cap limit. Likewise, the introduction of a reference line and the loss of the potential to gain carbon credits below it mean not all contributions to FM removals are weighted according to their true global warming potential.

The incentive gap: the impact of old and new measures

In what follows, we assess the magnitude of the IG across different sets of assumptions. For the purposes

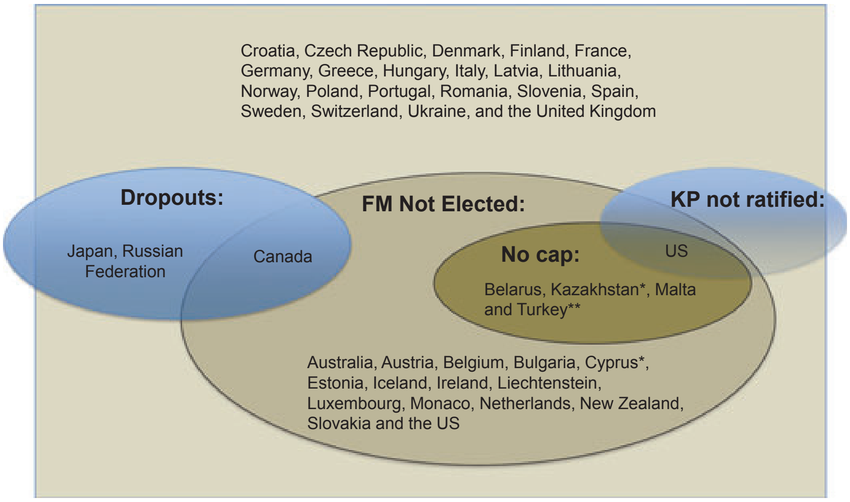

Fig. 3 Kyoto Protocol Annex I Signatories. Source: Various CP/CMP decisions, www.unfccc.int. *On 8 June 2011, Canada indicated that it does not intend to participate in a second commitment period of the Kyoto Protocol. In a communication dated 10 December 2010, Japan indicated that it does not have any intention to be under obligation of the second commitment period of the Kyoto Protocol after 2012. In a communication dated 8 December 2010 that was received by the secretariat on 9 December 2010, the Russian Federation indicated that it does not intend to assume a quantitative emission limitation or reduction commitment for the second commitment period. * Neither country is a Party to CP1. However, after the adoption of a cap (Kazakhstan), both Cyprus and Kazakhstan intend to participate in CP2. ** Turkey has stated its intention to participate in CP2, but has not formally submitted a projection line and was not included in the Durban data tables.*

of continuity, we continue to define the IG as a function of the 'share of carbon sequestration (net removals) not incentivized in the regulatory framework'. However, we indulge in several versions of this definition: considering in turn only nonaccounted FM carbon sequestration (net removals), the inclusion of HWP carbon accounting and other carbon pools, the inclusion of Non-Annex I and other countries, and the incorporation of unmanaged forests in the Post-Kyoto framework. We focus particular attention on the impact of change across the first and second commitment periods (CP1 and CP2) and the impact of the Durban 2011 COP17 changes to LULUCF accounting practices. With this approach we would like to demonstrate the relative magnitude of missed opportunities in the current Kyoto framework and possibly also future Post-Kyoto frameworks.

Ellison *et al.* (2011a) estimate the IG under FM for Annex I countries at approximately 75%. This estimate, however, was based on the projections of individual countries about what total forest carbon sequestration (net removals) would be after harvest. In this version of the IG, we focus instead on the actual carbon sequestration experience of Annex I countries over the first 2 years of Commitment Period 1 (2008–2009), as well as projections of FM removals for CP2 (2013–2020). Thus in this version of the IG, we compare the total amount of carbon sequestration (net removals) eligible for carbon credits under the Kyoto carbon accounting framework with that amount of carbon sequestration that is not accounted.

As illustrated in Fig. 3, Parties remain at very different stages of integration in the Kyoto Process. Thus, although all of the countries are signatories, one of them has failed to ratify it (United States) and three additional countries have either announced their intention to leave the KP (Canada) or have already left (Japan and the Russian Federation). More recently, Japan has shown signs of changing its mind and reentering CP2. However, no formal decision has been made at this writing. In addition to the failure of these countries to remain committed to the Kyoto goals, other countries demonstrate varying degrees of commitment to many of the features of the LULUCF portion of this agreement. Thus, a significantly large set of countries chose not to 'elect' FM in CP1, and some of these countries have also failed to negotiate an FM 'cap'.

For the purposes of the following analysis, we make a number of important assumptions. First, for countries that have chosen not to elect FM (this includes all countries that have not chosen a 'cap'), we assume an IG equal to 100% for CP1. Although these countries may have sizable FM sectors (e.g., the United States), choosing *not to elect* FM essentially means these countries are not subject to the same reporting requirements and are also not eligible for carbon credits under FM (nor can they be debited for increased harvesting, should this

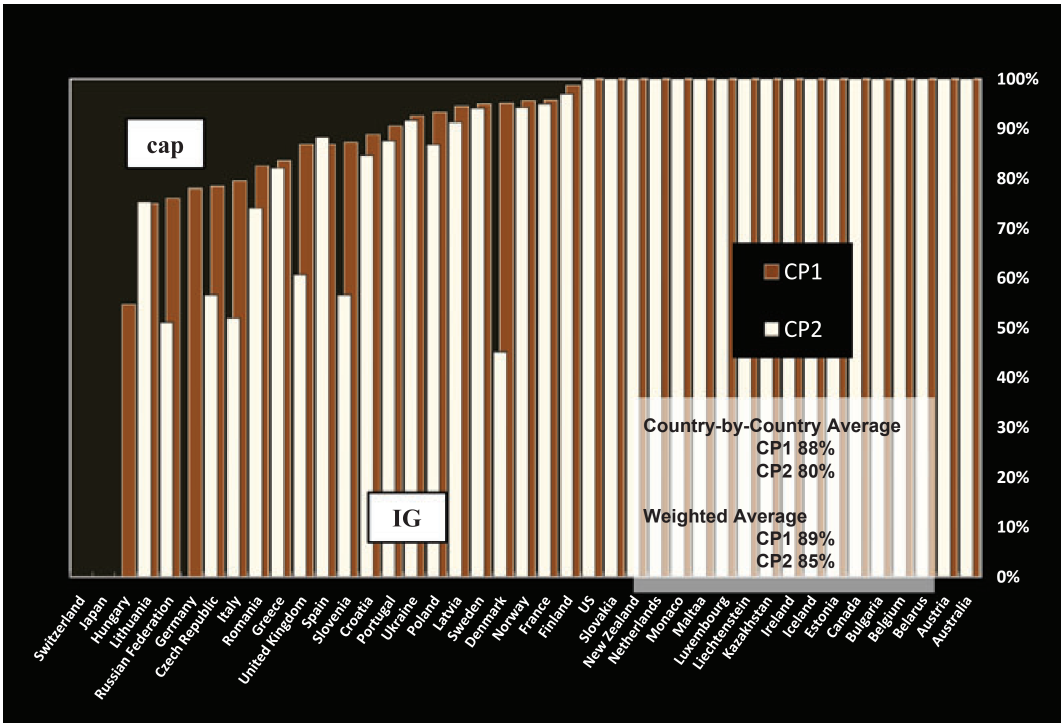

Fig. 4 Incentive Gap based on CP1 rules (cap/FM net removals). CP1 represents the current cap relative to 2008–2009 FM net removals. CP2 represents the current cap relative to 2013–2020 FM net removals based on submitted FMRL or other projections. For Parties not electing FM and/or without a negotiated 'cap', IG = 100%. The 'average' is the average of individual IG's. The weighted average is the total mobilized cap relative to total FM net removals. *Sources*: Based on 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php) and Annex I Party Submissions of information on forest management reference levels (http://unfccc.int/bodies/awg-kp/items/5896.php). The average FM net removal data considers average values for the years 2008 and 2009. For parties not electing FM, data on Forest land remaining forest land reported to the UNFCCC has been used as a proxy.

surpass annual growth rates). As countries are able to 'elect' or 'not elect' FM under the pre-Durban KP system, the size of the IG is larger than it would have been under mandatory reporting. For example, although Austria had a cap that permitted the accounting of up to 2.31 million tons CO_2 of carbon removals per year under FM, the decision not to elect FM meant this share of carbon sequestration could not be counted and thus was not *'incentivized'*. As a result of Durban, under CP2, FM reporting has become mandatory. Thus, although some countries exhibited a tendency to shield their forest resource from accounting, this option has now been foreclosed.

As illustrated in Fig. 4, based on pre-Durban rules, the IG across CP1 and CP2 is quite large. Weighted across all Annex I countries and based on estimated forest growth and fellings, the IG is 89% in CP1 and 85% in CP2. The area above the columns represents the share of net forest removals that can be accounted under the cap. Averaged across individual countries, the IG was larger: 88% in CP1 and 80% in CP2. The increased size of the IG for CP1 in this analysis (Ellison *et al.*, 2011a found an IG of 75%) was mostly due to the assumption regarding FM nonelection. Without this assumption, the IG was approximately the same (76%). In addition, much of the change in the IG between CP1 and CP2 under the old rules is the result of changes in the projection of the total harvest under CP2. The size of the IG is likewise strongly impacted by the total projected harvest. Where the projected harvest is large, the relative size of the IG diminishes and *vice versa*. As many Parties project bigger harvests in the 2nd CP due to increased demand, the age structure of the forest, etc., this is the principal explanation of the reduced IG in that period.

The 2011 COP17 conclusions from Durban introduce a new revised cap that will become effective in CP2. Generally speaking, the impact of the new cap is to raise the total amount of potential *accounted* carbon removals under FM that can be claimed by individual countries and thus reduce the IG. However, the impact of the new cap varies considerably across individual countries and Annex I as a whole. For individual coun-

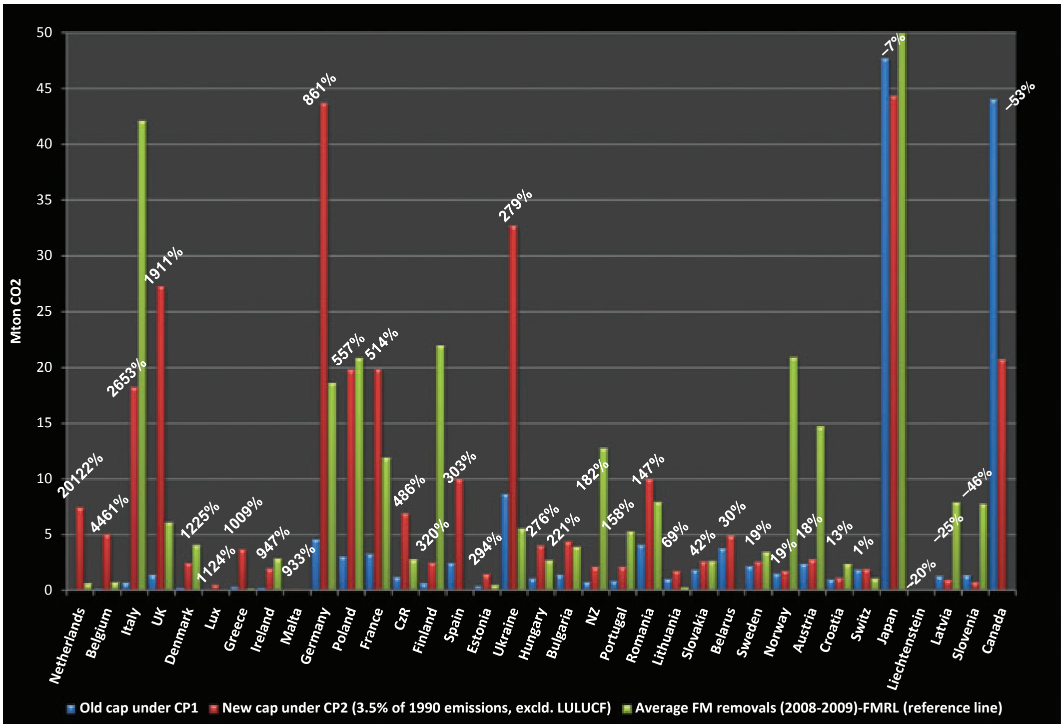

Fig. 5 Change in cap across Old CP1 and New CP2 Rules. *Sources*: Based on 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php), Annex I Party Submissions of information on forest management reference levels (http://unfccc.int/bodies/awg-kp/items/5896.php), Decision 16/CMP.1 (http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf), and Decision 2/CMP.7 (http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf). The average FM net removal data (green columns) consider average values for the years 2008 and 2009. For parties not electing FM, data on Forest land remaining forest land reported to the UNFCCC has been used as a proxy. *Note*: Countries are ordered by the largest increase in the cap from CP1 to CP2 (the Netherlands) to the largest reduction (Canada). Monaco, Iceland, and Australia previously had no cap under CP1. Furthermore, although not included here, the US cap has been increased by 81% and the Russian Federation cap reduced by 3%.

tries the new cap raises the total amount of incentivized carbon removals dramatically, on average some 10-fold (Fig. 5). Weighted across all Annex I countries by the relative size of the forest resource, the new cap increases the total amount of incentivized carbon by a significantly smaller amount, approximately 70%. Larger change in some countries is primarily the result of the more idiosyncratic caps adopted for the first CP, where countries chose between different options (the smaller of either 3% of 1990 emissions or 15% of 1990 net removals, or an independently negotiated amount). Japan, for example, negotiated a cap equal to 100% of total annual net growth for the 1st CP. For the 2nd CP based on the 3.5% rule, this amount has been reduced (by 7%). Moreover, as the United States, Russia, and Canada do not plan to participate in CP2, the overall impact on incentivized carbon removals – although still large for individual countries – will be much smaller than hoped: the United States, Canada, Russia, and Japan alone account for approximately 60% of the new cap and an even larger share of total forest cover.

For many countries, even with large increases in the new cap it may be difficult to benefit without significant efforts. Additional average carbon sequestration (net removals) under FM across 2008–2009 (after subtracting the new reference level, below which countries are not eligible for carbon credits) was frequently well below the level of the new cap (Fig. 5: green bar compared with red bar). Only a few countries have average net removals above the reference line that are also well above the new cap (Italy, Denmark, Ireland, Poland, Finland, NZ, Portugal, Sweden, Norway, Austria, Japan, Latvia, and Slovenia). For this latter set of countries, the new cap may not be large enough to encourage significant additional growth in the net forest sink. Moreover, under appropriate demand conditions, countries with no additional cap may be inclined to harvest additional growth, as this will not result in the loss of carbon credits. For many countries that already foresee an increase in the harvest in CP2, it may be particularly difficult to achieve increased growth and thus take advantage of the new cap.

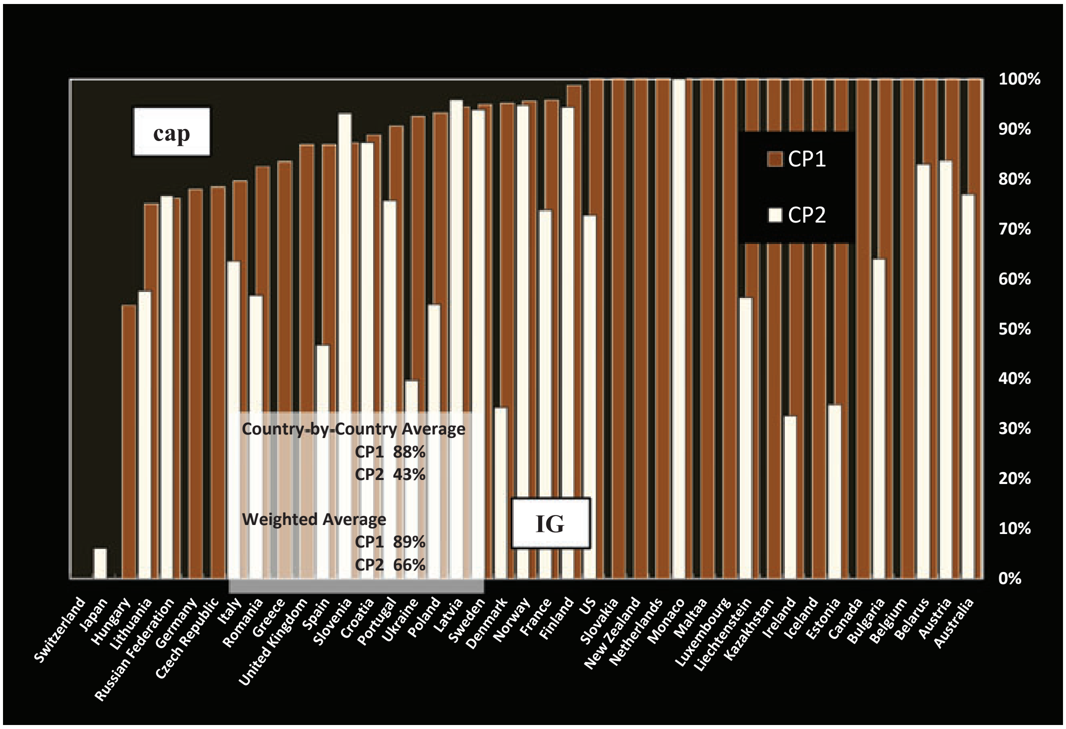

Fig. 6 Incentive Gap based on old/new rules (cap/FM net removals). CP1 represents the current cap relative to 2008–2009 FM net removals. CP2 represents the new cap vs. 2008–2009 FM net removals. For the CP1 estimate parties not electing FM in CP1 or having a negotiated cap for 1st, IG = 100%. For the CP2 estimate all parties are included. The 'average' is the average of individual IG's. The weighted average is the total mobilized cap in each commitment period relative to total FM net removals 2008–2009. *Sources*: Based on 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php), Annex I Party Submissions of information on forest management reference levels (http://unfccc.int/bodies/awg-kp/items/5896.php), Decision 16/CMP.1 (http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf), and Decision 2/CMP.7 (http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf). The average FM net removal data considers average values for the years 2008 and 2009. For parties not electing FM, data on Forest land remaining forest land reported to the UNFCCC has been used as a proxy.

The second big change resulting from the Durban conclusions is that FM reporting will become mandatory. Thus all Parties will be required to submit data for FM and will be subject to the cap requirements. In Fig. 6, we estimate the total IG under CP2 based on the new cap approved in Durban. We have ultimately elected to measure the IG under the new system in two ways. Countries have made assumptions about the future use of available forest resources without more powerful incentives for carbon sequestration (net removals) and additional increased forest growth in place. One strong assumption made by many Annex I countries is that the harvested share of the annual net increment will increase. Thus, as demonstrated for example in Table 4, the vast majority of Annex I countries are predicting significant drops in forest-related carbon sequestration (net removals) in CP2 compared with CP1. The only real exception here is Canada, which expects a quite significant increase in net annual growth (after harvest) of 281%. Assuming a different set of incentives, it may be reasonable to assume a modification in behavior.

We attempt to illustrate potential differences in the IG by comparing it with both the average net annual growth (after harvest) over the period 2008–2009 and with projected CP2 felling rates (only the first of these two options is depicted in Fig. 6). There is little surprise in the fact that the relative size of the IG is greater when measured against actual accounted carbon sequestration (net removals) in CP1 compared with the net annual growth projections for CP2. This suggests the potential incentives created by a more complete accounting of total potential net annual forest growth in the carbon accounting procedures could have a positive impact. On the other hand, both estimates indicate that, with the introduction of the new Durban rules, the total relative size of the IG has been significantly reduced in CP2. Averaged across all Parties, the IG has been reduced by approximately 50% (from 88% to 43%). However, weighted by relative forest growth

Table 4 Comparison of reported, average CP1 net FM removals (2008–2009) with projected removals (FMRL) for CP2

	Projections		Change (CP2/CP1)	
All parties	2008–2009	2013–2020	Reductions	Increases
Australia	−63.28939	8.5	−113%	
Austria	−16.74975	−2.121	−87%	
Belarus	−28.557785	−30.5		7%
Belgium	−3.108065	−2.407	−23%	
Bulgaria	−12.08121	−8.168	−32%	
Canada	−18.50992	−70.6		281%
Croatia	−8.6179472	−6.289	−27%	
Cyprus	None	−0.164		
Czech Republic	−5.4225716	−2.697	−50%	
Denmark	−3.6980544	0.334	−109%	
Estonia	−2.21796	−1.742	−21%	
Finland	−44.126223	−19.3	−56%	
France	−75.20376	−63.109	−16%	
Germany	−20.541325	−2.067	−90%	
Greece	−1.9947654	−1.83	−8%	
Hungary	−2.3379234	−0.892	−62%	
Iceland	−0.09465	−0.154		63%
Ireland	−2.847445	−0.008	−100%	
Italy	−49.785719	−21.182	−57%	
Japan	−47.19728	−37.8	−20%	
Kazakhstan	−1.81983	−1.81983	0%	
Latvia	−22.350461	−14.255	−36%	
Liechtenstein	−0.018315	−0.0025	−86%	
Lithuania	−4.0867876	−4.139		1%
Luxembourg	−0.37777	−0.418		11%
Malta	−0.048685	−0.049		1%
Monaco	0	0	0%	
Netherlands	−2.073815	−1.464	−29%	
New Zealand	1.54332	11.15	−622%	
Norway	−32.733225	−25.51	−22%	
Poland	−43.75179	−22.75	−48%	
Portugal	−8.5063107	−6.48	−24%	
Romania	−22.942722	−15.444	−33%	
Russian Federation	−504.39124	−246.8	−51%	
Slovakia	−2.249335	0.358	−116%	
Slovenia	−10.299651	−3.033	−71%	
Spain	−18.586164	−20.81		12%
Sweden	−41.207011	−36.057	−12%	
Switzerland	−0.9196591	0.22	−124%	
Ukraine	−54.228392	−48.7	−10%	
United Kingdom	−10.254284	−3.442	−66%	
US	−790.57597	−774.76445	−2%	
Average	−48.201459	−35.152518	−65%	54%
Weighted Average	−1976.2598	−1476.4058	−25%	

Negative numbers indicate a removal, positive numbers an emission. *Sources*: Based on Annex I Party Submissions of information on forest management reference levels (http://unfccc.int/bodies/awg-kp/items/5896.php) and Decision 2/CMP.7 (http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf). The average FM net removal data consider average values for the years 2008 and 2009.

Table 5 One- and two-way accounting and incentives under CP2

0 – FMRL	Deforestation yes, net removals no
FMRL – cap	Yes (two-way)
Cap – Total FM removal	Not accounted/incentivized

across all Annex I countries, the reduction in the incentivized share is smaller (from 88% to 66%).

The above data likewise suggest the relative size of the IG is strongly impacted by changes in forest harvesting practice. Increases in forest outtakes compete with potential increases in the forest sink. For this reason, we think it is important to fully incentivize this margin. Even with the changes brought about by the new Durban COP17 LULUCF rules, the new cap still fails to incentivize a significant share of forest removals (IG = 43–66%). Thus a significant share of forest cover is still not effectively mobilized in the climate change mitigation and adaptation framework. The margin between forest fellings and future carbon sequestration, in particular, is shielded from a weighting that could facilitate a more balanced and efficient use of forest-based resources. Further, because no net forest growth above the cap is incentivized, an incentive remains to harvest forest growth above the cap.

This analysis, however, neglects one important aspect that we treat in greater detail below: the introduction of an FM reference line (FMRL) at the 2011 Durban LULUCF agreement. As described in Table 5, countries are not permitted to account for carbon credits between 0 and the projected reference line (the FMRL). The FMRL reference line represents either a business-as-usual projection, historical data, or is set to zero (as in the case of Japan). Whereas previously countries could not be penalized for net emissions and/or harvesting below the cap, under CP2, all countries will be held accountable for any and all net emissions and/or harvesting *below* the reference level (FMRL) and are only eligible for carbon credits *between* the reference level and the cap.

The incentive gap continued

The methodology employed significantly affects the relative size of the IG. Thus far we have measured the IG as a function of the 'share of carbon sequestration (net removals) not incentivized in the regulatory framework'. However, other measurements are possible. As suggested above, the failure to incorporate HWP into the carbon accounting framework, or the role of omitted carbon pools (such as unmanaged forests) can also be thought of as failures to incentivize carbon sequestration. Figure 7 attempts to provide a more complete

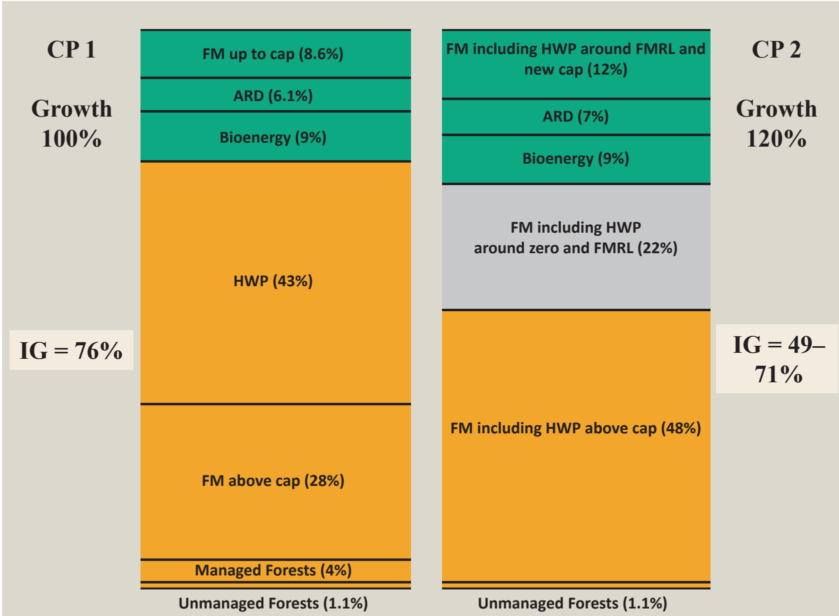

Fig. 7 IG CP1 based on 20% Total Growth Estimate for CP2. *Sources*: Based on own calculations and 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php), Annex I Party Submissions of information on forest management reference levels (http://unfccc.int/bodies/awg-kp/items/5896.php) and Decision 2/CMP.7 (http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf). *Note*: Orange represents nonincentivized forest growth, green incentivized, and gray (between zero growth and the FMRL) is only subject to one-directional negative and not positive incentives. Net emissions and/or harvesting *below* the reference level will be debited, whereas growth up to the reference line is not eligible for carbon credits. Estimates are based on own calculations using UNFCCC submission data and data from FAO (2010). As a simulation and estimate of potential future growth in 2020 (based on the assumption of increased growth of 20% up to 2020), several things remain unknown in the figure above. We do not know, for example, how this growth, if it in fact occurs at all, will be distributed across HWP, FM net removals, and bioenergy. We can only estimate broad relationships. And it is important to note these estimates of future growth well exceed those of the Parties to the current agreement, who all predict significantly less growth or higher harvests in the future (as illustrated, for example, by the projected reference lines (FMRL's) reproduced in Table 4).

picture of the IG from introducing CP2 rules and considers all of the LULUCF-based components under Arts. 3.3 (ARD) and 3.4 (FM) – including harvested growth – based on CP1 and CP2 rules. Figure 7 studies the IG represented by growth (living biomass). Growth is indirectly calculated from harvests using FAO data and net removals of living biomass based on UNFCCC data.

To illustrate the consequences of the new 3.5% cap, we assume a 20% increase in growth between CP1 and CP2. Instead of using a projected reference line, we use the average growth at CP1 recorded in 2008 and 2009 as a baseline for estimating the outcome in CP2. We feel this assumption is warranted. Averaged across all Annex I countries, during 2008 and 2009, countries averaged approximately 3% growth per year. Given 7 years of growth over the period 2013–2020, this comes to approximately 21% total growth. On the other hand, weighted across all Annex I countries, the average rate of growth in 2008–2009 is significantly smaller, approximately 1.2% yr^{-1}.

The IG estimated in Fig. 7 deviates somewhat from that estimated in Figs. 4 and 6. In this illustration, we incorporate *harvested growth*, dividing this quantity in the figure into HWP and bioenergy production and estimating the degree to which this share of FM is incentivized. A number of important conclusions can be drawn from this illustration. First, in CP1, the IG is again quite large (on average 75%, or a weighted 76%). As bioenergy is included and fully incentivized (bioenergy emissions are considered neutral), the total IG is somewhat smaller in CP1 than when harvested growth is not included in the model. At the same time, however, the relative *magnitude* of the IG, due in particular to the failure to incentivize HWP under CP1, is significantly large: in CP1, HWP alone is equivalent to 43% of the IG, or approximately 1062 $MtCO_2$, compared to only 687 $MtCO_2$ removals in FM above the cap. Thus, although the percentages do not change much, the amounts of potential carbon sequestration behind these numbers are large.

The mandatory inclusion of FM and HWP in CP2 has significantly improved the model. Under CP2, a greater share of carbon sequestration (net removals) and/or harvested growth is fully incentivized. Based on an assumption of 20% growth from CP1 to the end of CP2, most Annex I Parties would be able to claim the full cap. Thus a large number of countries would benefit from the new cap in the sense that they would be able to claim more carbon credits than before. On the other hand, the new cap limits the incentive to increase the sink because for many of these same countries (29 of 37), no additional room would be available under the cap that would incentivize additional forest growth. Thus although Sweden, for example, still has considerable potential for increasing forest growth, no incentives in the KP approach mobilize this potential, thereby potentially limiting investments in larger forest projects. This raises important questions about the impact and utility of the new cap. While it may limit the ability of some countries to take advantage of large forest areas, it simultaneously reduces incentives to pursue additional forest cover and growth and raises incentives to increase harvest. In this sense, tying the new cap to 1990 GHG emissions likewise makes little sense, as this number is not linked in any meaningful way with forest potential. Under the current climate context, this is presumably not a positive outcome.

A second 'gray area' is that share of forest removals that falls within the range between 0 growth and the reference line (indicated in gray under CP2). This area constitutes an important share of total forest removals – on average some 22% of total forest removals. Under the new Durban model, however, these removals are no longer eligible for carbon credits and, in this sense, are not incentivized. At the same time, there are incentives not to allow forest growth to fall below the FMRL: countries can be debited for any and all deforestation below the reference line.

Finally, as many countries have estimated quite low levels of net forest removals in CP2, it is possible many countries will be hard pressed to even rise above the individual reference lines set in the Durban LULUCF agreement. The FMRL strategy was ultimately justified with the intent of protecting country Kyoto commitments to achieve emission reductions. In this way, countries would not be able to amass large amounts of forest-based net removal carbon credits and count them against their Kyoto emission reduction commitments. Moreover, because the FMRL was generally set at the level of previous growth rates, countries would have to struggle to arrive above the FMRL and thus be eligible to receive additional forest-based carbon credits. On the other hand, an incentive exists to estimate a lower FMRL to increase the opportunity for carbon credits. Although we cannot easily know which factors most strongly influence Party projections, average observed FM removals for 2008–2009 provide a potentially interesting point of comparison.

What this means, however, for HWP and additional FM removals not weighted according to their true global warming (or cooling) potential remains uncertain. We have argued here and elsewhere (Ellison *et al.*, 2011a) that to place HWP and standing forests on an equal footing with bioenergy, they must be weighted in the same way. The new CP2 strategy from Durban essentially makes this impossible. Moreover, this approach ultimately means individual forest owners who make efforts to raise the total level of forest growth may not or may only receive partial compensation for their efforts.

Depending on whether one includes this gray area in the IG measure, we estimate the potential weighted IG in CP2 at between 49 and 71%, depending on how one considers the gray area (the unweighted averages are 38 and 61%). However, we stress that our estimates based on 20% growth by 2020 will exceed those of the individual Parties based on their estimated FMRL's.

The global context

Without effective strategies for incorporating this additional forest cover into an incentivized LULUCF framework, much of this forest area will not be adequately mobilized. Doing so, however, would go a long way to promoting increased global forest cover and growth.

We estimate total global forest cover at approximately 4033 million hectares (based on FAO data). Of this total, only a very small amount is currently incentivized in the Kyoto framework. Art. 3.3 (AR) alone, although fully incentivized under the KP framework, only covers some 0.2% of total global forest cover. While the actual amount of fully incentivized *potential* forest cover is greater than this amount – additional land can always be dedicated to ARD – the total amount of available land is limited to some extent by other land-use practices (agriculture, urban development, etc.). In addition, as we have demonstrated above, only a very small share of FM land is adequately incentivized under CP1. In this figure we estimate the IG at 86% of land under FM. Together, this suggests that only 3% of total potential forest cover (approximately 117 million hectares) is incentivized in the Kyoto framework. A very large amount of forest cover, on the other hand, is not incentivized or is only weakly incentivized. Our total estimate suggests some

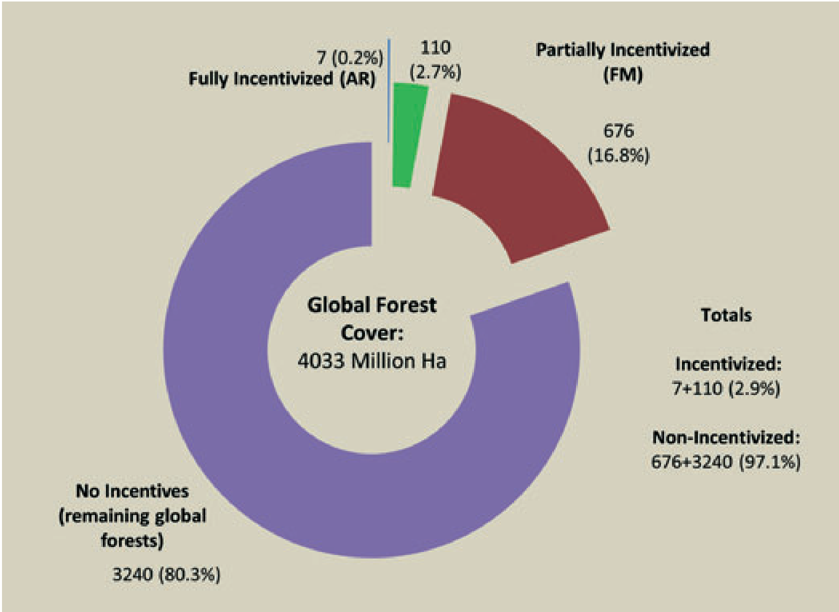

Fig. 8 Global Incentivized Forest Area under the Kyoto Protocol (CP1). *Note*: Based on CP1 rules. The total share of incentivized forest cover will increase under CP2 rules. *Sources*: Based on own calculations and 2011 Annex I Party GHG Inventory Submissions under the UNFCCC (http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php) and data from FAO (2010).

97% of forest cover (approximately 3916 million hectares) is not or is only weakly incentivized.

The Durban changes to the Kyoto framework for CP2 represent only a marginal change in this regard. If all Annex I countries continue to participate in the Kyoto process, this would potentially raise the total incentivized area to approximately 7% of total global forest cover (by approximately doubling the current amount of incentivized forest cover under FM). However, the United States, Canada, Japan, and Russia, four of the largest forest cover countries (making up more than 80% of the total forest area and 60% of total sequestered carbon potential across these and the remaining Annex I countries), have already indicated they will not participate in CP2 (or, as in the case of the United States, will fail to finally ratify the KP). Thus the total impact of the adjusted ruling under KP CP2 will be quite small.

The total amount of global incentivized forest in Fig. 8 misses reafforestation arising from REDD+ and the CDM market. However, according to Ecosystem Marketplace (2011), in 2010, the total CDM market amounted to only 19.5 $MtCO_2e$ (million tonnes carbon dioxide equivalents). Of the total ARD segment (Annex I ARD+ REDD+), this represents a total of only 19%, 23% of the Annex I ARD segment, or .05% of total global potential. Thus, although the emergence of the REDD+ market is encouraging, much more could be done to integrate the world's forests into the Kyoto framework. The incorporation of LULUCF into the EU's climate policy framework, for example, and the potential for trading CDM forest-based carbon credits could go a long way to further mobilizing REDD+ potential.

Thus, much could still be gained by further reforms of carbon accounting practices under the Kyoto Protocol and its future variants. In particular, there are substantial benefits to finding a suitable framework for encouraging additional countries to become Parties to the KP arrangement and thereby increasing the share of incentivized forest cover. Ellison *et al.* (2011a) suggest the introduction of a '*conditionality principle*' only allowing those countries that sign onto the KP agreement and make formal emission reduction commitments to sell forest-based carbon credits in the Kyoto carbon-trading framework. While currently much effort is invested in REDD+, a revised model could potentially provide a more suitable framework for rapid progress.

Evaluating potential change in carbon sequestration (net removals)

At heart, a certain impossibility inhabits the evaluation of the potential impact on change in LULUCF carbon sequestration (net removals) that could result from a rewriting of the KP LULUCF rules. To some degree we cannot know with any accuracy how actors might be influenced by the changing structure of incentives.

Table 6 Change in forest growing stock (1950–2010)

	Forest land in use (Mha)				Growing stock (Mm³ ob)				Removals (Mm^3)				Growing stock per hectare (m^3 ha^{-1})				Change in growing stock per hectare
	1950	1970	1990	2010	1950	1970	1990	2010	1950	1970	1990	2010	1950	1970	1990	2010	2010/1950
Spain	12.5	10.1	8.39	18.2	97	436	591	912	1.9	13.7	15.6	15.6	8	43	70	50	547%
Germany	9.48	10.1	10.5	11.1	878	1372	2815	3492	36.0	37.2	84.7	54.4	93	136	268	315	240%
Belgium	0.6	0.6	0.71	0.68	46	71	128	168	2.0	2.6	5.6	4.8	77	118	182	248	224%
Netherlands	0.25	0.4	0.33	0.37	15	20	52	70	0.6	0.9	1.4	1.1	60	50	156	192	220%
Austria	3.14	4.5	3.88	3.89	348	681	947	1135	9.4	11.8	16.8	17.8	111	151	244	292	163%
Hungary	1.25	1.5	1.68	2.03	85	174	288	359	2.2	5.0	6.0	5.7	68	116	172	177	161%
Ireland	0.12	0.3	0.4	0.74	4.8	15	61.5	74.3	0.2	0.4	1.6	2.8	39	50	155	101	160%
Italy	5.65	7.3	6.75	9.15	329	286	926	1384	13.5	11.7	8.0	7.3	58	39	137	151	160%
Luxembourg	0.08	0.1		0.09	10.1	13	20.4	26	0.2			0.3	125	130		299	140%
Bulgaria	2.96	4	3.39	3.93	210	264	405	656	5.6	5.1	4.1	5.7	71	66	120	167	136%
France	11.3	14	13.1	16	805	1307	2077	2584	26.7	37.9	62.6	55.5	71	93	158	162	127%
Denmark	0.44	0.5	0.47	0.54	40	45	64.9	108	1.8	2.3	2.3	2.7	91	90	139	199	118%
Great Britain	1.56	1.6	2.21	2.88	94.6	121	282	379	3.3	3.5	6.4	9.7	61	76	128	132	117%
Poland	7.1	8.6	8.67	9.34		1049	1485	2049	12.0	18.5	17.6	35.5		122	171	219	80%
Finland	20.7	19.1	20.1	22.2	1159	1445	1878	2189	40.8	45.1	43.2	51.0	56	76	93	99	76%
Norway	5.3	8.3	8.7	10.1	321	513	701	987	10.2	8.5	11.8	10.4	61	62	81	98	62%
Sweden	22.9	24.7	24.4	28.2	1820	2288	2791	3358	38.2	60.0	52.9	70.2	79	93	114	119	50%
Switzerland	0.85	1	1.13	1.24	200	270	392	428	3.2	4.2	6.3	4.9	237	270	347	345	46%
Romania	6.33	6.5	6.19	6.57		1268	1348	1390	16.0	22.3	12.6	13.1		195	218	212	8%
Portugal	2.47	2.8	2.76	3.46		166	203	186	4.8	6.4	11.2	9.6		59	74	54	−9%
Greece	2	2.7	2.51	3.9	129	150	156	185	3.9	3.0	2.5	1.7	65	56	62	47	−27%

Source: Based on FAO data.

Moreover, much depends on how individual Parties (or EU Member states) might ultimately decide to integrate suitable incentive structures into practice at the national level.

According to FAO data, global carbon stocks in forests are estimated at 652 371 million tons 2010 (stocks). The corresponding figure for Annex I countries is 249 923 million tons 2010 (carbon Annex I) or 38% of the global stock. Between 2005 and 2010 the carbon stock has remained quite stable at the global scale. Based on growing stock (stem volume), only 3% of the current stock is found on 'other wooded land' and 97% on forest land. The amount of change in global forest stocks between 2005 and 2010 has been small.

However, forest productivity and cover has changed significantly over time in many European countries. These changes are the result of two distinct processes. One of them is the increased degree of reafforestation. UNFCCC processes that encourage individual Parties to promote increased rates of afforestation and that have contributed to the development of EU-level efforts as well have favored such developments. Funding through the EU's Common Agricultural Policy (CAP), in particular, has led to significantly increased rates of afforestation. Spain, for example, by taking advantage of almost 50% of EU CAP afforestation resources, managed to raise total forest cover by some 50% between 1990 and 2000.

The other process that has significantly altered forest growth and productivity is change in FM practices. Countries like Spain, Germany, the Netherlands, Austria, and several others (Table 6) have substantially increased the total amount of growing stock, significantly raising total biomass production (and thus carbon sequestration) over the last several decades. For those countries for which we have adequate data over the time period (1950–2010), many of them have more than doubled their total available growing stock per hectare. Only one country has witnessed a rise and then a decline in total available growing stock over this period (Portugal), and Greece has seen total forest productivity decline consistently over the entire period. Likewise, despite an obvious interest in increasing the total growing stock, only three countries simultaneously witnessed a decline in total removals during this same period (Italy, Greece, and Romania).

Thus, it seems likely that other countries could also increase their total available growing stock. Verkerk *et al.* (2011), for example, suggest considerable additional 'theoretical' forest potential could be achieved with appropriate changes in FM practices. Moreover, although Verkerk *et al*. do not estimate the potential impact of changing land-use practices – in particular conversion of unused or former agricultural lands to forest – this area too represents potential for increased forest cover.

Conclusion

In many ways, the 2011 Durban agreement on LULUCF carbon accounting practices represents a significant step forward. The transition from voluntary to mandatory reporting now means countries are unable to utilize FM as a framework for avoiding the cost of increased forest harvesting and/or disguising deforestation. Second, the transition to the new cap likewise represents a step forward, as a significantly larger share of the forest sink is now incentivized.

In equity terms, however, the new cap could have been thought through more carefully. It remains unclear why heavy *per capita* emitters in 1990 should be rewarded with a higher cap than low emitters. Moreover, it remains unclear why FM caps should be based on a metric that has nothing to do with forest cover or potential. Likewise, it remains unclear why the new cap does not take the share of forest cover under FM into account. Under the 1st Commitment Period (2008–2012) countries could either adopt a cap equal to the smaller of two options (3% of 1990 emissions, or 15% of net removals in forests), or negotiate an alternative cap. No adjustments have so far been made under the new model.

As indicated in Table 3 above and argued throughout, a number of hurdles need to be cleared to adequately incentivize the effective, efficient, and balanced use of forest resources. This can only be effectively done when all forest resources are accounted based on their real global warming (cooling) potentials. The greatest obstacles in our view are the existence of a 'cap', the presence of omitted carbon pools that are not integrated into single all-encompassing national inventories, the inclusion of a reference level (FMRL), and the artificial division of LULUCF pools into Art. 3.3 (ARD) and Art. 3.4 (FM).

An additional impact likely to emerge from this arrangement is that more Parties to the agreement may feel pressured to move toward national-level setting of the permissible felling rate. This is likely to occur because countries will be held accountable in the 2nd CP (and beyond) for net emissions and/or harvesting *below* the reference level. Haphazard or noncoordinated management of the felling rate could ultimately lead some countries to fall below the reference level in individual years. This amount is already nationally or regionally negotiated in some of the timber-rich states (e.g., Finland). Although we think of this as a positive outcome, we favor the elimination of reference levels.

The continued emphasis on a 'cap' ultimately means that a large number of countries are not adequately incentivized to pursue additional forest growth. This appears to affect, above all, heavily forested countries, as these countries are likely to exhibit forest growth in excess of the new cap (see also Ellison *et al*., 2012c). This has the unfortunate consequence that countries potentially among the best positioned to increase forest growth (e.g., those countries with strong FM traditions) will not be incentivized through the new cap to further increase their forest sink and could adopt the alternative strategy of raising the harvest.

Likewise, the inclusion of a reference level essentially means not all forest-based resources are accounted based on their real potential. Thus both HWP and FM removals, as they do not yield carbon credits, are not fully incentivized in the new system. Although we understand and appreciate the reasons for doing this (to protect Party emission reduction commitments), in the long run such a system does not seem viable. This model continues to favor bioenergy over other uses of forest-based resources. Thus, in the long run, we think commitments should be set *after* the rules for LULUCF-based carbon accounting. In this sense, we suggest elsewhere (Ellison *et al*., 2012c) that the reference line approach is perhaps best utilized as part of the methodology for helping countries set overall emission reduction targets, rather than setting limits on the potential for Parties to gain carbon credits.

Finally, the greatest potential for increased forest removals will ultimately come from bringing new countries into the Kyoto Protocol fold. Based on CP1, some 97% of forest-based resources remain nonincentivized for increased forest-based carbon sequestration. Although the new cap under CP2 lowers this amount, the Kyoto Protocol has lost (or failed to win over) potential member states whose potential contribution to forest-based carbon sequestration is large (in particular Canada, Russia, and the United States). Moreover, how and in what ways other states will eventually be more fully incorporated into this framework remains to be seen. While REDD+ may represent a step in the right direction, this initiative still represents a small share of the world's forests.

As noted at the outset, our measure of the missed opportunities in the Kyoto and UNFCCC framework remains significantly large, despite the considerable advances in LULUCF accounting made at the 2011 Durban meetings. The climate challenge, however, is such that we think this remaining forest potential can and must be utilized. Moreover, by expanding this framework to as large a set of Parties as possible, a significant contribution could potentially be made to reducing or eliminating current rates of global deforestation.

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