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Speciale

Forests: a millenary heritage that guarantees us life
A cura di Laura Maria Padovani,
Barbara Di Giovanni e Paola Carrabba

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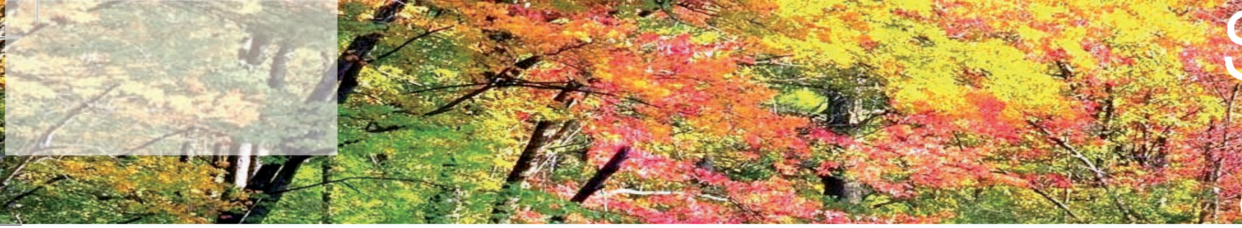
Indice



Lo speciale

di Laura Maria Padovani
ENEA, Unità Tecnica Sviluppo Sostenibile ed Innovazione del Sistema Agro-Industriale

Questo numero speciale della rivista ENEA, curato da Laura Maria Padovani, Barbara Di Giovanni e Paola Carrabba, vuole essere un contributo all'invito rivolto dal direttore del Forum sulle Foreste delle Nazioni Unite a far sì che "le nostre foreste siano gestite in modo sostenibile per le generazioni attuali e future"[1].

Il nostro pianeta è caratterizzato dalla presenza di acqua allo stato liquido che copre circa il 71% della superficie del globo e dalla presenza di esseri viventi. Le comunità vegetali sono un'importante componente della biosfera, occupando approssimativamente il 9,4% della superficie planetaria (o 30% delle terre emerse). In tempi remoti questa superficie arrivava fino a circa il 50% delle terre emerse, e questa differenza nel tempo è indicativa dell'entità delle modificazioni naturali e antropiche subite dall'ambiente nel corso dell'evoluzione.

Una larga porzione della componente vegetale è rappresentata dalle foreste, che svolgono un ruolo essenziale nel mantenimento della vita sulla terra, in qualità di dispensatori di servizi ecosistemici fondamentali. Esse contribuiscono, ad esempio, all'immagazzinamento del carbonio, alla regolazione del clima, ai flussi di energia e ai cicli nutritivi, all'equilibrio idrogeologico e alla conservazione dei suoli. Le foreste ospitano inoltre circa il 90% della biodiversità del pianeta e rappresentano una frazione

This Special Issue of EAI, the ENEA International Magazine, edited by Laura Maria Padovani, Barbara Di Giovanni e Paola Carrabba, is a contribution to the invitation by the Director of the United Nations Forum on Forests to ensure that "our forests are managed in a sustainable way for present and future generations"[1].

Our planet is characterized by the presence of water – that covers about 71% of the surface of the globe – and living beings as well. Plants are an important component of biosphere, approximately 9.4% of the planetary surface (or 30% of the land). In ancient times this area extended over up to about 50% of the land, and this difference in time is indicative of the natural and anthropic changes the environment went through in the course of evolution.

A large portion of the plant component is represented by forests, which play a key role in maintaining life on earth, as dispensers of fundamental ecosystem services. They contribute, for instance, to carbon storage, climate regulation, energy flows and nutrient cycles, hydrological balance and soil conservation. Moreover, forests host about 90% of the planet's biodiversity and represent a considerable fraction of the biomass present on it.

Forests have been essential for the development of human beings, as they offer shelter, food, energy and heat (in the form of firewood, coal, fossil fuels), considerevole della biomassa presente su di esso.

L'ambiente forestale è stato essenziale per lo sviluppo della specie umana, offrendo all'umanità rifugio, cibo, energia e calore (sotto forma di legna da ardere, carbone, combustibili fossili), materiali da costruzione e per la realizzazione di strumenti e applicazioni sempre più avanzati (si pensi alla tecnologia navale). Le foreste sono state anche culla di civiltà e culture, fin dalla comparsa dei Primati.

L'uomo ha, nel tempo, ampiamente sfruttato le foreste per sostenere i propri processi di sviluppo, per riscaldarsi, nutrirsi, costruire, conquistando, nel contempo, sempre nuovi spazi per l'agricoltura, l'industria e l'urbanizzazione. Ancora oggi una frazione rilevante dell'umanità utilizza la legna come fonte primaria di energia e per le costruzioni. Tutto questo ha portato nel tempo ad un sempre più diffuso processo di degrado, con conseguente riduzione dell'estensione e diversità delle foreste.

Fin dal processo di Rio del 1992, le foreste sono state al centro di un difficile dibattito internazionale, legato alla necessità di contrastare, arrestare ed invertire i processi di deforestazione, di definire i criteri per un loro uso sostenibile, di valutare i costi esterni delle attività umane, di coniugare le necessità della conservazione con le opportunità produttive, soprattutto per i paesi in via di sviluppo.

Il 20 dicembre 2006, l'Assemblea Generale delle Nazioni Unite ha proclamato il 2011 “Anno Internazionale delle Foreste”, sostenendo l'impegno ad una gestione, conservazione e sviluppo sostenibile delle foreste di tutto il mondo. Varie attività ed eventi sono stati organizzati da parte di enti internazionali, governi, organizzazioni regionali e locali, così come dalla stessa società civile, per favorire lo scambio di conoscenze sulle possibili strategie da adottare in materia.

building materials and the construction of ever advanced tools and applications (e.g., naval technology). Forests have also been the cradle of civilizations and cultures, since the very first appearance of Primates.

Man has widely exploited forests over time to: support his development processes, get warm, get nourishment, produce, gaining - at the same time - more and new areas for agriculture, industry and urbanization. To this day a major fraction of mankind still uses wood as a primary source of energy and construction. All this has led to a more widespread process of degradation over time with consequent reduction in forest extent and diversity.

Since the 1992 Rio process, forests have been the core of a difficult international debate, linked to the need to counter, stop and reverse the processes of deforestation, as well as to define the criteria for their sustainable use, evaluate the external costs of human activities, match the conservation needs with production opportunities, particularly for developing countries.

On 20 December, 2006, the United Nations General Assembly proclaimed 2011 as the “International Year of Forests”, in an effort to raise awareness on management, conservation and sustainable development of forests worldwide. Various activities and events had been organized by international agencies, governments, regional and local organizations, as well as by civil society itself, to promote the exchange of knowledge on possible strategies to be adopted in the field.

This Special Issue fits in the framework described above and is articulated in two parts: the first one, more general, begins with an analysis of man-forest relationship throughout history, to then focus on the latest state of the art at the global, European and

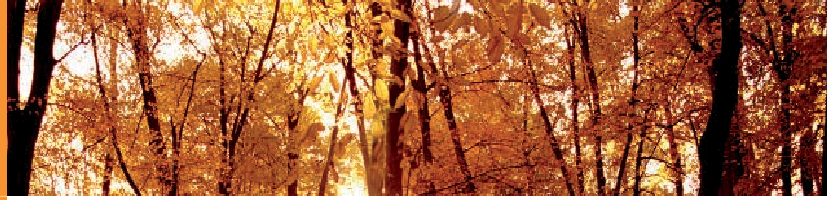
Questo speciale si inserisce nel contesto sopra descritto e si articola in due parti: la prima parte, più generale, apre con un'analisi del rapporto tra l'uomo e le foreste nel corso della storia, per poi focalizzare sul più recente stato dell'arte a livello globale, europeo e nazionale. La seconda parte, invece, illustra le iniziative e le questioni attualmente in essere, connessi al settore forestale. I vari contributi, anche in virtù delle diverse esperienze e provenienza degli autori – tutti coinvolti, a vario titolo, nei dibattiti internazionali e nazionali – mostrano una visuale variegata e completa degli scenari sulle foreste.

Consapevoli della difficoltà nell'essere esaustivi, vista la complessità dell'argomento, ci auguriamo tuttavia di aver saputo fornire una rassegna rappresentativa delle tematiche attuali ed emergenti, collegate alle foreste.

national levels. The second part, instead, outlines the initiatives and issues currently in place, related to forestry. The various contributions, also because of the different experiences and backgrounds of the authors – all involved, in various capacities, in international and national debates – provide a full and varied perspective of forest scenarios.

Aware that being exhaustive is no easy task when it comes to handle such complex a subject, however we hope that we have been able to provide a representative overview of the current and emerging issues related to forests.

[1] *"For the sake of current and future generations, we need to raise awareness and promote global action to sustainably manage, conserve and protect our world's forests"*. Statement by the Director, United Nations Forum on Forests Secretariat at the global launch of the International Year of Forests 2011 (http://www.un.org/en/events/iyof2011/)



Forests and humans throughout history

A brief history of the complex relationship between forests and modern man is traced. Emphasis is given to both the evolution of forests from the interglacial period prior to the last (Würm) glaciation to recent times and to the gradual increasing usage of wood and timber (for heating, cooking, housing, building, naval fleets, etc.) and the consequent exploitation of forests after the Neolithic revolution. The effect of agricultural practices and the occupation of space for farming is also described. Thus, the effects of fluctuating climatic and ecological changes and of anthropogenic causes are taken into consideration with attention to interacting ecological, economic, social, technological, and anthropological aspects. The history of forests and of humans is synthetically reconstructed for prehistoric times, ancient civilizations, the Middle Age, and modern times (underlining the effects of the manmade intercontinental transfer of species). Finally, the consequent current state of forests is schematically described together with possible future trends

Francesco Mauro

Introduction

Several definitions of *forest* have been proposed. The simplest one is: a dense growth of trees, plants, and underbrush covering a large area (American Heritage Dictionary of the English Language). More precisely: an ecosystem or assemblage of ecosystems dominated by trees and other woody vegetation[1].

Other terms are used instead of *forest*: *wood* or *woods*, and less often and more archaically *wold* (or *weald*), *holt*, *frith* (or *firth*), all indicating an area with a high density of trees. *Foresta* is a Medieval Latin word of obscure origin, while *wood* derives from the Old English *widu* (possibly from the Indo-European *weidh* meaning *separate* in the sense of *remote*): *forest* was also used to indicate hunting grounds or land where to gather mushrooms and other non-wood products. The Latin world for *forest* was *silva* (the same root of *silvaticus*, that is, *savage*). *Silva* was used by Romans as distinct from *saltus*, an area of pasture obtained by cutting down trees. The derivatives of *selva* (later also *sylva*) are still used now, together with *forest*, in Romance languages. In modern Italian, *selva* is somehow archaic:

Nel mezzo del cammin di nostra vita
mi ritrovai per una selva oscura
(Dante Alighieri, *Divina Commedia*, *Inferno*, 1308-1321)

whereas *foresta* is commonly used, and *bosco* is the equivalent of *woods*, often as referring to a smaller entity in respect to cognate with English *bush*), and in French *bois*, are more commonly used than *foresta* or

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one of its derivatives; in Spanish *selva* and *floresta* are rarer. In Portuguese, both *bosques* and *floresta* are used. There is no antonym of *forest*: but *prairie* or *pasture* are sometime used as the Latin *saltus* (modern Italian: *pascolo*).

The Prehistory

The relation of humans with forests is very ancient. The image of prehistoric man coming down from the forest trees was a sort of neo-positivist legend of the 19th century. However, recent comparative research on the form and function of the wrist bone of primate species suggests that man bipedalism did not evolve from knuckle-walking ancestors (as in the case of gorilla). Rather, it is a likely evidence of arboreality. In simpler words, the ancestors of *Homo*, some 7 million years ago, were living on trees, then moved to the ground, and began walking upright, taking advantage of mutations to adapt to a new environment.

Of course, the relation between the ancestors of *Homo sapiens* and forests went on, whilst the extent of the vegetation fluctuated through the last four glaciations and three interglacial periods. Woody areas became useful for man as a source of heat and light: archeological evidence of controlled use of fire dates from 400,000 to 300,000 years BP ("before present").

Archaic *Homo sapiens* is believed to have evolved to anatomically modern man, *Homo sapiens sapiens*, in Africa between 200,000 and 150,000 years BP, and to have migrated out of Africa between 70,000 and 60,000 years ago. The last glaciation (Würm) began approximately 115,000 years BP, and entered its coldest phase 65,000 years BP. 73,500 years ago, the Toba volcano in Sumatra underwent a super-eruption and exploded (8th degree of the VEI, the volcanic explosivity index) scale, leaving a crater of 100 km diameter, releasing up to 6,000 km^3 of dust and tephra (fragmented material), and possibly 5 billion tons sulfuric acid aerosol; it is estimated that it caused six years of "volcanic winter". The possible role of this catastrophe in triggering the main phase of the Würm glaciation is under discussion. Apparently, *Homo sapiens sapiens* came out of Africa after that catastrophe, after surviving some kind of "genetic bottleneck. In Europe, 18-14,000 years ago, there was still a full glacial condition: a massive ice shield covered almost all of Britain, central-northern France and Germany, Scandinavia, and Russia; vast glaciers extended southward from mountains such as Alps, Pyrenees, the Caucasus, even parts of the Apennines and the North African Atlas. A similar situation existed in North America (Wisconsinan glaciation) and Siberia, but not in the southern hemisphere (due to the astronomic position of Earth and to geographic differences in land distribution).

The causes of glaciations, of their triggering and termination, are not completely clear and several (overlapping) mechanisms have been invoked: the Croll-Milankovic cycles based on long-term variations of Earth's orbit and rotation, the axis precession cycle, astronomic forcing, etc.; and their intensity and duration may be affected by the surface albedo, volcanic activity, solar cycles, oceanic current streams, even meteoric collision events, etc. In this Würm phase, the climate was characterized by water being locked in ice, consequent high aridity, and very cold conditions: forests were at a minimum, especially at the tropics, and deserts very extended (the Sahara-Arabic and the central-eastern Asian desert belts were thicker than they are today).

FIGURE 1

An Alaska glacier giving an image similar to a view towards the end of the last glaciation

By 13,000 years BP, the glaciacion could be considered ended. By 12,000 years BP, there was a rapid warming of the environment and thawing of frozen water, but in 12,000-11,700 BP the Older Dryas and in 11,000-10,000 BP the Younger Dryas cold waves (possibly due to the flow into the ocean of the cold water from the post-glacial Agassiz lake in central Canada and the central Siberian lake and/or to minor collision events) for a time arrested the process. The sea level started to rise around 10,000 years BP. The climate was entering the so-called Holocene Climatic Optimum (7,000-3,000 BC). In the early-Holocene around 8,000 BC, the interglacial period was firmly in, exhibiting a climate warmer and moister than today. The tropical forest expanded in Africa and Asia as well, the desert decreased, the ice regressed, the trees were able to re-colonize the North with the temperate and boreal forests. Humans started to exploit forests not only for wood and food, but also for space: with the beginning of the Neolithic Revolution (6,500 BC), agriculture was born in the Fertile Crescent (with the domestication of wheat, other grains, legumes), and around 6,000 BC the domestication of animals (goat, *Capra hircus*, and then sheep, *Ovis aries*) was achieved, with consequent increase in overgrazing and tree-grazing due to pastoralist mismanagement. In the East, herd pig (*Sus scrofa*) was managed, millet was introduced, wild rice harvested, chicken domesticated, but, for instance in the Yunnan, human presence was already affecting the permanent vegetation cover (deciduous forests and marshes giving way to loess plateau).

The ancient human civilizations

In mid-Holocene, around 5,000 years BP, the climate remained practically the same even if with a reduction in monsoon rain. The Near East was fully forested from Anatolia to Syria and Lebanon, to Mesopotamia, to Persia, to the Indus and Ganges valleys, and also in the large islands of the Mediterranean: beech, oak, maple, cork, accompanied by maquis and garrigue (bush and brush). Human exploitation of forests increased in this region: in addition to agriculture, urbanization and the construction of states were under way, with increasing need of wood and timber for the building of public structures and housing. Stone axes were being fabricated from about 3,000 BC. The epic of Gilgamesh (around 2,500 BC) narrates clearly about anthropogenic deforestation to obtain building material. The human expansion was favored by a humid warm period (5,500-3,500 BC).

In late-Holocene, 4,000-3,000 years BP, a minor climate change favored the re-expansion of the desert, while the full impact of agriculture started, and deforestation in Greece and the Aegean region increased for the needs of agriculture and the beginning of the constructions of fleets and navies. The first thalassocracy, the Minoan civilization on Crete, Cyprus, and the Aegean islands, started in 2,600 BC, collapsed around 1,450-1,425 BC (or 1628-1626 BC according to another dating), possibly following the explosive eruption of the Thira (Santorini) island volcano with consequent tsunami, but also linked to an ecological crisis caused by deforestation, aggravated by over-grazing. Evidence of deforestation has been found in the environs of the Palace of Knossos in Crete. Other instances of possibly deforestation-related civilization collapses have been reported, from Greece and Syria during the last centuries BC, especially as effect of alluvial silt deposits, to the Easter Island in the 17th-18th century AD.

In 2,500-1,200 BC, there was a cold period, but the agriculture (cereals, legumes, millet) continued to expand. In 1,200 BC, a large eruption of Iceland's Hekla-3 volcano possibly elicited climatic effects. The climate was again warmish at the time of the foundation of Rome (753 BC): irrigation systems were developed, particularly in Mesopotamia, Italy, and China. By 400 BC, a cold period was again in (the Tiber river was reported frozen by Livius in 401 BC), at least in the North Hemisphere.

The second half of the 2nd millennium and the 1st millennium BC were characterized by the growth of commercial and military naval power in the Mediterranean, with very high consumption of forest timber by the various peoples trading and expanding through the sea: Sea Peoples (2,600-1,175 BC), Mycenaean Greeks (1,600-1,500 BC), Dorian Greeks (1,200-338 BC), Phoenicians (969-322 BC) and Carthaginians (814-202), Etruscans (600-464 BC), Macedonians and Diadochi states (322-30 BC), Romans (348 BC to 476 AD), ancient Mediterranean pirates (Liburnians, Cilicians, Balearics, pirates of Sextus Pompeius, approximately from the 2nd century to 30 BC), Vandals (429-534 AD). The naval technology underwent enormous progresses, until the launching of the Roman *quinqueremes* warship and transport *oneraria*, but the cost for the Mediterranean forests was high: Lebanon, Syria, and Asia Minor were devastated, and, to the East, Persia, Afghanistan, Baluchistan, and the Indus valley. The temple of Solomon (963-923 BC) was built from cedarwood. After 168 BC, the Romans, having conquered Macedonia, were compelled to introduce the prohibition of tree-cutting in that province. In Italy, oak and beech forests (*Quercus*, *Robur*, *Fagus*, etc.), arriving in some cases to the marine waterline, started to disappear; in the hills, the traditional Mediterranean landscape of olive groves, grape, almond, and fig, was established next to the pastures of transhumance's sheeps: the traditional money was called *pecunia* from *pecus*, another term for sheep, and *salarium* (salary) from *sal* (salt). Plantations of willow were created for the production of wicker baskets. In the late Republic and the Empire, the food provision of the populace and of Rome itself caused an expansion abroad of the land dedicated to wheat cultivation (from Italy to Sicily, to Egypt, to North Africa), with further, in certain cases, full deforestation. Chestnut was the predominant cultivated arboreal species. In the first half of the 1st millennium AD, imperial Rome exploited for wood and timber the still almost intact German forests (e.g. Teutoburg Wald).

FIGURE 2

A roman ship

Difficulties and reactions in the Middle Age

It seems that the Sahara was inhabited in permanent villages surrounded by woody areas in the period 320-680 AD and even before (see Herodotus and Pliny), undergoing a desertification process in later historical times, and moving southward 1 m/year in the last 500 years along a front of 3,000 km (e.g., diminishing of Lake Chad), probably due to both natural and anthropogenic causes. During the last 3,000 years, gradual deforestation and desertification has affected Northern Sudan, Libya, Egypt, the Arabian Peninsula, the Somali coast.
In the late 1st and early 2nd millennia of our era, the naval expansion continued: Austronesians (from Borneo to Madagascar, as early as the 1st century), Arabs (since 711), Vikings (790-1300, opening also the route Norway-Iceland-Greenland-Labrador) and Normans (1000-1194), the Italian maritime republics (Venice, Amalfi, Naples, Sorrento, Gaeta, Pisa, Genoa, Ancona, Bari, Ragusa/Dubrovnik, etc., since 726) and Byzantine territories, Portuguese and Biscayne fishermen in the Atlantic (approximately since the 9th century).

The naval progress went on, with the construction of larger and technologically more advanced ships (e.g., *caravels, galleons*, etc.), capable of high-sea transoceanic journeys: Polynesian migration in the Pacific (1,300 BC to 800 AD), the Dravidian Chola Empire in the Indian Ocean (900-1100), Arabs in the Indian Ocean (since at least the 12th century), the Hansa in the northern seas (since 1150), China (1274-1433), Turks and Barbaresques (since 1413), Portugal (since 1415, opening the route of Cape of Good Hope), Aragon (since 1096) and Castile (since 1312) becoming Spain (1492), Netherlands (since 1580), England (since 1584), France (since 1603). The amount of forest timber consumed was staggering: for instance, Venice, after consuming practically all the woods of the Terraferma (alpine and subalpine forests), resolved to import the material to be used in its yards from North Europe.

In the 1580s, the building of galleons and barrels for the Spanish Armada (130 ships against 150 of the British fleet, of which 36 only participated to the confrontation in the British Channel) was a problem. The material could not be found in the residual Spanish forests, and king Philip II had to buy trees in Poland and to confiscate all enemy ships he could find: after a disastrous campaign, only 16 ships went back to Spain, the other being lost at sea. This tragic waste of forest wood was not unusual: in the battle of Lepanto (1571), the Christian fleet was composed of 212 ships (115 of which from Venice), against an Ottoman Turk fleet of more than 278 ship, 67 of which were sunk or lost at sea; in the Nine Years War (1594-1603) and in the War of the Spanish Succession (1701-1714), the British lost 4,000 and 3,250 ships, respectively, a number lower than that of the Spanish ships lost to privateers in the 16th-17th century. Finally, in the 19th century, there was the exploit of the river steamboats, using the wood cut every day from the riverbanks (Mississippi, Ohio, African and South American rivers).

The Middle Age was characterized by a Climatic Maximum (600-1300), following an episode of possible "volcanic winter" (535-536, reported by Procopius, perhaps due to a Krakatoa eruption), and by a population decrease (linked to the end of the Roman Empire, malaria outbreaks, invasions and raids, famines, plagues): the consequences were a de-structuration of the agricultural landscape and a return of the forests (for instance, in England), favored by castle feudalization, but also erosion due to the lack of proper land management. Some remedies were offered by the diffusion of monastic orders (since 529, the Benedictines), institutionally committed to countryside work. The Arabs introduced new irrigation systems and the cultivation of cotton, carob, pistachio, citruses; the Chinese developed the irrigated terraced rice paddies. The forests became royal properties (see also the legend of Robin Hood in the Sherwood Forest):

Omnia nemora et pasqua sunt curiae
("all forests and pastures are of throne's property")
(Frederick II, 1220-1250)

The hilly slopes were colonized by fir, beech, oak, aider, elm. There were episodes of weather-related famines (e.g. 1314-1317, the dry, harvest-less years "of the comets").

Buscar el Levante por el Ponente: the coming of the modern age

In 1492, Columbus landed in America. The so-called "Columbus exchange" implied the introduction from the Americas of corn, potato, squash, beans, tomato, pepper, cocoa, and peanuts, while some crops went the opposite route: wheat, coffee, etc. The new expansion of agriculture caused further deforestation, even in the mountains. The climate changed again: the so-called Small Ice Age (1550-1850), very cold, dry in the beginning (1572-1620 in Europe, 1580-1640 in the monsoon regions). The end of the 16th century was characterized by economic, agricultural, and alimentary crisis, with population decrease, favored by the Black Death (peak in 1630).

After 1250 (the Europeans) became so skilled at deforestation that by 1500 they were running short of wood for heating and cooking,
(Norman F. Cantor)

In the 17th century, the climate remained cold, but changed to moist and wet, as shown by the frequent disastrous floods. There was an expansion of cereal

FIGURE 3

The practice of slash-and-burning in Latin America

farming in the coastal plains of temperate countries, and of plantations of tea, coffee, sugarcane, and fruits in the tropics and islands; and the first experiences of re-forestation (like the pine forests in Italy, starting in 1700, the eucalyptus in Europe, starting in 1850, and the sycamores on the road margins planted by the Napoleonic administration). There were several eruption-related episodes of "volcanic winters" from Iceland and South-east Asia's volcanoes (1601-1603, 1783-1784, 1815-1816, 1883-1888). In 1825, modern agriculture, animal breeding and rearing, and ranching started: mechanization, drainage and reclamation, irrigation, use of natural phosphates and production of chemical fertilizers (superphosphate of lime), tractors, implements, scientific genetic selection, all factors progressing toward the Green Revolution. Forests were again pushed back to gain space for agriculture.
Furthermore, the use of charcoal made from wood lead to an increase of forest exploitation with, in addition, the danger of wildfire and of landslide from erosion (1600-1900). However, from the 18th century, peat and coke produced from fossil coal became available and were essential for carrying out the Industrial Revolution.

The imaginary of the forest was very much used in the Romanticism and neo-Gothic literature:

The path strangled onward into the mystery of the primeval forest.

(Nathaniel Hawthorn, *The Scarlet Letter*, 1850)

Further needs of wood were due to the modern production of paper and, even more, with the rapid increase of population, to the use of such material to build wooden houses (traditionally in Scandinavia, Germany, Russia and Slavic countries, Alps, North America, British dominions) and even temples and public buildings (Japan). In the meanwhile, in developing countries, wood continued to be used for heat and cooking, the practice of slash-and-burning was employed to prepare new agricultural terrains, erroneous pastoralist practices induced vegetal cover degradation. Space was increasingly needed for urbanization, agriculture, other anthropic uses, under the pressure of population growth (particularly in India and China). Finally, in recent times, the demand of quality tropical wood (e.g., teak, mahogany, sandalwood, etc.) for household furniture and floors elicited some tropical countries (and also boreal countries) to massive export of forest produce.
A very recent problem for forests concerns criminal fires, in general to clear-up ground for illegal housing and resorts (Italy and other Mediterranean countries). But at the same times, the expectation is increasing for forest conservation, recreational uses, even spiritual needs (by indigenous peoples and local communities), for afforestation and re-forestation. The first national park, Yellowstone, was established in the US in 1872; in Italy, Gran Paradiso in 1922; in Africa, the Virunga Mountains in the Congo in 1925; there are now about 7,000 national parks worldwide (2% to 25% of the national area in selected countries; specific European policies are in force from 1992).
Re-forestation turned out to be particularly useful during the anti-malarial campaigns. Malaria was diffuse in the Mediterranean region by the 5th century BC. In Republican Rome the problem was aggravated by the arrival of the *Plasmodium falciparum*, responsible of the most severe form of the disease, probably from Africa, and furthermore by the abandonment of agricultural land and water control works in the Middle Age, with the consequent diffusion of the efficient vector *Anopheles labrachiae*. Towards the end of the 19th century, more than one-third of the Italian population was affected by malaria. The mosquito was eradicated by a

long-term integral reclamation (1920-1940) of swampy areas with re-forestation (*Pinus pinaster* on the sea line, *Pinus pinea* on the dunes, and herbaceous species as protection of the seedlings) and finally eradicated with DDT (1950s). Re-forestation is important in the combat against other environment-related infectious diseases, in the production of natural therapeutic agents, in the sedentarization of hunter-gatherers, etc.

The current situation

To summarize the complex history of forests during the time of human presence on the planet is not simple. The main aspect appears to be the fluctuation as a function of time of the space of land occupied by forests. It is estimated that, currently, forests cover 30-33% of the surface of Earth's land mass, but that, in the past, the cover has reached, more than once, at least 50%. Three main factors appear to govern these fluctuations:

- climate changes;
- occupation, exploitation, and destruction of forests by humans;
- pollution (mainly caused by anthropogenic activities).

The mechanism of the first factor is relatively simple, even if the origin of the changes is complex. The different types of ecosystems, and forest ecosystems in particular, depend to a large extent on the temperature and level of rainfall. They are, therefore, found in broad bands between the poles and the equator which change location, for considerable distances over a period of several thousand years, according to climate change, with their position sometime affected by geographical factors (orography, presence of an inner sea, position of the continental land masses in respect to the ocean). Thus, as a sequence from the pole, the following types of forest can be found:

- tundra (poorly drained acid soils covered in low scrub), affected by low rainfall, low temperature, and presence of permafrost;
- great coniferous boreal forests known as taiga (not in the south hemisphere due to the lack of emerged land in the right position);
- temperate forests, with rich secondary flora and better soils (the Mediterranean forest is a secondary type characterized by semi-aridity conditions and the presence of bush and brush);
- grasslands, with less rain and poorer soils, interspaced with large desert belts affected by large masses of very dry air, and sometimes followed by savannas with scattered thorny trees;
- tropical rainforest with both high rainfall and temperature but relatively poor soil (producing up to 40% of all terrestrial primary plant production and containing half of the plant and animal species).

Until recently, the climate changes affecting the position on the globe of the vegetation bands were due to completely natural, although complex causes. Anthropogenic deforestation, as indicated above, depends from a variety of activities: harvest of wood for heating and cooking, slash-and-burning to obtain cultivable land for subsistence agriculture, space for urbanization and other human necessities. Recently, new factors have come into the picture. Modern agriculture is a main factor, especially for its main crops:

- wheat and other cereals; main exporters: USA (the south-north belt from Texas to the Dakotas), Canada (the provinces north of the US belt), France, Argentina, Russia (South Russia and Siberia); for internal consumption: China (mainly Manchuria), India;
- corn (USA, with the Minnesota-Wisconsin-Michigan belt, as the main producer and exporter, not least Brazil) and rice (China, India, Indonesia, etc.);
- fruits and Mediterranean produce: Mediterranean countries (Spain, Italy, France), California, Chile, South Africa (Cape), Australia, Argentina.

Many of these territories, before farming, were originally prairies, but others, especially in tropical and subtropical areas, were forests. To these crops, the agriculture based on a monoculture or a main commodity must be added (often in plantations of colonial origin): coffee (Brazil, Viet Nam, Colombia), tea (China, India, Sri Lanka, Kenya), cocoa (Ivory Coast, Ghana, Indonesia).

More recently, the subtraction of space from forests has been accompanied by the demand of timber for the developed countries market: not only timber from sustainably managed forests (e.g. USA, Canada) but also from developing countries at risk of deforestation (India, Brazil, Indonesia, Ethiopia, Congo-Kinshasa, Nigeria, etc.). Wood pulp for paper production comes from boreal forests harvested sustainably (USA, Canada, Finland, Sweden, etc.).

Of course, pollution affecting forests (physical, chemical, photochemical smog, biological pollution) is of human origin as well as the possible human interference with climate. It is estimated that tropical deforestation releases 1.5 billion tons of carbon each year into the atmosphere. Other hydrological, on soils, and ecological effects are recognized. The issue of carbon dioxide and the carbon cycle will be treated elsewhere.

It is estimated by the FAO that, in the period 1950-1980, Central America underwent a 40% loss of its forest area, and Africa a 23% loss. At present, the edges of the rainforest undergoing the most rapid deforestation are: the southern margin and the Colombian border of the Amazon basin, the north-western margin of the Brazilian coastal forest, parts of the Meso-America forests, the Sahel margin of the African rainforest, areas of Congo, Angola, Malawi, Mozambique, Madagascar, Tanzania, and Kenya, the residual Indian forests, areas of Indochina and Indonesia.

According to the UN Framework Convention on Climate Change (FCCC), the main direct cause of deforestation is agriculture: subsistence farming is responsible for 48% of deforestation, commercial agriculture for 32%, logging for 14%, and fuel wood removals for up to 5%. However, previously, in modern times, deforestation was due not only to extensive agriculture, but also to extractive industries, other industrial factors, and large-scale cattle ranching (especially in the Americas). Furthermore, an additional ecological injury is represented by forest fragmentation, affecting, especially in Europe, even marginal lands, abandoned by agriculture, that could be open to trees re-colonization.

FIGURE 4

The effect of the modern agricultural methods on landscape

Currently, the first ranking countries in terms of percentage of forest areas higher than 45% of the national territory are (data between 2007 and now):

Rank Country	Area (km^2)	Percent national territory	Trend
* 1. Russia	8,086,000	49	increasing
* 2. Brazil	7,415,000	62	increasing
* 7. Congo DR (Kinshasa)	1,330,000	56	
* 8. Indonesia	940,000	52	
* 9. Peru	686,000	53	stable
* 13. Colombia	606,000	55	increasing
and with less than 45%:			
* 3. Canada	3,101,000	31	increasing
* 4. United States	3,034,000	33	increasing
* 5. China	2,054,000	22	stable
* 6. Australia	1,233,000	19	decreasing
notable cases:			
* 23 Japan	249,000	69	increasing
* Finland & Sweden		65-70	increasing
* 52 Italy	102,000	34	increasing
* 58 South Africa	92,000	8	decreasing
* 83 Kenya	35,000	6	decreasing
* 98 Algeria	23,000	1	decreasing

Over the last five years, the world suffered a net loss of about 37 million hectares (7.3 million hectares per year) of forest. This number comprehends the felling of 64 million hectares of trees and the planting or regeneration of 28 million hectares of new forest. The overall decrease of forested surface interests some continents (Africa, South America), while other continents are stationary (Asia, North and Central America, Oceania), and Europe shows an increase. The currently most endangered forests are in Indochina and Myanmar, New Caledonia, Borneo and Sumatra, the Philippines, Eastern Africa and Indian Ocean islands, all in the tropics; and the temperate forests in South America and Southwest China. The problem is still open.

FIGURE 5

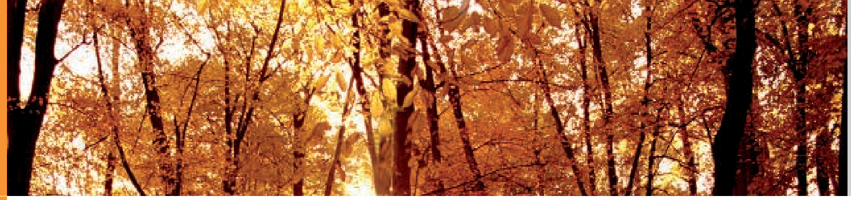
An intact part of the great Amazon Forest

Notes

1 Other scientific or specialized definitions are possible. In particular, specific definitions are used by the Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to quantitatively estimate the carbon sink function carried out by forests and to evaluate the vegetal carbon stock accumulated in arboreal organic matter: in this case, to distinguish forests from bushland, glades, heaths, and similar formations, parameters such as the average tree height and the minimal tree density (number of trees per hectar or square kilometer) are taken into account.

References

[1] Adams J.M. *Global land environments since the last interglacial*. Oak Ridge National Laboratory, TN, http://www.esd.ornl.gov/ern/qen/nerc.html, 1997.
[2] Adams J.M., Faure H. (eds.). *Review and Atlas of Palaeovegetation: Preliminary land ecosystem maps of the world since the Last Glacial Maximum*. Oak Ridge National Laboratory, TN, http://www.esd.ornl.gov/ern/qen/adams1.html, 1997.
[3] Beta.com. *Forests*. targetstudy.com/nature/habitats/forests/, 2010.
[4] *Calendario Atlante De Agostini 2011*. Istituto Geografico De Agostini, Novara, 2010.
[5] Curtis R.O., DeBell D.S., Miller R.E., Newton M., St. Clair J.B., Stein W.I. *Silvicultural research and the evolution of forest practices in the Douglas-fir region*. Gen. Tech. Rep. PNW-GTR-696. Portland, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 2007.
[6] Diamond J.M. *Collapse: How Societies Choose to Fail or Succeed*. Viking Books, New York, 2005.
[7] Duke University. *Bipedal Humans Came Down From The Trees, Not Up From The Ground*. ScienceDaily, 2009. http://www.sciencedaily.com/releases/2009/08/090810162005.htm.
[8] Earth Policy Institute. *Global Forest Resources Assessment 2005*. FAO (UN Food and Agriculture Organization), Rome, 2006.
[9] FAO. *Forest and Human Health*. Unasylva, www.fao.org/docrep/009/a0789e/ a0789e01.htm, 2009.
[10] Hammond. *The World Almanac*. Hammond World Atlas Corporation, Union, NJ, 2010.
[11] Mygatt E. *World's forests continue to shrink*. www.earth-policy.org/publications/C39, 2006.
[12] Oedekoven K.H. *Forest history of the Near East*. Unasylva, www.fao.org/docrep/ 009/a0789e/ a0789e01.htm, 2009.
[13] Oosthoek K.J.W. *The role of wood in world history*. www.eh-resources.org/ wood.html, 1993.
[14] Ovary R. *Atlas of the 20th Century History*. Collins, New York, 2004.
[15] Paletto A., Sereno C., Furuido H. *Historical evolution of forest management in Europe and in Japan*. Bull. Tokyo University Forests 119: 25-44, 2008.
[16] Perlin J, *A Forest Journey: The Story of Wood and Civilization*. Harvard University Press, Cambridge, MA, 1989.
[17] Ponting C. *A Green History of the World*. Penguin, New York, 1991.
[18] Thirgood J.V. *Men and the Mediterranean Forest: A History of Resource Depletion*. Academic Press, Maryland Heights, 1981.
[19] United Nations Statistics Division. *Main Environmental Indicators*. United Nations, New York, 2011.
[20] Williams M. *Deforesting the Earth*. University of Chicago Press, Chicago, 2003.
[21] en.wikipedia.org
[22] unfccc.int
[23] www.amicidellaterra.it/adt/index.php?option=com_content&task=blogcategory&id=56&Itemid=225
[24] www.cbd.int
[25] www.fao.org
[26] www.museum.state.il.us/muslink/forest/htmls/intro_def.html
[27] www.unccd.int
[28] www.un.org/esa/forests/about.html



An unprecedented opportunity for forests

In the wake of the 1992 Rio Conference on Environment and Development, many decision-makers in the forest sector expressed their disappointment at the absence of a much-anticipated global agreement on forests. Since then, however, forests have not been off the global political agenda – far from it. Two decades later, there are good reasons to be optimistic

Benjamin Singer

I. Forests since 1992

In the years following the 1992 Rio Convention, considerable efforts were made at the intergovernmental level to maintain forests high on the international political agenda. In 1995, the International Panel on Forests (IPF) was established and in its two-year existence put forward a number of proposals for action which were taken up by its successor, the Intergovernmental Forum on Forests (IFF). When the United Nations Forum on Forests (UNFF) was set up to replace the IFF in 2000, forests rose substantially on the agenda of the United Nations.

For the first time, an intergovernmental body with universal membership – all 193 Member States of the United Nations are members of the UNFF – was created with a focus on sustainable forest management. The importance of the UNFF was further bolstered with the 2002 establishment of the Collaborative Partnership on Forests, bringing together 14 international organisations[1] with substantive work on forests, to support the UNFF in the implementation of sustainable forest management.

However, many actors and observers of global forest policies alike expressed disappointment at the discrepancy between political efforts undertaken and continuing rates of deforestation. Since 1992, forests have continued to disappear at an alarming rate.

Figures compiled by the Food and Agriculture Organisation (FAO) of the United Nations, paint a bleak picture of the world's forests since 1990.[2] In particular, these show that deforestation rates have decreased in the past decade (2000-2010) in comparison to the previous decade (1990-2000), down from 16 million to 13 million hectares per year. Yet this figure remains high and shows no sign of abating.

According to this same source, the world's forests have "only" decreased in cover by 0.14% annually between 2005 and 2010 – a figure which appears to pale into insignificance when compared with some national deforestation rates. However, behind this world average lie major discrepancies, notably between temperate and boreal forests on the one hand, and tropical forests on the other. Whilst forests of North America, Europe and northern and northeast Asia have mostly grown in size, spearheaded by China's impressive increase in forest cover, a majority of tropical countries have seen large swathes of their forests disappear during the same period. Hence the low figure at the global level which mostly results from trends from different latitudes cancelling each other out.

II. A New Impetus

Observers are justifiably pessimistic when faced with such figures. However, global forest policies have

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made a number of major steps forward in the past half decade that could prove to be crucial in reversing deforestation rates over the long run. Several factors have boosted the visibility of forests in the international policy agenda beyond to levels exceeding those of 1992, providing an unprecedented opportunity for commitment to sustainable forest management.

II.1. The Forest Instrument

The adoption of the UNFF Non-legally binding instrument on all types of forests, also known as the Forest Instrument, is one of the major breakthroughs of the past few years. The Forest Instrument emerged as a compromise between Member States opposed to a legally binding convention, and those in favour, and was perceived as a platform which could include a legally binding arrangement in the future.

Before 2007, global agreements on forests had taken place on a piecemeal basis. Forests are taken into consideration in the three Rio Conventions (on biological diversity, combating desertification and climate change) as well as older environmental agreements, including the Ramsar Convention on wetlands and the Convention on the illegal trade of endangered species (CITES).

Yet until 2007, no global agreement had ever focused specifically on forests. In this regard, the Forests Instrument represents a major landmark in that it sets sustainable forest management as the primary and universally-recognised solution to the deforestation crisis.

Furthermore, the Forests Instrument provides a simple but effective operationalisation of sustainable forest management by translating it into four Global Objectives on Forests (see box below). But above all, it lays the basis for a truly holistic, 360-degree approach to forests. In its scope, The Forests Instrument emphasises its relevance to "all types of forests" and defines sustainable forest management in the most encompassing way as "a dynamic and evolving concept [which] aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations". Both elements of the scope thus embrace the diversity of forests as well as the multiplicity of their functions and values to humanity.

Last but not least, the Forests Instrument places sustainable forest management in the broader development context by stating among its purposes the enhancement of "the contribution of forests to the achievement of the internationally agreed development goals, including the Millennium Development Goals, in particular with respect to poverty eradication and environmental sustainability". In other words, it brings forests out of the traditional sectoral vision, thus recognising them as an integral part of the development agenda of the international community. This sets forth the basis for a promising paradigm shift, as is further illustrated below.

Box I. — The Four Global Objectives on Forests of the Forests Instrument

1. Reverse the loss of forest cover worldwide through sustainable forest management (SFM), including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation;
2. Enhance forest-based economic, social and environmental benefits, including by improving the livelihoods of forest-dependent people;
3. Increase significantly the area of sustainably managed forests, including protected forests, and increase the proportion of forest products derived from sustainably managed forests; and
4. Reverse the decline in official development assistance for sustainable forest management and mobilize significantly-increased new and additional financial resources from all sources for the implementation of SFM.

http://www.un.org/esa/forests/about.html

II.2. Forest Financing

Following the adoption of the Forest Instrument, discussions within the UNFF on implementing sustainable forest management rapidly came to focus on the issue of forest financing. Since 1992, the issue of associating financial flows to combating deforestation had marred intergovernmental discussions.

From 2005, REDD+ (Reducing emissions from deforestation and forest degradation) partly addressed this issue as it proposes to remunerate developing countries for progress made in reducing deforestation rates and forest degradation. The principle immediately sparked interest and enthusiasm, especially as it builds a conceptual bridge between global forest policies and climate change. The concept was given further impetus when it was presented by the Stern Review,[3] a 700-page report on the economics of climate change for the British Government, as being one of the most cost-effective solutions to mitigating climate change.

In the past few years, some have voiced their reservations about the feasibility of REDD+ as a mechanism and its focus on carbon storage. For instance, it has been pointed out that in its current state, REDD+ runs the risk of undermining tenure rights of local communities. In a 2010 article in the journal *Science*, Jacob Phelps, Edward Webb and Arun Agrawal[4] warned that the funding and monitoring requirements for REDD+ might undermine decentralisation. In addition, the prospect of large amounts of funds from REDD+ could encourage policy-makers to recentralise certain decision-making powers away from the local level, thus reversing the advances made in land tenure rights in recent years.

In spite of this, REDD+ has provided a tremendous impetus to global commitment to forests worldwide. Yet until 2009 the issue remained of broader forest financing, *i.e.*, the landscape of finance flows to maintain and enhance all aspects of sustainable forest management – carbon storage, but also all of the other ecological, economic and social functions of forests.

A historic resolution[5] was finally adopted in 2009, known as the Resolution on the Means of Implementation of Sustainable Forest Management, setting forth a two-pronged approach to forest financing. On the one hand, the Facilitative Process was set up with the aim, among others, of assisting in the mobilisation of forest financing for developing countries. The Facilitative Process recognises the availability of existing funds, many of which are underused, as well as the need to raise new and additional funding for sustainable forest management. One of its primary functions is therefore to bridge the gap between donors and recipients so as to ensure that all opportunities are harnessed to overcome current gaps and obstacles to forest financing.

The Facilitative Process has attracted considerable donor enthusiasm and has witnessed the implementation of three projects so far, including on the identification of gaps, obstacles and opportunities for forest financing in small island developing states, low forest cover countries, Africa and least developed countries, and an initiative to assess the impact of REDD+ on the broader forest financing landscape.

On the other hand, an Ad Hoc Expert Group was set up to meet twice before 2013 – once in 2010 in Nairobi, and once in 2012. Whilst the Facilitative Process works using a bottom-up approach by scaling up field experiences and sharing them across different categories of countries, the Ad Hoc Expert Group operates in a complementary top-down fashion by providing strategic guidance and recommendations on forest financing discussions within the UNFF.

The strategic work plan on forest financing, which combines this two-pronged approach, applies the perspective laid forth in the Forest Instrument by adopting a cross-sectoral approach to sustainable forest management. At every step of its implementation, specific measures are established to address the relationship between forests and other sectors so as to break down the narrow silos that sectors constitute, and which impede the identification of innovative solutions to forest financing.

II.3. Forests 2011

Raising awareness is a crucial step to promoting the importance of forests and addressing deforestation. Most global awareness campaigns are either targeted at key decision-makers or, when they are targeted at the general public, deliver specific messages on the urgency of deforestation.

Forests 2011 clearly departs from this pattern. Through the UNFF which acts as its coordination platform, the International Year of Forests targets not only the 193 Member States of the United Nations, but the world's population as a whole. Through a great diversity of celebrations of all things forests at international and national levels, it delivers a positive message – how forests contribute to the well-being of all humanity in a myriad ways. Both the motto of Forests 2011 – "Forests for People" – and the logo designed by the United Nations (Figure 1) reflect this crucial relationship between forests and humans.

FIGURE 1 Logo of the International Year of Forests

As 2011 draws to an end, the International Year of Forests has shown to be a great success. The logo, translated into over 50 languages, was projected onto the Secretariat Building of the United Nations Headquarters on the launch of the Year in February 2011. Since then, requests to use the logo have been pouring in, with over 800 organisations – governments, companies and civil society organisations alike – who now use the logo around the world.

The launch of the International Year of Forests, which received global media coverage, took place in the iconic General Assembly Hall of the United Nations and brought together a wide range of senior government officials and high-level keynote speakers, including Wangari Maathai, 2004 Nobel Peace Prize Laureate, who tragically passed away in September 2011. As part of the celebrations, an international forest film festival and forest heroes programme and awards were held, drawing interest from across the world. In particular, the sheer diversity and originality of competing films was such that many were shown at the Jackson Hold Wildlife Film Festival, which brings together the world's most acclaimed nature film and documentary producers.

This global awareness-raising exercise is also aimed at providing a grassroots, bottom-up approach to increasing the importance of forests in the global development agenda. By enabling the world's population to know more about how useful forests are in their daily lives and to sustainable development generally, the objective of the International Year of Forests is to boost existing policies to combat deforestation by building a strong ground of public support.

The past five years have spelled major changes in world forest policies. By (i) laying down a solid set of principles through the Forests Instrument, (ii) achieving a broad consensus on forest financing (including REDD+), and (iii) promoting the visibility of forests to a new level through the International Year of Forests, we have created a unique opportunity to take action to reduce both deforestation and forest degradation on a global scale.

III. Promising Initiatives

In particular, the basis laid by these recent initiatives reveals two promising trends which may hold the key to solving the deforestation crisis, namely a cross-sectoral approach and a focus on people.

III.1. Beyond the Forest Sector

Over the years, global discussions have widened to embrace the diversity, multiplicity and complexity of forests. Within this trend is the gradual recognition that the solution to deforestation does not necessarily lie only within the forest sector. For over a decade, academics have shown that many – if not most – of the causes of deforestation are outside of the forest sector (*e.g.*, Angelsen & Kaimowitz 1999).[6] The timber sector has been blamed excessively for being the primary cause of deforestation, although it is now widely known that other sectors such as agriculture, transport and energy often have a greater impact on forest cover than does the forest sector itself.

Yet this reality has yet to be internalised by global forest policies. In spite of numerous calls for a cross-sectoral approach, most policies continue to be elaborated and implemented within the narrow silos of traditional sectors, with little to no communication, let alone collaboration, between them. Along with the 360-degree perspective adopted by the UNFF, however, a handful of promising initiatives break down sectoral barriers in a bid to implemented sustainable forest management more efficiently.

Forest landscape restoration is one such activity. The Global Partnership on Forest Landscape Restoration is an ambitious initiative based on the recognition that over half of the world's forest cover has been cleared by humans in the space of a few centuries. By acknowledging the potential benefits of restoring these degraded landscapes – not only for forests themselves, but also to hundreds of millions of livelihoods, this initiative integrates forests into the broader landscape – which includes agriculture, transport and other land uses essential to human well-being.

Over two billion hectares around the world stand to benefit from forest landscape restoration. The first projects launched, which reflect the sheer scale of this potential, have already produced astounding results. Within a decade of introducing landscape restoration measures, the dry, dusty Loess plateau north of Xi'an, China, has been turned into a mixed green landscape of forests and fields, where trees and terracing fixed the soil, increasing fertility and producing clean water for communities and livestock alike. But the most impressive aspect of this feat is its size: this US$ 500 million project enabled the incredible recovery of an area the size of Belgium – no less than 35,000 square kilometres.

This initiative was reproduced in Ethiopia with similar results and more recently still, the Government of Rwanda declared the creation of a border-to-border Forest Landscape Restoration project across the entire country. This is the first time that such a project has taken national proportions. For such an ambitious project of integrating landscape restoration into its national development plans, the Government of Rwanda has given itself 25 years to reach its objectives of turning the degraded landscapes of the "Country of a Thousand Hills" into a green and productive landscape. By using a cross-sectoral, landscape approach to addressing deforestation, an innovative solution has thus been found for forests and people.

III.2. Forests for People

Decision-makers and the wider public alike are often aware of the ecological functions of forests, such as the contribution of forests to maintaining biodiversity and storing carbon. Likewise, the timber sector, which produces an income of some US$ 3.4 billion annually[7] epitomises the significant cash contribution of forests to the world economy.

However, among the multiple values of forests, social functions have almost systematically been underrated. Two main factors account for this. First, rural villagers – 1.6 billion of whom depend on forests for their livelihoods – are frequently underrepresented in the policy arena, and their voices remain all too often unheard. Secondly, because these livelihoods are generally informal and non-monetarised, they appear invisible in national and international statistics, despite their huge importance in reducing poverty.

This is even more the case for the cultural and spiritual values that forests represent in the eyes of countless local and indigenous communities around the world. Forests have always fascinated humanity, and humans have always woven them into their cultures, mythologies and cosmologies and often given them a very special place. Yet because these values are the least tangible, because they are the most difficult to quantify, they are virtually always left out.

Recognising the full social value of forests is not only of immense benefit to local communities. It is key to adding value to forests in the eyes of decision-makers who have all the more reason to implement sustainable forest management. Likewise, local communities – as custodians of forests – are generally more inclined to manage forest sustainably when they tenure systems and rights of access are clearly recognised.

In order to restore the importance of the social functions of forests, the UNFF dedicated the International Year of Forests to people. The day following its launch, the UNFF also adopted a ministerial declaration recognising that "nearly one quarter of the world's population depend on forests for subsistence, livelihood, employment and income generation." It also stressed "the crucial role of local people, including women, and local and indigenous communities in achieving sustainable forest management".[8]

Emphasising the role of forests for people not only helps alleviate poverty *per se*, but it also places forests in the broader development context. Far from "drowning" forests among more pressing development issues which are often seen to have greater priority in the eyes of decision-makers, underlining the link with poverty reduction actually increases the political visibility of forests by making sustainable forest management an essential building block of the global development agenda.

Such initiatives might not be sufficient in reversing the tide of deforestation on their own, but they illustrate a trend towards greater integration of forests within economic and social development at the global scale. Moreover, this trend appears at a time when forests are higher on the global policy agenda than they ever have been. Together, these form both a unique and highly promising window of opportunity for the international community to take action and promote sustainable forest management on a widespread scale – for the benefit of both forests and humanity.

Notes

1 CIFOR, FAO, ITTO, IUFRO, CBD Secretariat, GEF Secretariat, UNCCD Secretariat, UNFF Secretariat, UNFCCC Secretariat, UNDP, UNEP, ICRAF, World Bank, IUCN.

2 FAO (2010). *Global Forest Resources Assessment 2010.* FAO Forestry Paper 163. Rome: FAO, 378 pp.

3 Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press, 712 pp.

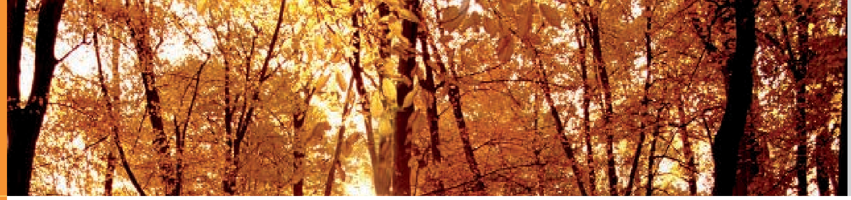
4 Phelps, J., Webb, E.L. & Agrawal, A. (2010). Does REDD+ Threaten to Recentralize Forest Governance? Science 328(5976):312-3.

5 Resolution of the Special Session of the 9th Session of the UNFF on the Means of Implementation of Sustainable Forest Management, available at http://daccess-dds-ny.un.org / doc / UNDOC / GEN / N09 / 608 / 38 / PDF / N0960838.pdf?OpenElement

6 Angelsen, A. & Kaimowitz, D. (1999). *Rethinking the causes of deforestation: lessons from economic models*, World Bank Research Observer 14(1):73-98.

7 FAO (2010). *Global Forest Resources Assessment 2010.* FAO Forestry Paper 163. Rome: FAO, 378 pp.

8 The full text of the Ministerial Declaration is available at the following website: http://www.un.org/esa/forests/documents-unff.html#10



Forests and climate change. A venomous or amorous embrace?

The paper examines the multifaceted relationships between climate change and forests. On one side, climate change is altering forest distribution, composition, structure and functions and phenology of forest species. On the other side, forests and forestry offer significant climate change mitigation options, including measures that reduce greenhouse-gas emissions, especially through reducing deforestation and forest degradation in developing countries; increase the rate of greenhouse-gas removals from the atmosphere (e.g, through afforestation, reforestation, forest restoration and changes to forest management practices); and substitute forest products for fossil fuels or products requiring fossil fuels in their production. Climate change adaptation measures in the forestry sector are essential both to climate change mitigation and for underpinning sustainable development

Because of this, forests feature prominently in the climate change past and ongoing negotiations on commitments of countries under the United Nations agreements to combat climate change.
The forestry sector has much to gain by using existing political support and emerging financial opportunities from the climate change policies to take appropriate action. Nevertheless, the use of forests for climate change mitigation and adaptation also poses a number of unique problems, such as long-term climate benefits, and ownership and fair allocation of these benefits, that need to be confronted

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Introduction

Human activities have enhanced the natural greenhouse effect by adding carbon dioxide (CO_2) and other greenhouse gases (GHGs) to the atmosphere[1] and this is very likely causing the Earth's average temperature to rise. These additional GHGs come primarily from burning fossil fuels. In 2010 the combustion of fossil fuel released 30.6 billion tons (Gt) of CO_2 equivalent into the atmosphere (3.2 $GtCO_2$ in the EU-15), 9% more than the previous year. Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to GHGs produced by human activities. Temperature projections depend on specific emissions scenarios and the fact that they integrate climate-carbon cycle feedbacks. The 2007 Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC, 2007) in-

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dicates that during the 21st century the global surface temperature is likely to rise a further 1.5 to 1.9 °C for their lowest emissions scenario and 3.4 to 6.1 °C for their highest (Solomon *et al.*, 2007)[2].

Forests and the global carbon cycle

Terrestrial biosphere has major role in the global carbon cycle and in climate change. This is because it stores large amount carbon (C) in vegetation (550±100 Gt)[3] and soils (two to three times this amount in the top meter and as much as 2300 Gt in the top 3 meters) (Houghton, 2007). Forests are particularly important as a C reservoir because they hold much more C per unit area (up 250 tC/ha) than other types of ecosystem and they cover about 4 billion hectares, or about 30 percent of the world's land area. In addition, terrestrial biosphere exchanges massive amounts of CO_2 and other gases with the atmosphere through natural processes and biotic and abiotic disturbances. Forests act as *carbon sources*, adding CO_2 to the atmosphere, when total respiration or oxidation of plants, soil, and dead organic matter exceed net primary productivity; they act as *carbon sinks*, removing CO_2 from the atmosphere, when agricultural land and pasture are abandoned and revert naturally to forests, or are restored to native forests or plantations through new forest planting. Aggrading forests also fix more C than they respire.

Deforestation and forest degradation in the tropics and forest regrowth in the temperate zone and parts of the boreal zone are the major factors responsible for emissions and removals, respectively. In the period 2000-2009, deforestation (about 13 Mha/yr) and forest degradation resulted in an estimated release to the atmosphere of about 1.26 GtC, or about 12% of total anthropogenic GHG emissions. However, the extent to which the C loss due to tropical deforestation and forest degradation is offset by expanding forest areas and accumulating woody biomass in the boreal and temperate zones is an area of disagreement between field observations and estimates by top-down model (Houghton, 2007; Reich, 2011).

The role of forests in the climate change mitigation strategies

The significance of both emissions and removals and the potential of humans to alter the magnitude of terrestrial C stocks and the direction of C fluxes explain why the United Nations Framework Convention on Climate Change (UNFCCC, 1992) and the Kyoto Protocol[4] (KP, 1997) include forestry and land-based activities — dubbed land use, land-use change and forestry (LULUCF) — in the international climate change contest.

There are five fundamental approaches to sequestering C in terrestrial ecosystems and reducing net GHG emissions: supplying of renewable energy; replacement for more fossil carbon-intensive products; decrease of emissions of non-CO_2 gases (e.g., from agriculture); sequestration of C through the enhancement of terrestrial C stocks; and conservation of existing C stocks.

Nabuurs *et al.* 2007, quoting bottom-up regional studies, proved that forestry mitigation options have the 'economic' potential at costs up to 100 US$/tCO2-eq to contribute 1.3-4.2 $GtCO_2$ eq/yr (average 2.7 $GtCO_2$ eq/yr) in 2030. Global top-down models predict far higher mitigation potentials of 13.8 $GtCO_2$ eq/yr in 2030 at prices less than or equal to 100 US$/$tCO_2$-eq, depending on a multitude of factors, such as the changes in other economic sectors, political and social changes, the cost-competitiveness of forestry mitigation versus other sector options in achieving climate mitigation goals and the future impacts of climate change itself on growth and decomposition rates, on the frequency and intensity of natural disturbances, on land-use patterns, and on other ecological processes of forests.

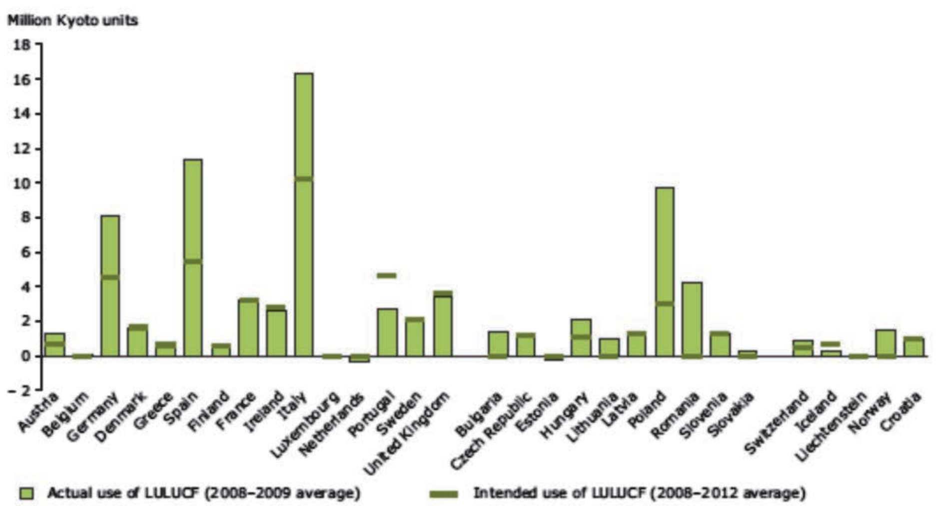
In the negotiation process subsequent to the KP several rules specifically related to LULUCF have been agreed upon for the first commitment period 2008-2012, some of which are quite restrictive for forestry projects. Specifically, C stock changes and non-CO_2 emissions between 2008 and 2012 on new forest areas (afforestation and reforestation) created or deforested since 1990 *must* be included in the commitments of industrialised countries (KP's Article 3.3). In addition, industrialised countries *may* also elect to include C stock changes and non-CO_2 emissions between 2008 and 2012 on areas subject to forest management, up to a cap that is, in most cases, a fraction of the anticipated uptake; on areas subject to cropland management, grazing land management and revegetation relative to carbon stock changes and associated greenhouse gas emissions from these activities in 1990 (KP's Article 3.4); on new forest areas created due to projects in developing countries, agreed under the terms of the Clean Development Mechanism (CDM), up to a limit of 1% of the industrialised country's total emissions in 1990 (KP's Article 12).

In point of fact, these provisions restraint the mitigation potential of LULUCF activities. Firstly, they do not address deforestation and forest degradation in developing countries, the major source of anthropogenic emissions. In addition, they do not allow countries to make ample use of the options offered by LULUCF activities to sequestering carbon in terrestrial ecosystems and reduce net GHG emissions to fulfill the GHG reductions commitments. At EU scale, for example, a new report from the European Environmental Agency shows that the «projected» use of carbon sink under Articles 3.3 and 3.4 during the 2008-2012 period by the EU-15 —which include 'forestry' countries such as Finland, Sweden and Germany — is relatively small: about 40 Mt CO_2 per year of the commitment period (1.0% of EU-15 base-year emissions) (EEA, 2011). Italy, Spain and Poland reported the highest removals from LULUCF activities (Figure 1).

Effects of climate change on forests

Climate change is altering forest plant processes, biodiversity, the structure and function of ecosystems, disturbance interactions through higher mean global temperatures, combined with higher atmospheric CO_2 levels, changed precipitation patterns, more extreme weather events such as hurricanes, heat waves and wind storms.

In terrestrial ecosystems, the earlier timing of spring events and poleward and upward shifts in plant and animal ranges (Kellomaki *et al*. 2008; Lenoir *et al*. 2008; Malhi *et al*. 2009) have been linked with high



Note: A positive value indicates that the country has/expects net removals from LULUCF activities, taking into account the caps for forest management. It does not necessarily mean that the country intends to actually use RMUs to achieve its Kyoto commitment. The estimate of the actual effects of LULUCF activities might change in future years if better data becomes available.

FIGURE 1 Actual (2008 and 2009) and expected (2008-2012) average annual emissions and removals from LULUCF activities
Fonte: EEA, 2011

confidence to recent warming. Scientists assume that each 1 °C of temperature increase in the northern emisphere moves ecological zones by about 125 km northward, 125 m higher in altitude, to find a suitable climatic regime. Mediterranean-type ecosystems, such as maquis and garigue, are especially sensitive, as increased temperature and drought favour development of desert and grassland.

The extension of the growing season has contributed to an observed increase in forest productivity in boreal and temperate regions, while warmer and drier conditions are partly responsible for reduced forest productivity, increased forest fires and pests and pathogens in the Mediterranean Basin. However, Zhao and Running (2010) reported a reduction of 0.55 GtC in global terrestrial net primary production (NPP) of 535.21 Gt C over the period 2000 to 2009. They attributed this decline to a drying trend in the Southern Hemisphere that decreased NPP by 1.83 Gt C (0.34%) and that was counteracted by increased NPP in the Northern Hemisphere by 1.28 Gt C (0.24%).

Projections for the 21st century suggest that the climate will change faster than at any other time in at least the past 10 thousand years. The projections for the European climate predict mean temperatures are likely to increase more than the global mean in the 21st century (Christensen *et al*., 2007). The largest warming is likely to be in northern Europe in winter and in the Mediterranean area in summer. Annual precipitation is very likely to increase in most of northern Europe and decrease in most of the Mediterranean area. In central Europe, precipitation is likely to increase in winter but decrease in summer. Risk of summer drought is likely to increase in central Europe and in the Mediterranean area, where summer rainfall could decline by as much as 80 percent. The duration of the snow season is very likely to shorten, and snow depth is likely to decrease in most of Europe.

A multitude of studies based on field experimental research, combination of ecological modelling with different climate change scenarios and process modelling affirm that the responses of forests to climate change trends across Europe described above may be considerable (Lindner *et al*., 2010).

Forest area is assumed to contract in the South. Native coniferous forests are likely to be replaced by broadleaved forests in western and central Europe. Distribution of archetypal European species, as common oak (*Quercus robur*.) and sessile oak (*Quercus petraea*), will be relatively unaffected by climate change. Other species' distribution will be significantly affected, such as Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and many other temperate and boreal trees. These species' distributions should contract substantially with climate change, with migration northward being limited by the sea. A third category of species' distribution will be very much affected by climate change and this is mainly Mediterranean and temperate native coniferous species, such as European larch (*Larix decidua*) and silver fir (*Abies alba*), European black pine (*Pinus nigra*) and maritime pine (*Pinus pinaster*). These species should disappear from most of their present distributions. In Europ, for some species the new colonisable areas may be disconnected from the present ones (*Pinus nigra*, *P. pinaster*). The distribution of a number of typical tree species is likely to decrease in the Mediterranean.

Thuiller *et al*. (2005), in projecting late 21st century distributions for 1,350 European plant species under seven climate change scenarios, showed that many European plant species could become severely threatened and more than half of the species studied could be vulnerable or threatened by 2080. Despite the coarse scale of the analysis, mountain species could be seen to be disproportionably sensitive to climate change (60% species loss) due to the narrow habitat tolerances of the mountain flora, in conjunction with marginal habitats for many species. The boreal region was projected to lose few species, although gaining many others from immigration. The southern Mediterranean and part of the Pannonian regions have a negative residual for species loss. Both regions are characterized by hot and dry summers and are occupied by species that tolerate strong heat and drought.

Under the scenarios used here, these species are likely to continue to be well adapted to future conditions.
Water use efficiency in forest trees may increase due to the fertilisation effect of increased atmospheric CO_2 concentrations, but in some parts of Europe, leaf area and associated evapotranspiration from forests may increase, resulting in decreased water flow from forests. Negative impacts of drought on deciduous forests are also likely. Water stress in the south may be partially compensated by increased water-use efficiency, elevated CO_2 and increased leaf area index, although this is currently under debate. Plant physiological responses, including growth responses to increased atmospheric CO_2 and changes in water use efficiency, are expected to ameliorate the response of some plant functional types to climate change. On the other hand, nitrogen deposition, the enhanced potential for invasion by exotic species (that may benefit more than slower growers in more productive environments) or the promotion of more competitive native species may change competitive interactions in plant communities, yielding novel patterns of dominance and ecosystem function.
Abiotic disturbances for forests are likely to increase, although expected impacts are regionally specific and will be substantially dependent on the forest management system used. A substantial increase in wind damage is not predicted. In northern Europe, snow cover will decrease, and soil frost-free periods and winter rainfall increase, leading to increased soil waterlogging and winter floods. Warming will prevent chilling requirements from being met, reduce cold-hardiness during autumn and spring, and increase needle loss and limit seed reproductive success.
Frost damage is expected to be reduced in winter, unchanged in spring and more severe in autumn due to later hardening, although this may vary among regions and species. The risk of frost damage to trees may even increase after possible dehardening and growth onset during mild spells in winter and early spring. Increased temperatures and reduced precipitation, combined with abandonment of forest management, appear to be increasing fire frequency and severity, duration and intensity of the wildfire season in the Mediterranean. Climate-induced shifts in vegetation, associated with changes in fuel characteristics, such as dominance of shrubs over trees (Lindner *et al.*, 2007) can amplify fire spread. Nonetheless, CO_2 fertilization might diminish fire risk due to increased water use efficiencies of plants, thereby reducing the demand for water uptake from the soil and increasing litter moisture.
Fire danger is likely to also increase in central, eastern and northern Europe. This, however, does not translate directly into increased fire occurrence or changes in vegetation. In the forest-tundra ecotone, increased frequency of fire and other anthropogenic impacts are likely to lead to a long-term (over several hundred years) replacement of forest by low productivity grassy glades or wetlands over large areas. The range of important forest pests may expand northward.
Finally, as the biosphere and the atmosphere are a coupled system, changes in the structure and function of terrestrial ecosystems, as expected under a changing climate, may in turn feed back to climete, both positively and negatively. These feedbacks are mediated through changes to albedo (Euskirchen *et al*. 2010), altered carbon cycle dynamics (Phillips *et al*. 2009), energy fluxes and moisture exchange, resulting in increased fires.

Conclusion

Upcoming negotiations on a post-2012 agreement provide an opportunity to reassess and simplify the inclusion of LULUCF mitigation activities in next international climate change regime. Progress is being made on addressing forest management accounting provisions, including a proposal to rationalize and increase transparency in setting possible reference levels for forest management. The treatment of harvested wood products and natural disturbances, particularly extreme events, are also under discussion within the context of forest management, as is the voluntary versus mandatory nature of Article 3.4 additional activities, and the possible inclusion of more activities (e.g., wetland management). Negotiators are also considering broadening the scope of LULUCF activities that are eligible under the CDM. Proposals to expand the scope to include REDD (reducing emissions from deforestation and forest degradation), wetlands, sustainable forest management and reforestation of 'forests in exhaustion' are being debated. Opportunities to implement REDD policies include simplifying procedures, developing certainty over future commitments, reducing transaction costs, building confidence and capacity among potential buyers, investors and project participants; setting harmonized standards for forest-carbon credits, which include rules for profit-sharing with indigenous communities or local landowners, monitoring and verifying credits and protecting biodiversity.

A key factor for encouraging the forestry sector to play a greater role in helping cut atmospheric GHG concentrations is the creation of an institutional framework that values forestry carbon offsets. Though, current policies reveal that the prospects for European forest owners to valorise the carbon sequestration service under current regulations and schemes are limited at the moment.

At EU scale, policy does not seem to be very coherent with regard to the use of forest sinks in climate change policies and measures. Already the diverging attitudes towards the election of forest management according to Art.3.4 of the Kyoto protocol reveal some inconsistency between member states in this regard, which may also be correlated with diverging interests between different EU directorates (specifically those for agriculture and environment), as well as between the respective ministries at national level. While an EU decision to include LULUCF carbon credits in its ETS is still lacking, selling LULUCF credits on the regular Emissions Trading market will not be doable in the near future. Furthermore, under the current institutional framework LULUCF credits appear in the national GHG accounts and serve to help Member States comply with GHG abatement commitments at national level. In this respect, aggregate property rights for carbon sequestration by forests rest implicitly with governments.

Voluntary carbon markets may offer an alternative for marketing the sequestration service of forest enterprises. However, due to the limited prices for carbon units, this alternative may be regarded as an opportunity for additional income rather than an incentive to prioritise carbon sequestration as the main product. Two problems remain to be solved: the high transaction cost associated with the monitoring, verification and certification, and marketing of carbon units; the lack of market transparency with regard to quality and reliability of voluntary carbon certificates, which in the long run could sap the market participants' confidence in this kind of product (Ciccarese *et al.*, 2011).

Even if net global carbon emissions are controlled and reversed by mid-century, it could take centuries for atmospheric carbon levels and temperatures to stabilise. In this regard, adaptation (which refers to efforts to reduce the vulnerability and increase the resilience of natural and human systems to the impacts of climate change) has a new and pressing dimension. Specific adaptation responses might comprise: reducing the impact of stresses that can exacerbate the effects of climate change (wildfire, insects, air pollution, etc.); intensifying measures to prevent and control the expansion of invasive species; avoid or reducing obstructions to species migration; helping forests regenerate after large-scale disturbances (forest restoration); taking historical climate changes into account in planning forest management; considering the future impacts of climate change in selecting genotypes and planting stock types, and choosing planting methods.

Meeting the adaptive forest management challenge needs support from the research sector, called to provide more reliable climate change models at regional scale and to better understand forest vulnerability to multiple stresses and to find ways to enhance forest resilience.

Decision making where and how to allocate scarce funding to conserve plants (and animals) in a changing and uncertain climate is a challenging issue

(Lawler *et al.*, 2011). A key issue is to identify the most effective mix of conservation measures based on the level of available spending.

In the long-term, carbon will only be one of the goals that drive forest management and land-use decisions. Within each region, local solutions have to be found that optimize all goals and provisions of forests goods and services and aim at integrated and sustainable land use.

Notes

1 The 2010 average annual concentration of CO_2 in the atmosphere, 389.78 parts per million (ppm), has risen about 23% since 1958, according to the U.S. National Oceanic and Atmospheric Administration. For the past decade the average annual increase is 2.04 ppm per year.

2 The ranges of these estimates arise from the use of models with differing sensitivity to greenhouse gas concentrations.

3 This amount is on the order of the amount in the atmosphere (800 Gt).

4 Under the Kyoto Protocol 38 industrialised countries (listed in Annex I to the UNFCCC) have committed themselves to reduce national anthropogenic GHG emissions by at least 5.2% below 1990 levels, within the first commitment period (2008-2012).

References

[1] Christensen J.H. *et al.* (2007). Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon S. *et al.*, eds)]. Cambridge University Press. Cambridge, UK.

[2] Ciccarese L. *et al*. (2011). Emergence of innovative market opportunities due to carbon sequestration in EU forest enterprises?: 131-53. In: Innovation in Forestry: Territorial and Value Chain Approaches, edited by G. Weiss, P. Ollonqvist, D. Pettenella, B. Slee. 344 p. Wallingford (UK). CABI. ISBN-13: 978 1 84593 689 1.

[3] EEA (2011). Greenhouse gas emission trends and projections in Europe 2011. Tracking progress towards Kyoto and 2020 targets. EEA Report No 4/2011, Luxembourg: Publications Office of the European Union, 2011. ISBN 978-92-9213-224-8. 147 p.

[4] Euskirchen E.S. *et al.* (2010). The changing effects of Alaska's boreal forests on the climate system. Can. J. For. Res. 40: 1336–1346.

[5] Hannah L. *et al.* (2007). Protected area needs in a changing climate. Frontiers in Ecology and the Environment 5: 131–8.

[6] Houghton R.A. (2007). Balancing the Global Carbon Budget. The Annual Review of Earth and Planetary Sciences 35: 313-47.

[7] IPCC (2007). Climate Change 2007 - Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[8] Kellomaki S. *et al.*. 2008. Sensitivity of managed boreal forests in Finland to climate change, with implications for adaptive management. Phil. Trans. Roy. Soc. B: 363: 2341-51.

[9] KP (1997): Kyoto Protocol to the United Nations Framework Convention on Climate Change. URL: http://unfccc.int/resource/docs/convkp/kpeng.pdf

[10] Lawler J.J. (2011). Conservation for any budget. Nature Climate Change 1: 350–351.

[11] Lenoir J. *et al.* (2008). A Significant Upward Shift in Plant Species Optimum Elevation During the 20th Century. Science 320: 1768-71.

[12] Lindner M. *et al.* (2010). Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. Forest Ecology and Management 259, (4): 698-709.

[13] Malhi, Y. *et al.* (2009). Exploring the likelihood and mechanism of a climate-change-induced dieback of the Amazon rainforest. Science 2011 334 (6053) 230-232.

[14] Milada M. *et al.* (2011). Climate change and nature conservation in Central European forests: A review of consequences, concepts and challenges. Forest Ecology and Management 261 (4): 829-43.

[15] Nabuurs G.J. *et al.* (2007). Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[16] Phillips, O.L. *et al.* 2009. Drought sensitivity of the Amazon rainforest. Science 323: 1344-7.

[17] Reich P.B. (2011). Biogeochemistry: Taking stock of forest carbon. Nature Climate Change 1, 346–7.

[18] Schlamadinger B. *et al*. (2007): A synopsis of land-use, land-use change and forestry (LULUCF) under the Kyoto Protocol and Marrakesh Accords. Environmental Science & Policy 10 (4), 271-82.

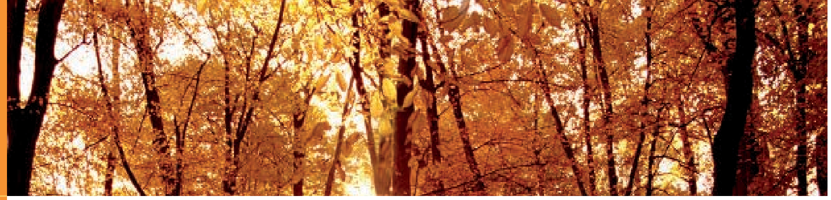
[19] Solomon S. *et al*. (2007). The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. ISBN 978-0-521-88009-1.

[20] Thuiller W. *et al*. (2005). Climate change threats to plant diversity in Europe. PNAS 102 (23): 8245–50.

[21] UNFCCC (1992): United Nations Framework Convention on Climate Change. URL: http://unfccc.int/resource/docs/convkp/conveng.pdf (23.8.2005)

[22] van der Werf G.R. *et al*. (2009). CO_2 emissions from forest loss. Nature Geoscience 2 (2): 737–8.

[23] Zhao M. and Running S. W. (2010). Drought-induced reduction in global terrestrial net primary production from 2000 through 2009. Science 20 (329): 940-3.



The role of forests in the international negotiation process of UNFCCC

Forests are crucial for climate change. The deforestation process is one of the main greenhouse gases emission sources in developing countries and it is also greatly important at the global level. New mechanisms to fight this process are under development and implementation at the national and international level. At the same time, the UNFCCC negotiation process seems to go through one of the main crises ever seen before. The real risk is that the Kyoto Protocol and maybe the entire UNFCCC process may collapse. In this context, forests may find a new role to move from one of the main causes of climate change to one of the most important potential solutions. In the view of the Rainforest Coalition, REDD+ could be the right key for this change

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Introduction

The forest sector is one of the main causes of climate change and also one of the main driving forces towards the solution path.

Through photosynthesis the flora removes the carbon present in the atmosphere as CO_2 and fixes it as organic carbon in its vegetal tissues. With crops this process takes a year cycle, consequently carbon may still be available as CO_2 for the next cycle, after biomass is burned or used as energy in biological systems. A tree lives for several years and this implies that the atmospheric CO_2 is fixed for a longer period, introducing the important aspect of carbon storage in the forest biomass.

The quantity of stored carbon is very important in the carbon cycle's dynamics. The European forests are *per se* able to remove around 870 million t of CO_2 annually, a quantity approximately correspondent to 10% of the GHG (greenhouse gas) emissions in 2008[6].

With deforestation this capacity is lost and the result is an indirect increase of CO_2 in the atmosphere: for this reason deforestation could be formally considered as a source of CO_2.

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Forest in the unfcc negotiation process

Not only may the forest cause a reduction in the net capacity to fix CO_2, but also the whole change in land use (i.e., from forest to graze or from graze to agriculture) These situations are considered as LULUCF (Land Use and Land Use Change and Forestation) in the UNFCCC context, the United Nations negotiation process on climate change. At the global level the emission generated by LULUCF is almost 20%[1] of the global GHG emissions.

Therefore, it should not surprise to know that LULUCF played and is still playing a key role for an international climate treaty, but probably it is not as much known that it was very important for the first Kyoto Protocol process too.

The opposition of the USA to the Kyoto Protocol started before the negative vote of the Senate that blocked the ratification of the document. During the process of development of the Protocol, the USA negotiators clearly demonstrated their disagreement about the way it was decided to account the biomass carbon stock in developed countries, the so called Activity Based approach. The USA preferred the Land Based approach, asking all developed countries to consider their entire national area, in order to have a reliable description of the reality.

The Activity Based approach allows developed countries to decide which area to initially take into consideration during the definition of the baseline for LULUCF. The area under activities shall be monitored during the years in order to track any increase or decrease in stored amount of CO_2. On the one side, this approach could be helpful in a first phase of implementation due to the lack of data that can make hard a complete account of all emissions and removals from the whole territory of the country.

On the other side, the risk is that each country applies a sort of selection on the areas where they may obtain benefits. As a consequence, when a country accounts areas where the forest has grown but it doesn't consider where the situation has worsen it will describe a better situation than it actually is. The creation of a benefit in the total GHG amount of a country that does not correspond to the real situation is called "hot air".

The decision to apply the Land Based or the Activity Based approach was very crucial during the development of the Kyoto Protocol but Kevin Conrad, the chief negotiator for the Papua New Guinea delegation in UNFCCC, believes this problem is not yet solved in the actual critical phase of the negotiation for the second commitment period of the Kyoto Protocol. In an interview of June 2010 he declares: "LULUCF is the biggest escape clause in the entire UNFCCC. It is a very serious issue. You can call it fraud or you can call it whatever you want, but the fact is that the rich countries are allowed to pick the area of forest they want to account and ignore the area of the forest where they are cutting trees. This has such significant impacts that Russia has said: *"If you make me honest on the forest we have to cut our target from 30% reduction to 15%"*, so they have to make a 50% change. We say they are cheating in the forest area. We, as developing countries, have to pledge to be far more honest than the rich countries. We agreed already on the international accounting, whereas the rich countries have not"[16].

Mechanisms to fight deforestation in developing countries

In developing countries the context is different because in their case the risk is not to hide the real situation in order to have a benefit in the reduction target as it is for developed countries. Here the problem is normally the high deforestation rate and the need to establish an economic tool able to stop or reverse the deforestation process. The financial support from developed countries is fundamental because it is not enough to spread out the idea that forests have an international value for climate change if this idea is not economically supported in order to help populations living in those areas in view of poverty eradication.

It is important to introduce a new and more effective system to financially support developing countries to preserve their forest.

In the past, often the financial support was directed to reforest areas previously interested by deforestation activities. As usual, working on the outcomes of a problem is not so effective as acting on its cause and this approach was not really able to reduce the international deforestation dynamics.

Therefore, a new approach was suggested in Bali during COP 13, the annual Conference of Parties in the UNFCCC. During this meeting, in 2007, it was decided to reduce the deforestation activities through a proactive approach. The basic idea is that forests have a worldwide value and that developed countries shall help developing countries to avoid any deforestation activity that may reduce the capacity of our "planet's lungs".

This mechanism is called REDD+ (Reduction Emissions from Deforestation and Forest Degradation)[5] and will be applied in developing countries. In Bali COP 13, Norway was very active and gave a big contribution to mould the REDD. In order to better show their intention and push the international context towards the creation of REDD+, the Prime Minister Jens Stoltenberg launched the NICFI, Norway's International Climate and Forest Initiative[8], during the UNFCCC Conference. Through this initiative, Norway offered 500 million dollars per year in bilateral agreements with some developing countries which have a very important coverage of forests like Mexico, Brazil, Guyana, Tanzania and Indonesia, through a multilateral cooperation with the UN-REDD Programme, the Democratic Republic of Congo (DRC), the Congo Basin Forest Fund (CBFF), Forest Investment Programme (FIP), Forest Carbon Partnership Facility (FCPF), as well as with scientific institutions and NGOs, such as ITTO REDDES and the Civil Society Support Fund[9].

This project turns out to be crucial in order to actively fight deforestation activities in developing countries and move the international negotiation context, although it doesn't seem to be so effective at the moment.

This is also the thought of Carlos Ritti, Responsible for WWF Brazil of the Climate Change and Energy Programme: "Until now the international cooperation is still moving slowly because the system is still very bureaucratic and the Brazilian banks lost time to give their approval to the projects"[18].

Strong difficulties for the unfccc

In June 2011, Norway hosted two important meetings in Oslo that confirmed the strong commitment of the Scandinavian country on the forest sector[17]. The first meeting was the European Ministerial Conference on Forests that achieved a very important result. In fact, during this meeting it was agreed to launch a negotiation process for the creation of a legally binding accord level and to adopt European target for 2020 in this sector[5]. The second one was an international meeting to update on the REDD+[10] progress.

Nevertheless, all these initiatives lose an important part of their effectiveness if they are not part of a larger international agreement and the only potential context for them at the moment is the UNFCCC. But times are not so healthy for the Convention and in the last few years it seems to have been rather a sick patient on the deathbed. In this situation the forest may play a very interesting role to assure a future to the Kyoto Protocol (KP)[7]. To better describe this potentiality it is, therefore, necessary to draw an overview of the negotiation process during the last five years.

The definition of the new reduction targets for developed countries in the second commitment period of the KP is a crucial item and it has been planned to start in 2006[11]. But during the COP 12 in Nairobi it was not possible to start any discussion on this matter, because positions of the parties were too distant. The only significant decision during COP 12 was to put the oxygen mask to the sick patient, postponing any decision on the KP at the next COP. In 2007, at the Conference in Bali, the situation started in the same way than in Nairobi, but at the end a decision arrived: to create a two-year period of specific negotiation, the Bali Road map. The two-year track should permit the definition of new reduction targets for developed countries, creating, at the same time, a new context, called LCA, where to define commitments also for developed countries that didn't ratify the KP (USA) and some adequate actions for the main developing countries. Another positive output was, indeed, launching the idea of financing the fight against deforestation through the REDD and the NICFI of Norway.

In Autumn 2008 G.W. Bush, probably the main opponent to a new legally binding agreement, lost the elections, but the new President Barack Obama was not yet in charge in December during the COP14. The USA

went to Poznan with a delegation that followed the old USA Presidency's instructions and the real consequence was that a progress was not possible and another year was lost.
Later on, in 2009, the COP 15 took place in Copenhagen with very high expectations, if considering that it was the conclusion of the Bali Road Map[12]. The entire world was waiting for a new international agreement but the Conference was able to produce only an enormous failure[13]. The only positive thing was the attention that all the media and citizens paid to climate change and the attendance at the COP of almost the totality of Prime Ministers and Chiefs of State of the world. At same time, this was part of the reason why the Conference failed. In fact, all expectations were addressed to the actions of Prime Ministers but some of them started a parallel negotiation process and discussed the solution in very small groups, without taking into consideration all the work done in the past by the official delegations.
At the end, the mountain roared and brought forth a mouse in the Copenhagen Accord[14], somehow more an obstacle rather than an improvement for the negotiation work in the following years.
During 2010 not only the KP, but the entire process of UNFCCC could have, in some way, collapsed because it seemed unable to produce any effective results[15].
Probably this situation helped reach a partial agreement[2] in Cancun, during the COP 16, where a positive output arrived for technology transfer and financing, with some progress for the REDD+ too, but still nothing for the future of the KP.
The next step is the COP 17 in Durban from 28 November to 9 December 2011, and it should be the final stop for the KP. The first commitment period expires in 2012 and if a decision for the second commitment period for the KP doesn't come, our patient will not survive. The actual perspective seems not to be so positive for the strong opposition of Canada, Russia and Japan. What seems possible is that some Parties, probably the EU and maybe Australia, can offer some extra time to the KP. A new oxygen mask of two or three years to our patient, expecting some more positive changes in the USA, where now the Senate doesn't show any intention to come to any kind of legally binding agreement, or the result of the V IPCC Assessment Report, where it is highly probable to find a strongest message of urgency.

A solution may come from the forest

The "extra time" option is not so attractive for developing countries interested in having a full agreement for the second commitment period of the KP, the only internationally legally binding document on climate change, and they are trying to find some other solutions to revitalize the KP.
In such context, space was given to the proposal of the Coalition for Rainforest Nations[3], a worldwide group of countries inside the UNFCC particularly interested in forests.
Federica Bietta, Deputy Director of the Coalition, thinks that their proposal may be the bridge between who is in and who is out of the KP. "In Mexico started Phase 1 of countries' preparation for REDD+, now we are in the implementation phase, but it is with Phase 3 of full application that forest may play a strategic role for the future of KP. It is now important to move forward to the idea to have formal commitments only from developed countries, but there is no doubt that developing countries should be helped with financial support. Our idea is to introduce in the second period of KP the commitment to fight deforestation adopted at national level. In this way it is possible to obtain the double result to have more transparency in the developing countries commitment and more ambitious emission targets from the rich countries.
Actually we have several positive feedbacks and we are looking with optimism to the next COP in South Africa"[19].
Ms. Bietta does not meet the requests of the most problematic countries in the direction of this proposal,

but it is possible to imagine that the emerging economies, as China, could in some way be worried that a big flow of money may move from the existing projects like CDM (Clean Development Mechanism) to the forest sector.

But deforestation is still on the daily agenda

Whilst negotiations on this issue is frenetic and may open a new door for a successful future to the KP, some troubles are involving other emerging economies, like Brazil.

A new proposal of law, the Forest Code, has passed by the Low Chamber and it is now stopped before being voted by the Senate. A big movement of associations, including the 10 previous Environmental Ministers, is fighting in order to obtain the withdrawal or a strong modification of the law, because otherwise there is the serious risk that deforestation, after the minimum level achieved in 2010[4], starts growing again.

And what is on the table is something really critical to the planet. "The destruction of the Amazon forest could cause a strong consequence for the fight on climate change", says Carlos Ritti, "with the risk to nullify the strongest commitment of developed countries"[18].

The option for President Dilma Roussef to use the veto power for this law is supported from 79% of the Brazilians, but everyone hopes that in the end she won't have to use it, the law having been changed in advance.

At the end of 2011, it seems that forests are playing a crucial role in tackling climate change as they have never done before. The last months of the International Year of Forests will show if this will happen in a positive way, giving forests the role they deserve.

References

[1] CAIT WRI – Dati su emissioni di GHG - http://cait.wri.org/cait.php?page=sectors

[2] Cancun agreement, UNFCC, Cancun December 2010 http://unfccc.int/meetings/cop_16/cancun_agreements/items/6005.php

[3] Coalition for Rainforest Nations - http://www.rainforestcoalition.org/

[4] Deforestation rate in Brazil, 1988-2010 - http://www.mongabay.com/brazil.html

[5] Forest Europe Ministerial Conference, Oslo 14-16 June 2011. http://www.foresteurope2011.org/

[6] FOREST EUROPE, UNECE and FAO 2011: *State of Europe's Forests 2011. Status and Trends in Sustainable Forest Management in Europe.* Ministerial Conference on the Protection of Forests in Europe FOREST EUROPE Liaison Unit Oslo, 2011.

[7] Kyoto Protocol - http://unfccc.int/resource/docs/convkp/kpeng.pd

[8] NICFI – Norway - http://www.regjeringen.no/en/dep/md/Selected-topics/climate/the-government-of-norways-international-.html?id=548491

[9] Norad (Norwegian Agency for Development Cooperation) – *Real-Time Evaluation of Norway's International Climate and Forest Initiative* – Contributions to a Global REDD+ Regime 2007-2010 – Rapporto di valutazione 12/2010.

[10] Oslo REDD Exchange 2011, Oslo 23-24 June 2011 - http://www.osloreddexchange.org/

[11] Pernigotti D. – *Conversando con… Rajendra Kumar Pachauri* - Unità, 19 agosto 2009.

[12] Pernigotti D. – *Intervista a Yvo de Boer. Sono ottimista. A Copenhagen si farà l'accordo sul clima* - Unità, 6 dicembre 2009.

[13] Pernigotti D. – *Il punto –Il fallimento, il prezzo della Cina* - Unità, 20 dicembre 2009.

[14] Pernigotti D. – *L'accordo non c'è. Ma si "prende nota"* - Unità, 20 dicembre 2009.

[15] Pernigotti D. - *Con o senza Copenhagen, da Bonn riparte il trattato sul clima* - Il Sole 24 ORE online, 10 aprile 2010.

[16] Pernigotti D. – *Quel che resta di COP 15* – Radio 24- Reportage, 10 luglio 2010.

[17] Pernigotti D. – *È l'anno mondiale delle foreste ma non c'è accordo per salvarle* - Unità, 25 luglio 2011.

[18] Pernigotti D. – *Amazzonia a rischio. Scontro in Brasile sulla deforestazione* - Unità, 12 agosto 2011.

[19] Pernigotti D. – *Salvare gli alberi può salvare anche il Protocollo di Kyoto* - Unità, 12 agosto 2011.

[20] UN-REDD - http://www.un-redd.org/AboutREDD/tabid/582/Default.aspx

A European forest biodiversity status indicator

The European Environment Agency has released the Report "Development and harmonization of a Forest Status Indicator (FSI)", entirely developed by the Corpo Forestale dello Stato – Italian Forest Service (CONECOFOR Service), on the basis of a grant from the Agency in the framework of the Pan-European Process for the Implementation of Biodiversity Indicators SEBI2010, aimed at implementing the International Convention on Biological Diversity in Europe.

The objective of the report is to implement a new European forest biodiversity status indicator (FSI) obtained through the elaboration and synthesis of current metadata and methodologies at European level. In particular, the work involved detailed collection of the metadata and harmonized methods available in European Networks. The following step was based on SEBI2010 (EG6) sub-indicators, developed progressively at the time of this study (naturalness, deadwood, tree condition, structure, vegetation) and their use as parameters of forest biodiversity in FSI. The last phase of the elaboration is a synthesis and interpretation of FSI parameters, expressed through "radar" graphs. Finally, simulations for a graphic representation of FSI were designed for two metadata collections: one for Italy and one for Slovakia, Spain and Germany.

FSI is based on qualitative attributes of the forest ecosystem, essential to evaluate the quantitative results of other biodiversity indicators, e.g., giving the correct significance to the observed trends in forest types cover. Nowadays, FSI is ready to be included and combined into the SEBI2010 headline macro-indicator "Trend in extent and composition of selected ecosystems"

■ *Bruno Petriccione*

Introduction

The *Pan-European Biological and Landscape Biodiversity Strategy (PEBLDS)* was developed to support implementation of the UN Convention on Biological Diversity at pan-European level, on the initiative of the Council of Europe (CoE) and the United Nations Environment Programme (UNEP). In this framework, the biodiversity resolution passed by the 5th Conference of the European Environment Ministers "Environment for Europe" (Kiev, 2003) includes a key target to develop a core set of biodiversity indicators by 2006 and to establish a pan-European biodiversity monitoring and reporting programme by 2008, with a framework of collaboration with the Ministerial Conference on the Protection of Forests in Europe (MCPFE). A pan-European Co-ordination Team, formed by the Euro-

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pean Environment Agency (EEA), UNEP World Conservation Monitoring Centre (UNEP-WCMC), European Centre for Nature Conservation (ECNC) and the Expert Group leaders has been operating since 2004, having initiated its work by collecting available information. The elaborated work plan provides the logical framework for the activities required in order to ensure European coordination of the development and implementation of biodiversity indicators. The indicators will be applied in assessing, reporting on and communicating achievement of the 2010 target to halt biodiversity loss. This activity is called *Streamlining European 2010 Biodiversity Indicators (SEBI2010*, European Community Biodiversity Clearing House Mechanism, 2006).

In this framework, an overall headline indicator called *Trend in extent and composition of selected ecosystems* has been developed by the SEBI2010 Expert Group 2. A specific *Forest Area Indicator* is ready for implementation, mainly based on quantitative data (trend of forest area, considering forest types), but for proper understanding and evaluation it needs to be complemented by a qualitative indicator taking into account the status and trends of key characteristics of forest ecosystems, a *Forest Status Indicator (FSI,* Petriccione et al., 2007).

Results

FSI, entirely developed by the Corpo Forestale dello Stato – Italian Forest Service (CONECOFOR Service) on the basis of a grant from the European Environment Agency, is based on the detailed collection of available metadata and harmonized methods (EU Forest Focus & UN/ECE ICPs, National Forest Inventories, Natura2000 National Reports, MCPFE Reports, etc.). It consists of a synthesis of surrogate measures (sub-indicators) for biodiversity (tree condition, deadwood amount and type, plant species composition, etc., Fig. 1) per forest type in Europe, with the aim of evaluating the results provided by the Forest Area Indicator, taking into account concepts like the quality, functionality and integrity of forest ecosystems. It will be based on sub-indicators identified at pan-European level (4th Ministerial Conference on the Protection of Forests in Europe, MCPFE) and implemented at pan-European (EU Forest Focus & UN/ECE ICP Forests) and National level (NFIs), as follows:

(1) EU Forest Focus & UN/ECE ICP Forests Level I: tree condition data on ca. 3000 points, since 1985 (continuously for 20 years); forest structure, deadwood and plant species composition on ca. 6000 points, since 2007 (pilot project BioSoil);
(2) EU Forest Focus & UN/ECE ICP Forests Level II: tree condition data on ca. 700 plots and plant species composition on ca. 500 plots, since 1995 (continuously for 10 years); deadwood data on ca. 100 plots, since 2006 (pilot project ForestBIOTA, Petriccione, 2004, Ferretti et al, 2006);
(3) National Focal Points: tree species composition and deadwood data from a number of NFIs all over Europe;
(4) Natura2000 National Reports: "conservation status" of a number of SCIs (47% of them including forests) all over Europe;
(5) MCPFE Reports and National data: "protected forests" amount.

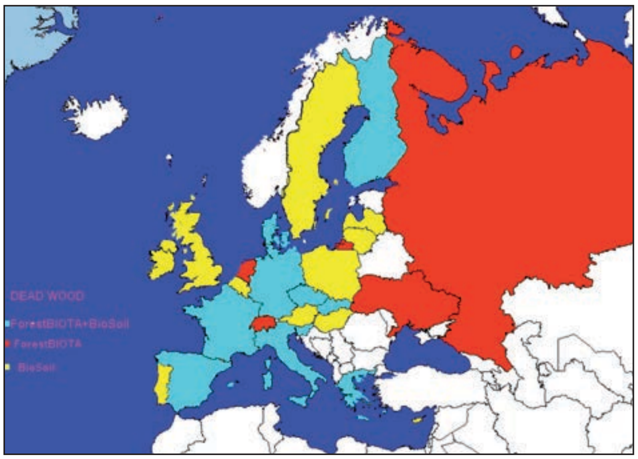

FIGURE 1 Deadwood: meta-data availability in the CoE Countries (EU/ICP Forests Lev. I and II)
Source: Petriccione et al., 2007

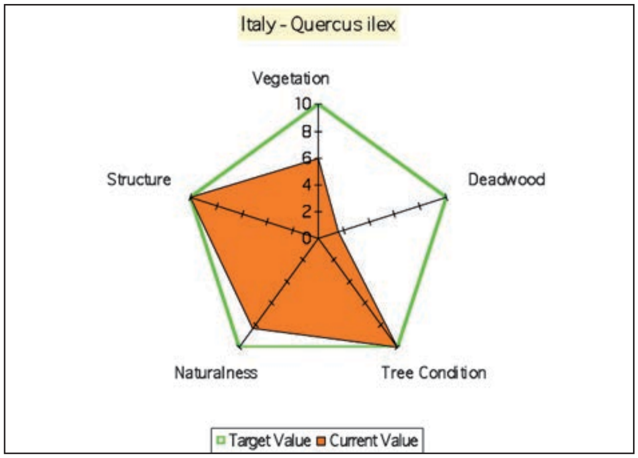

FIGURE 2 FSI radar diagram (*Quercus ilex* forest plots in Italy)
Source: elaborated from 2005 original data, Ferretti et al., 2006, Petriccione, 2004

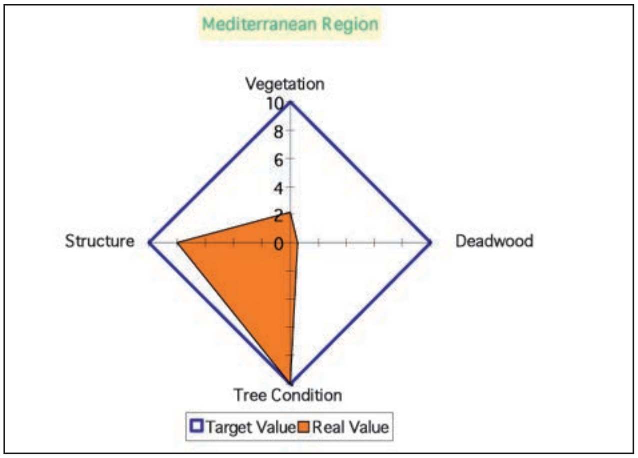

FIGURE 4 FSI radar diagram (*Quercus ilex* forest plots in Italy and Spain)
Source: Petriccione et al., 2007

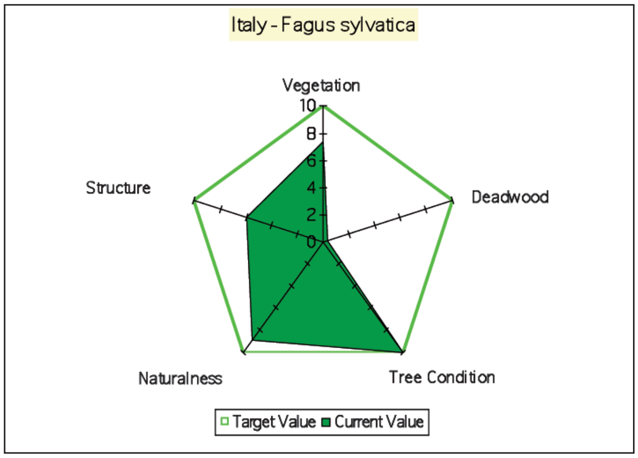

FIGURE 3 FSI radar diagram (*Fagus sylvatica* forest plots in Italy)
Source: elaborated from 2005 original data, Ferretti et al., 2006, Petriccione, 2004

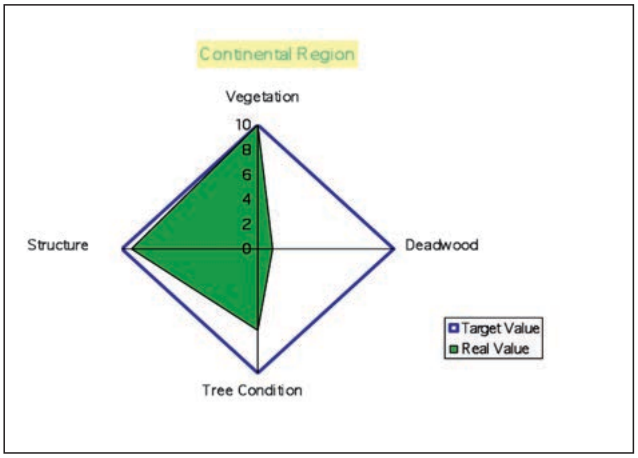

FIGURE 5 FSI radar diagram *(Fagus sylvatica* forest plots in Italy and Germany)
Source: Petriccione et al., 2007

Data are organized according to a revised and improved version of FTBA (*BEAR Forest Types for Biodiversity Assessment*), recently released by EEA.
The indicator is represented by radar diagrams including all sub-indicators/forest types/year (each diagram per each available year). Changes in the time and "distance" from target values can be easily recognized by the change in shape of the diagrams. Some examples, related to the Italian *Quercus ilex* and *Fagus sylvatica* forest plots, is reported in Fig. 2 and 3.
Testing of the developed methodology has been done on three key forest types (*Picea abies, Fagus sylvatica* and *Quercus ilex*-dominated forests), across three biogeographical Regions (data from EU/ICP Forests Lev.

II plots participating to the pilot project ForestBIOTA):

- Alpine Region (Picea abies forest): data from Italy, Germany and Slovakia;
- Continental Region (Fagus sylvatica forest): data from Italy and Germany (Fig. 4);
- Mediterranean Region (Quercus ilex forest): data from Italy and Spain (Fig. 5).

Conclusion and perspectives

FSI developing meets the requirements of SEBI2010 delivering data on changes over time of some key attributes of forest ecosystem in Europe; the emphasis on the qualitative aspects of biodiversity is a policy fundamental to the management of the environment. Most data is harmonized at Pan-European level; in some cases they cover a period of 20 years, according to a systematic network which accurately represents all Europe and are easily available from international bodies (EU & UN-ECE). There is the possibility for up- and down-scaling of data collected at Level I and Level II. FSI is based on broadly accepted sub-indicators, it is very sensitive, being able to detect changes in the timeframes and on the scales important to decisions. It can be updated regularly, if adopted at European level, on the basis of routine monitoring programmes. The available data are consistent in space and cover most EEA countries. The FSI, based on quantitative attributes of forest ecosystems, has been included in the SEBI2010 indicators, in the area *Trend in extent and composition of selected ecosystems.*

References

[1] *European Community Biodiversity Clearing House Mechanism* (2006). *SEBI2010.* http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995

[2] Ferretti. M., Petriccione. B., Fabbio. G. and Bussotti, F. (ed.) (2006). *Aspects of biodiversity in selected forest ecosystems in Italy: status and changes over the period 1996-2003*. Third report of the Task Force on Integrated and Combined (I&C) evaluation of the CONECOFOR programme. Annali Istituto Sperimentale per la Selvicoltura, Special Issue (Arezzo) 30, Suppl. 2: 107-111.

[3] Petriccione, B. (2004). *First results of the ICP Forests biodiversity test-phase in Italy*. In: Marchetti, M. (ed.). Monitoring and Indicators of Forest Biodiversity in Europe. From Ideas to Operationality. EFI Proceedings 51: 445-454.

[4] Petriccione, B., Cindolo, C., Cocciufa, C., Ferlazzo, S. and Parisi, G. (2007). *Development and harmonization of a Forest Status Indicator (FSI)*. Technical Report of SEBI2010 special ad hoc project (Italian Forest Service, CONECOFOR Board). European Community Biodiversity Clearing House Mechanism, EEA, Copenhagen. 50 pp. http://biodiversity-chm.eea.europa.eu/news/news266459

Future scenarios of European forests

Scenarios that are based on contrasting storylines can be used as a tool to explore the different ways in which the future may develop and their impacts on the sustainability of European forestry. These scenarios are neither predictions nor forecasts, but are used to create a consistent image of a future, and to help decision makers and other actors in making well informed choices. Each storyline assumes a distinctly different direction for future developments. Here we discuss characteristics of scenario studies in general, and focus on few recent trends and their long term impact on European forests as, e.g., nature oriented management, carbon credits, and extra demand for bioenergy

Gert-Jan Nabuurs

Introduction

European forests cover 36% of the European land area, and they fulfil a multitude of functions; from wood production to nature conservation, climate mitigation, water protection, etc. It's this multitude of functions that is achieved by a huge variety of forest owners and national legislations that make these forests unique in the world. Europe namely went through a centuries long period of deforestation and degradation which already started before the Roman Era. Then in Medieval times, wood became a scarce product in many regions, resulting in the first ideas of a sustainably managed forest as published by Von Carlowitz (1713). This has resulted in many new plantings and also after WWII large scale restoration and afforestation took place in a time when resources were needed. This has yielded us the present day vast area of forest, still increasing in area and amount of wood.

Until quite recently, forests and forest policy have been regarded as a sovereign issue in Europe, with few international measures. This diversity also led to

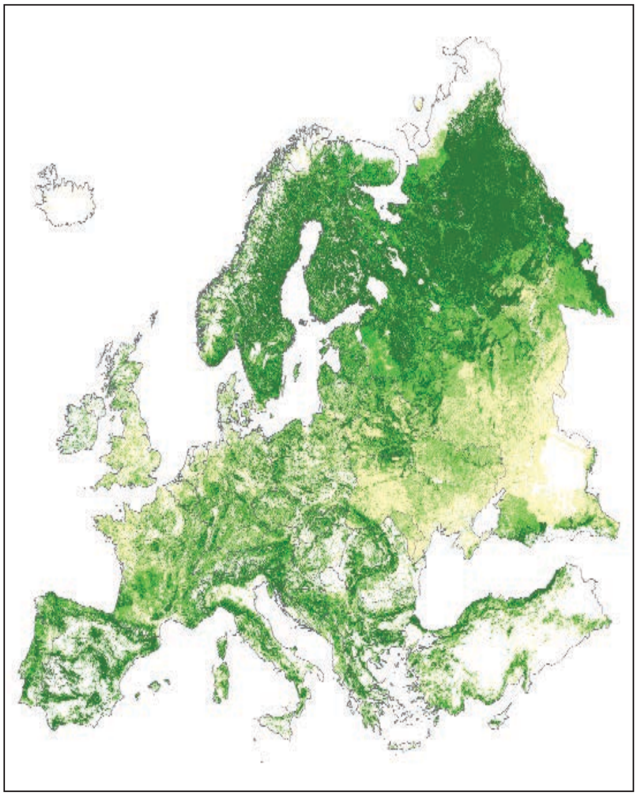

FIGURE 1 Forest probability map of European forests
The EU27 countries cover some 178 million ha; Europe's main form of land use.
Source: Gunia et al., 2011

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fragmentation in research, and a concentration on national ecological and silvicultural aspects. Now, however, we stand for ever larger and more complex forest-related issues, that are cross sectoral, and require a multi-national effort. Only with this multi-national and interdisciplinary effort the required innovation in forest and forest products research can take place. Scenario studies are one way of gaining insight in alternative futures of European forests.

Characteristics of Scenario studies in general

By 2050 the world will have changed in ways that are difficult to imagine – as difficult as it would have been at the end of the 19th century to imagine the changes of the following 100 years. Scenarios that are based on contrasting storylines can be used as a tool to explore the different ways in which the future may develop and their impacts on the sustainability of European forestry.

These scenarios are neither predictions nor forecasts, but are used to create a consistent image of a future, and to help decision makers and other actors make well informed choices (Arets et al.2008). Each storyline assumes a distinctly different direction for future developments, and does not necessarily aim to be realistic. Conclusions should not be drawn from these storylines.

A set of scenarios aims to describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. These drivers cover a wide range of key characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of *current* economic, technological, and social trends.

Reference futures (a baseline) and policy scenarios should be separated. Reference futures are 'benchmark' scenarios with dynamics, but without major policy interventions. Then subsequent comparison with policy scenarios enables the assessment of the effect certain policies will have.

Since driving forces can take different directions, it is better to develop multiple baseline scenarios. It is not recommended to use three alternatives because practice shows that policy makers then tend to focus on the middle scenario, which is believed to be the most realistic (Alcamo 2001).

In 1996 the IPCC decided to develop a new set of emission scenarios that are described in the Special Report on Emission Scenarios (SRES) (IPCC 1997). This set of scenarios is now known as the SRES scenarios, which were used by the IPCC for their third and fourth assessments. The scenarios are mostly developed for energy system parameters and related emissions. The underlying 4 reference futures, however, provide consistent storylines on the development of drivers like population growth and economic development in the future.

Developments in the multi sectoral surroundings

Forests have to play their role in mitigating climate change, in providing biomass for bio energy, in pro-

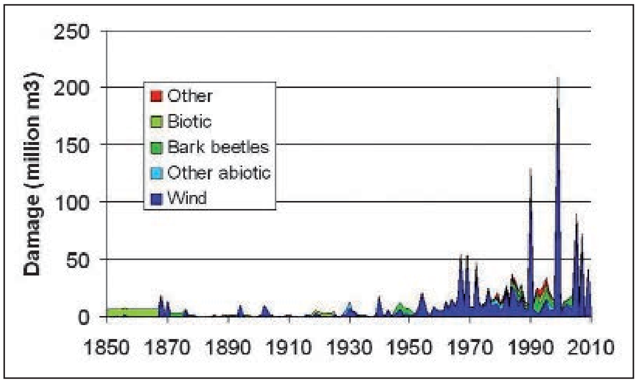

FIGURE 2 Total damage due to disturbances in Europe
Insight in future development of these disturbances will help decision makers make the right choices. Scenario studies can provide that insight, as well as into multi sectoral causes of these disturbances.
Source: Schelhaas et al., 2008

viding jobs and opportunities in the rural areas of Europe, i.e., playing their role in the green economy. Furthermore, the vast land covered with forest needs to be managed sustainably and to protect soils and water, provide space for tourism, sequester carbon, and protect biodiversity. All this, under the impacts of climate change.

To meet these needs, changes in governance, institutions, and research structure need to take place in order to be much more innovative along the whole chain from genetics, to forest management, to harvesting, and via a variety of products, back to recycling. Also, the multi sectoral and integrated aspects need to stand out much more in research. Only then, the sustainability in all its aspects can be guaranteed.

At the international policy level, forest policy is moving to an international level in Europe. In June 2011, Ministers responsible for forests met in Oslo at the FOREST EUROPE Ministerial Conference on the Protection of Forests in Europe. They made the far-reaching decision to launch negotiations for a Legally Binding Agreement on Forests in Europe. This is a first step towards pan European forest legislation. Also the EU forest strategy is being revised. Maybe through these international policy measures, developments as the economic crisis can be turned into a break point for new developments of the forest sector.

The financial crisis which developed in autumn 2008 and the subsequent economic consequences namely have led to a fundamental shift within forestry and the forest industry sectors, the effects of which are being felt through the entire chain from forest to markets. Never, since the oil crisis in the 1970s, have the forest products markets experienced such a downturn. In response, some countries have implemented economic stimulus packages to tackle the crisis and to promote a move towards a greener economy.

Recently, attention has shifted towards economic objectives and the green economy: The wood and forestry sectors can make a significant contribution towards meeting green economy objectives, linked to climate change policies, mainly through the abatement of greenhouse gas emissions and expansion of renewable energy objectives. There are several main routes by which the wood and forestry sectors can contribute. These are sustainable wood consumption including certification and green buildings, a low carbon forest sector, creating green jobs, valuation of ecosystem services, and improved governance of the forest sector. Through this combined set of measures stimulated by government measures, and supported by research, the forest sector can really make its contribution.

Examples of scenario studies

Here, we touch upon some examples of scenario studies, and the tool by which they can be carried out. Scenario studies can be carried out in a multitude of ways, but in the last decades they are more and more carried out with computerized models, aided by a fast increase in synchronised data, at ever higher level of detail. These computerized models span a wide variety, from multi sectoral global integrated models as, e.g., IMAGE (Alcamo et al. 1998), and EURURALIS (http://www.eururalis.eu, Helming et al. 2010) to specific forest sector market models and to European forest resource models. The European Forest Information SCENario model (EFISCEN; (Sallnäs 1990, schelhaas et al 2007, Nabuurs et al. 2006) is a large-scale forest scenario model that projects forest resource development on regional to European scale (Eggers *et al.* 2008). Here we look into three scenarios as developed for European forests (see for further details Nabuurs et al. 2006) .

Nature oriented management

It was assumed that NOM is going to be important for European forestry in the future and will reduce a forest owner's willingness to supply, i.e., as a result of less dependency of the forest owner's income on the forest, and the valuation of other functions the average owner is assumed to supply less at the same stumpage prices. This reduction in supply willingness is incorporated for the 27 European countries as a combination of the following assumptions:

- longer rotations (20 years for long rotations, and 10 years for short rotation species (<60 years)). This was kept rather simple because of a lack of detailed information on how the management of each tree species may change under NOM;
- from total fellings an additional 10% must originate from thinnings/group fellings;
- thinning can only be carried out in forests with growing stocks over 150 to 300 m^3/ha, depending on the forest type. This is based on the assumption that non-commercial thinnings are not being practised anymore;
- a species change towards the more natural/indigenous species is incorporated as a 30 to 40% chance that species like spruce and pine will be regenerated with species like beech and oak. The accompanying assumption is that sufficient sites are available where this is a logical step;
- set aside from harvesting all beech and oak forests older than 150 years. Initially, this usually affects 1 to 1.5% of the total forest area in a country. Due to ageing of the forest during simulation, this area may increase to some 6-10% by 2060 depending on management regimes, felling levels, etc. These forest areas remain part of the simulation, but are simply not affected by harvesting anymore.

Carbon credits

Amount of new areas being planted due to Kyoto Protocol measures

Changes in forest areas are already taking place at the moment without any carbon credits being paid. The average annual net changes in the forest area during the period 1983-1993 were highest in France and Spain with, respectively, 61.6 and 86 thousand hectares annually. Belgium, Serbia & Montenegro and Albania had seen an overall decrease in forest area[2]. However, these are the net changes between the gross increases and decreases in forest available for wood supply (FAWS) and forest not available for wood supply (FNAWS). For the 27 countries under study, an average annual increase in FNAWS of 324,200 ha and in FAWS of 103,600 ha has been reported. Thus, there is an overall increase in forest area of some 0.3% but only part of it is available for wood supply.

It was assumed that Article 3.3 of the Kyoto Protocol will indeed stimulate the gross FAWS area expansion: from the current +103,000 ha per year to 290,000 ha per year (on average over the whole simulation period). This scenario assumption will increase the total forest available for wood supply in the 27 European countries from the present 134 million ha (in our database) to 150 million ha. This increase was assumed to take place mainly between 2010 and 2040 and to apply to the present forest area per country with some emphasis on pre-accession countries.

Likelihood that forest owners will be financially compensated for building up carbon (growing stock) in the existing forest.

Additional carbon credits can be gained from ‘forest management’ up to the maximum amount individually defined for each Annex I Party (available as annex to UNFCCC, 2001). As it is in line with a strong trend in forestry, owners may be interested in it, provided that it is paid for. Taking all this into consideration, as well as taking into account the high uncertainty level in outcomes of future international climate negotiations, it would be fair to assume that Article 3.4 may lead to a prolongation of rotation lengths by 10 years (irrespective of country or site). However, rotation length prolongation was mentioned under owner behaviour, NOM, and now under Kyoto Protocol issues. If forests were subjected to prolongation under all these issues, it might have resulted in assumed prolongated rotations of an extra 30 to 40 years. This seemed unrealistic and a total maximum of 20 years prolongation was assumed as a constraint.

Bio-energy

In the EU policy on bio-energy (EC 1997) the EU aims at doubling the contribution of Renewable Energy

Sources (RES) from a current 6% to 12% by 2010. The European Commission has designated biomass as an important Renewable Energy Source on top of the current consumption of roundwood and industrial residues of approximately 40 million m^3 y^{-1} in EU and EFTA countries. In 2005, the European Commission published a Biomass Action Plan (EC, 2005b), followed by a communication on an EU Strategy for Biofuels (EC, 2006). The Biomass Action Plan aims to increase biomass use to 150 Million tonne oil equivalents (in primary energy terms) in 2010 or soon after.

Due to the above mentioned RES policy, an increase in demand for wood fibres from forest resources for the production of bio-energy has already been recorded and it can be expected to increase further. The increased demand for roundwood, based on the EU Whitepaper, has been calculated to amount to approximately 92 million m^3 by 2010. Later, Lindner for EEA (2006) assessed an availability of environmentally compatible biomass from forestry of around 39 million tonne oil equivalent (~ 200 million m^3 from both stemwood and branches).

From the current state of implementation of the RES policy in Europe, it can be concluded that it is unlikely that the RES targets for woody biomass will be met within the intended time span. Adjustment of the time span or of the quantitative targets seem inevitable. An extra felling of 80 million m^3 of roundwood by 2025-2030, matches this requirement and is incorporated as an assumption in the 'new management trends' scenario. This additional fellings is distributed over the countries of study with respect to their current share in total fellings.

Combining all these trends mentioned above is called the new management trends scenario. Not applying these trends is called the 'projection of historical management' still with increased demand, stable demand is called 'benchmark'.

Results

Foremost, the results show that a large increase in supply can be achieved sustainably in European forests.

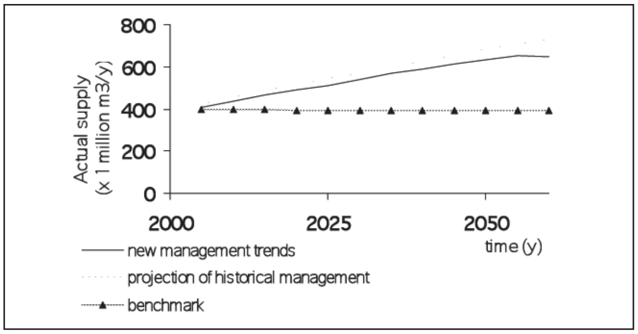

FIGURE 3 Actual supply under the various scenarios
Source: Nabuurs et al., 2006

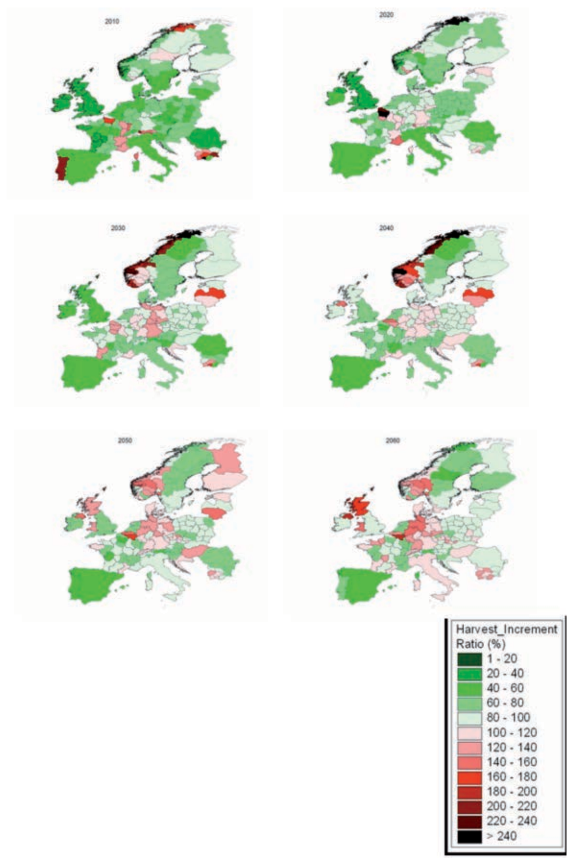

FIGURE 4 Felling over increment ratio in the new management trend scenario
Source: Nabuurs et al., 2006

The supply under 'new management trends' increased from 409 million m^3 y^{-1} in 2005 to 647 million m^3 y^{-1} in 2060. Under the projection of historical management, the supply increased to 729 million m^3 y^{-1} in 2060 (Figure 3). So, despite an 80 million m^3 higher demand, the new management trends give a reduction in actual fellings of 82 million m^3. Thus, in total a reduced supply or shortage of 162 million m^3 y^{-1} was found despite an increase in forest area of 16 million ha over a time period of 55 years in the new management trends scenario. When keeping the felling level very stable (Benchmark), the average growing stock rises from 188 to 287 m^3 ha^{-1}. Higher rates of mortality were found under these growing stocks.

The high supply levels were found within European forests, because we allow temporarily overharvesting in comparison to increment (Figure 4). Overharvesting occurs more severely in the 'projection of historical management' scenario. Still the average growing stock increases in this scenario. In all regions where overharvesting occurs (usually starting in 2040), this happens often with an increasing linear trend in time. This in contrast to the 'new management scenario', where overharvesting is severe in some regions in 2030 and 2040, but then declines again in 2050 because of the constraints taking effect, i.e., the available stock is used up in a certain decade.

In the new management trends scenario we quantified the large scale effect of management constraints. It becomes clear that effects of management changes like setting aside forests for nature reserves, tree species changes, and rotation prolongation have their influence on total fellings mainly in the long term (Fig 3). Namely only after 2050 the fellings, as achieved under 'new management trends', start to decline. Without the afforestations the decline in fellings would have been stronger, but still the afforestations did not fully compensate for the effect of the constraints.

When keeping the felling level very stable (Benchmark), the average growing stock rises strongest from 188 to 287 m^3 ha^{-1}. The age class distributions (Fig 5) also show a combination of effects of different measures. Although the aim of the 'new management trends' scenario was to enhance biodiversity by creating more old forests, this is only partly achieved. We can see in Figure 5 (bottom) that the area of forests older than 200 years has increased from 1.7 million ha in 2000 to 4.4 million ha in 2060. However, the average age has hardly increased because in this scenario we also try to increase fellings a lot in combination with prolongated rotations. This leads to more forest area in 2060 in the age classes 100 to 150, but leads to less forest area in the classes 150 – 200. That is, prolongating a rotation means that you have to find the same amount of wood, but in the older age classes! Figure 5 (top) shows, for the benchmark scenario (with simply a stable and rather low amount of fellings), that the ageing of the forest is much more pronounced in this case in the classes 80-200 years.

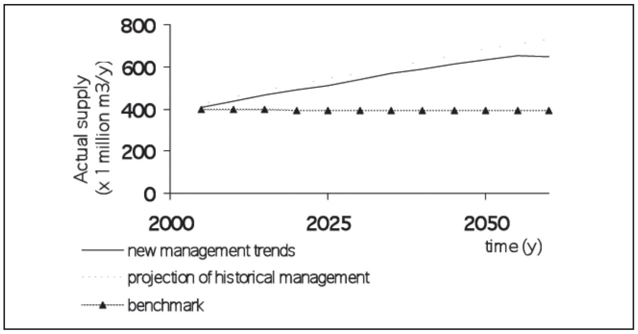

FIGURE 5 Age class distribution in 2000 and in 2060 of all European forests under simulation in the benchmark (*top*) and the new management trends scenario (*bottom*)
Source: Nabuurs et al., 2006

Concluding

Models and scenario analysis can provide a very powerful tool for explorative studies, provided they use reliable input data, and are based on thorough understanding of ecosystem functioning as well as of needs and demands from society (Mohren 2003). Large-scale scenario models in combination with land cover data provide a means for upscaling and expansion of stand-based approaches, and can be used to explore policy options and to show consequences of different management objectives. The usefulness of the results of such studies in a decision-making context depends as much on the quality of the research design as on the communication and dissemination of results to the stakeholders and decision-makers involved, whereby it should be made very clear that results from scenario studies should not be viewed as blueprints for future developments, but rather as explorations of possible futures.

Notes

1 This is not completely true anymore according to updated TBFRA data as published by UNECE/MCPFE's State of Europe's Forests, 2003.

References

[1] Alcamo, J. 2001. *Scenarios as tools for international environmental assessments*. Experts' corner report, Prospects and Scenarios No 5. Environmental issue report No 24, European Environment Agency, Copenhagen, Denmark.

[2] Alcamo, J., R. Leemans and E. Kreileman (eds), *Global change scenarios of the 21st century. Results from the IMAGE 2.1 model.* Pergamon & Elseviers Science, London. pp 296, 1998.

[3] Arets, E., T. Palosuo, A. Moiseev, G.J. Nabuurs, D. Slimani, C. Olsmat, J. Laurijssen, B. Mason, D. McGowan, D. Vötter. 2008. D 1.4.7. *Reference futures and Scenarios for the European FWC*. Eforwood deliverable to Brussels. 32p.

[4] European Commission (2005) *Communication from the European Commission on the Biomass Action Plan*, COM(2005)628.

[5] European Commission (2006). *Communication from the European Commission on An EU Strategy for Biofuels*, COM(2006)34.

[6] Eggers, J., M Lindner, S Zudin, S. Zaehle, and J Liski 2008. *Impact of changing wood demand, climate and land use on European forest resources and carbon stocks during the 21st century*. Global Change Biology 14: 1-18.

[7] Gunia, K. Et al. 2011 www.efi.int/portal/virtual_library/information_services/mapping_services/forest_map_of_europe

[8] Helming, J.F.M., Janssen, S., Meijl, van, H., en Tabeau. A., (2010). *Impact assessment of post 2013 CAP measures on European agriculture*. LEI report 2010/085. The Hague.

[9] IPCC 2000. *Special report on emission scenario*. IPCC. Cambridge University Press. 599 p.

[10] Nabuurs, G.J., J. van Brusselen, A Pussinen. M.J. Schelhaas. 2006. *Future harvesting pressure on European forests*. European Journal of Forest Research. 126: 391–400.

[11] Sallnäs, O., 1990. *A matrix growth model of the Swedish forest*. Studia Forestalia Suecica 183. Uppsala, Swedish University of Agricultural Sciences, Faculty of Forestry, 23 pp.

[12] Mohren, G.M.J. 2003. *Large-scale scenario analysis in forest ecology and management*. Forest Policy and economics. 5:103-110.

[13] Schelhaas, M.J., J Eggers, M Lindner, G.J. Nabuurs, A Pussinen, R Paivinen, A Schuck, P.J Verkerk, D.C. van der Werf and S Zudin. 2007. *Model documentation for the European Forest Information Scenario Model (EFISCEN 3.1.3)*. Alterra Report 1559. 118 p.

[14] Schelhaas, M.J., 2008a. *Impacts of natural disturbances on the development of European forest resources: application of model approaches from tree and stand levels to large-scale scenarios*. Dissertationes Forestales 56, Alterra Scientific Contributions 23.

[15] Von Carlowitz, 1713. *Sylvicultura oeconomica*.

[16] UN ECE/ FAO 2011. *The European Forest sector Outlook*. Study II 2010-2030. ECE/TIM/SP8. Geneva. 111 p.

The importance of EU forests for biodiversity conservation and ecosystem services

Forests are crucial for climate change. The deforestation process is one of the main greenhouse gases emission sources in developing countries and it is also greatly important at the global level. New mechanisms to fight this process are under development and implementation at the national and international level. At the same time, the UNFCCC negotiation process seems to go through one of the main crises ever seen before. The real risk is that the Kyoto Protocol and maybe the entire UNFCCC process may collapse. In this context, forests may find a new role to move from one of the main causes of climate change to one of the most important potential solutions. In the view of the Rainforest Coalition, REDD+ could be the right key for this change

Clunie Keenleyside

Ecosystem services provided by EU forests

The forests of the EU are just as important as farmland in terms of the area they cover and the range of services they provide but until recently their contribution to ecosystem services has received comparatively little attention. Europe's forests and other wooded land occupy 42% of the EU-27 land area, a total of 177 million hectares of which 89 million hectares are used to obtain wood and other products for the market (EC, 2011). These include sawn timber, wood-based panels, pulp for paper, cork, woodfuel for renewable energy, and non-wood products such as berries, mushrooms and wild game. All forests, whether harvested or not, have the capacity to provide a wide range of 'non-market' ecosystem services including the protection of soils and water and the storage and sequestration of carbon, all underpinned by the biodiversity of EU forests.

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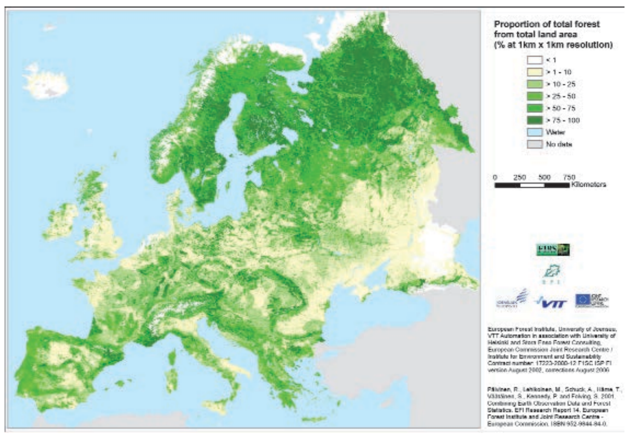

FIGURE 1 Forest land as proportion of total land area
Source: European Forest Institute, 2011

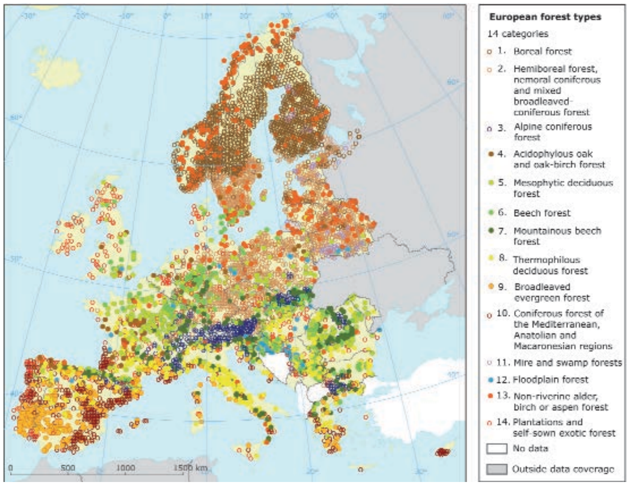

FIGURE 2 Main categories of European forest types
Source: EEA, 2008

The largest forest areas are found in Sweden, Finland, Spain and France but, as Figure 1 shows, some parts of Europe now have very little wooded land. In sharp contrast to concerns about deforestation in other parts of the world, forest cover in the EU has increased over the past few decades, as a result of public investment in afforestation and natural regeneration on marginal land. An area the size of Hungary has been afforested since 1990, and at the same time the volume of standing timber in the EU has been increasing too, not just because of the larger area of forests but because only about 60 or 70 per cent of the annual timber growth in the EU is harvested, and some forests are no longer managed.

There is great diversity in the forests of Europe, both in terms of the characteristic tree species (Figure 2), and the objectives for which they are managed. Three broad types of forest management can be described as:

- **mono-functional forests** managed for intensive production of a timber and other wood products; in some parts of the EU these are mainly plantation forests of non-native species;
- **multi-functional forests** managed to produce timber alongside ecosystem services (protecting air, soil, water, and carbon), biodiversity conservation and the provision of social benefits (cultural heritage, recreational opportunities and aesthetic landscapes); the management of these forests is 'closer to nature' than that of mono-functional forests, but likely to require some trade-offs between the many different objectives;
- **conservation** forests are managed primarily for their biodiversity value, for specific ecosystem services and/or for the benefit of people; this group includes old-growth native forests with very little intervention, nature reserves and also protective forests and urban forests.

Forest biodiversity

Forest species make up the greatest assemblage of biodiversity in any terrestrial ecosystem, and have been important in our lives for such a long time that trees and forests are a treasured part of our cultural and historical heritage, and still shape our landscapes. Very few 'old growth' forests are left in Europe now, accounting for only around 1% to 3% of all forests in the EU (the largest of these in Romania and Bulgaria) but many other forests that have been modified by man are still very important for biodiversity. A total of 13% of EU forests are protected areas, while 30% of Natura 2000 sites are forest habitats, covering 23 million hectares[1].

Because of their structural complexity, forests provide ideal habitats for a particularly rich array of plants and animals and a natural refuge for many large carnivores, such as bears and wolves, which were once a characteristic feature of many of Europe's wooded landscapes, and are still found in some forests, especially in Eastern Europe. Forests of high biodiversity value are likely to share some of the following characteristics:

- native tree, shrub and ground cover species in forests with a high degree of naturalness;
- forests of tall trees, including old and dead trees, with deadwood on the forest floor;

- forests with a sizeable area that have been managed sustainably for quite a long time.

So far, Europe's efforts in halting biodiversity loss in forests has had mixed results. Nearly 170 species of European interest (identified in the EC Habitats Directive) are linked to forest ecosystems, but EU Member States report that only 14% of these species and 16% of important forest habitats are in 'favourable conservation status', with the highest percentage of favourable assessments in the Mediterranean and the Alpine regions, but no favourable assessments reported in the Macronesian, Boreal and Atlantic regions (EEA 2011). According to IUCN, 11 mammal species depending on forest in some stage of their life cycle should be considered as threatened, including the 'critically endangered' Bavarian vole, *Microtus bavaricus* and Iberian lynx, *Lynx pardinus* (EEA, 2008). In the case of forest birds, common populations show a decline in Northern and Southern Europe, while they are largely stable in the West and East (Figure 3).
Managing forests for biodiversity requires silvicultural systems that recognise the importance of letting nature take its course. For example many specialised woodland plants and animals depend on a supply of dead wood as food and living space, breaking it down to be returned to the soil. The amount of deadwood in forests is rather low in the intensively managed production forests of northern Europe and in dry Mediterranean areas where foresters clear it away because of the fire risk. Changes in land use, logging operations and forest fires can reduce the movement of forest species and affect their ability to survive and adapt to climate change. The natural genetic diversity of native forests could be the most important resource of all, when we need to find disease and drought resistant strains of timber-producing trees to combat the effects of a changing climate.

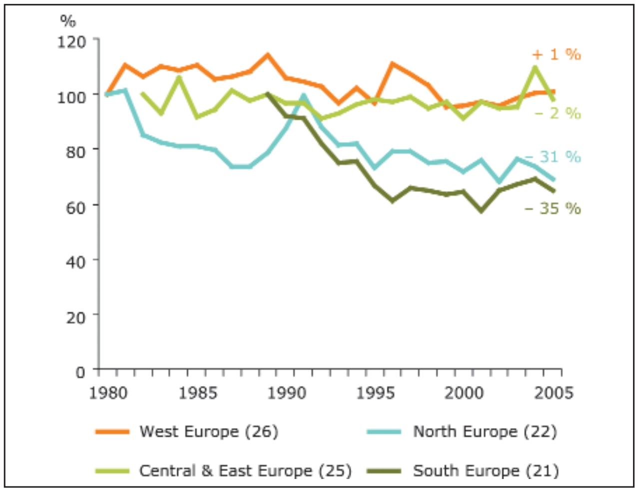

FIGURE 3 Regional indicators of common forest birds in four European regions
Source: EEA, 2008

EU forests - a carbon sink or a carbon source?

The EU's forest stores large reserves of carbon as biomass, 73% of it above ground, 20% below ground and 7% in deadwood. Old-growth forests with little management intervention are some of the richest repositories of both carbon and biodiversity. Where forests are managed for timber production there are opportunities to improve both carbon sequestration and biodiversity, for example by:

- establishing forest reserve areas within conservation forests, where withdrawal of management interventions can enhance carbon sequestration, even in old growth forests;
- restoring forest wetlands can provide benefits for climate mitigation if the effect on emissions of other greenhouse gases from the wetland is properly taken into account;
- changing to a silvicultural system of continuous cover forestry, already a well-established policy in the public forest estate, which can potentially increase carbon sequestration in growing stock;
- preventing forest fires, especially in the Mediterranean region. Specific silvicultural management can lower the risk of fires while increasing the yield of biomass for energy substitution, raising

the marketable timber output and enhancing biodiversity (ECCP,2003).

At present EU forests are a carbon 'sink', storing more carbon than they produce, but this could change quite quickly, because the demand for biomass for renewable energy from agricultural and forest sources may increase by a factor of two or three to meet EU renewable energy targets. If this stimulates an increase in harvesting timber that exceeds the annual rate of growth, some EU forests could become a temporary source of carbon within the next ten years.

Protecting soils water and contributing to the quality of life

Forests protect vulnerable soils from erosion by limiting run-off and reducing wind speed, and also enrich the soil organic matter, helping to store and purify rainwater, thus improving water quality and reducing flooding. These protective functions of forests are particularly important in the alpine and Mediterranean regions of Europe. Forests have a considerable effect on the micro-climate and can provide a valuable buffer around urban areas to moderate the effects of extreme weather, as well as offering recreation opportunities and improving the physical and mental health of residents.

Ensuring the future supply of forest services

There are clearly trade-offs to be made in future between the different types of forest management needed to deliver all these ecosystem services, while continuing to conserve the biodiversity of Europe's forests. Some of these decisions will be difficult to make – for example in terms of climate change mitigation is it better in the short-term to increase the carbon stored in forest biomass or to harvest much more of this biomass to use as a source of renewable energy? Only healthy forests can supply these multiple forest ecosystem goods and services, and it is essential to make EU forests resilient to the potentially damaging effects of climate change, and to preserve their genetic diversity.

At EU level the main funding mechanism to support forest management for biodiversity and ecosystem services is Pillar 2 of the CAP, co-financed by the Member States, who can choose from seven measures specifically for environmental forest management. Many of the beneficiaries are small forest owners, who play an important role in sustainable forest management.

A total of €5.5 billion EU funding has been allocated to these measures for the 2007-13 period across the EU-27, but uptake of some of the key incentives has been very disappointing, including the annual payments for forest-environment and Natura 2000 management that were introduced in 2005.

Last year the EU launched a public consultation on forest protection and climate change[2], which emphasised the environmental role of forests in protecting soil, regulating freshwater supplies, and conserving biodiversity. Worryingly, research suggests that there is a significant gap between the understanding of forest issues in Europe and the reality, both among the public and some policy makers. For example, the majority of European people perceive that the total forest area in the EU is decreasing, when in fact it has increased over the past two decades. Most EU citizens support more active management of forests, yet harvesting and management are seen as being some of the biggest threats to our forests.

Today, forestry in Europe aims at supporting the multiple forest functions by the sustainable management of forest resources. Sustainable forest management (SFM) is defined as *'the stewardship and use of forests and forest lands in a way, and at a rate, that maintains*

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their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems'. Despite the consensus on guidelines, criteria and indicators, SFM is not implemented consistently throughout Europe. According to Forest Europe's recent 'State of European Forests' report, there are substantial differences among regions. It is clear that SFM needs to improve the state of Europe's forests and to ensure that they continue to fulfil their multifunctional role, while taking into account regional differences (EEA 2011).

Some of the key points to be considered in the forthcoming debate on CAP reform and the role of forestry support include:

- developing a common standard for a baseline of good forestry practices, to be applied to all forest support payments;
- in delivering EU policies, striking the appropriate balance of support between sustainable forest management and sustainable management of farmland;
- ensuring future EU support for sustainable forestry is fully coherent with EU environmental, biodiversity, energy reduction and efficiency policies;
- prioritising improved forest management to deliver ecosystem services and climate benefits, while protecting biodiversity and improving resilience to climate change;
- ensuring that afforestation protects soil and water resources and does not harm biodiversity.

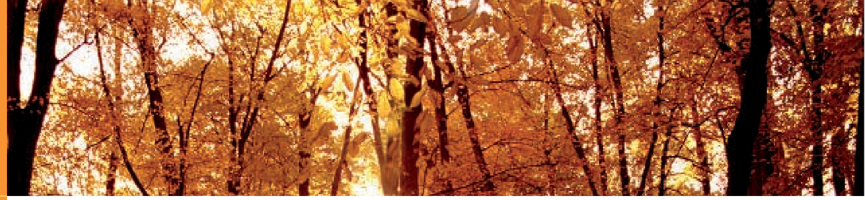
These are major challenges, and meeting them will require a significant change in the management of large areas of Europe's rural land, supported by a coherent programme of research, information, advice and funding. Forestry is a long-term activity and changes now will have an effect in decades to come.

Notes

1 http://ec.europa.eu/agriculture/fore/publi/leaflet-2010_en.pdf
2 http://eur-lex.europa.eu / LexUriServ / LexUriServ.do?uri = COM : 2010 : 0066 : FIN : EN : PDF

References

[1] EC (2011) Europe's forests sustaining life. Directorate General for Agriculture and Rural Development, European Commission. Brussels. http://ec.europa.eu/agriculture/fore/publi/leaflet-2010_en.pdf
[2] ECCP (2003) Conclusions and recommendations regarding forest related sinks and climate change mitigation. European Climate Change Programme - Working Group on Forest Sinks http://ec.europa.eu/clima/policies/forests/docs/forest_sinks_final_report_en.pdf
[3] EEA (2010) Forest: deadwood (SEBI 018) - Assessment published May 2010. European Environment Agency, Copenhagen.
[4] EEA (2011) Europe's forests at a glance: a breath of fresh air in a changing climate. European Environment Agency, Copenhagen.



Monitoring the Italian forests

The Italian National forest Service, in addition to other institutional duties, carries out forest monitoring through two working programs: the National Forest and Carbon Sink Inventory (INFC) and the National Network for Forest Ecosystems Control (CONECOFOR)

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National Forest and Carbon Sink Inventory (INFC)

The second Italian national forest inventory (the first one was published in 1985) is named "National Inventory of Forests and forest Carbon pools" whose acronym in Italian is INFC. INFC is performed by CFS with the scientific coordination of CRA-MPF (www.sito.entecra.it) and in co-operation with the Italian Ministry of the Environment (www.minambiente.it).

The national forest inventory developed a three-phase sampling research. To assess the land cover/land use class, during the **first phase** approximately 300,000 sample points, randomly located on a 1-km x 1-km grid covering the whole Italian territory, were photo-interpreted on digital orthophotos by 50 NFS technicians. The FAO-Forest Resources Assessment (FRA) definition of Forest and Other Wooded Land (OWL) was adopted. The "Total Wooded Area" is given by Forest and OWL together.

The **second phase** allowed to finalize the classification of sample points, estimating separately Forest and OWL areas assigned to the same land cover/use class by the photo-interpreters, and to separate the sample points into eight inventory categories, 23 vegetation types and 91 sub-types using a national classification scheme. The second phase has been implemented through field surveys on a sub sample of 30,000 points randomly selected from the Forest and Other Wooded Land stratum. By this phase, information on 40 qualitative attributes was collected, such as the management status, stand origin and structure, health condition, slope instability and erosion, etc. Administrative information, such as ownership, protection status, management plans, etc., has been collected through interviews or public database queries, while digital orthophotos were used in the field to assess crown cover, texture (horizontal spatial distribution of trees), and forest edges.

In the **third phase** field surveys were carried out to obtain quantitative measurements of trees and assessments of stand attributes. Among the attributes related to dendrometric measurements, lying and standing dead wood was measured. Silvicultural aspects were assessed as well as stand health condition and non timber goods production. Measurements were taken on approximately 7,000 points randomly selected from the second phase sample and stratified by ad-

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ministrative region and forest type (see www.infc.it).
The field monitoring activities started in 2003 and were concluded at the end of 2008. During this period the CFS staff took lots of data from Italian forests.
During 2010 the CFS, with the scientific coordination of CRA-MPF, realized an inventory of forest soil carbon content to complete the research on the fifth forest carbon sink expected from the Kyoto Protocol: ground plant biomass, underground plant biomass, dead wood, litterfall and soil.
All these parameters have been carefully analyzed and estimated at regional and national level. The surveys consider forests as a whole as well as their main categories (tree species, structure, forest management).
First results show that in Italy:

- there are 12 billion trees distributed on 10.467.533 hectares of forest areas (Fig. 1);
- beech is the most common species: there are more than 1 billion beech trees covering almost all the Apennines;
- forests contain more than 1.260.000.000 m^3 of wood (144 m^3 ha^{-1}), i.e., more than 870.000.000 tons of wood (100 t ha^{-1}) meaning about 435.000.000 tons of stocked carbon;
- The total annual gross increment is 35.862 Mio m^3 and the Annual gross increment is 4.1 m^3 ha^{-1};
- The total deadwood is 70.000.000 m3 (8 m^3 ha^{-1}).

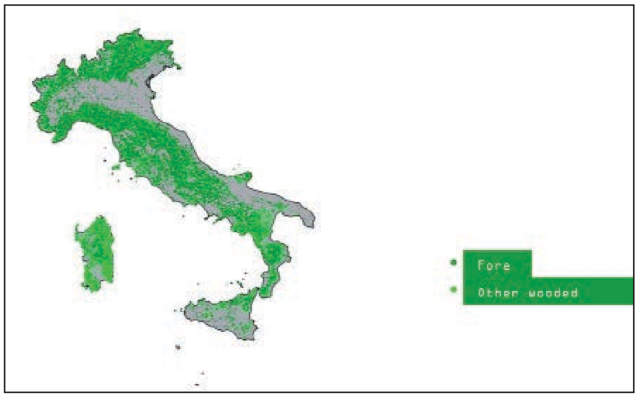

FIGURE 1 INFC results
Source: Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA)

These data are very important for the Italian economy in the framework of the Kyoto Protocol. The storage of Carbon dioxide in our forests can decrease the amount of Italian greenhouse gas emissions: this particular effect could be estimated in about 1.000.000.000 euro within the mechanism of the Kyoto Protocol Italian commitments.

The CONECOFOR Programme: National net for Forest Ecosystems Control

Forest condition monitoring at national scale has been promoted in Italy since 1987 under the coordination of the National Forest Service and the cooperation of Research Centres of national relevance (CRA, CNR, Italian Universities). The programme named CONECOFOR (Forest Ecosystems Monitoring) started in 1995 and involved investigations on 265 Level 1 plots (large scale monitoring) and 31 Level 2 plots (intensive monitoring), in the framework of the UN/ECE Convention on Long-range Transboundary Air Pollution, in cooperation with ICP Forests and ICP IM.
During the last 15 years the CONECOFOR programme was co-financed by the EC through some EU Regulations (e.g., Forest Focus) and by the LIFE + FutMon project for the years 2009-2010. The activities carried out during the years 2008 and 2011 were financed directly by CFS in the absence of EU co-financing to avoid a gap inside the data series.

Working Programme

The CONECOFOR net is composed by 31 plots which are widespread in Italy to represent all the main forest types (beech, pine tree, oak species, plain forests, etc.).
The large-scale monitoring consists in annual forest assessment on 265 Level I plots (Fig. 2), where the health of trees is studied.
In 2009-2010 the research institute *Consiglio per la Ricerca e la Sperimentazione in Agricoltura – Unità di Ri-*

FIGURE 2 Level I: Estensive Network
Source: CONECOFOR Service

FIGURE 3 NFI plots selected for Level I CONECOFOR plots
Source: CRA

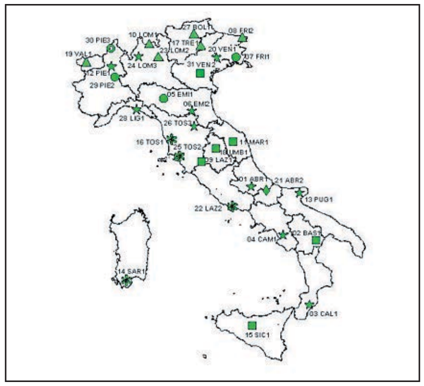

FIGURE 4 Level II: Intensive work
Source: CONECOFOR Service

cerca per il Monitoraggio e la Pianificazione Forestale (CRA-MPF) started the implementation of a large-scale representative monitoring grid (Fig. 3).

It revised the existing monitoring system and its integration with the network of sampling of the later National Forest Inventory (NFI).

A new protocol introducing the major principles and criteria adopted for the current monitoring system NFI was developed. In 2009, the protocol applied to Level I plots was made more similar to protocol NFI, maintaining the previous criteria for the selection of the subjects to detect; in 2010, the protocol applied in the two systems was rather the same for all aspects.

During the last 3 years 600 plots were monitored according to this new scheme.

In particular:

- **meteorological measurements and water budgets** analysis are being carried out by Consiglio per la Ricerca e la Sperimentazione in Agricoltura – Centro di ricerca per lo studio delle Relazioni tra Pianta e Suolo (CRA–RPS) since 1996. This activity allows to define the climatic characteristics of the areas, assess the climatic indices and associated risk factors, identify the extraordinary events and climate trends and evaluate the hydrological balance.
- **deposition and ozone measurements in forest** are carried out by Consiglio Nazionale delle Ricerche - Istituto per lo Studio degli Ecosistemi (CNR-ISE) since 1997, by sampling the atmospheric deposition in the open air under the canopy and along the trunks and waterways, and measuring ozone by passive samplers (Fig. 5);

  CNR also performs the **evaluation and improvement of the analytical quality in laboratories** analyzing deposition and soil solutions since 2002. It organizes a series of intercalibration exercises and arranges visits on request to evaluate the analytical quality in laboratories involved in the ICP Forests, to verify problems on the spot and suggesting solutions.
- the Consiglio Nazionale delle Ricerche – Istituto di Biologia Agroambientale e Forestale (CNR-IBAF) is involved in the **sampling and analysis of needles and leaves** (since 1995), **litterfall and nutrient**

FIGURE 5 Sampling instruments: colleptor for precipitation quantity- stem flow - ozone
Source: CNR

cycling and critical loads (since 2009). This activity allows to: assess the nutritional status of the monitored forests; compare the different concentrations of nutrient for different years of sampling and for different species; test the degree of concordance between the values found in the Italian sites and the critical loads established at European level (for any nutritional imbalances) and investigate the reasons for the differences found; analyze any differences that occurred during the monitoring period; investigate the differences between the concentrations found in the leaves and litterfall.

- the **tree growth analysis** is carried out by the Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Centro di ricerca per la Selvicoltura di Arezzo (CRA–SEL) since 1996. It consists in periodic sampling and measurements of the main tree growth parameters (diameter; basal area, height and/or volume).
- the University of Florence (Biotecnologie Agrarie Department) and Linnaeambiente R.A. srl (Florence) carry out the **annual visual assessment of crown condition and damaging agents** including removals and mortality, since 1996. This activity is carried out also on Level I CONECOFOR plots (Fig. 6 e 7).

Since 2001 these institutes also study the **annual visible ozone injury on vegetation assessment** in Lev. II CONECOFOR plots, where ozone passive samplers are installed. This analysis aims at evaluating the risk of ozone damage on forests (Fig. 8-9).

- University of Florence first, and TerraData environmetrics (academic spin-off University of Siena) then, on behalf of CONECOFOR, carries out the **integrated management and processing of data collected** since 1995. This activity consists in collecting data from the monitoring in Level II CONECOFOR plots and developing indicators for the different response of forest in these plots.
- TerraData environmetrics, on behalf of CONECOFOR, made also the **trans-national coordination of data quality assurance and data quality control** in all phases of data management in 2009-2010. This activity consists in coordinating the harmonization of methods from the definition of procedures for collecting up the sampling to data evaluation and processing. From the integration of

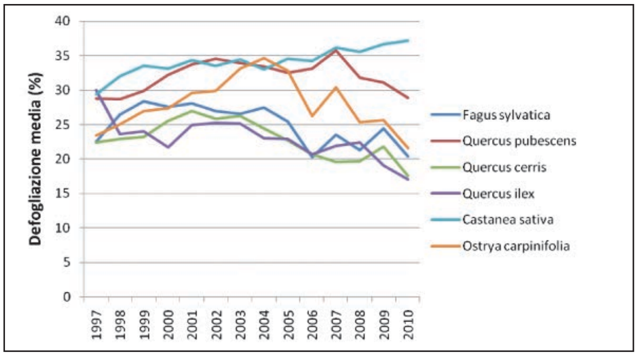

FIGURE 6 Average values of defoliation for deciduous
Source: Linneambiente R.A. srl

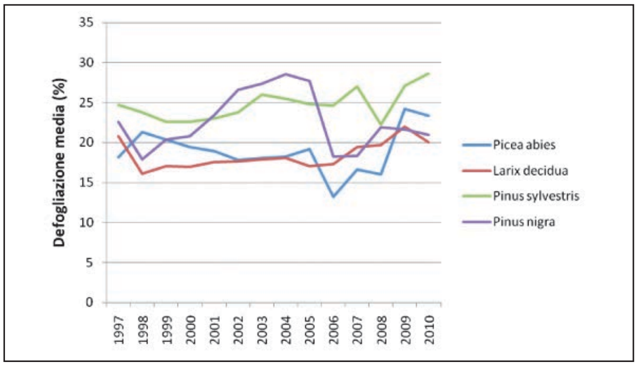

FIGURE 7 Average values of defoliation for conifers
Source: Linneambiente R.A. srl

FIGURE 8
Ozone symptoms on Acer pseudoplatanus
Source: University of Florence

FIGURE 9
Ozone symptoms on Populus spp
Source: University of Florence

different methodologies, a single manual of standard operating procedures was established.

Main Recent Results

The survey of level I in 2010 took into consideration the condition of the crown by 8338 selected trees in 253 plots belonging to the EU network 16x16 km. The number of sample areas has decreased by 4 units compared to the survey of 2009 following the failure to meet the requirements for the feasibility of the area (threshold diameters, dominance, etc.). The number of plants has increased considerably as a result of integrating the second adjustment inventory model.
By analyzing the sample for groups of species, conifers and broadleaves, it appears that conifers suffer **defoliation** less than deciduous trees: 31.8% of conifers and 21.3% of broadleaves do not present any defoliation.
The 93.1% of conifers and 95.8% of broadleaves have no problem of **discoloration**.
Starting from 2005, a new methodology for a deeper assessment of damage factors (biotic and abiotic) was introduced. Most of the observed symptoms were attributed to insects (25.5%), subdivided into defoliators (19,1%), wood borers (1.9%), aphids (0.9%), needle miners (0.8%), following symptoms attributed to fungi (5.9%), the most significant being attributed to "dieback and canker fungi" (3.4%), then those assigned to abiotic agents, the most significant one being the "hail" (1.6%).

In 15 years of monitoring forest conditions in Level 2 plots, the combined and integrated data evaluation shows the particular risk of high acid and nitrogen deposition for sensitive soils and biodiversity status. Ozone concentrations exceed the critical level at all monitoring sites, especially in summer, and reduce the vitality of sensitive forest species. Ozone affects crown transparency (defoliation) and is related to carbon sequestration through its effects on tree growth. Such data confirms that ozone represents a potential risk factor for Italian forests.

LIFE+ projects

In recent years the CONECOFOR Service monitoring activities have been co-financed by the EU through LIFE+ projects. In fact it participates in the EnvEurope Project, while the FutMon Project has just concluded (2009-2010) and another LIFE+ Project was presented in the 2011 "call".

"Further Development and Implementation of an EU-level Forest Monitoring System (FutMon)" Reg. (CE) n.614/2007 LIFE+ Progetto n. LIFE07 ENV/D/000218

FutMon (www.FutMon.org) was a 2-year LIFE+ project (2009-2010) establishing a long term monitoring system on the health of European Forests.
The aim of FutMon is the establishment of a pan-European forest monitoring system serving as a basis for the provision of policy relevant information on forests in the European Union as required under international obligations and key action 8 of the Forest Action Plan (COM 2006 final).
Moreover, the Project aims at improving the monitoring system through the integration and harmonization of National Inventories and Monitoring Networks (Lev. 1 and 2) of the involved European Countries.
FutMon, coordinated by the German research institute vTI (www.vti.bund.de), was carried out by 38 beneficiaries from nearly all EU-Member States (Italians Associated beneficiaries: C.F.S., C.N.R. and C.R.A.).

ENVEurope "Environmental quality and pressures assessment across Europe"

ENVEurope (www.enveurope.eu) is a 4-year LIFE+ Project (2010–2013) proposing a design for environ-

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mental high quality monitoring and long-term research sites: it represents the exemplary establishment of common parameter sets to be collected across the largest site-based network of Long-Term Ecosystem Research in Europe (www.lter-europe.net), which was recently established (2006) under the auspices of the FP6 Network of Excellence ALTER-Net, building on existing infrastructures and thus a lot of valuable data series. http:77www.alter-net.info/

The Project, internationally coordinated by CNR-ISMAR, is focused on three types of ecosystems (terrestrial, freshwater and marine), and it aims at defining research and monitoring activities relevant to different levels/scales of investigation. The project has been designed and planned in the conceptual and operative context of SEIS (http://ec.europa.eu/environment/seis) and will also contribute to the development of the GMES (http://ec.europa.eu/gmes) initiative.

CONECOFOR Service, in co-operation with the National Center for Study and Forest Biodiversity "Bosco della Fontana" of CFS, is an Associated Beneficiary of this LIFE+ Project together with other 15 Research Institutes from 12 different European Countries. In particular, it is involved in monitoring terrestrial sites and coordinates the action for a proposal of a new ecological network.

More info

- www.corpoforestale.it
- www.icp.forest (ICP manual: http://icp-forests.net/page/icp-forests-manual)
- CRA www.sito.entecra.it
- CNR www.cnr.it
- FutMon Project http://www.sian.it/inventarioforestale/jsp/futmon.jsp
- INFC www.infc.it

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- CNR-IBAF: Giorgio Matteucci
- CRA-RPS: Luca Salvati
- CRA-SEL: Gianfranco Fabbio
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Fighting against deforestation and forest degradation: public and private initiatives

The paper deals with the regulative and voluntary policy tools implemented by public institutions, enterprises and civil society to reduce the problems of forest destruction and degradation. In reviewing the initiatives related to the FLEGT and FLEG programs, REDD+ projects, the Due Diligence Regulation and the voluntary instruments like forest certification, a contradiction between the general principles that inspire the policy action and operational decisions is raised and discussed. Modern policy action should in theory favour a shift from regulative to voluntary policy tools, a shift that can be understood in the light of a general change of attention from "government" to "governance". However, if we examine the development of public institutions' action to reduce forest degradation, we see the emerging role of "hard" tools like the compulsory Due Diligence system, the VPA-based and the CITES licences. This emerging trend is creating problems of public actions' effectiveness, of coordination costs and in the active involvement of civil society

Davide Pettenella

Introduction

The global forest cover – which the Forest Resources Assessment organized by FAO (2011) has recently estimated to be almost 4 billion hectares, or 30 percent of the world's total land area – is shrinking at the rate of 13 million hectares per year, mainly because of land-use change in the tropics and Oceania. In addition, though forest cover has reportedly expanded in industrialized countries during the last decade, a large portion of these forest ecosystems is heavily degraded, as they are subjected to more intense and frequent biotic and abiotic stresses, such as overexploitation, wildfires, environmental pollution, introduction of non-native invasive species, urbanization, fragmentation, and the effects of climate change (Ciccarese, 2011). Forest degradation and deforestation account for at least 15% of the global anthropogenic emissions of greenhouse gases (Van der Werf et al., 2009).

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The process of deforestation is, in most countries, decreasing both in absolute and relative terms, but this cannot always be assumed as a positive indicator of the reduced human pressure on forest resources: due to the definition of forest by FAO, formally accepted by international and national organizations, a clear-cut of 80% of a primary forest, with the harvesting of all old trees, is not statistically recorded as a deforestation. It appears obvious that the real problem has become the process of forest degradation, much more difficult to be monitored, measured and communicated to the public and policy makers.

The processes of forest destruction and degradation are strongly connected to poverty and to the need to cover the basic needs of the local population in developing countries (e.g., fuelwood, building materials, land for cultivation and grazing), but a certain role is also played by timber exploitation both for the domestics markets and for trade. When these commercial activities are causing forest processes of deforestation or serious degradation of the forest resources they are normally connected with the problem of illegality. As a matter of fact, countries, including third world's, have developed quite strict regulative frameworks in order to protect and conserve their forest resources; the main problem relies on law enforcement and corruption of public officials. Illegal acts occur in various forms along the wood supply chain, but they tend to be concentrated in timber harvesting and wood trading. The many different types of illegalities include: violation of standards set out in licences and concessions; unauthorized harvesting; unauthorised trade; the use of bribery to gain harvesting rights; evasion of taxes or other charges (Morozov, 2000; Sasse, 2000; Buttoud, 2001; FAO 2001; Brack et al., 2002; ITTO, 2002; Scotland and Ludwig, 2002).

The dimension of the problem is not officially known, but the Organisation for Economic Co-operation and Development (OECD, 2001) estimates that approximately one tenth of the international trade in timber is illegal, worth a minimum value of USD 150 billion/year. In several countries illegal harvesting exists along with legal harvesting; in other countries, illegality is more common than legality (World Bank, 2000). This opinion is confirmed also by various sources of information: "It seems likely that at least half of all the logging activities in particularly vulnerable regions – the Amazon Basin, Central Africa, South-east Asia and the Russian Federation – is illegal" (Brack et al., 2002). In many countries the situation in recent years appears to have become critical.

Apart from the obvious negative environmental and social impacts, there is direct economic damage to the national treasuries of countries affected by high levels of illegal practices in the forestry sector, in the form of lost tax revenue, licence fees, and customs duties, the total of which is estimated to be in the range of EUR 10-15 billion per year (World Bank, 2004). These economic losses feed the problem since they can affect a government's capacity to monitor and enforce regulations as well as its potential to re-invest in the forestry sector, for example, to fund programmes for the sustainable management of its forest resources. Over the medium to long term, these conditions of illegality deplete the standing stock of timber and deteriorate the economic wealth of the country. In addition, illegalities tend to drive timber prices down, thus reducing the profit margins and possibly the competitiveness of those enterprises that are complying with the laws.

There are also secondary effects of illegality connected with the problems of deforestation and forest degradation. An example of this is the use of funds from "timber that has been traded at some point in the chain of custody by armed groups, be they rebel factions, regular soldiers or the civilian administration, either to perpetuate conflict or [to] take advantage of conflict situations for personal gain" (Global Witness 2003, p. 8). This definition of conflict timber by Global Witness was provided after the term was first coined in the report to the United Nations Security Council. There is evidence of the use of conflict timber in regional conflicts in Cambodia, Liberia, and the Democratic Republic of the Congo and other countries (Brack et al., 2002).

How to face the problem of forest degradation

The policy tools implemented by public institutions, enterprises and civil society to deal with environmental resources protection can be classified in two groups (see table 1):

- the regulative instruments based on a "command and control" approach, i.e., obligations, bans, thresholds, tax, licences,...; public authorities impose these instruments, they control economic actors that passively have to respect the rules;
- the voluntary instruments and market-led mechanisms (or "soft" tools); these include definition of standards, certification and labelling, reporting,

TABLE 1 Instruments for supporting environmental protection measures
Source: processed by the author

Instruments	Direct costs for the public sector	Transaction costs for the public sector	Approach
Passive: command and control			
• Obligations, bans, thresholds, tax, licences,...	Relatively low	Relatively low costs	Top down
Active: stimulus to economic activities, creation of new markets			
• Tax deductions, tax exemption	Relatively high		
• Fixed incentives and compensations			
• Market-based instruments			
– PES and PES-like schemes	Very low (zero costs)	Low costs	Mixed
– Socially responsible procurement policies	Relatively high*	Low costs	Mixed
– Tradable permits	Relatively low	Low costs	Mixed
– Standard setting, certification and labelling	Zero costs	Zero costs	Bottom up
– Sponsoring, donations (philanthropy)	Zero costs	Zero costs	Bottom up
– Technical support, provision of services, promotion, …	Relatively high	Low costs	Mixed

(*): only if carried out by public organizations.

contractual agreements for the payments for environmental services, adoption of codes of conduct and best practices, ... where public authorities are playing a minor role and the economic actors are active in defining, negotiating, and controlling the use of the instruments.

The implementation costs of voluntary instruments are, for the public institutions, generally lower than the "hard", passive, instruments based on command and control criteria. This is only one, but significant, reason justifying a shift in the focus of policy makers from hard to soft policy tools, a shift that can be understood in the light of a general change of attention by policy makers and the civil society from "government" to "governance" (Secco et al., 2011).

The traditional government approach to decision-making is a hierarchical, typically top-down, one decision point-based, with well-defined and delimited tasks. The innovative participatory governance approach (Shannon, 2006) is networking, multi-decision level-based, with dynamics interactivity among actors, intersectoral links and less clearly defined tasks. Governance can be defined as "a method or system of management", i.e., the set of processes, procedures, resources, institutions and actors that determine how decisions are made and implemented. When it applies to a country, it is the method or system by which society is governed; when it applies to a sector, like forestry, it is the method or system by which the sector – with all its components, processes and actors – is managed. It includes "regionalisation, decentralisation and all the other formal (and informal) interactions between governmental institutions and other actors and the roles they play in delivering effective, accountable solutions to shared problems" (Swiderska et al., 2008). In other words, the concept relies on the distribution of authority among actors within a certain sector or relationships chain (Cashore, 2002). The term *per se* does neither imply an equal distribution of authority nor a high-level of stakeholders involvement: depending on the concerned sector and context, governance can be dominated by private actors, non-governmental organizations, public authorities or others. The difference in types of governance "is simply who is involved in making collective choices" (Shannon, 2006) and how the involvement is managed. Judgement and accountability are reported as main responsibilities of the public in an effective governance (Buttoud, 2000). Key indicators to assess the quality of governance are transparency, accountabili-

ty, legitimacy, law enforcement, stability, public participation, real capacity of various actors to influence policy and regulatory processes, social justice, equity, and mainstreaming of environmental and social aspects (Hemmati, 2001; Kaufmann and Kraay, 2002; Dowdle, 2006; Nakhooda et al., 2007).
In the following pages, presenting actions by public institutions and the voluntary initiatives by the private sector, we will try to verify the presence of the shift from a government to a governance-based approach when dealing with forest degradation and deforestation.

Public institutions' actions to fight against forest degradation

At international and national level many plans and programs have been approved in the last two decades with the aim of promoting the protection of forests and the production and trade of "legal wood", starting from the G8 Action Programme on forests and the conferences on Forest Law Enforcement and Governance organised by the World Bank with the support from major donor countries. Policy programs promoting legal activity along the wood supply chain were also defined through some international and national regulations and agreements, like the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the formal commitments by the International Tropical Timber Organization (like the Objective 2000) or bilateral agreements between commercial partners, like the Indonesia-United Kingdom Tropical Forest Management Programme (ITFMP, 1999).
For the European Union (EU) countries the two leading instruments implemented to control illegality in the forestry sector are the Action Plan for Forest Law Enforcement, Governance, and Trade (FLEGT), which was adopted by the European Parliament in 2003 (EU Commission, 2003) and Regulation No 995/2010.
The EU FLEGT Action Plan provides a number of measures to exclude illegal timber from markets, improve the supply of legal timber and increase the demand for responsible wood products (Florian et al., in press). One of the key elements of the EU FLEGT framework are the Voluntary Partnership Agreements (VPAs), which aim to ensure legal timber trade and support good forest governance in the developing countries. A VPA should help identify legal timber and timber products in producer countries and license them for export to the EU. For different reasons, so far only six VPAs have been signed with exporter countries (Ghana, Cameroon, Republic of Congo, Central African Republic, Indonesia and Liberia).
Regulation No 995/2010, also known as EU Timber Regulation (EU-TR), is an additional measure expected to enter into force in March 2013 that should help prevent imports of illegal products from non-VPA countries to the EU. The EU-TR lays down requirements for different participants in the EU wood supply chain. For example, all organisations introducing timber and timber products in the EU market, either through import of rough materials from non-EU countries or from forest operations in a member country, shall have in place a Due Diligence system to demonstrate the legality of the wood origin. In addition the EU-TR also specifies requirements for traders (traceability), i.e., all the other participants in the supply chain prior to sale to the final consumer. The Regulation will be applicable for most wood products commonly traded in the EU, except for recycled and printing industry products.
While the above-mentioned initiatives are mainly connected to "hard" tools, some conventions, plan and programs have activated voluntary instruments, as in the case of Payments for Environmental Services that will be examined in the following section.

Voluntary instruments and initiatives

The second category of means used to fight illegal activities causing forest degradation and deforestation includes voluntary initiatives implemented by private organisations (i.e., both for profit and non-profit) or by national and/or local government authorities. The

TABLE 2 Potential global and regional supply of roundwood from certified resources, 2009-2011
Source: UNECE/FAO,2011

	Total forest area (M ha)	Certified forest area (M ha)			Certified forest area (%)			Estimated volume of timber from certified forest (M m³)			Estimated volume of timber from certified forest (%)		
		2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
North America	614.2	180.3	199.8	201.0	29.4	32.6	32.7	175.6	194.6	201.0	9.8	10.9	11.3
Western Europe	168.1	82.2	85.0	85.3	46.5	51.2	50.8	238.1	261.7	227.5	13.3	14.6	12.8
CIS	836.9	25.2	29.9	44.3	3.0	3.6	5.3	4.9	5.8	8.5	0.3	0.3	0.5
Oceania	191.4	10.3	11.6	12.3	5.0	5.6	6.4	2.5	2.8	3.5	0.1	0.2	0.2
Africa	674.4	5.6	7.3	7.6	0.9	1.2	1.1	0.6	0.8	0.8	0.0	0.0	0.0
Latin America	955.6	14.6	14.4	16.1	2.1	1.6	1.7	3.6	2.7	3.2	0.2	0.1	0.2
Asia	592.5	3.0	8.6	8.1	1.4	1.5	1.4	3.1	3.4	2.8	0.2	0.2	0.2
World total	**4033.1**	**321.2**	**356.7**	**374.9**	**8.2**	**9.0**	**9.3**	**428.4**	**471.8**	**447.3**	**24.0**	**26.4**	**25.3**

range of these initiatives and the goals vary; these instruments are established to provide public goods and services, to give assurance about the sustainability of the forest management practices, to develop legal markets, to promote transparency, as well as to increase the consumers' awareness of the current level of illegal activity in the forestry sector.

The most effective voluntary instrument implemented up until now to reduce forest degradation and raise the awareness of companies and consumers is by far the third-party certification of environmentally appropriate, socially beneficial, and economically viable forest management under the Forest Stewardship Council's (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) schemes (see table 2). FSC in particular has developed a scheme involving, at the moment, 12 African, 11 Asian and 17 Latin American countries with more than 25 million hectares (M ha) of certified forests (for PEFC these data are respectively: 0, 1 and 2, with 7.7 M ha certified).

"Green" procurement policies (now better defined as socially responsible procurement policies) are another quite effective voluntary best practices implemented by companies (like the large retailers) and public institutions. There are several positive examples of environmentally and socially friendly criteria being introduced as part of the purchasing procedures of national, regional, and local authorities, as well as in the private sector. The impact in the public sector may result remarkable: in the EU, government purchasing amounts to an average of 12% of the gross domestic product. Public spending is distributed over a wide range of "legal" wood-based products and services from paper to wood playgrounds and furniture. Responsible government spending could also influence private consumers to modify their behaviour, when they are buying goods and services.

One of the leading new instrument, promoted around the end of the nineties both by public institutions and by private operators are the Payments for Environmental Services (PES). As a matter of fact, PES are a class of instruments specifically oriented to a proactive environment resources conservation and to the provision of public services: biodiversity conservation, water supply, carbon sequestration, landscape protection, ... A PES scheme is defined as a "voluntary" transaction where a "well-defined" environmental service (or a land-use likely to secure that service) is being "bought" by a (minimum one) "buyer" from a (minimum one) "provider", if and only if the provider secures service provision (conditionality) (Wunder, 2005). Generally, PES are contract-based schemes acting as a financial tool. They target environmental service as traded goods among the parties, particularly where no public regulations have been implemented.

The forestry sector is probably the most considerable and dynamic field of implementation of the PES idea, with many examples (especially in developing countries) related to water provision but, more recently, with increasing interest towards investments aiming at reducing CO_2 emissions deriving from deforestation and forest degradation. During the 15th Conference of the Parties (COP-15) of the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen, projects aiming at Reducing Emissions from Deforestation and forest Degradation (REDD) and supporting the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries were confirmed as priority measures to reduce forestry-based carbon emissions (UNFCCC, 2009). The early Avoided Deforestation (AD) proposal called for a national level implementation to prevent leakage risks inherently associated with project-based forest conservation activities (Santilli et al., 2003). Despite this, the need for a rapid on-the-ground testing of the AD proposal has allowed the development of pilot project-based activities under the broader set of initiatives projected by the United Nations REDD Programme and the World Bank Forest Carbon Partnership Facility. The possibility of developing sub-national activities, either at provincial or federal state level, has been called the "hybrid or nested" approach (Pedroni et al., 2008) and is likely to heavily involve local institutions. In the short term fast track actions are financed through bilateral and multilateral agreements.

Parallel to the policy discussion on the "compliance" or "regulated" market (i.e., the market connected with the implementation of the Kyoto Protocol), REDD projects are already reaching the end of the pipeline in the voluntary carbon market. In the future, single project interventions are likely to play an important role in both markets, regulated and voluntary.

Despite the intense and sometimes passionate international political debate, the field implementation of REDD projects has been rather limited up until now: apart from the traditional difficulties for project developers to demonstrate additionality, ensure permanence, no leakage effects and correct baseline estimation connected to the delay in the approval of REDD methodologies (Hamilton et al., 2009), there are critical organizational aspects related to governance, such as dealing with stakeholders' participation (e.g., governments and forest dependent communities), tenure of land and carbon credits, transparency and accountability in the decision-making process, etc. (Lawlor et al., 2010).

In fact, a good governance system, based on a clear regulatory framework, effective law enforcement and transparent and participatory decision-making, is often claimed as an essential element for the successful implementation of REDD projects (Saunders and Reeve, 2010; Forsyth, 2009). Funds provided to countries with poor governance systems are likely not to be used in an efficient and effective way unless they are invested, at least to some extent, in improving the governance system.

Finally it is worthwhile to note that the distinction between "compulsory and "voluntary" instruments is not always so clear: some tools can start to be used on voluntary ground and later become an obligation for some private or public organisations, like in the case of "green" public procurement policies or, maybe in the near future, the REDD projects.

Conclusions

As we have mentioned, in political and social sciences literature there is an ongoing debate about a shift from government to participatory governance in policy formulation and related decision-making procedures which is taking place at global level, characterized by State transformation, privatization processes, shared public and private authority, cooperative partnerships, increasing role of voluntary-based instruments and soft laws, and stakeholders involvement (Shannon, 2006). As a matter of fact, the forest sector is considered one of the most advanced arenas for finding examples of this new type of governance, with several non-State market-driven governance systems already in place and consolidated, like, for example, those launched by forest certification initiatives (Cashore, 2002; Gulbrandsen, 2004; Chan and Pattberg, 2008) or through PES schemes. However, looking at the development of international programs to fight against deforestation and forest degradation some contrasting trends seems to be emerging.

Often, before State and intergovernmental organisations assumed official responsibilities for dealing with forest degradation, non-governmental organisations and close-knit networks of local groups have already established efficient ways of collecting, sharing, and presenting information to make the public and policymakers aware of these problems. Public institutions' initiatives are in many cases a (rather delayed) reaction to a growing concern by the civil society. No proactive interventions are implemented by public institutions and the time lag between the four steps – "problem raising", "public perception", "planning of action by public institutions" and "concrete actions" – is growing. This is a problem mainly connected to the financial crisis (that now tends to be considered also a political crisis) and to the lack of funding for long-term programs of environmental protection (or – on the policy side – on concrete actions to stimulate the green-economy, notwithstanding all the rhetoric statements made by policy makers).

Finally, considering how the public sector is reacting to the emerging problem of forest degradation, it is interesting to note a contradiction between general principles that inspire the policy action and operational decisions. In theory, modern policy action should focus on developing "soft tools", while, if we examine the development of public institutions' action, we see the emerging role of "hard" tools like the compulsory Due Diligence system, the VPA-based licences and the Legally Binding Forest Agreement (now in advanced state of approval by the Inter-Ministerial Conference on the Forest Protection in Europe)[2]. Some voluntary instruments can be marginalised by the development of new systems of command and control: why tropical wood importers should be interested to get a voluntary certification of properly managed forest when they are constrained to get the VPA-licence and have a Due Diligence systems in place, under the periodical control of some external authorities?

Moreover, various national agencies are now dealing with the implementation of the above-mentioned public initiatives, and this increasing number of activities related to international regulations is creating inter-agency coordination problems. Information on costs and effectiveness of these new forms of bureaucratic control are not always very easy to collect and evaluate.

The process of forest degradation is a multi-faceted and multi-agent process and no single best solution or means can be found to tackle the problem. The development of a wide range of instruments that can be implemented at different scales and by different actors is required to deal with the diverse features of illegality in the forestry sector, but more attention should be given to those instruments that are based on the direct, active, and voluntary involvement of companies and civil society.

Notes

1 "Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ."

2 See the documents reported in the Forest Europe's web site: www.foresteurope.org/eng/What_we_work_for/Legally_Binding_Agreement/

References

[1] Brack D., Marijnissen C. and Ozinga S. (2002). Controlling imports of illegal timber: options for Europe. Forests and the European Union Resource Network (FERN)/Royal Institute of International Affairs (RIIA), Brussels. 72 p.

[2] Buttoud G. (2000). How can policy take into consideration the "full value" of forests? Land Use Policy 17: 169-175.

[3] Buttoud G. (2001). Gérer les Forets du sud: L'essentiel sur la politique et l'économie forestières dans les pays en développement L'Harmattan, Paris. 256 p. [In French].

[4] Cashore B. (2002). Legitimacy and the Privatization of Environmental Governance: How Non-State Market-Driven (NSDM) Governance Systems Gain Rule-Making Authority. Governance: An International Journal of Policy, Administration, and Institutions, 15 (4): 503-529.

[5] Ciccarese L. (2011). Ecosystem services from forest restoration. Thinking ahead. In: Restoring forests. Advances in Techniques and Theory: 8-10. Abstract book of IUFRO Conference, 27-29 September 2011. 124 p.

[6] Chan S. and Pattberg P. (2008). Private Rule-Making and the Politics of Accountability: Analyzing Global Forest Governance. Global Environmental Politics 8 (3): 103-121.

[7] Dowdle M.W. (2006). Public Accountability. Designs, Dilemmas and Experiences. Cambridge Studies in Law and Society. Cambridge University Press. Cambridge, UK.

[8] EU Commission (2003). Communication from the Commission to the Council and the European Parliament Forest Law Enforcement, Governance and Trade (Flegt). Proposal for an EU Action Plan. EU Commission, Brussels.COM (2003) 251 final http://www.euflegt.efi.int/files/attachments/euflegt/01flegtactionplanenfinalen.pdf

[9] FAO (2011). Global forest resources assessment 2010: Main report. Food and Agricultural Organization of the United Nations, Rome. http://www.fao.org/forestry/fra/fra2010/en/

[10] Florian D., Masiero M., Mavsar R. and Pettenella D. (in press). How to support the implementation of Due Diligence systems through the EU Rural Development Programme: problems and potentials. Italia Forestale e Montana.

[11] Forsyth T. (2009). Multilevel, multiactor governance in REDD+ Participation, integration and coordination. In: Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. D., & Wertz-Kanounnikoff, S. (2009). Realising REDD+: national strategy and policy options. CIFOR, Bogor, Indonesia.

[12] Global Witness (2003). The usual suspects: Liberia's weapons and mercenaries in Côte d'Ivoire and Sierra Leone, Why it's Still possible, How it works and how to break the trend. Report March 2003. Global Witness, London. 63 p. http://www.globalwitness.org/reports/download.php/00068.pdf

[13] Gulbrandsen L.H. (2004). Overlapping Public and Private Governance: Can Forest Certification Fill the Gaps in the Global Forest Regime? Global Environmental Politics 4 (2): 75-99.

[14] Hamilton K., Sjardin M., Marcello T. and Shapiro A. (2009). Fortifying the foundation: state of the voluntary carbon markets 2009. Ecosystem Marketplace and New Carbon Finance. Washington, DC, and New York, USA.

[15] Hemmati M. (2001). Multi-Stakeholder Processes for Governance and Sustainability – Beyond Deadlock and Conflict. Earthscan, London.

[16] ITFMP (1999). A draft position paper on threats to sustainable forest management in Indonesia: Roundwood supply and demand and illegal logging. Indonesia/United Kingdom Tropical Forest Management Programme, Report no. PFM/EC/99/01. Jakarta.

[17] ITTO (2002). Annual Review and Assessment of the World Timber Situation. International Tropical Timber Organization, Yokohama. 198 p.

[18] Kaufmann D. and Kraay A. (2002). Growth Without Governance. World Bank Policy Research Working Paper No. 2928. http://ssrn.com/abstract=316861

[19] Kjær M.A. (2004). Governance. Key concepts. Polity Press. Cambridge UK. pp. 240.

[20] Lawlor K., Weinthal E. and Lander L. (2010). Institutions and policies to protect rural livelihoods in REDD plus regimes. Global Environmental Politics, 10 (4) 1-11.

[21] Morozov A. (2000). Survey of illegal forest felling activities in Russia: Forms and methods of illegal cuttings. Greenpeace Russia, Moscow. http://www.forest.ru/eng/publications/illegal/

[22] Nakhooda S., Dixit S. and Dubash N.K. (2007). Empowering people. A Governance Analysis of Electricity. Prayas Energy Group, India /World Resource Institute, Washington D.C., USA. http://www.wri.org.

[23] OECD (2001). OECD environmental outlook. Organisation for Economic Cooperation and Development Publications, Paris. 328 p. http://www1.oecd.org/publications/e-book/9701011e.pdf

[24] Pedroni, L., Dutschke, M., Streck, C., Estrada Porrua, M., (2008). Creating incentives for avoiding further deforestation: the nested approach. Climate Policy, 8.

[25] Santilli M., Moutinho P., Schwartzman S., Nepstad D., Curran L., Nobre C. (2003). Deforestation and the Kyoto Protocol: a new proposal. Paper presented at COP-9, December 2003, Milan, Italy.

[26] Sasse V. (2000). Wood raw material: production, trade and consumption, chapter 7. In: Economic Commission for Europe, Food and Agriculture Organization of the United Nations (ECE-FAO), Timber Committee. Forest Products Annual Market Review 1999-2000. Timber Bulletin, Volume LIII, ECE/TIM/BULL/53/3. Economic Commission for Europe. Genève. pp. 81-90. http://www.unece.org/trade/timber/docs/rev-00/07.pdf

[27] Saunders J. and Reeve R. (2010). Monitoring governance safeguards in REDD+. Background Paper One. Expert Workshop 24th – 25th May 2010, Chatham House, London.

[28] Scotland N. and Ludwig S. (2002). Deforestation, the timber trade and illegal logging. EC Workshop on Forest Law, Enforcement, Governance and Trade, Brussels, April 22-24, 2002.

[29] Secco, L., Da Re R., Gatto P., Pettenella D. and Cesaro L. (2011). How to Measure Innovative Modes of Governance in the EU Rural Policy: Key Dimensions, Indicators and Case Studies. Proc. 122nd EAAE Seminar "Evidence-based agricultural and rural policy making: methodological and empirical challenges of policy evaluation". Ancona, February 17-18, 2011.

[30] Shannon M. (2006). Participation as Social Inquiry and Social Learning. Schweizerische Zeitschrift für Forstwesen (Swiss Forestry Journal) 157 (10): 430-437.

[31] Swiderska K., Roe D., Siegele L., and Grieg-Gran M. (2008). The Governance of Nature and the Nature of Governance: Policy that works for biodiversity and livelihoods. IIED, London. http://www.iied.org/pubs/pdfs/14564IIED.pdf.

[32] UNECE-FAO (2011). Forest Products Annual Market Review 2010-2011. Economic Commission for Europe and the UN Food and Agriculture Organization (FAO), Timber and Forest Study Paper 27, Geneve. http://www.unece.org/fileadmin/DAM/publications/timber/FPAMR_2010-2011_HQ.pdf

[33] UNFCCC (2009). Copenhagen Accord. Decision CP 15. The Conference of the Parties.

[34] van der Werf G.R., Morton D.C., DeFries R.S., Olivier J.G.J., Kasibhatla P.S., Jackson R.B., Collatz, J.B., Randerson, J.T. (2009). CO_2 emissions from forest loss. Nature Geoscience 2, 737-738.

[35] WB (2000). The World Bank Forest Strategy: Striking the Right Balance. World Bank, Washington, DC. http://www-wds.worldbank.org

[36] WB (2004). Sustaining Forests. A Development Strategy. World Bank, Washington, DC. http://siteresources.worldbank.org/INTFORESTS/Resources/SustainingForests.pdf

[37] Wunder S. (2005). Payments for environmental services: some nuts and bolts. Occasional paper No 42. CIFOR, Bogor.

Present opportunities for sustainable and multifunctional forest management for the development of rural areas

The principles of sustainability and multifunctionality underpin forest policy in Europe. Other principles such as the ecosystem services approach are increasingly used to explore sustainable natural resource management under conditions of multifunctionality. The enhanced contribution of European forests to rural development will come more from innovation in response to the current need to decarbonise economic activity and wider innovation than the formal application of any of these principles. This paper reviews the organising concepts of sustainability and multifunctionality and points out some critical issues in the delivery of enhanced opportunity, recognising the need for enhanced innovation to support the necessary transition to a low carbon economy and thereby better support rural development

Bill Slee

Introduction

This paper explores the present opportunities for sustainable and multifunctional forest management for the development of rural areas, with particular reference to Europe. It argues that the opportunities for the forest sector to contribute to sustainable rural development are perhaps greater than at any time in the last fifty years. Nonetheless, sectoral path dependencies, policy inadequacies, slow innovation processes, the absence of management of the necessary transitions and competition for land from agriculture may limit potential. These factors point to a need to create more supportive framework conditions for developments in innovation, policy and practice to unlock the potential of this most sustainable of land uses.

The twin principles of sustainability and multifunctionality underpin European forestry, but the application of these principles varies greatly from place to place. The six principles of sustainable forest management are articulated in the work of the Ministerial Conference on the Protection of Forests in Europe (MCFPE) and provide the context for national level action by state, private and third sector forest owners. The principles draw on the fundamental tenets of sustainability based on the Brundtland definition of sustainability as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). Multifunctionality, in contrast, implies the delivery of more than one function/benefit/service from a particular land use, and, in normal European use, implies the presence of both market and non-market benefits.

Forestry's positive future is framed by the major challenges as the economic forces of global market capitalism and the demographic forces of population growth combine to create an unprecedented demand

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for natural resources. Natural and man-made capital stocks are threatened by climate change; technological potential for increasing food yields appears to have stalled somewhat; and the stock of critical non-renewable natural resources is being depleted. This has created a context for an impending global crisis but also a boost for induced innovation. It is leading to significant efforts to decarbonise both production and energy systems and lifestyles. Stern (2007) has argued that climate change is the greatest negative economic externality ever to confront mankind. The pervasive but spatially variable impact of climate change, its insidious character, and the fact that it confronts head-on the established *modi operandi* of industrial and consumer activities mean that it cannot be ignored.

In the post-war period, European nations have seen unprecedented economic growth. More recently, globalisation has extended the reach of market economies and is producing a new global order with the rise of Asian economies with growth rates markedly exceeding those of western countries. Globalisation has also generated enormous stresses, arising from restructuring of economic activity, the emergent raw materials shortage, rising external costs of production and consumption and the specificities of the recent financial crisis. The pace of growth and its impacts have also promoted critical reflection on the nature and impact of contemporary material demands (Jackson, 2009) and the extent to which narrowly conceived economic metrics measure societal well-being effectively (Fitoussi, Sen and Stiglitz, 2009). Given this sombre context, and the critical opportunity it creates for renewable natural resources, the exploration of how forests can contribute to solutions is an urgent task.

Forests' contributions to development are wide ranging and can be seen in terms of contributions to both livelihoods and to 'liveability'. Livelihoods result from forests' capacities to support material wellbeing, through access both to the products derived from forests and through wages and income derived directly and indirectly from the exploitation of forests. This is essentially the market-based dimension of forests' economic usefulness. Here, forests contribute to the most basic of human needs such as warmth and shelter. Equally, forests also contribute to creating attractive 'green infrastructure' and have important cultural and spiritual values (Schama, 1995). The term 'liveability' is used to describe the need for high quality environments as living space (Shaw et al., 2004) and forests contribute to these. Especially in more lightly forested countries, trees create a premium on living and recreational space (Slee et al., 2004). 'Liveability' can be used to describe the enhanced non-material quality of life created by the existence of trees, woods and forests (Slee, 2011). These are still economic benefits, but of a non-market character. In delivering both enhanced livelihoods and enhanced liveability, forests provide significant support for rural development.

Given the urgency of the task to decarbonise the energy system (Mackay, 2009) and the search for a 'new energy paradigm' (De la Torre Ugarte, 2005), wood ought to be a highly favoured commodity. Oil prices are two to three times higher than they were in the early part of the last decade. This ought to shift the energy mix to favour wood energy developments. The market for bio-composites ought to be enhanced too for the same reason because of the high hydrocarbon content of many alternatives. Climate change also creates scope for new afforestation to sequester carbon in cost-effective ways. In addition, avoided deforestation should benefit developing country forests through the REDD mechanism.

In spite of these apparent advantages, there are parts of Europe where under-management of the forest resource is the norm. Land abandonment from agriculture is a phenomenon in many parts of Eastern and Southern Europe, although estimating the extent is problematic (Keenleyside and Tucker 2010). Particularly on poorer quality land in remote rural areas around the Mediterranean, scrub woodland is a widespread if unmanaged form of land cover. In other places, such as South-west England, a majority of the privately owned woodland has no active management for wood production. For all the rhetoric from bodies such as the UK Committee on Climate Change (2010), which has promoted wood energy, progress in developing woodland for fuel remains rather slow.

Concepts

The key organising concepts of the title of this paper, sustainability and multifunctionality, are convenient explanatory concepts relating to natural resource management. They are, however, distinctly different. Sustainability is a normative social construction, given particular meaning in a European forestry context through the Sustainable Forest Management Principles and their articulation into European practice by the MCPFE. Sustainability represents a socially desirable end-state, in forestry's case associated with a set of criteria and indicators that can assess progress and trends. In contract, multifunctionality is an uncontestable fact; it is a feature of certain types of natural resource the management of which generates joint products.

Sustainability has been defined by the MCPFE in relation to forests as:

"the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."

http://www.foresteurope.org/eng/What_we_work_for/Sustainable_Forest_Management/

This definition of sustainability necessitates a holistic view of environmental (ecological), social and economic functions, but gives no guidelines as to how trade offs between different functions might be negotiated. In practice, there is a tendency to explore direction of trend in relation to a suite of indicators that reflects the multiple dimensions of sustainability. This is the basis of the Criteria and Indicators approach to sustainable forest management, which establishes a framework but which by-passes the awkward questions about trade-offs.

According to the OECD (2008), the key elements of multifunctionality are the existence of multiple commodity and non-commodity outputs jointly produced by land use—and the fact that some of the non-commodity outputs exhibit the characteristics of externalities or public goods for which markets do not exist or function poorly. Multifunctionality had already been articulated as a central feature of the European model of agriculture at an EU council meeting in 1997 (Council of the European Union, 1997) and has now become culturally embedded in the European way of looking at rural land use.

There is also need to be sensitive to new conceptual schema. At present, many policy analysts look at natural resource management using the ecosystem approach and the idea of ecosystem services (Millennium Ecosystem Assessment, 2005, Defra, 2007, UKNEA 2011). The MCPFE has also explored this approach (MCFPE, 2004) and it is also being picked up at European Commission level. It identifies four types of ecosystem service (provisioning; supporting; regulating and cultural). It builds on the idea of multifunctionality but, at the same time, constitutes a subtle step away from an exclusively economic perspective towards more ecocentric thinking. Yet, in its recent use in the UK Ecosystem Assessment, the economic value of ecosystem services is still very much to the fore. In the case of forestry, the multiple ecosystem services are often manifested in high levels of provision of supporting or regulating services.

A further reconfiguration of old concepts is found in the idea of payments for ecosystem services (PES), built around the design of mechanisms which reward the provider of public goods. Public policy measures, especially in the farm sector, have often been the principal arena of PES. The concept has been explored by the OECD (2005) and, given tight public sector budgets, the scope for private and voluntary PES schemes in forestry looks attractive.

Behind these concepts there are some fundamental organising concepts that should not be neglected and which may be especially important in the case of forestry. There are two critical connected concepts that need to be recognised. The first is the concept of a public good. The second is the idea of internalising externalities. Public goods are defined as non-rival, non excludable goods/services. Many of what are now routinely described as supporting and regulating services in the new ecosystem services terminology are public goods or have at least some of the attributes of public goods. For example, flood control or protection forest functions, carbon storage, biodiversity protection and landscape services are all examples of the multifunctional goods and services provided by forests with some public good characteristics

The idea of internalising externalities arises from the realisation, articulated by Mantau et al. (2001), that market opportunities often depend on institutional innovation. So, rather than looking for market failure, institutional innovation should be sought to create that market. Slee (1995) had argued somewhat earlier that there is scope for indirect marketisation of some public goods. Although no-one has to pay for access to the iconic pine forests of Eastern Scotland because of Scottish access laws, the landowner can (and in one case does) charge a fee for parking a car in the vicinity of those iconic views. There may be many different forms of secondary marketisation, and these merge almost imperceptibly with conventional enterprise diversification into normal market-based activities by forest owners. The attribution of value to forests may be problematic if the forests sit in a wider range of land uses with positive externalities.

Issues in the development of new rural development possibilities

A number of issues stand in the way of realising the opportunities that forestry could contribute to sustainable rural development. At a practical level, these include characteristics of the owner and the resource. At a theoretical level, the ability to generate spatially explicit benefit measurements with respect to public goods is problematic. The scope for realising new benefits by redefining property rights and the challenge of trying to optimise the multifunctional outputs of forests, especially the trade offs with regard to global, national and local benefits comprise further challenges. Finally, multifunctionality opens up forestry to a range of new policy arenas, creating complexity and uncertainty.

Forest owners may have rather specific views about what they want from their forests. As landowners, they have rights to act, subject to various laws and regulations. Their preferences may not coincide with what is socially and economically optimal. In parts of the UK, woodland is used widely for sport shooting, which is often not marketed formally, but represents a form of landowner/manager recreation. Such forest landowners tend not to want to manage their forest for timber production or woodfuel. Decisions are not driven by any profit maximising motive but by social customs and preferences which may not optimise development outcomes (Urquhart et al. 2009). In other parts of Europe, there are evident tensions between the now-urban-based owners of farm forests and the rural population.

In some parts of Europe the structure of forest ownership is inimical to the rational and sustainable use of forests. In Eastern and South-eastern Europe there are many tiny plots of restituted forest. The average size of private forest holdings in some Balkan countries is below 1 hectare. Absentee ownership is common. Sustainable management is impossible. Large industrially run forests with highly focused wood production objectives may also make multifunctional delivery difficult because of the over-riding desire to strip costs out of the wood supply chain.

Ownership structures for forests are highly varied. Italy contains some of the oldest community forests in Europe and they provide interesting examples of sustainable support for their rural communities. Some have adapted to new demands, especially tourism and generate substantial revenues therefrom. In the UK,

new charitable bodies such as the Woodland Trust have acquired woodlands. The public sector is often a major forest owner and it can manage forests multi-functionally for the public good, but the remote location of many state forests means that development opportunities are limited.
One of the great obstacles associated with public goods is the measurement of their value. The recent National Ecosystem Assessment in the UK has recognised a broad-ranging suite of public goods but has held back from valuing most of them (Valatin and Starling, 2011). A decade ago Willis et al. (2003) estimated the annual value of the public goods associated with UK forests at £1 billion. Other work has shown how the value of these public goods varies over space (Willis and Benson, 1989). The public goods and multifunctional outputs are highly significant. Benefit estimation has advanced, but few are confident about the ability to generate spatially explicit values for non-market ecosystem goods and services.
Property rights with respect to forests may seem fixed in long-settled advanced market economies, but they can be significantly renegotiated as a result of culturally constructed demand changes. An obvious example of this is the clear difference that has emerged between rights of public recreational access in different parts of the UK. Since a new law of access in Scotland in 2003, the public in Scotland can freely access forests as in the Nordic *Allemensretten* system. In contrast, English and Welsh access is limited to historic linear rights of way. Property rights can be contentious. They also vary significantly across Europe. Where exclusion can occur is contingent on property rights. It is easier to think of property rights as complex evolving institutions reformulated in the light of societal values and which in different contexts may create or negate commercial economic opportunities. Slee (1995) has noted how indirect valorisation can arise as a result of the ability to exploit views, car parking or accommodation in or near to attractive forests. A considerable impediment to rural development arises where the forest owner is unable to derive any value from his forest property which has high public good characteristics. Given the evolutionary nature of the EU Rural Development Programme and the scope for revision of property rights, there is a range of possibilities regarding the creation of quasi-markets and the development of schemes for the Payment for Environmental Services.
Multifunctionality seems a desirable characteristic for a forest, but it is by no means impossible to end up in a multifunctional muddle which serves neither the forest owner nor rural development well. Nijnik et al. (2011) note how multifunctionality can be horizontal or vertical. But delivery requires careful management and navigation of the policy field. The transaction costs of creating and sustaining multifunctionality may be considerable and what is the optimal mix today may be sub-optimal tomorrow. The policy environment may change. Long production cycles can produce path dependencies from which it can be costly to 'unhitch'.
The forest sector connects to a range of policies at multiple scales, from sub-national to national to international. To a degree, supra-national and sub-national policies now have greater importance. Conventional forest policy provides the foundation policies, but forest owners also now draw on a range of policies for support from energy, to climate change, to biodiversity, to health, to recreation, to rural development, to agriculture, to regional development, enterprise and innovation. Foresters must confront a multiple array of possible support and regulation with the obvious transaction costs in a complex policy maze.

Framework conditions

The development of opportunities is contingent on a combination of markets, human capacities, governance structures, and a supportive institutional milieu, including well-targeted public support. Many approaches derived from management science, regional geography and regional economics explore innovation processes. In the cluster model and many other sectoral or regional innovation models, the public sector and research and educational institutions combine with industry in what has been termed a 'triple helix' to provide supportive framework conditions. Other researchers have advocated an innovation system model which similarly recognises the need for collaboration among a range of actors and institutions (Weiss, 2011).

One problem that confronts those exploring innovation in the forest sector is the boundaries drawn around the wood production sector. In Weiss' COST E51 action, the forestry industry included not just the wood supply chain and the actors along it, but all those directly and indirectly connected to the forest for their wellbeing. This exposes a potential tension between the search for efficiency and innovation in the wood supply chain and the move to a more multifunctional forestry linked to public goods and environmental services. Where there is a strong production forest sector, this may actually comprise a barrier rather than an opportunity to enhancing sustainable forest management and rural development (Slee 2011).

The market drivers are central, if perturbed occasionally by policy 'biases' which emerge from effective rent seeking by sectional interests. Markets will be crucial in realising new opportunities. The rising price of hydrocarbons is perhaps the most important of these in recent years, with impacts on the demand for woodfuel. When there are matching policy drivers, the scope for rapid sectoral development may arise. However, the demand for food is also rising. Inevitably there will be competition for land for food production. In Scotland, where government policy is committed to expanding the forest cover, farmers feel threatened. There is a need to research the optimal land use mix intelligently.

Rural development policy is strongly shaped by the CAP. In the future Pillar 2 may begin to better address more thoroughly issues including water quality and climate change, with the Commission asserting that 'the future CAP should contain a greener and more equitably distributed first pillar and a second pillar focussing more on competitiveness and innovation, climate change and the environment'(CEC, 2010).

Three examples of breaking away from traditions provide illustrations of the opportunities. First, as part of COST E51, Weiss et al (2011) have indicated the possibilities of transformational change in the forest sector. In response to earlier hydrocarbon price rises in the 1970s, Austrian farmers' organisations and municipal authorities collaborated in the development of woodfuel supply chains, including community heating schemes and combined heat and power developments. This revitalised a mature industry facing low returns and engaged the farmers as major forest owners. This example may not be repeatable everywhere, but the preconditions are by no means unique and sustainable and profitable wood energy supply chains have become well established. Second, the UK Forestry Commission has developed world class mountain biking centres. These developments began in North Wales. Within a few years of a £200,000 investment, the development was drawing in between £3 and 4 million of expenditure into the local economy. This represents between up to 100 full-time equivalent jobs in an area with high unemployment. These are figures that regional development agencies would regard with enormous envy. Mountain biking developments have subsequently been rolled out more widely. The third example is Italian and is articulated at theoretical level by Pettenella and Maso (2011). In the Borgotaro region of Northern Italy, a range of institutional actors including municipalities, forest owners, restauranteurs and tourist providers have linked together to develop forest based tourism, building on the highly valued porcini that are found in the area.

Whether we are dealing with wood-based forest products or non-wood forest products and services, the case for innovation with respect to processes, products, services and markets is strong. At EU level, the case for innovation was first articulated in the Lisbon strategy and has subsequently been reinforced in the

Europe 2020 strategy for smart, sustainable growth. The assumption that because forestry is a low-tech industry it has limited potential for innovation is untenable. The breadth of products and services provided by forests creates a context ripe for innovation. However, path dependencies may limit future innovation.
Particularly where there is scope for transforming predominantly monofunctional forestry into something more multifunctional, there may be a need for new modes of governance and new policy instruments to bring the relevant stakeholders together. This is most necessary in the predominantly monofunctional forests of North America and some parts of western Europe (Galicia, Portugal, Ireland, the UK) but transformation costs may be large. Kelly and Bliss (2009) articulate a new 'healthy forests healthy communities paradigm' in the aftermath of failed industrial forestry in the US. They argue that a local example 'can point a way to restoring forest health, overcoming the jobs versus-environment debate, building community capacity, and developing a local forest restoration workforce.'
There is a growing body of work in Europe built around the idea of transition management and the need to create participatory processes involving visioning of regime changes towards more sustainable outcomes. This work has been pioneered by Kemp and Martens (2007) and Loorbach (2007). They assert that many established regimes (e.g., of energy, water management) are proving increasingly unsustainable. These sectors are the settings of open-ended complex and difficult to resolve 'wicked' problems that hinge around the breakdown of socio-technical systems. Loorbach (2007) argues that niche innovations can become a testing ground for alternative ways of addressing these challenges.

Conclusions

There is a need to explore the scope for forestry's contribution to rural development. Its achievement will be contingent on innovation but may also be framed by major policy changes for example in relation to climate change. However, the framework conditions may not always be appropriate to realise enhanced opportunities. The nature of forestry is that it is highly multifunctional and requires well-designed policy and regulation to ensure the delivery of numerous public goods. Some of these public goods are hugely important in underpinning global not just rural prosperity and sustainability. However the realisation of more positive effects is contingent on a transition in terms of governance and policy to help unlock the enormous opportunities offered by forests.
It is not inconceivable that we have adopted an overly ecocentric model of sustainable forest management. We may need to cease to see forests as objects to preserve and instead treat them as places for the delivery of an enormous raft of goods and services which create scope for new employment and for new and more sustainable products. These are examples of niches that need up-scaling in regionally sensitive ways to realise the multiple opportunities. Yet, the prospects are still hedged with uncertainties, but as we face what Sir John Beddington, the UK's chief scientist calls the threat of a 'perfect storm' the realisation of that opportunity and the rural development outcomes that it can and should engender depend on creating and nurturing the preconditions in which renewable natural resources such as forest products can assume their rightful importance as the world searches for low carbon growth.

References

[1] Committee on Climate Change, (2010), *Scotland's path to a low-carbon economy*, CCC, London.

[2] Council of the European Union, (1997), Council- Agriculture, Press Release, Brussels (19-11-1997) press 343, Nr: 12241/97, Brussels.

[3] Defra, (2007), *An introductory guide to valuing ecosystem services*, Defra: London.

[4] De la Torre Ugarte, D., (2005), The contribution of bioenergy to a new energy paradigm, *EuroChoices* 4, 6-11.

[5] European Commission, (2010) The CAP towards 2020. COM(2010) 672 final.

[6] Fitoussi,J-P., Sen, A., and Stiglitz, G., (2008), Report by the Commission on the Measurement of Economic Performance and Social Progress, Paris.

[7] Jackson, T, (2009) Prosperity without growth, Earthscan, London.

[8] Keenleyside, C. and Tucker, G. M. (2010) *Farmland Abandonment in the EU: an assessment of trends and prospects*. Report prepared for WWF, Institute for European Environmental Policy, London.

[9] Kelly, E.C. and Bliss, J.C., (2009), Healthy Forests, Healthy Communities: an emerging paradigm for natural resource-dependent communities*? Society & Natural Resources*, 22, 519-537.

[10] Kemp, R. and Martens, P., (2007), Sustainable development: how to manage something that is subjective and can never be achieved? *Sustainability Science, Practice and Policy* 3: 1-10.

[11] Loorbach, D., (2007), *Transition management: new mode of governance for sustainable development* Utrecht, International Books.

[12] MacKay, D.J.C. (2009), *Sustainable energy without the hot air*, UIT, Cambridge

[13] Mantau, U., Merlo, M.,Sekot, W. and Welcker, B., (2001), Recreational and environmental markets for forest enterprises : a new approach towards marketability of public goods. CABI Publishing, Wallingford.

[14] MCFPE, (2004), *Sustainable forest management and the ecosystem approach*, MCFPE, Warsaw.

[15] Millennium Ecosystem Assessment, (2005) *Ecosystems and human well-being: synthesis.* Island Press, Washington. The UK National Ecosystem Asses

[16] Nijnik, M., Slee, B., and Pajot, G., (2011) Opportunities and challenges for terrestrial carbon offsetting and marketing, with some implications for forestry in the UK, *South-East European Forestry* (SEEFOR) in press.

[17] OECD, (1998), Meeting of the Committee for Agriculture at Ministerial Level. Agricultural policy: the need for reform, *Discussion Paper AGR/CA/MIN(98)2*, OECD, Paris.

[18] OECD, (2008), *Multifunctionality in agriculture, evaluating the degree of jointness, policy implications*, OECD, Paris.

[19] Pettenella, D., and Maso, D., (2011) Networks of Small-Medium Enterprises operating in Forestry; Some theoretical concepts and empirical evidence, Ch 3 of Weiss, G., Pettenella, D., Ollonqvist, P. and Slee, B. eds. (2011), *Innovation in forestry: territorial and value chain relationships*, CABI, Wallingford.

[20] Schama, S., (1995) *Landscape and Memory*, Harper Collins, London.

[21] Shaw, K., (2004) Liveability in NDC Areas: Findings from six case studies, New Deal for Communities, The National Evaluation, *Research Report 22*, Sustainable Cities, The Neighbourhood Renewal Unit, London.

[22] Slee, W, (2011), Governance, multifunctional forestry and economic literacy, Scottish Forestry, 65(2) 18-23.

[23] Slee, W., Roberts, D. Evans, R. (2004), Forestry in the rural economy: a new approach to assessing the impact of forestry on rural development, *Forestry 77* (5) 441-453.

[24] Slee, R.W., (1995), Market-led Environmental Provision : a Case Study of the Cairngorms. In Symes D and Jansen A J Eds. *Agricultural Restructuring and Rural Change in Europe*, Agricultural University: Wageningen.

[25] Slee, B., (2011) Innovation in forest-related territorial goods and services, Ch 8 of Weiss, G., Pettenella, D., Ollonqvist, P. and Slee, B. eds. (2011), *Innovation in forestry: territorial and value chain relationships*, CABI, Wallingford.

[26] Stern, N (2007) *The economics of climate change*: the *Stern Review*. Cambridge, Cambridge University Press.

[27] UK National Ecosystem Assessment (2011) *Synthesis of the Key Findings.* UNEP-WCMC, Cambridge, UK.

[28] Urquhart, J., Courtney, P. and Slee, B. (2009). Exploring the relationship between private ownership and public good provision in English woodlands, *Small Scale Forestry*, 9, 1-20.

[29] Valatin, G. and Starling, B., (2010), *Economic assessment of ecosystem services provided by UK woodlands*, The Economics Team of the UK Ecosystem Assessment, Forest Research.

[30] Weiss, G., Pettenella, D., Ollonqvist, P. and Slee, B. eds. (2011), *Innovation in forestry: territorial and value chain relationships*, CABI, Wallingford.

[31] Weiss, G., (2011), Theoretical approaches for the analysis of innovation processes in the forest sector, Ch 2 of Weiss, G., Pettenella, D., Ollonqvist, P. and Slee, B. eds. *Innovation in forestry: territorial and value chain relationships*, CABI, Wallingford.

[32] Willis, K.G. and Benson, J., (1989), 'Recreation value of forestry.' *Forestry* 62(2): 93-110.

[33] Willis, K.G., et al. (2003). *The social and economic benefits of forests in Great Britain*. Centre for Research in Environmental Appraisal & Management (CREAM), University of Newcastle, UK.

[34] World Commission on Environment and Development, (1987), *Our common future, report of the World Commission on Environment and Development*, (The Brundtland Commission), Oxford University Press, Oxford.

Tropical deforestation: current trends and potential sustainable policies

On the basis of the most recent data concerning the extent of tropical deforestation and its implications for the terrestrial carbon budget, the paper describes the main drivers of deforestation and forest degradation in tropical regions. Although several studies indicate that it has no direct relationship with deforestation in the current situation (in particular as regards sugar cane cultivation in Brazil), production of biofuels (biodiesel, ethanol) through cultivation of energy crops, may represent a serious concern in the coming years, due to projected increases in the demand of biodiesel and ethanol. In order to limit the environmental and social impacts of such productions, both legal restrictions and market instruments have been used: certification systems are expected to play a major role in the future, in connection with sustainability criteria. Finally, current efforts under the UNFCCC to reach a global agreement on reducing emissions from deforestation and forest degradation may represent an important contribution to efforts already in place, provided that policy tools take into account the diverse national circumstances faced by forest-rich developing countries seeking to reduce their emissions

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Trends in forest land and carbon sink

Deforestation, consisting in the conversion of tropical forest to agricultural land, continues at the global level, despite signs of decreasing in several countries. A quantitative assessment of deforestation levels and trends is hindered by the differences in national approaches to forest monitoring: countries use differing frequencies, classification systems and assessment methods, which makes it difficult to obtain consistent data at the global level. These uncertainties were already discussed by the authors in a report published in 1992, which focused on the assessment of deforestation rates in Brazil (Magrini and Gaudioso, 1992). According to FAO's Global Forest Resources Assessment 2010 (FRA 2010), around 13 million hectares of forest were converted to other uses or lost through natural causes each year in the last decade, compared

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TABLE 1 Annual change in the area of tropical forsts by region, 1990-2000
Source: FRA 2010 (FAO 2010)

Region/subregion	1990–2000		2000–2010	
	1000 ha/yr	%	1000 ha/yr	%
Eastern and Southern Africa	-1 841	-0.62	-1 839	-0.66
Western and Central Africa	-1 637	-0.46	-1 535	-0.46
South and Southeast Asia	-2 428	-0.77	-677	-0.23
South America	-4 213	-0.45	-3 997	-0.45

with 16 million hectares per year in the 1990s (FAO, 2010); annual deforested areas by region are shown in Table 1. It is worth noting that FAO's 2010 estimate for the 1990s is significantly higher, but more accurate, than FAO's 2005 estimate, equal to 13 million hectares per year.

Estimates for the net exchange of carbon between terrestrial ecosystems and the atmosphere are even more differentiated, depending on the approach used: inverse calculations, compilation of national forest inventories, top-down calculations based on land-use change data. A recent study, which makes use of recent forest inventory data and long-term field observations coupled to statistical or process models, quantifies emissions due to tropical deforestation in 3.0 PgC yr^{-1} in 1990-1999 and 2.9 PgC yr^{-1} in 2000-2007. In particular, the sink reduction in tropical forests in the period 2000 - 2007 was caused by deforestation reducing intact forest area (8%), and a severe Amazon drought in 2005 which appeared strong enough to affect the tropics-wide decadal C sink estimate (15%).

Tropical deforestation emissions are partially offset by tropical forest regrowth, which amounted to 1.6 PgC yr^{-1} in 1990-1999 and 1.7 PgC yr^{-1} in 2000-2007. In addition to that, tropical intact forests remove carbon from the atmosphere, representing a carbon sink, the magnitude of which was estimated on the order of 1.3 PgC yr^{-1} in 1990-1999 and 1.0 PgC yr^{-1} in 2000-2007, as shown in Table 2 (Pan *et al.*, 2011).

Table 2 shows that, when both removals from intact forests and from forest regrowth are combined, the tropical sinks sum to 2.9 ± 0.6 and 2.7 ± 0.7 PgC yr^{-1} over the two periods, respectively (Table 2), and on average account for about 70% of the gross C sink in the world forests (~4.0 PgC yr^{-1}). However, given that gross emissions from tropical deforestation are almost of the same order, tropical forests are nearly carbon neutral.

TABLE 2 Carbon budget in tropical forests
Source: Pan et alt., 2011

Global forests:	1990-1999	2000-2007
Tropical *gross* deforestation	3.0±0.5	2.9±0.5
Tropical forest regrowth	1.6±0.5	1.7±0.5
Tropical land use change	1.5±0.7	1.1±0.7
Tropical intact forests	1.3±0.4	1.0±0.5
Tropical *net* forest emissions	0.1±0.8	0.2±0.8

Without implementation of effective policies and measures to slow deforestation, clearing of tropical forests will likely release an additional 87 to 130 GtC by 2100, corresponding to the carbon release of more than a decade of global fossil fuel combustion at current rates. On the contrary, reducing deforestation rates 50% by 2050 and then maintaining them at this level until 2100 would avoid the direct release of up to 50 GtC this century (equivalent to nearly 6 years of recent annual fossil fuel emissions, and up to 12% of the total reductions that must be achieved from all sources through 2100 to be consistent with stabilizing atmospheric concentrations of CO_2 at 450 ppm. Emissions reductions from reduced deforestation may be among the least expensive mitigation options available at the global scale (although this should not lead to lower reduction commitments for other GHG emitting sectors). The IPCC estimates that reductions equal to or greater than the scale suggested here could be achieved at ≤U.S.$20 per ton CO_2 (IPCC, 2007).

Drivers of deforestation and forest degradation

Global demand for agricultural products such as food, feed and fuel is now a major driver of cropland and pasture expansion across the developing world. However, the environmental consequences of this expansion are significantly influenced by the conversion pathways: new agricultural land can in fact replace forests, degraded forests or grassland. As a whole, between 1980 and 2000 more than 55% of new agricultural land came at the expense of intact forests, and

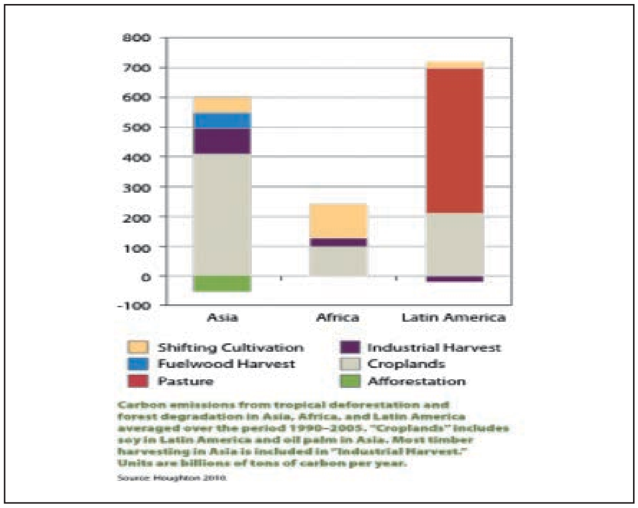

FIGURE 1 Sources of Carbon Emissions from Deforestation and Degradation in Tropical Regions
Source: Houghton, 2010

another 28% came from disturbed forests, according to a recent global survey which used the library of classified Landsat scenes originally processed by the FAO as part of the Forest Resources Assessment (Gibbs *et al.*, 2009).

However, as tropical forests are not all the same, so the drivers of tropical deforestation vary a great deal between continents (see, for instance, the assessment of sources of carbon emissions in Fig. 1): cattle and soy are important only in Latin America, while palm oil plantations are found almost exclusively in Indonesia and Malaysia. The timber industry has a particularly important role in deforestation in southeast Asia, where logging is often followed by conversion to plantations to produce palm oil or pulpwood (UCS, 2011).Soybean production is heavily concentrated in three countries: the United States, Brazil, and Argentina. Expansion of large-scale commercial soy production into the Amazon in the 1990s was an important cause of deforestation, and Brazil became the largest soybean exporter in the world. However, pressure from civil society led to an industry moratorium on buying soybeans from deforested areas beginning in 2006, and recent data indicates that soy's role as an agent of deforestation has greatly diminished; although attributing this recent reduction in deforestation in part to the soy moratorium is still premature, nevertheless the initiative has certainly exerted an inhibitory effect on the soybean frontier expansion in the Amazon biome (Rudorff *et al.*, 2011).

Pasture expansion to produce beef cattle is the main agent of deforestation in Brazil, occupying more than three-quarters of the deforested area. Beef production in the Amazon tends to be extensive, with low levels of meat production per unit area. As with soy, civil society pressure in Brazil has led to a moratorium since 2009 on buying beef from ranches that have cleared forests to create pasture. Pasture expansion remains an important driver of deforestation in Colombia and other Latin American countries, although over much smaller areas than in Brazil. Cattle breeding is not an important cause of deforestation in Africa or Asia (UCS, 2011).

Expansion of sugarcane cultivation in Brazil takes place, according to recent surveys, through conversion of pasture land (71%) or land previously hosting soy (19%) corn (5%) or orange (5%) crops (MAPA and CONAB, 2008). In the traditional Brazilian agricultural practices, sugar cane does not have a role as a pioneer crop in agricultural frontier areas; a direct relationship between the expansion of sugar cane and deforestation should therefore be excluded, and sugarcane is likely to expand in previously cleared area (Cardoso Silva, 2010).

The palm oil industry is heavily concentrated in two tropical forest countries, Indonesia and Malaysia, and has been expanding rapidly in recent years. Emissions from deforestation caused by palm oil plantations are particularly important as concerns their impact on global warming, as considerable plantation expansion take place in peat swamps with very large amounts of carbon in the soil. The palm industry is dominated by large integrated companies, that are also involved in timber cutting and establishing tree plantations for pulpwood production, so southeast Asian deforestation depends on complex interactions between logging and palm and pulp plantations.

Though only a small part of global timber production and trade, logging in tropical forests can be an important cause of forest degradation. In southeast Asia, where many more tree species are commercially valuable, it leads to deforestation as well. In Latin America and Africa most clearing is for land, not timber, but logging is often the first step to complete the deforestation of an area. Plantations of native species can supply large amounts of wood to take some of the pressure off of natural forests, but only if established in already cleared areas.

Firewood collection has often been blamed for deforestation, but although the volume of wood involved is large, most of it comes from already dead trees and branches, from non-forest areas, or from small trees and shrubs in the understory. Thus it is generally not causing deforestation or even significant degradation. Moreover, firewood use is expected to diminish in the tropics in coming decades, and has already dropped considerably in Latin America (UCS, 2011). On the contrary, charcoal use is expected to increase considerably over the next 20 years, particularly in Africa, to supply nearby cities; charcoal production can be a locally important driver of degradation and eventual deforestation. In Brazil there is a great deal of concern over charcoal produced for the pig iron and cement industries. Brazil is the largest consumer of industrial charcoal in the world: much of this comes from native forests, but the amount supplied by eucalyptus plantations is increasing to meet these demands: charcoal from native forests has increased from 16.9 million m^3 in 1980 (86%) to 18.8 million m^3 in 2005 (49.6%), while coal originating from planted forests has increased from 2.8 million m^3 in 1980 (14.1%) to 19.2 million m^3 in 2005 (50.4%) (Oliveira *et al.*, 2007). As in other regions, charcoal use is expected to increase in the future.

Small-scale farming has become less important to deforestation in recent decades, as rural populations have leveled off or declined and large businesses producing commodities for urban and export markets have expanded into tropical forest regions, in particular in the Amazon and southeast Asia; Africa is an exception to this generalization (Rudel *et al.*, 2009).

Impacts of biofuels production on deforestation

Globally, there is a large interest, in expanding the energy use of biomass, with a view to mitigating climate change while enhancing energy security, and in particular in finding renewable fuels to substitute for petroleum-based fuels. Biofuels such as biodiesel and ethanol are being promoted in several industrialised and developing countries through targets for substituting biofuels for diesel and gasoline, with proportions ranging from 5% to 20%, to be met at various times within the period 2010-2030 whereas in specific cases, such as Brazil, replacement with ethanol can reach 100% in "flex-fuel" cars.

Increasing biofuel production requires crop expansion. On the basis of current projections of the demand for transportation fuels, the amount of land required to meet 10% of the projected biodiesel demand for 2030 – i.e., 179 Mt - has been estimated to be 173 Mha for jatropha, 48 Mha for palm oil and 361 Mha for soybean; similarly, the land required to meet the ethanol demand – i.e., 289 Mt - has been estimated to be 147 Mha for maize, 70 Mha for sugarcane and 116 Mha for sweet sorghum (Ravindranath, 2009). This corresponds to an increase in the extent of agricultural land (arable land + permanent crops) ranging from 3,2% to 23,8% for biodiesel, and from 4,6% to 9,7% for ethanol, at the global level.

However, actual carbon savings offered from biofuels depend on how they are produced. Crop expansion leads to direct and, in many instances, indirect land-use change (LUC), depending whether additional cropland is made available through the conversion of native ecosystems such as peat lands, forests and grasslands or, alternatively, by diverting land currently cropped for non-energy production.

Recent studies by Fargione *et al*. (2008) and Gibbs *et al*. (2008) show that land-use conversion from native

land-uses to biofuel crops would lead consistently to significant GHG emissions and a negative carbon balance, or carbon-debt, for decades to centuries. Only in a limited number of cases (conversion of Brazilian Cerrado to sugarcane ethanol or soybean biodiesel, conversion of Indonesian or Malaysian grasslands to sugarcane or oil palm), the time required to offset the carbon-debt is of the order of some decades.
If biofuels are to help mitigate global climate change, they need to be produced with little reduction of organic carbon stocks in the soils and vegetation of natural and managed ecosystems. Degraded and abandoned agricultural lands could be used to grow native perennials for biofuel production, which could spare the destruction of native ecosystems and reduce GHG emissions.
In addition to the impact on GHG emissions, cultivation of food-based biofuel crops could have adverse impacts on food security, biodiversity and water. Second-generation biofuels, produced through the conversion of lignocellulosic feedstocks, use less or no water for irrigation, will not compete with food if grown on abandoned or marginal cropland and may maintain or increase biodiversity if grown in ways that are compatible with wildlife (FAO, 2008). However, these technologies have yet to become commercially viable.

Sustainability criteria and sustainable policies

As part of policies aimed at promoting the energy use of biomass, many industrialized countries, some countries where energy crops are cultivated and, more recently, some international organizations are envisaging and implementing public and private environmental management policies (legal restrictions and market instruments, respectively) aimed at limiting the environmental and social impacts of such productions. In particular, Brazil, the first country to launch a large-scale program – PROALCOOL – for the substitution of biofuels for petroleum derivatives (1975) and the dissemination of flex-fuel vehicles in 2003, introduced in 2009 a land-use regulation - Zoneamento Agroecológico da Cana-de-Açucar (ZAE), which bans the production of bioethanol in the territories of the Amazon, the Pantanal and the Upper Paraguay Basin (Daemon, 2010). Brazil had already introduced in 2006 a moratorium on soy expansion in the Amazon, whereas in 2009 a moratorium was established on buying beef from ranches that had cleared forests to create pasture. In 2011, Indonesia has introduced a moratorium on new forestry, agricultural and mining business permits on natural primary forest and peat land over the next two years.
Zoning approaches are an essential tool for protecting land with high biodiversity value; however, they have serious limitations, consisting not only in the difficulty of enforcing the protection regime, but especially in the lack of protection for the remaining territory. In the specific case of sugarcane cultivation in Brazil, the Zoneamento Agroecológico da Cana-de-Açucar (ZAE) does not provide any protection for the Cerrado ecoregion, which would not be affected, as well as the possible production of sugar cane, but also by the displacement of traditional activities (cereal cultivation, livestock breeding) that currently take place in the areas affected by a more rigorous system of protection (Daemon, 2010).
To address these limitations, initially at the national level but increasingly at the international level, in relation to the growing trade of biofuels, different subjects have developed sustainability criteria, which generally focus on greenhouse gas emissions, biodiversity, agricultural practices and social impacts. At the international level, the most influential criteria have been those proposed by the Government of the Netherlands, adopted by the Cramer Commission in 2006 (Cramer, 2008), by the Roundtable on Sustainable Development (RSB, 2008) and by the Bonsucro / Better Sugarcane Initiative (BSI), a global non-profit initiative (Bonsucro, 2011).
Certification is a tool compatible with market approaches, and its ability to ensure sustainable production systems is recognized in other areas of agribusi-

ness (as shown by the experience of the FSC, Forest Stewardship Council). Its effectiveness depends on several factors related to its practical implementation, and in particular by:

1. the identification of the subject responsible for the monitoring of production systems and the preparation of statements;
2. the definition of criteria and indicators that are appropriate to the reality of each country;
3. the costs of the certification scheme, compared to production costs.

The experience with traditional certification systems shows that they have the ability to reduce emissions of greenhouse gases from production processes (if only by stimulating improvements in the efficiency of the conversion process), while they are not effective in protecting biodiversity, ensuring net GHG emission benefits (taking into account the entire life cycle) and avoiding adverse impacts on the availability and the quality of water resources (Searchinger, 2009). The most effective environmental management model should therefore comprise a land-use regulation, a certification scheme and appropriate policy incentives.

A similar approach has been used by the European Union in the definition of sustainability criteria that must be met by biofuels so that they can help achieve the targets set under Directive 2009/28/EC for the promotion of renewable energy sources. In fact, these criteria include a minimum GHG emissions reduction target from the fuel production cycle (35% initially, rising to 50% from 1 January 2017 and 60% from 1 January 2018), together with a series of production bans for protected areas, primary forests and areas with high biodiversity or carbon stock. The directive provides for the economic operators to demonstrate that the criteria have been met, and also provides that the Commission may enter into agreements with third countries allowing for the recognition of certification schemes. As for solid biomass or biogas, for which no provisions are included in the directive, the European Commission recommends that where Member States impose sustainability criteria, they should be in almost all respects the same as the ones imposed by the Renewables Directive for bioliquids.

Possible impact of a successful REDD+ policy process

Despite the huge emission reduction potential, forest clearing is not addressed by the flexible mechanisms introduced in the first commitment period (2008-2012) of the Kyoto Protocol. Article 3.4 of the Protocol only considers afforestation and reforestation activities, although the impact of these activities on annual emissions and removals from Land-Use, Land-Use Change and Forestry is very low, as shown in Fig. 2. This the reason why current negotiations aimed at reaching a global agreement for the period after 2008-2012 focus on Reducing Emissions from Deforestation and Forest Degradation (REDD).

Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond de-

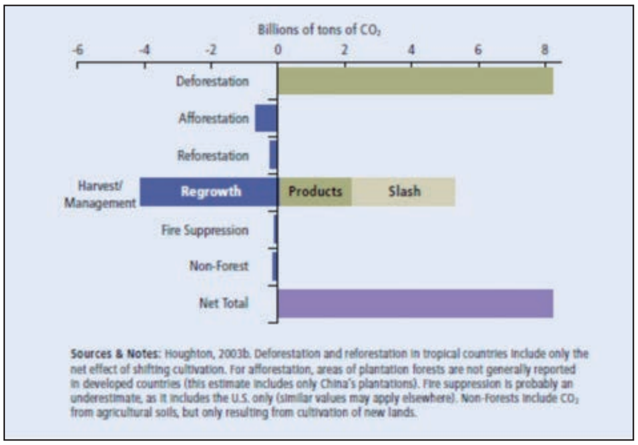

FIGURE 2 Annual emissions and removals from LULUCF activities, global estimates for the 1990s
Source: Baumert et al., 2005

forestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

Different policy approaches are needed to address the diverse national circumstances faced by forest-rich developing countries seeking to reduce their emissions. In some countries, it may be possible, at relatively low cost, to reduce emissions from deforestation and forest degradation that provide little or no benefit to local and regional economies, for example reducing accidental fire and eliminating forest clearing on lands inappropriate for agriculture. Other measures are unlikely to be implemented at large scales without financial incentives, that may be possible only within the framework of comprehensive environmental service payments, such as through carbon-market financing. In forests slated for timber production, for example, moderate carbon prices could support widespread adoption of sustainable forestry practices that directly reduce both emissions and the vulnerability of logged forests to further emissions from fire and drought exacerbated by global warming. On forested lands threatened by agricultural expansion, financing could provide significant incentives for forest retention and enable, for example, more effective implementation of land-use regulations on private property and protected area networks (Gullison *et al.*, 2007).

Key requirements for effective carbon-market approaches to reduce tropical deforestation include strengthened technical and institutional capacity in many developing countries, agreement on a robust system for measuring and monitoring emissions reductions, and commitments to deeper reductions by industrialized countries to create demand for REDD+ carbon credits and to ensure that these reductions are not simply traded off against less emission reductions from fossil fuels.

Whether a successful REDD+ policy process will make an important contribution to global efforts to stop deforestation and forest degradation depends on how it will be negotiated and actually implemented. Current negotiations mainly refer to technical issues, such as the establishment of baselines and the definition of reliable MRV (monitoring, reporting and verification) procedures, but also reflect the uncertainty about the general architecture of the mechanism.

The central question is to create a multilevel scheme (national and international) of payments for the environmental services offered by forests. At the international level, buyers of services will make payments (driven by mandatory markets or voluntary compliance) for service providers (government or sub-national entities in developing countries) for an environmental service (REDD+), or by measures to provide this service (for example, land reform, law enforcement). Nationally, buyers of services (government or other intermediaries) will pay service providers (sub-national governments or local landowners) to reduce emissions or to take other measures to reduce emissions (e.g., reduced impact logging) (de Oliveira Faria, 2010). One advantage of a national approach is that these broad policies can be implemented and credited to the extent that result in emission reductions; on the other hand, a sub-national approach would favor the involvement of the private sector in developing countries with serious institutional and technical deficiencies at national level (Rubio Alvarado and Wertz-Kanounnikoff, 2008).

In the background, two opposing options compete: on one side the creation of a publicly financed international fund that supports public policies; and on the other side the development of a market-based mechanism responsible for organizing the distribution of tradable carbon credits on international carbon markets (Pirard 2008). The final architecture of the system will depend on the balance of negotiations between North and South and by an evaluation of the effectiveness of two types of approaches. There are, of course, more general uncertainties related to the current economic crisis in the industrialized countries and the push for growth by developing countries, which could even jeopardize the outcome of the negotiations.

References

[1] Baumert *et al.,* 2005. K. A. Baumert, T. Herzog, J. Pershing, Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, World Resources International (WRI), 2005.

[2] Bonsucro, 2011. Bonsucro Production Standard– Version 3.0 March 2011, Including Bonsucro EU Production Standard.

[3] Cramer, 2008. Testing framework for sustainable biomass - Final report from the project group "Sustainable production of biomass".

[4] Cardoso Silva, 2010. Conceiçao Elaine Cardoso Silva, Avaliação dos condicionantes ambientais na perspectiva de expansão da produção de etanol no Brasil, M.Sc. dissertation, COPPE-UFRJ, Rio de Janeiro, Brazil, Marçh 2010.

[5] Daemon, 2010. Leonardo Daemon D'Oliveira Silva, Sustentabilidade do etanol brasileiro: uma proposta de princípios e critérios, M.Sc. dissertation, COPPE-UFRJ, Rio de Janeiro, Brazil,, March 2010.

[6] de Oliveira Faria, 2010. Claudia de Oliveira Faria, As florestas nas negociações internationais sobre mudanças climaticas:estado da arte e perspectivas, M.Sc. dissertation, COPPE-UFRJ, Rio de Janeiro, Brazil, February 2010.

[7] FAO, 2008. The State of Food and Agriculture. Food and Agriculture Organization, Rome.

[8] Fargione *et al.*, 2008. J. Fargione, J. Hill, D. Tilman, S. Polasky, P. Hawthorne, Land Clearing and the Biofuel Carbon Debt, Sciencexpress, www.sciencexpress.org/7 February 2008/Page 3/10.1126/science.1152747.

[9] Gibbs H.K., M Johnston, J. Foley, T. Holloway, C. Monfreda, N. Ramakutty, D. Zaks, Carbon payback times for crop-based biofuel expansion in the tropics: the effects of changing yield and technology, Environ. Res. Lett. 3 (034001):10 pp.

[10] H.K. Gibbs, A.S. Ruesch, F. Achard, M.K. Clayton, P. Holmgren, N. Ramankutty, J.A. Foley. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings of the National Academy of Sciences, 2010; DOI: 10.1073/pnas.0910275107.

[11] R.E. Gullison, P.C. Frumhoff, J.G. Canadell, C.B. Field, D.C. Nepstad, K. Hayhoe, R. Avissar, L.M. Curran, P. Friedlingstein, C.D. Jones, C. Nobre, 2007. Tropical Forests and Climate Policy, Science, Vol. 316, 18 May 2007.

[12] Houghton, R.A. 2010. How well do we know the flux of CO_2 from land-use change? Tellus 62B: 337-351.

[13] IPCC, 2007. G.J. Nabuurs et al., in Climate Change 2007: Mitigation of Climate Change (Contribution of Working Group III to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Cambridge Univ. Press, Cambridge, in press), chap. 9.

[14] Magrini, D. Gaudioso D., Il Brasile e la problematica dell'effetto serra, Rapporto ENEA, 1992.

[15] MAPA and CONAB, 2008, Perfil do Setor do Açúcar e do Álcool no Brasil, Situação Observada em Novembro de 2007, abril/2008 / Companhia Nacional de Abastecimento. - Brasília: Conab, 2008.

[16] L.S. Oliveira, E. Duboc, R.F. Veloso, 2007. Carvão vegetal no Brasil e no Cerrado, EMBRAPA, Documentos 176, ISSN 1517-5111, Maio 2007.

[17] Y. Pan, R.A. Birdsey, J. Fang, R. Houghton, P.E. Kauppi, W.A. Kurz, O.L. Phillips, A. Shvidenko, S.L. Lewis, J.G. Canadell, P. Ciais, R.B. Jackson, S. Pacala, A.D. McGuire, S. Piao, A. Rautiainen, S. Sitch, D. Hayes, A Large and Persistent Carbon Sink in the World's Forests, Science, /www.sciencexpress.org/14 July 2011 /Page 1/ 10.1126/science.1201609.

[18] R. Pirard, 2008. The fight against deforestation (REDD): Economic implications of market-based funding, IDDRI, Idées, N° 20/2008.

[19] N.H. Ravindranath, R. Manuvie, J. Fargione, J.G. Canadell, G. Berndes, J. Woods, H. Watson and J. Sathaye. 2009. Greenhouse gas implications of land use and land conversion to biofuel crops. In: Biofuels: Environmental Consequences and Interactions with Changing Land Use. Howarth RW, Bringezu S. (eds.), Scientific Committee on Problems of the Environment (SCOPE), Island Press, New York. Online access: http://cip.cornell.edu/biofuels

[20] RSB, 2008. Roundtable on Sustainable Biofuels: Global Principles and Criteria for Sustainable Biofuels Production, Version Zero. Ecole Polytechnique Fédérale de Lausanne, 2008

[21] L.X. Rubio Alvarado, S. Wertz-Kanounnikoff, 2008. Why are we seeing "REDD"? An analysis of the international debate on reducing emissions from deforestation and degradation in developing countries, IDDRI, analyses N° 01/2008 I NATURAL RESOURCES (updated version January 2008).

[22] T.K. Rudel, R.S. Defries, G.P. Defries, G.P. Asner and W.F. Laurance, 2009. Changing drivers of deforestation and new opportunities for conservation. Conservation Biology 23: 1396-1405.

[23] B.F.T. Rudorff, M. Adami, D.A. Aguilar, M.A. Moreira, M.P. Mello, L. Fabiani, D.F. Amaral, and B.M. Pires. 2011. The soy moratorium in the Amazon biome monitored by remote sensing images. Remote Sensing 3:185–202.

[24] T.D. Searchinger. 2009. Government policies and drivers of world biofuels, sustainability criteria, certification proposals and their limitations. In: Biofuels: Environmental Consequences and Inteactions with Changing Land Use. Howarth R.W., Bringezu S. (eds.), Scientific Committee on Problems of the Environment (SCOPE), Island Press, New York. Online access: http://cip.cornell.edu/biofuels

[25] UCS, 2011. The Root of the Problem: What's Driving Tropical Deforestation Today? Edited by D. Boucher, P. Elias, K. Lininger, C. May-Tobin, S. Roquemore, and E. Saxon, Tropical Forest and Climate Initiative, Union of Concerned Scientists, June 2011.

REDD and Clean Technologies Innovations, is there a Trade-off

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A key policy question when discussing REDD is how to balance low-cost forestry emission reductions, available in the near term, with investments to drive technological innovation in energy, industry, and other sectors over the longer period. In this article we report a research effort showing that the link of REDD to an international carbon market is, as expected, economically efficient. In addition, provided that the climate policy is stringent (we explore here a 535 ppmv CO^2 e concentration target), the cost savings due to REDD should entail only a modest tradeoff in terms of reduced clean energy innovation. Reduced clean energy innovation could in principle handicap future efforts to reduce global emissions. However, this analysis suggests that the availability of REDD, in particular when combined with the possibility of banking emission allowances, could provide a head start on climate mitigation that is an aggregate hedge against uncertain future costs. Integrating REDD into global carbon markets could thus lower policy costs and facilitate more ambitious climate policies now and in the future

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While there is broad agreement that global strategies to combat climate change should include policies to reduce emissions from tropical deforestation, the linkage of international forestry and other land sectors to the carbon markets remains a critical policy issue. Policies for Reducing Emissions from tropical Deforestation and forest Degradation (REDD) offer the opportunity to mitigate a major share of global GHG emissions at low estimated costs based on existing technologies (Stern 2008). Investments in REDD are also a potentially attractive "wooden bridge" for reducing near-term emissions while buying time to reengineer other sectors of the economy (Chomitz 2006). The policy debate has been increasingly focusing on a specific issue: how to balance low-cost emission reductions from tropical forest conservation with innovation investments that are needed to drive down future mitigation costs. The research reported in this article has used a global climate-energy-economy model to investigate the implications of linking REDD credits to a global carbon market, with a focus on the consequences for technology innovation in the energy sector.

So far, the Kyoto Protocol excluded mechanisms to reduce tropical deforestation. However, there is growing consensus on including REDD as a critical element of a

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future global climate policy regime. The Copenhagen Accord of December 2009 calls for immediately establishing a mechanism to finance REDD and other forestry sequestration activities in developing countries (UNFCCC 2009). The Accord specifically calls for exploring both public and private market-based financing approaches, but the details remain to be determined and no major steps forward on this have been made during the Cancun COP in 2010. Governments and other organizations have put forth multiple proposals for financing REDD activities, including market-based approaches with different degrees of fungibility between forest carbon credits and GHG reductions in other countries and sectors.[1] Policymakers in the United States are also considering multiple means of financing international forest carbon activities within emerging regional compliance markets for GHG reductions as well as in recent legislative proposals for a cap-and-trade system at the Federal level.[2]

Measured at a national scale against a reference level[3], reduction of tropical forest emissions would generate credits that could be sold and traded in a carbon market for GHG. Trade of permits would allow abatement to take place where it is cheapest, lowering the costs of climate policies and generating significant financing for REDD over the near term. This would obviously produce additional ancillary benefits as biodiversity and ecosystem services preservation would derive as side benefits of the carbon market driven forest preservation.

Although seemingly a win-win solution, there exists several thorny issues associated with the linking of REDD to a carbon market, ranging from social to environmental concerns. One set of concerns, that we explicitly investigate in the research reported here, is that linking international forest carbon credits to GHG compliance markets could lower near-term costs at the expense of reductions in developed countries' mitigation efforts and associated incentives to develop critical low-carbon technologies.

Concerns over the potential of REDD credits to "flood" compliance markets and dampen clean technology innovation have been largely voiced with regard to the scale of potential forest carbon credits related to the size of the European Union's existing Emissions Trading Scheme (ETS) market. For example, the European Commission cited a potential "imbalance" between the supply and demand for REDD credits as one of the reasons for its recommendation to defer the inclusion of REDD from the EU ETS at the end of last year (EC 2008).

In previous research Tavoni et al, 2007, pointed out that in the case of a mild climate policy, REDD could reduce our ability to face the downward revision of climate targets that could follow the discovery of new information. The reason for this would in fact be the lower incentive to innovation that would derive from the presence of forestry emissions in the market. On the other hand, researchers have argued that relatively modest investments to preserve tropical forests could also generate additional near-term emissions reductions that could help preserve flexibility for achieving more ambitious emissions reductions that may be needed in the future.

In the research reported here we analyze the effects of linking REDD to a global carbon market when the climate target is stringent, i.e., in line with the 2 °C target agreed upon by most of the world economies. The analysis is performed through a dynamic integrated assessment framework (based on Bosetti et al., 2006), which explicitly models induced technological change in the energy sector. We incorporate expected patterns of global participation as well as institutional features considered likely, such as limits on initial international trading and potential for permit banking, and also use a range of scenarios for costs and potentials of REDD. The first set of supply curves comprises the estimated compensation needed to cover 30 years of opportunity costs of reducing deforestation emissions in the Brazilian Amazon based on modeling from the Woods Hole Research Center (WHRC; Nepstad et al. 2007). We also consider two sets of estimates covering a global scale, based on a scenario in which all tropical forest nations immediately join a carbon trading system and have the institutional and governance capacity to fully implement deforestation-reduction programs. The first is based on results from the Global Timber Model (GTM) prepared for the Energy Model Forum 21 at Stanford University (Sohngen and Sedjo, 2006). The second is based on a estimates produced with a model developed at the International Institute for Applied Systems Analysis (Gusti et al. 2008) and prepared for the U.K. Office of Climate Change as part of the Eliasch Review (2008).

Our research confirms that integrating REDD into global carbon markets can provide significant incentives for reducing deforestation while lowering the costs of global climate change protection. We find that the cost savings from REDD have only modest tradeoffs in terms of reduced clean energy innovation. Investments in cleaner energy technologies over the next four decades are reduced by a maximum of 10% in the case of energy-intensity R&D investments. Figure 1 shows changes in cumulative investments in carbon-free technologies. It clearly shows how the presence of a stringent climate policy is such that the REDD plays only a modest role in lowering clean-technology deployment.

Moreover, while reduced clean energy innovation could in principle hinder future efforts to reduce emissions, our estimates suggest a positive net effect of REDD on the ability to adopt more stringent policies by the middle of the century. In particular, synergies between REDD and the possibility of banking provide a head start on climate mitigation that lower the costs of more ambitious targets that may be needed in the future.

The reported research concludes that concerns over REDD discouraging technological innovation are largely misplaced, as long as the climate policy is stringent (i.e., roughly in line with a 2 °C). Reducing the costs of climate change protection by steering efforts into the lowest marginal cost options for mitigation is precisely the economic rationale for an emissions trading system, providing a net gain for society as whole as long as the right long-term emissions reduction targets are in place. Furthermore, the interaction of REDD and banking helps cushion the risk of unanticipated higher costs when there is less than perfect anticipation of increases in future emission-reduction targets. Of course, if there is a concern that forest carbon credits will be too plentiful, policy makers al-

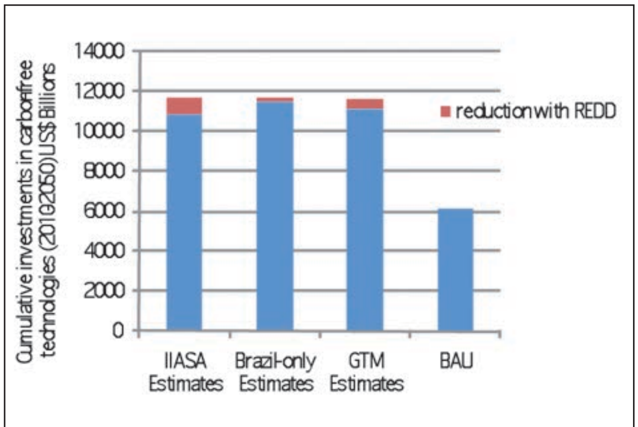

FIGURE 1 Impact of REDD on cumulative investments in carbon-free technologies (wind plus solar and nuclear) over 2010-49, under alternative REDD potentials and costs assumptions (in particular we use the WHRC Brazil study, the Global Timber Model, and the GLOBIUM Model)
Note: The entire height of each column indicates the case without REDD, while the red portion indicates the reduction with REDD. Business-as-usual (BAU) projections without any climate policy are provided for comparison
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ways have the option of limiting the numbers allowed in the system and it is surprising that this has not been taken up by the EU in its revised ETS proposals. At the same time we should not lose sight of the costs of excluding REDD from the carbon market: doing so risks making climate change protection policies unnecessarily expensive and misses important opportunities to enable political agreement on more stringent GHG reduction targets now and in the future. On top of these considerations we should not forget the many other sources of value that protecting the rain forest could imply for the planet and for us.

Notes

1. Parker et al. (2008) provide a user-friendly guide to the most recent and influential proposals for REDD, including the alternative financing options, while Parker et al. (2009) focus specifically on the financing alternatives.
2. The American Clean Energy and Security Act (H.R.2454) passed by the House of Representatives in June, 2009 sets an absolute limit of 1-1.5 billion tons per year on the allowed use reduced deforestation and other international mitigation credits from uncapped nations, although these “offsets” would be subject to a 20% discount after 2017. The bill includes a “strategic allowance reserve” that allows additional use of deforestation reduction credits if the carbon price hits particular levels. The bill also dedicates 5% of allowance auction revenues to fund additional international forest carbon activities.
3. On detailed discussion of how to compute the reference level, the issue of permanency and the efficiency of nation-wide rather than project-based systems is discussed elsewhere in the present issue.

References

[1] Bosetti, V., C. Carraro, M. Galeotti, E. Massetti and M. Tavoni. 2006. “WITCH: A World Induced Technical Change Hybrid Model.” *The Energy Journal*. Special Issue on Hybrid Modeling of Energy-Environment Policies: Reconciling Bottom-up and Top-down: 13-38.

[2] Chomitz, Ken. 2006. *Policies for National-Level Avoided Deforestation Programs: A Proposal for Discussion*. Background paper for policy research paper on tropical deforestation. World Bank, Washington, DC.

[3] Commission of the European Communities (EC). 2008. *Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss*. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM(2008) 645/3. Brussels, Belgium.

[4] Eliasch, Johann. 2008. *Climate Change: Financing Global Forests*. Office of Climate Change, UK.

[5] Fisher, Brian, Nebojsa Nakicenovic, Knut Alfsen, Jan Corfee Morlot, Francicso de la Chesnaye, Jean-Charles Hourcade, Kejun Jiang, Mikiko Kainuma, Emilio La Rovere, Anna Matysek, Ashish Rana, Keywan Riahi, Richard Richels, Steven Rose, Detlef Van Vuuren, Rachel Warren. 2007. “Issues related to mitigation in the long term context.” Chapter 3 in *Climate Change 2007: Contribution of Working Group III to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change*, B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds.), Cambridge University Press, Cambridge, U.K.

[6] Gusti, Mykola, Mykola Gusti, Petr Havlik and Michael Obersteiner. 2008. *Technical Description of the IIASA model cluster*. International Institute for Applied Systems Analysis (IIASA). http://www.occ.gov.uk/activities/eliasch/Gusti_IIASA_model_cluster.pdf

[7] Nepstad, Daniel, Britaldo Soares-Filho, Frank Merry, Paulo Moutinho, Hermann Oliveira Rodrigues, Maria Bowman, Steve Schwartzman, Oriana Almeida, Sergio Rivero. 2007. *The Costs and Benefits of Reducing Deforestation in the Brazilian Amazon.* The Woods Hole Research Center. Woods Hole, MA.

[8] Parker, Charlie, Andrew Mitchell, Mandar Trivedi and Niki Mardas. 2008. *The Little REDD Book: A guide to governmental and non-governmental proposals for reducing emissions from deforestation and degradation.* Global Canopy Programme. Oxford, UK.

[9] Sohngen, Brent, Sedjo, Roger 2006. *Carbon Sequestration in Global Forests under Different Carbon Price Regimes*. Energy Journal 27:109-126

[10] Stern, Nicholas. 2007. *The economics of climate change: the Stern review.* Cambridge University Press, Cambridge, UK.

[11] Tavoni, Massimo, Brent Sohngen and Valentina Bosetti (2007), *Forestry and the carbon market response to stabilise climate*, Energy Policy, 35(11): 5346-5353.

[12] United Nations Framework Convention on Climate Change (UNFCCC). 2009. *Draft decision -/CP.15. Decision by the President. Copenhagen Accord*. FCCC/CP/2009/L.7/ http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf