Woods are more than a group of trees.
Emily Carr, Canadian Painter
(1871 – 1945)

Forest

The forest. Pool of carbon. Fountain of water. Giant of biodiversity. Safe-keeper of our climate and our soils. Source of timber and much more. Metaphor and reality of interconnectedness, interbeing.

Forests are in danger due to human actions. Like a mirror reflecting, human beings are in danger also, not least due to endangered forests. We used to think: sustainable forestry would be nice... *Now we know: it's one of the urgent tasks of humankind today.*

The present document gives an overview over issues of sustainable forestry at the beginning of the 21th century. It does so in view of possible flagship initiatives in pilot regions that can enhance reforestation efforts worldwide.

1. Forestry: the Birth-Bed of Sustainability

Think of forests, and you think of trees – which are the tip of one marvellous iceberg, consisting of many other organisms (plants, animals, microbes) and the soil system. Thirty percent of global land area is forested. Forests contain roughly 90% of terrestrial biodiversity. Forest soils store globally significant amounts of carbon, and contain tremendous biodiversity especially in regions where above-ground forest biodiversity is comparatively low. Forests regulate local as well as planetary climate. More than three-quarters of the world's accessible fresh-water comes from forested catchments. Forests take a hold of land masses and retain water – without them erosion, land slides and floods would be more frequent and more pronounced, not only a little bit, but by a devastating amount. Forests provide us with timber, medicine, fruit, fodder, inspiration and beauty. People derive a multitude of services from forests globally.

Presently, forests cover about a third of the Earth's land surface, 300 years ago they covered about half. Humans have cleared forests since the beginning of our species, mainly in temperate regions. For example, 2000 years ago the Romans were cutting down Mediterranean forests for their Navy and to grow grain, 1000 years ago little forest was left in England. Nevertheless, over the past ten millennia total forest area decreased only by about 5%, i.e. by less than 0.01% per decade. Now, however, it is a blatant understatement to say "the pace has quickened": Since more than a century, global forest area shrinks at a rate in the order of 2% per decade (figure 1).

For millennia, our ancestors saw no problem in cutting trees and clearing forests. Towards the end of the Middle Ages, however, people in mountain regions realized that the loss of forests could lead to dangers of avalanches and floods. This led to local regulations, often as customs maintained in rural communities.

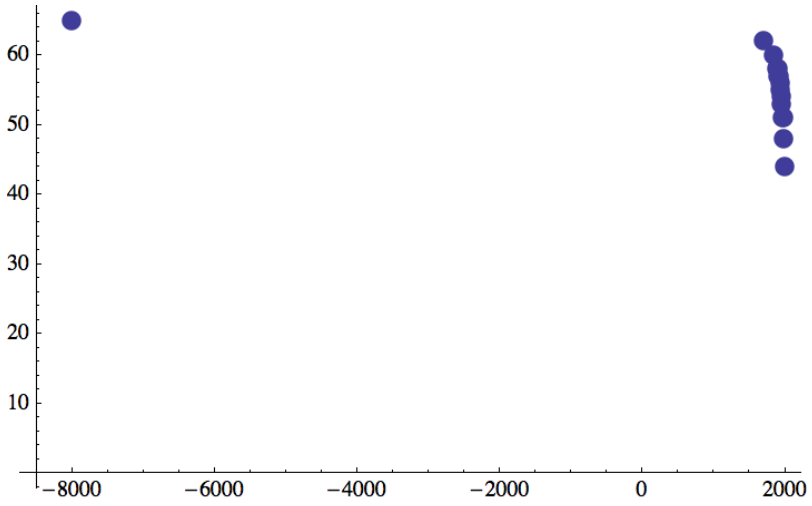

Figure 1: Forests and woodlands on Earth[1] 8000bc to1990, mio km^2.

In the 17th century, the writer and gardener John Evelyn argued for reforestation to provide timber for the Navy, while the French finance minister Jean-Baptiste Colbert triggered a forest ordonnance with the same goal in mind. With his ordonnance, forest policy begun to be a matter of national laws.

It was in the German forestry literature of the 18th century, however, that a powerful new idea emerged: the idea of sustainability. The main concern there was the supply of wood needed in mining, but the answer was not simply a measure to overcome a particular case of wood shortage. Rather, influential civil servants and writers began to argue that as a general rule forests had to be managed so as to enable present as well as future generations to use and enjoy them.

2. Forests in the Scarcity Paradigm

2.1 Sustainability and Optimization

In the 19th century, universities in Germany and elsewhere introduced the discipline of forestry. Insights from biology, economics, and mathematics were combined to produce a formula for the harvesting time that would achieve the maximum sustainable yield of a forest – the celebrated *Faustmann rule*. The basic claim was that optimal harvesting time is reached when the marginal benefits from delaying harvest are equal to the marginal costs of doing so. In other words, one does not necessarily harvest trees at the age at which the benefit per tree is largest, but at the age where the additional benefits of waiting one more year are equal to the costs engendered by such waiting. In the long run, this strategy will lead to the highest possible rate of return on investment.

By focussing on this idea, sustainability was increasingly framed within the scarcity paradigm that has shaped contemporary economics. At the core of this paradigm lies the image that human life is shaped by the contrast between unbounded desires and increasing difficulties in mobilizing the resources needed to satisfy those desires. The fundamental claim of the paradigm is that people can and should choose their actions so that for each agent her marginal benefits from any action equal her marginal costs from the same action.

[1] Source: McNeill (2000)

Private property, competitive markets, and a government providing public goods are seen as key institutions enabling people to behave according to the scarcity paradigm. For forests, this meant that private property of land, competitive markets for forest products, and the rule of law maintained by government would be necessary and sufficient to ensure sustainability.

However, the criterion of optimal sustainable yield presupposes clarity about what the yield is. In practice, the focus on one particular yield led to monocultures and to complaints about their undesirable consequences. As a result, in 1960 the U.S. decided the Multiple-Use Sustained Yield Act. There, five kinds of benefits from forests were identified: timber, fish and wildlife, outdoor recreation, range and fodder, and watershed protection.

Unfortunately, trying to identify a marginal change in watershed protection resulting from changes in harvesting time in general is a rather meaningless exercise: first, watershed protection is not something that could be assessed by a single number, and second, a change of harvesting time by, say, one year, can lead to very different – and often not observable – changes in watershed protection. Often, this kind of problem makes it impossible to identify the marginal benefits needed to apply the Faustmann rule.

Therefore, as soon as the benefits to be obtained from forests were specified with a minimum of common sense, the idea of sustainability had to combine the principle of optimal sustainable yield with a lot of common sense, too. The former was used to manage forests with well-defined commercial yields and to train students in forestry, economics and other fields, the latter to handle those aspects of forests that for some reason or another could not be turned into marketable goods.

This hybrid of an analytical formula and a remainder of common sense where it does not work has led to remarkable results. By and large, countries with boreal forests – Scandinavia, Canada, and to a lesser extent Russia – have been able to set up efficient forest industries – for pulp and paper, construction, and more – while maintaining the overall area of boreal forests as well as their productivity.

To a considerable extent, the same is true of countries with temperate forests, including the U.S. and large parts of Europe. With regard to Europe, however, a particular issue needs consideration. In the 1980s, German public opinion was churned up by rapidly increasing damages to trees in Germany and neighbouring countries. This led to a heated debate on “Waldsterben”, i.e. “forest death”. Meanwhile the relevant forests have stabilized, in part due to policy measures against air pollution. Moreover, recent research has shown that similar episodes have happened in the historical past (Kandler, 1992). Still, those debates played an important role in establishing “green” perspectives as an essential component of the German political system. Given Germany’s role in shaping European policies, the role of forests in German collective memory should not be ignored.

One of the main hypotheses about the rapid increase in damaged trees in the 1980s in Europe singled out acid rain as a key factor. As a by-product of burning fossil fuels, especially coal, various aerosols were (and to some extent still are) ejected in the atmosphere, where they made water droplets acidic, resulting in what is known as acid rain. Via this mechanism, British power plants, e.g., could damage Swedish forests, lakes, and more. This is an important example of what is known in economics as an external effect – a key concept for sustainable forest management.

2.2 Sustainability and External Effects

An external effect is an effect of the action of agent A on the wellbeing of agent B that is not mediated by a market. Telling a joke without being paid for it is an external effect, and usually not a problematic one. A more worrying example is the effect of deforestation on global climate: the actions of people destroying forests today may in fact destroy the houses of people not yet born by inducing global sea level rise via climate change. The existence of worrying external effect is often termed a market failure.

Table 1. Main ecosystem services of forests (with current trends)[2].

Ecosystem service	Status	Notes
Wild foods	↓	declining production
Timber	+/-	forest loss in some regions, growth in others
Wood fuel	↓	declining production
Genetic resources	↓	lost through extinction and genetic resource loss in plantations
Biochemicals, natural medicines, pharmaceuticals	↓	lost through extinction, overharvest
Fresh water	↓	unsustainable use for drinking, industry, irrigation; amount of hydro energy unchanged, but dams increase ability to use that energy
Air quality regulation	↓	decline in ability of atmosphere to cleanse itself
Climate regulations		
global	↑	net source of carbon sequestration since mid-century
regional and local	↓	preponderance of negative impacts
Water regulation	+/-	varies depending on ecosystem change and location
Erosion regulation	↓	increased soil degradation
Water purification and waste treatment	↓	declining water quality
Disease regulation	+/-	varies depending on ecosystem change
Pest regulation	↓	natural control degraded through pesticide use
Pollination	↓	apparent global decline in abundance of pollinators
Natural hazard regulation	↓	loss of natural buffers (wetlands, mangroves)
Spiritual and religious values	↓	rapid decline in sacred groves and species
Aesthetic values	↓	decline in quantity and quality of natural lands
Recreation and ecotourism	+/-	more areas accessible but many degraded

To correct such market failures is known as internalizing those effects. There are two basic strategies to do so. One is to introduce taxes and subsidies that act as if there was a market for the effect in question, the other is to actually implement such a market. In the case of forests, this approach has led to great efforts to identify so-called ecosystem services and to estimate an appropriate monetary value for them. Such ecosystem services valuation can then be used both to introduce taxes and subsidies and to create new markets for those services.

For example, it has been estimated that in most countries the marketed values of ecosystems associated with timber and fuelwood production are less than one third of the total economic value. Non-marketed values such as carbon sequestration,

[2] Ecosystem services that are in part or entirely provided by forests, with global trends regarding service provisioning. Adapted from the Millennium Ecosystem Assessment (2005).

watershed protection, and recreation make up the remaining two thirds (Millennium Ecosystem Assessment 2005). According to this estimate, whenever timber is extracted to such an extent that the forest ecosystem is degraded, a far larger economic loss for society is realized than is reflected in the respective company's books.

In view of external effects, it is important to notice that the Faustmann rule is dependent on the rate of interest. If one can invest money at a rate of, say, 4%, there is no point in investing it in a forest whose value grows only at 3%. In the case of slow growing populations of plants (or animals), this can lead to optimal rates of extinction – the rational thing to do can be to exploit a forest at that rate until it has disappeared. Indeed, this is the reason why clearing forests makes perfect sense in many situations. But of course there is a danger that when market prices do not reflect the fact that the existence of a particular ecosystem or species will be highly valuable in the future, that ecosystem or species will become extinct for no good reason.

Under conditions of external effects, optimization by competitive agents – landlords, farmers, etc. – can lead to outcomes that are clearly sub-optimal for some or all of them. According to the scarcity paradigm, individual optimization will lead to collectively optimal outcomes if and only if the relevant external effects have been suitably internalized. To see how far this paradigm can get us towards sustainable forestry, we now look at specific kinds of forests.

3. Kinds of Forests

Forests come in many varieties. The differences depend mainly on differences in climate and the shape of the land: forests in the Congo grow under a very different climate than those in Canada, and forests in the Rocky Mountains grow under very different conditions than those in the plains nearby. Table 2 gives an overview over main kinds of forests.

Table 2. Global forest areas[3]

	(million km^2)		
	Land area	Forest area	%
World total	131	44	33
Temperate forest		7	16
Boreal forest		13	29
Subtropical forest		4	8
Tropical forest		20	47
			100
Mediterranean forest		2	5
Mountain forest		9	21

[3] Above the double line, the table lists forests by bioclimatic categories: temperate, boreal, subtropical and tropical. Below the double line, Mediterranean and Mountain Forest are listed – two forest categories of interest in their own right. Mediterranean forests occur within both the temperate and subtropical area (mainly, but not only in the Mediterranean region); mountain forests occur within all bioclimatic categories. Sources: Shvidenko et al. 2005, FAO 2010; for mountain forests: Price 2000; for Mediterranean forests: WWF online.

3.1 Temperate Forest

The temperate zone holds deciduous and evergreen, broad-leafed and coniferous (needle-leafed) forests[4], which in some regions were planted widely mostly for timber. Temperate forests are largely located in industrialised countries, and their area of ca. 7 million km^2 or 16 % of global forest area is on the increase, contrary to the marked trends of area decrease in other forest types.

Temperate forests hold significant biodiversity, particularly below the ground, in decomposing organic material. They regulate local climate and cleanse the air. Forests can build significant corridors for cold air in hot summers, lowering city temperatures by meaningful amounts during heat waves. They are also important recreational areas around settlements, provide opportunities for outdoor activities, hunting and educational as well as spiritual inspiration. Forest fibre is an important trade product as building materials (timber) and, more recently for energy production, e.g. wood pellets. Some touristic regions are built entirely around larger regions of temperate forests (e.g. the Black Forest), and many eco-touristic opportunities depend on landscapes of open lands surrounded by larger and smaller forest patches. This kind of landscape is particularly attractive in higher altitudes, where a particular culture with its traditions and local products is increasingly identified as asset for the tourism industry. Eco-touristic developments around forests concentrate on two main areas of activity, outdoor sports and wellness spas.

3.2 Boreal Forest

Boreal forest – or taiga – grows in the subarctic and is generally evergreen and needle-leafed. The second largest forest type after tropical forests, it accounts for about one third of the planet's total forest area (29 % or ca. 13 million km^2). It is one of the earth's largest carbon pools (Bolger et al. 2000). In fact, the boreal biomass is so huge that during the peak of the growth phase, during northern spring and summer, global atmospheric carbon dioxide levels fall and oxygen levels rise – *the planet breathes in*. The broad circumpolar band of the northern boreal ecoregion runs through most of Canada, Scandinavia and Russia. Boreal forest is comprised of relatively few tree species, almost entirely coniferous, such as spruces and firs, and only a few intermittent deciduous species, such as larch and birch. The biome is only sparsely populated, and the small settlements often rely on mining and or forestry as their mainstay.

Economic activity in the boreal forest biome is partly intense, and consists mostly of mining and forestry, for timber, pulp and paper. In some regions, the production of hydroelectricity is an important activity. Dams built for this purpose change the landscape, flooding large areas, changing natural stream flows and cause the production of methylmercury, a bioaccumulative toxicant.

Although few are loudly concerned about the boreal forest, this environment faces some serious threats: clear-cutting, water pollution, potential disruption of habitats through new shipping routes, pollution with radioactivity, heavy metals and other

[4] Deciduous trees shed their leaves to endure dry seasons. Mostly they are broad-leafed, but needle-leafed deciduous trees exist also (e.g. the larch). Evergreen trees are mostly needle-leafed, but in warm temperate regions one also finds broad-leafed evergreens, like laurel.

toxins (from nuclear power plants, weapon testing, new mineral, oil and gas extractions), and air pollution through power plants and smelters. Reforestation of clear-cut areas is considerably slower than in warmer climates. To the global human-environment system and our own well-being, boreal forest is as important as tropical forest.

3.3 Subtropical Forest

Subtropical forests make up nearly 10% of global forests. In contrast to the rainforests of the tropics, they are dry forests, characterised by long drought seasons and usually deciduous trees. However, evergreens can dominate in some regions, e.g. when there is access to ground water.

From a social point of view, subtropical forests are of key importance for indigenous people whose culture is intertwined with this kind of environment. Their beauty in turn matters to many people who only occasionally visit them, or even know of their existence only via products like precious woods, and of their beauty via pictures and other kinds of information. From an ecological point of view, they are home to many species – like the jaguar – whose loss is hardly to be traded against any sum of money. And from an economic point of view their potential is truly remarkable, especially in view of sustainable forestry. They can be a highly valuable resource for eco-tourism, for producing precious woods as well as products like cocoa. Indeed, some of the most successful initiatives to protect endangered forests by sustainable, economically viable use are unfolding in subtropical forests.

3.4 Tropical Forest

Forty-seven percent of the world's forest is tropical, corresponding to roughly 20 million km^2 (Shvidenko et al. 2005). The tropical zone holds mainly warm and wet forests (rainforests; broad-leafed evergreen forest). Forests like the Amazonian rainforest, or the jungles of Africa are characterized by a continuous canopy of foliage providing dense shade for lower layers and the ground; thick, woody lianas supported by trunks and branches of trees; and epiphytes ("air plants") which use their hosts solely for physical support.

Compared to destroying or degrading the tropical forest ecosystem by conversion to farmland or logging, sustainable tropical forest management by far exceeds the net benefits obtained (even though the private benefits would be greater from the converted ecosystems): converting Cameroon tropical forest to small-scale agriculture yields a net-benefit of ca. $2000 per hectare, while sustainable forestry would yield ca. $3500. Unsustainable timber harvest in Cambodia's tropical forests yields a net-benefit of ca. $100 per hectare, while traditional forest uses yield ca. $1400 (Millennium Ecosystem Assessment 2005b).[5]

Despite the increasing amount of attention paid to the potential conservation of tropical forest, it is continuously destroyed through clearing for agriculture, logging, cultivation of cash crops (such as animal fodder, e.g. soy) and animal grazing. Past slash-and-burn practices by native people in low-latitude rainforests produced a short cycle that in low intensity poses no large harm to the rainforest. For this, a small area of

[5] Traditional use here includes hunting and gathering, slash and burn, as well as growing plants and keeping animals under the "roof" of the forest. The resulting benefits estimate then is based mainly on a valuation of non-market products.

vegetation is cut, burned on site, to release nutrients[6], and cultivated for a few seasons, while rapidly losing soil quality until the field is abandoned. The abandoned site is re-settled by rainforest plants and eventually the original state returns.

Today's modern, intensive agriculture is different. Larger areas are cleared, and even if abandoned will not return to the original rainforest state, because the seed sources of the original rainforest species are far away. Instead other plant species invade and establish a permanent secondary rainforest.

The large scale clearing of rainforest changes the local climate and contributes to global warming by releasing carbon dioxide. The local climate becomes warmer through increase surface and soil temperatures, and drier, due to decreased precipitation and evaporation. Wind patterns are also changed, and in the case of the Amazon basin this results in decreased inflow of water vapour, making the basin even drier.

3.5 Mountain Forest

Mountain forests are found from the equator to high latitudes, north and south, and include generally needle-leafed and broad-leaved forests that grow in the sub-alpine zone, below the tree line. Approximately 20 % of global forest is mountain forest, which corresponds to ca. 9 million km^2 (table 2). Needle-leafed evergreen mountain forests are dominant in North America and parts of Europe and Asia, while deciduous needle-leafed forests are more common in Russia and Asia. Tropical mountain forests mainly occur in South and Central America, Australasia and Africa. The altitude of the tree line, beyond which trees do not grow in significant density and number, varies widely, depending on latitude and climate. It can be as low as 700 m in the far North, or even higher than 4500 m in parts of the sub-tropical Andes. In recent decades, mountain forests have expanded in industrialized countries, while they are continually lost in developing countries, particularly in the tropics.

Mountain forests provide a huge range of services to people. They produce timber, fuel wood (critical for local populations), non-timber forest products (e.g. wild game and foods, such as mushrooms and berries), and grazing opportunities for subsistence farming. Furthermore, mountain forests serve a critical protection function, retaining the soil, as well as shielding valley communities from avalanches and rockfalls. They also have high water retention capacity (particularly cloud forest), intercepting and storing water from rainfall, mist and snow, and releasing it gradually, and thus maintaining large-scale hydrological cycles. They limit peak stream flow rates, which reduces soil erosion, and the severity of avalanches and downstream flooding. As a critical component of climate mitigation, mountain forests represent a major carbon sink, with ongoing carbon sequestration. They are high in endemism, due to the frequent occurrence of relative isolation and contrasting climates, and commonly represent global biodiversity hotspots, which offers opportunities to tourism, recreation, hunting and fishing. Mountain forests are rich with intrinsic spiritual and aesthetic values. The customs and belief systems of many mountain communities are intricately linked with forests.

Human mountain populations are often highly vulnerable to environmental, economic and social changes at all scales. Ninety percent of all mountain people live in rural areas in developing countries (Price et al. 2011). In mountain areas, poor communities, both rural and urban, tend to be heavily dependent on their forests. In many places, this

[6] In rainforest ecosystems most nutrients are held within living plants rather than in the soil.

leads to over-exploitation for food and fuel, fragmenting and decreasing the primary forest cover. Further losses may occur through encroaching urbanization, more frequent wildfires, development projects such as roads, dams, and hydropower plants, the development of tourism infrastructure, and the transformation of primary forest to other land uses such as small-scale agriculture. In regions where population expansion causes migration from urban to rural areas, lowland farmers are often displaced and commonly move to higher, steeper slopes, often clearing away forest to establish new smallholdings. These are often farmed intensively, due to high demands from nearby cities. Thus, nutrients are quickly depleted, topsoil is lost, overall soil stability can be decreased, and rivers silted. The smallholding will have to be abandoned for a fresh patch, and more biodiversity and primary forest are lost.

3.6 Mediterranean Forest

Mediterranean forests occur in the world's five Mediterranean climate zones, on the west coasts of continents in the mid-latitudes[7]. Five percent of the global forest is Mediterranean, corresponding to ca. 2 million km^2. Mediterranean forests typically consist of evergreen broadleaved, coniferous or sclerophyll[8] trees (such as pine, holm oak, and Eucalyptus) and are rich in biodiversity. Mediterranean forests share some aspects of mountain forests, such as adaptation to extreme climates (hot, dry summers) and a tendency to increased endemism[9] – for example, in the Fynbos region of South Africa 68 % of vascular plants are endemic to that region. In the Mediterranean climate agricultural trees such as olives, chestnuts, citrus, almonds and cork are grown. Often Mediterranean forests are part of landscapes that are interesting to tourism. Climate change (more frequent heat-waves, longer droughts) in concert with changes in forest species composition e.g. from oaks toward fast growing Eucalyptus have exacerbated the risk of forest fires. Eucalyptus leaves produce volatile and highly combustible oils. Furthermore, the trees produce large amounts of litter which is high in phenolics, preventing its breakdown by fungi, and thus accumulates as large amounts of dry, combustible fuel.

In the Mediterranean Basin, collaboration across national borders has been difficult. To change this the Union for the Mediterranean (UfM) was created in 2008, a multilateral partnership that encompasses 43 countries from Europe and the Mediterranean Basin: the 27 member states of the European Union and 16 Mediterranean partner countries from North Africa, the Middle East and the Balkans. The political power of the UfM is limited. Nevertheless this could become an important Union for large-scale sustainability efforts, such as creating vast solar power plants in the Sahara desert (often referred to as "desertec" and reported to be able to satisfy 30 % of the current EU demand for electricity). Other sustainable concerted efforts may prove to be equally sound, e.g. efforts aiming at an agreement to manage land use and land cover to counteract undesirable climatic trends, curb the increasing frequency of wildfires and impending problems with heat-waves and droughts.

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[7] Mediterranean Basin, Chilean Matorral, Californian chaparral and woodland and Baja California Peninsula, Cape Province – Western Cape of South Africa, and the southwest Australia corner area.

[8] Sclerophyll is the term for a type of vegetation that has hard leaves and short internodes (the distance between leaves along the stem).

[9] Endemism is the ecological state of being unique to a defined geographic location, such as an island, nation or other defined zone, or habitat type. Endemic species occur only in a defined location and are not found elsewhere.

3.7 First Steps Towards Priority Setting

What kind of forests should initiatives towards major advances in sustainable forestry focus on? When asking that question, it is useful to start with the paradigm of scarcity – but not to stop there. In countries with boreal forests, this paradigm has led to remarkable results. By and large, they have set up successful forest industries while maintaining the overall area of boreal forests as well as their productivity. To a considerable extent, the same is true of countries with temperate forests, including the U.S. and large parts of Europe.

In this perspective, two questions must be asked, one rather straightforward, the other more complex. The first question refers to the Faustmann formula and the idea of optimal harvesting time: in what kind of forests are there still substantial improvements to be made in terms of harvesting time? The second refers to the idea of external effects: what kind of forests affords the biggest opportunities from internalizing external effects ?

As for the first question, it seems fair to say that in boreal and temperate forests harvesting times have been optimized over a period of more than two centuries, with the result that little further gains are to be made along those lines. In fact, these kinds of forests still provide the greatest turnover and the greatest returns to the global forestry sector (PwC 2011).

Things are different in sub-tropical and tropical forests, where the growth rates of forestry turnover and profits are greatest. Here, informing and training the people involved in forestry decisions about optimal harvesting time is still warranted. However, this happens quite naturally through the progression of competitive firms on forestry markets, so that there is little need for additional action from other agents.

Things are different with external effects: without corrective action, the progression of competitive firms makes the impact of negative external effects more, not less worrying. But the relevant effects vary greatly between different kinds of forests.

It seems fair to say that with boreal forests right now negative external effects are rather limited. Two candidates need long-term monitoring, however. First, clearing boreal forests can increase the albedo, i.e. decrease the darkness, of the surface of the Earth as seen from outer space. This effect can become so large as to make a difference for the reflection of sunrays and therefore for the climate. Second, changes in the management of boreal forests can massively affect the biodiversity of those forests. While monitoring these developments – especially the latter – is an important task, there can be no doubt that more urgent challenges arise in other kinds of forests.

In general, the situation of temperate forests is similar to the one of boreal forests. However, the crisis around "Waldsterben" has shown that sudden risks can emerge in this setting, mainly because temperate forests are more exposed to the effects of industrial production and urban life than boreal ones. Again, long-term monitoring is warranted. Fortunately, programs for such monitoring are now in place in many countries so that the danger of bad surprises is somewhat limited.

There are two exceptions, and they concern mountain and Mediterranean forests. Mountain forests play an extremely important role in dampening a whole series of risks: floods, droughts, avalanches and mudslides all strongly depend on them. And as these risks are increasing with climate change, the importance of mountain forests is increasing, too. It is quite difficult, often impossible to internalize these effects of

mountain forests by creating markets for them. In this case, therefore, the ecological dimension of sustainability seems to warrant a high priority for corrective action.

Mediterranean forests often grow on mountainous terrain, so that the point just made applies to them as well. In the Mediterranean proper, there is an additional effect that needs more consideration than it has gotten so far: in ways unique to that region, the climate of Mediterranean countries depends on the existence and state of Mediterranean forests. Here, the environmental, economic and social dimensions of sustainability all combine in a remarkable opportunity for action towards sustainable forestry. We will come back to this point below.

As for sub-tropical forests, the external effects that can and should be internalized are huge: they range from the neglect of biodiversity to the opportunities for eco-tourism, from the possibility to improve the cocoa production chain to the opportunities to develop new kinds of products based on precious woods. Fortunately, a wide variety of actors has begun to develop promising initiatives. NGOs are active along with businesses pursuing sustainability strategies, foundations act along with local governments. Additional forces are welcome, but it seems unlikely that a game-changing initiative is required.

Such an initiative may well be needed with regard to tropical forests. Here, a race against time has started, as the pressures of economic and to some extent also demographic growth drive critical ecosystems towards "optimal extinction". The problems are well-known, and it is very difficult indeed to see how the huge negative externalities involved could be internalized with current strategies. Creating a market for carbon emissions certificates that would work in tropical rainforests, e.g., seems a hopeless exercise. Implementing taxes and subsidies that would put a well-founded price tag on biodiversity in the Congo basin looks like an utterly naïve proposition. After all in this region over 4 million people were killed by cruel warfare in the recent past, and natural resources from diamonds to rare earths are feeding a collusion between the economies of developed countries and the organized crime of warlords and various local elites.

In view of these challenges, something essential is missing in the scarcity paradigm. In order to set priorities for major initiatives towards sustainable forestry, it will be necessary to consciously move towards a new paradigm.

4. Towards a New Paradigm

4.1 Sustainability and Social Networks

Careful studies of forests that have been maintained over long periods of time under difficult circumstances – e.g. in mountains with harsh weather conditions – have shown that the relevant communities often relied neither on taxes and subsidies nor on markets for ecosystem services (Ostrom 1999). Instead they relied on the power of social networks to develop and maintain formal and informal rules of behaviour that are sufficient to take care of important external effects. Similar results have been obtained for other common pool resources like fisheries and pastures.

A simple example is provided by Swiss mountain villages where critical forests were threatened by the need for firewood required to make cheese during summer, when the cattle was sent above the timberline. A typical social norm in such a village said that for each piece of cattle a farmer would send a certain amount of firewood to the

herdsman, who was also in charge of making cheese. This kind of culture is the background against which in in the 19th century Switzerland introduced a highly effective forest law focussed on sustainability.

Social norms can help to address problems of scarcity, but their point is to address problems of coordination. The very simple question of whether to drive on the right hand side or on the left hand side of the road is a useful example: without finding a shared answer to that question, modern traffic systems are impossible, yet the question is not one of scarcity, but of coordination.

To make progress towards sustainable forestry beyond what has been achieved in the course of patient efforts by past generations, therefore, we need to move towards a paradigm that embeds problems of scarcity in the broader framework of coordination problems.

Paying attention to coordination issues helps to understand that both markets and states become dysfunctional when they are not embedded in a suitable fabric of social norms. These norms need to ensure the trust and reliability required by key institutions of modern society. To establish a market, e.g., presupposes a complex fabric of norms – about what counts as a good of a certain kind, how market participants can communicate with each other, how transactions can be performed and much more.

Establishing this fabric of norms is sometimes described as a transaction cost. As long as this cost is negligible, one can focus on actual and possible market processes and rely on the paradigm of scarcity. Sustainability can then be understood as optimizing yield in the course of time while internalizing the relevant external effects. In many problems of forestry management, however, especially in tropical and sub-tropical forests, the fabric of norms necessary to establish functioning states and markets is missing. Then, transaction costs are so important that they cannot be neglected without leading to failure.

In those cases, however, the very expression "transactions costs" can become misleading. Speaking of costs suggests that what is at stake can be expressed by a simple number somehow analogous to a monetary cost. But the challenge to establish, e.g., a culture of making and keeping promises about monetary issues, is exactly that: a challenge, and not a cost. It cannot be expressed in monetary quantities again. Such challenges have to be described on a case by case basis – e.g. as the task to establish trust, to mobilize and enhance local knowledge, to let norms for coordinated behaviour emerge, etc.

These challenges cannot simply be met by "the state". The kind of state that is needed for a market economy to work properly again presupposes a fabric of norms – of reliable public service, avoiding corruption, and much more –, that can only evolve out of complex historical processes. The focus of attention shifts for a while from the operation of markets to the social fabric that solves problems that "markets and hierarchies" – to quote the famous phrase by Oliver Williamson, pioneer of transaction cost research – are unable to solve.

There is a key point here that is more important than is often acknowledged: for external effects to be internalized, they must not only be known in principle, they must be known so precisely that the monetary effect of marginally changing one of the relevant actions can be assessed. Consider the case of telling jokes among friends. Clearly there is an external effect here, as those jokes enhance the wellbeing of people

without involving a market transaction. But asking whether one more joke by Harry will increase Sally's wellbeing by 5 cents or by 50 is to ask a meaningless question. This is why it is a bad idea to substitute friendship by markets – or by government authority.

Norms evolve in social networks. Therefore, a key question for our present purposes is where to find social networks that can generate fabrics of norms conducive to sustainable forestry. Ideally, they will do so in a way that can trigger and reinforce similar processes elsewhere.

Who are the agents making up such networks? The following types of agents provide a useful framework to look into this question (we always assume that the agents take advantage of or have an impact on a given forest):

- *small farmers*
- *indigenous people*
- *small and medium enterprises*
- *large companies producing:*
    - *timber for construction*
    - *pulp and paper*
    - *soy beans, palm oil etc.*
    - *cattle and meat*
- *banks and insurance companies*
- *local and national authorities*
- *international bodies*
- *religious communities*
- *media*
- *NGOs*
- *trade unions and professional associations*
- *researchers*

Within the scarcity paradigm, all these agents can be treated as rationally pursuing their particular interests. But they do so in a situation where important aspects of forests are simply not represented on any marketplace. There is no market, e.g., in 2012 for biodiversity in the Amazon basin in 2030. But as Amazonian biodiversity may be quite important in 2030 – for medicine, tourism, agriculture, real estate, and more – optimizing behaviour by the present generation will expose future generations to considerable risks to their well-being: the basic idea of sustainability is jeopardized.

We need to move towards a paradigm that acknowledges the fact that these agents are nodes in social networks structured by social norms. And we need to use that emerging paradigm to learn how to foster the evolution of norms that are conducive to sustainable forestry.

This also means that we need to accept that a whole range of important questions cannot be currently answered, despite the fact that those answers are badly needed. It

is only through a patient combination of practical initiatives and research investigating their experiences that we can hope to find answers to questions like the following:

- *How can the cosmopolitan networks formed by global markets, multinational companies, international bodies, large NGOs, academic institutions, etc. interact in a fruitful way with regional networks linked to specific forest areas?*
- *How can social networks locked into unsustainable patterns of forest abuse enter a period of creative disruption (destruction?) out of which more sustainable patterns of forest use evolve?*
- *How can small, but innovative and energetic agents crystallize new coalitions with an active interest in sustainable forestry?*
- *How can the inevitable conflicts around the use of forest resources be kept from degenerating into violence and/or paralysis and become sources of joint learning?*

Two examples of possible networks linked to particular forests are especially instructive here. One relates to tropical forests, the other to Mediterranean ones. An important shared characteristic is a regional focus. Even the high-tech culture of contemporary computing evolved in networks with a strong regional focus – the bay area in California, route 128 in Massachusetts, Seattle in Washington State. Social networks that hold promise for sustainable forestry may have similar regional foci, albeit in very different countries.

4.2 Regional Networks and Tropical Forests

While sustainable forestry remains a major challenge with boreal and temperate forests, global deforestation is now clearly concentrated in tropical (and to a lesser extent subtropical) forests – and there at truly alarming rates in the order of 5% per decade.[10]

Fortunately, this situation has provoked a wide range of initiatives to stop tropical deforestation and engage in reforestation. They include:[11]

- Government measures: e.g., in 1992 the parliament of Panama decided a reforestation law (law 24) that triggered many reforestation activities in that country.
- NGO activities: e.g., in 2010 a NGO focussing on the Gishwati national park in Rwanda decided to fund a reforestation project that may save a group of chimpanzees and reduce landslides and soil erosion.
- Business efforts: e.g. since 1990 the Swiss company Precious Woods is engaged in reforestation of abandoned pastureland in Costa Rica, expecting a return of about 10% from processing and selling the timber of mixed forests.
- Global initiatives: e.g. in 2008 the U.N. launched the Redd - Reducing Emissions from Deforestation and Degradation – programme; it is supposed to develop a globally coordinated effort towards sustainable forest management.
- All sorts of interactions between and combinations of the above

[10] Estimates for global tropical deforestation vary due to different definitions and measurement problems. 5% per decade is a conservative estimate consistent with the data in figure 1.

[11] Sources for the examples (as of April 2012): www.panamadera.com/law_24.htm, www.newtimes.co.rw/news/index.php?i=14158&a=25425#.T1MlzE-XgqE, www.preciouswoods.com/index.php?option=com_content&task=view&id=78&Itemid=139&lang=en_US. ISO8859-1.

These efforts have contributed to a global slowdown in deforestation in the decade 2000-2010 as compared to the two previous decades. Whether this is the beginning of a long-term transition towards globally sustainable forest management, is by no means clear, however. It depends very much on further improving the effectiveness of such initiatives.

Recently, important instances of social networks playing a key role in sustainable forest management have been identified in the tropics. They include small and medium enterprises in Uganda - in part organized via the Uganda Wood Farmers Association and the Uganda Community Tourism Association –, a network of communities in the Peten region in Guatemala, the Movement for the Survival of the Transamazon in Brazil, and more (see Campos 2006, and Schwartzmann 2010). Clearly, these networks point in the direction of "use or loose" rather than "pure protection". The best way to keep portions of fully protected forest may well be to surround them with areas of active, but sustainable use sustained by a social networks including farmers, small and medium enterprises, and many other agents.

These kind of regional networks engaging in sustainable forest management point the way to a next stage of projects in forest protection and reforestation worldwide. A focus on whole regions and on the evolution of norms in regional social networks can trigger initiatives that will make a major difference in the years to come.

4.2 Regional Networks and Mediterranean Forests

Since the days of ancient Rome, the forests surrounding the Mediterranean have been abused and mishandled so that their amazing beauty is visible only in a few remaining places. In general, they have been reduced to severely impaired forest areas, to maquis shrubland, or cleared for usually rather chaotic urbanization. At the same time, the Mediterranean region provides a unique opportunity for afforestation, offerning a true win-win strategy in many dimensions (Issar, 2010; Caparrós et al., 2010; Millán, 2007).[12] Like forests elsewhere, Mediterranean forests provide a hydrological buffer that greatly alleviates the problems generated by the combination of droughts and floods that many expect from climate change. They can capture a considerable amount of carbon both in the biomass and the topsoil, thereby contributing to mitigation of climate change. Moreover, they can be combined with biofuel production on lands where this does not compete with food production.

But perhaps the greatest advantage of afforestation in Mediterranean regions is the possibility to change regional precipitation patterns. Precipitation in Mediterranean regions is fed mainly by evaporation from the Mediterranean, but without forests, the microclimate of Mediterranean coastal zones is such that most of that evaporation leaves the Mediterranean basin before it precipitates again on the surface of the earth. In these regions, therefore, afforestation can lead to an increase rather than a decrease of precipitation in the future decades, with considerable advantages both for agriculture and for general living standards.

The coastal region around the Mediterranean covers about 1.5 mio square km. If afforestation happened in just 10% of this area, with a density of about 1000 trees per hectare (somewhat less than typical tree density in the Mediterranean), this would result in an additional 15 billions of trees planted. A sapling costs about 2€, but the other costs involved in afforestation are likely to exceed 20€ per tree. An annual investment of 50 billion € over a decade is a reasonable first estimate. The payback

[12] For a more extensive treatment of this case, see Jaeger (in press).

period from biofuels and traditional forestry is in the order of 5 years. Again, limited non-profit incentives could be sufficient to trigger the private investment required.

Given the challenges engendered on the Southern shores of the Mediterranean by the historical transformation known as the Arab spring of 2011 the opportunities offered by afforestation in the Mediterranean deserve careful attention. On the Northern shores, this situation is compounded by the huge challenges faced by many countries in the aftermath of the global financial crisis of 2007. In the Mediterranean region, fostering social networks around the shared task of afforestation could play an important role in tipping the balance between a dangerous future of decay and a future of reality-based hope.

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