



Future from fibre

From forest
to finished product

November 2012



wbcscd forest solutions



Disclaimer

This is a technical report prepared by Pöyry commissioned by the Forest Solutions Group of the World Business Council for Sustainable Development (WBCSD) in cooperation with WWF International; it does not necessarily reflect the views or opinions of each member of the Forest Solutions Group, WBCSD or WWF.

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Preface

This technical report has a twofold origin: the WWF's "Living Forests" campaign/ report and WBCSD activities in the same area – which found each other. Likewise, the streams of Pöyry and IIASA work in this area also found each other here. From initial WWF/WBCSD collaboration and discussions, we have as an outcome this look at forest and new forest products up to 2050.

The report, commissioned by the WBCSD Forest Solutions Group in cooperation with WWF International, is based on work by Pöyry Management Consulting Oy (Pöyry), and written by Petri Vasara and Hannele Lehtinen from Pöyry.

Introduction

Background

This technical report has a twofold origin: the **WWF's "Living Forests" campaign/ report and WBCSD activities in the same area** – which found each other. Likewise, the streams of Pöyry and IIASA work in this area also found each other here. From initial WWF/ WBCSD collaboration and discussions, we have as an outcome this **look at forest and new forest products up to 2050**.

The report, commissioned by WBCSD in cooperation with WWF, is based on work by Pöyry Management Consulting Oy (Pöyry) and IIASA. On the WBCSD front, it started in the Forest Solutions "Forest Resources" Action Team and moved to the "Value Chain" one.

To make what was to begin with a set of separate questions into as coherent a whole as possible, Pöyry decided to go for a "scenic route" storyline. That is:

- start with the value chain from forest to consumer end use value chain as a "landscape"
- on this landscape, take the scenic route and annotate the stops where a closer look is taken
- along the stops, give a perspective on the future of forests and forest products up to 2050
- link in Pöyry supply and demand expertise, visions, facts and IIASA models and forestry knowhow as combined in the project.

Scenic route

A scenic route, tourist road, tourist route, theme route, or scenic byway is a specially designated road or waterway that travels through an area of natural or cultural beauty. In this case, it is a storyline stopping at points of particular interest.

The key messages

The value chain is a very useful tool for understanding a product, a service, an industry: and the forest products value chain is a long and complex one, from a unique renewable multipurpose resource to the most simple and advanced end uses in daily lives.

If we add a perspective from up to 2050 into the mix, we have a very broad canvas on which to work.

We have to focus the narrative, and a way is to isolate a few key messages. The forest products industry has a long and glorious tradition, so these messages can also be encapsulated in an item with a long and glorious history: Rembrandt's famous painting "The Night Watch" (Figure 1)

The messages from the painting, which is surrounded by very many true and false stories and rumours, are in this case

- Correcting **misconceptions**
- The growing importance of the **consumer**
- **Resource efficiency**
- A **long time horizon**

Message 1: Correcting misconceptions

A persistent myth claims that the painting was received very negatively, which started Rembrandt's decline in popularity. However, the myth has little support in facts: there are no records of public disaffection at the time. Likewise, the painting has for most of its lifetime been covered with a dark varnish, removed in 1940, which gave rise to the claim that it depicted a night scene. It depicts a night watch, a group of civic militia guards, but not the night.

The forest products industry is, likewise, cloaked in misconceptions, as if with a dark varnish. However, getting down to facts tells the story of an adaptive industry with a long history based on a unique renewable resource.



Figure 1 Rembrandt's "The Night Watch" (De Nachtwacht)

Message 2: The growing importance of the consumer

The painting is said to have been commissioned by captain Frans Banning Cocq and 17 members of his Kloveniers (civic militia guards) for the very large sum 1600 guilders. The consumer (captain Cocq) had a watercolour made for his personal album. However, Rembrandt's style started slowly going out of fashion, in favour of brighter colours and different poses.

Being a single individual of genius doesn't mean that one can remain in fashion over even a shorter period. However, an entire sector such as the forest products industry can adapt to meet consumer demands, together, in various ways, without compromising its identity.

Message 3: Resource efficiency

The painting first occupied the Groote Zaal (Great Hall) of the Kloveniersdoelen in Amsterdam. When it in 1715 was moved to Amsterdam town hall, it was cut down to fit the new space - slices from the top, right and left were taken off.

Land is by all indications going to be a key scarce resource in the future, perhaps even the scarcest. Little new land can be "taken from the ocean", land degradation has occurred, and without land there is no fibre, biodiversity, life on land. A renewable resource such as forest is an efficient use of available land. However, just cutting land availability for forest to fit a need of the moment is shortsighted and potentially harmful over a long period. Resource efficiency must be defined well and interpreted intelligently, or we just commit vandalism.

As a further illustration of "wrong resource efficiency", let's make a scandalous experiment. We need to cut down "Night Watch" to 40 % of its original size, while keeping the key characters. With current computer algorithms, this is not a problem. We use smart compression, cut down on empty space, while keeping the proportions right for the key topics. The result is in Figure 2 below: "Night Watch" down to 40 percent. Resource efficiency? Land footprint is 40 percent of the original: what a yield/cm²!

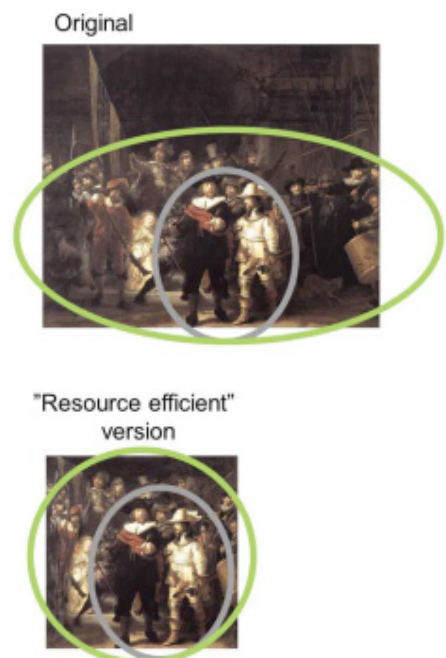
The development context of WBCSD's Inclusive Business includes e.g. "need for a transition towards a more inclusive, low-carbon and **resource efficient** economy".



Figure 2 A resource-efficient "Night Watch"?

Obviously, this is a drastic example, but it illustrates several points, including

- resource efficiency must take into account the resource Big Picture: water, land, energy, metals, materials including carbon, not just focus on one dimension (e.g. land) - otherwise the purpose is lost, just as in the "efficient Night Watch"
- the forest products industry is in a unique position, since it has actually increased forestry yield/land area, and can continue to do so (being "land efficient"), and also considers other issues



Message 4: A long time horizon

Even though Rembrandt went out of fashion for a while in the years following "Night Watch", the painting has stood the test of time. It will return to its original place in the Nachtwachtzaal (Dutch for "Room of the Night Watch") in 2013.

Likewise, the fibre-based industry has withstood being temporarily out of fashion, and its history from papyrus to current top products is millennia long - and a story of change and adaptation. There is nothing to indicate that fibre products would not be a success in 2050, the horizon of this report.

The value chain landscape and scenic route

The value chain used to tell the story here goes from forest to consumer, **with the steps forest biomass, other forest-related issues, production, trade, biomaterials conversion and future products**. The scenic route taken is as in Figure 3 below.



Figure 3 A scenic tour around the value chain to 2050

The scenic route stations: Description for tourists

Extract from tourist guide for visionaries to 2050

Forest biomass and biodiversity

This station offers a wonderful scenery all around the world. Through the experiences in this area you will learn about potential forests and their productivity, and conservation mapping priorities. After the visit you know where in the world potential afforestation sites are located, and what type of forest there will be.

Special biomass and biodiversity-related issues

A show of ecosystem services at this station complements the experiences at the first stop.

Production projections

Here, you will find out how the future behaviour of the users of pulp and sawnwood in different regions will have an impact on wood consumption.

Tradeflows

At this station you will meet other travellers and be introduced to other scenic routes, where wood pulp, sawnwood and wood-based panels travel between the main regions of the world.

Biomaterials

Here, there is a possibility to catch a glimpse of new and upcoming potential star attractions.

Future products

Here you can see wood-based products in people's everyday lives in the future."

Station	
Introduction	2011
Forest biomass and biodiversity	2010
Special biomass and biodiversity-related issues	2015
Production projections	2020
Trade flows	2025
Biomaterials	2030
Future products	2050
Conclusion	2051

Figure 4 Scenic route timetable

FIRST STOP: FOREST BIOMASS AND BIODIVERSITY

The messages
at this stop:
correcting
misconceptions,
resource efficiency,
long time horizon.

WHY VISIT THIS STOP? NO VISIT TO THE WORLD OF THE FOREST PRODUCTS INDUSTRY IS COMPLETE WITHOUT GOING TO THE FOUNTAIN OF RENEWABILITY, FOREST BIOMASS.

Forest biomass resources are situated all around the world, in different types of forests and plantations. The current forest areas, production potential for new forest areas, and the distribution of different type of forests now and in the future are discussed here. The purpose is to give a concise yet wide perspective on key issues in forest biomass.

Potential afforestation sites

To describe afforestation possibilities, maps highlighting different aspects of current and potential forest areas are used. The plot in this limited tour is given in Figure 5

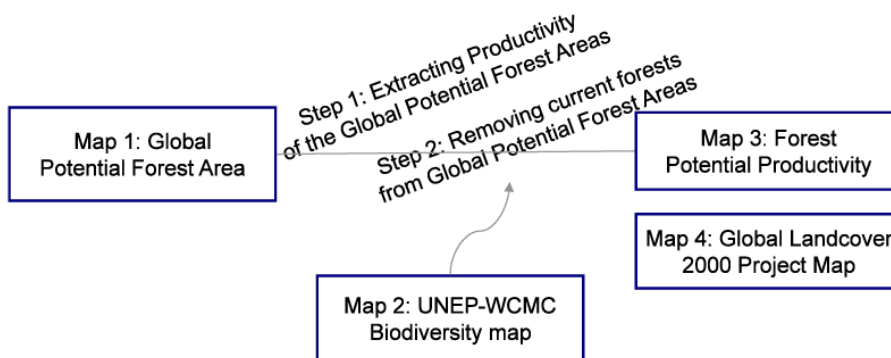


Figure 6 Steps for Processing the Potential Afforestation Sites Map at IIASA

WHERE, WHAT, HOW: WHERE is there land suitable for forests?

To begin with, we should locate the areas favourable to forest growth. As the origin of the story, there is a map of global potential forest, prepared by IIASA. This map (Figure 6) shows all areas of the world where forests could potentially occur. The areas shown are a combination of (a) areas of existing forest cover, and (b) non-forested areas with the biophysical characteristics needed to make restoration of forest cover a possibility. The global Landcover 2000 map¹ was used to identify existing forests. The IIASA G4M biophysical model was used to identify areas where forests could appear. This was based on climate variables (temperature and precipitation) from WorldClim - Global Climate Data² and soil characteristics from the Harmonised World Soil database³. These data were used to estimate the potential above ground Net Primary Production (NPP) of a given area, i.e. the net accumulation of carbon in above-ground biomass per hectare per year. The range of potential forms of vegetation (from desert through grassland, shrubland, to forest) that a given area could potentially support was based on conservative estimates of NPP thresholds for each vegetation type.

REVERSING URBANISATION

Urbanisation and the march towards megacities is proceeding at a formidable pace. Clearing forests for human habitation is of course nothing new, rather the norm in history. However, we are also dealing with different waves of urbanisation, and poorly planned and/or abandoned urban space conversion into biomass production, from “city rooftop gardens” to managed forests, is an interesting new trend.

Figure 6 Areas of the world with potential forest cover



1 <http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php>

2 <http://www.worldclim.org/>

3 <http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html>

WHERE, WHAT, HOW: WHAT is the method used for assessing biodiversity?

Obviously, all possible areas will not be used for forests and afforestation. One key issue is biodiversity and how to assess it. As an answer, the UNEP-WCMC map4 of overlapping global biodiversity priorities in terrestrial areas is presented in Figure 7.

The map should be interpreted so that class 0 (the yellow colour as in the legend) indicates an urban area, and classes 1-6 indicate the number of overlapping priority schemes. Class 1 denotes an area where all biodiversity maps are combined, and class 6 indicates an area where all six biodiversity maps are overlapping. The darker blue the area is, the more priority schemes are overlapping there. Since the areas where the largest numbers of these priority schemes overlap are those with the greatest degree of consensus as to their importance for conservation, it is logical to regard them as of high importance for biodiversity. However, this is not a map of the distribution of biodiversity itself, such as a map of species richness or ecosystem diversity. Neither is it a map of all global conservation prioritisation schemes.

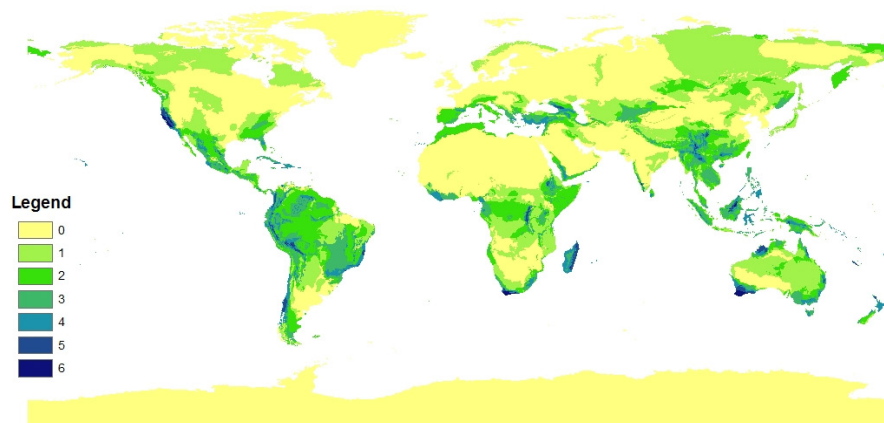


Figure 7 Spatial overlap of global terrestrial biodiversity priority areas identified by different conservation mapping processes (Source: UNEP-WCMC)

WHERE, WHAT, HOW: HOW is fertile and infertile land distributed?

Now, all land is not created equal in productivity, where can we find the most fertile and the most infertile soil? The third map in Figure 8 shows potential areas for restoration of forest cover. The green shading indicates relative differences in expected productivity.

This builds on the map in Figure 6 by excluding existing forests. Within the potential expansion areas, the map shows the potential forest productivity, in terms of expected mean annual increment of above ground carbon. The darker green areas are where afforestation activities would have greatest productivity, which depending on the goal of the activities will translate into the speed at which carbon is sequestered, commercial timber is grown, or habitat is restored. Afforestation would convert mainly current croplands, grasslands and barren lands back to their original forest cover via assisted or natural revegetation, or create new forest cover via artificial plantations.

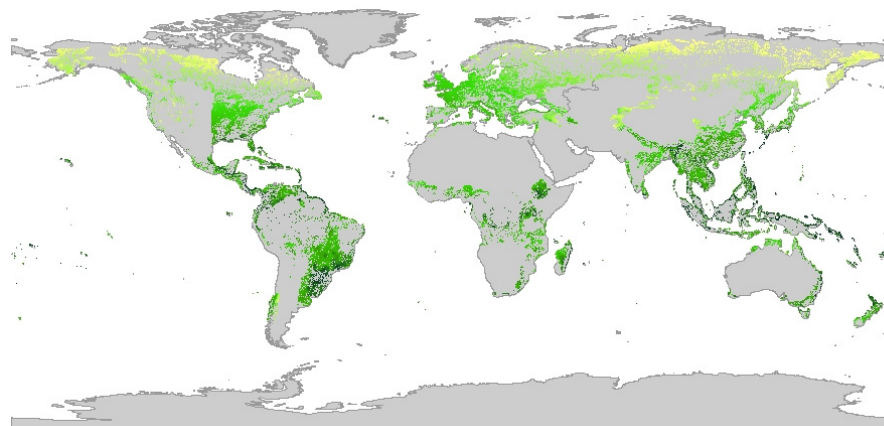


Figure 8 Productivity of the global potential forest areas

There is potential, and then there are productivity factors. A natural final step is looking at the current status of forests. The fourth map giving an overview on the existing forests is the Global Landcover 2000 Project (GLC 2000) map5. Managed and unmanaged forests are not differentiated in this Figure 9.

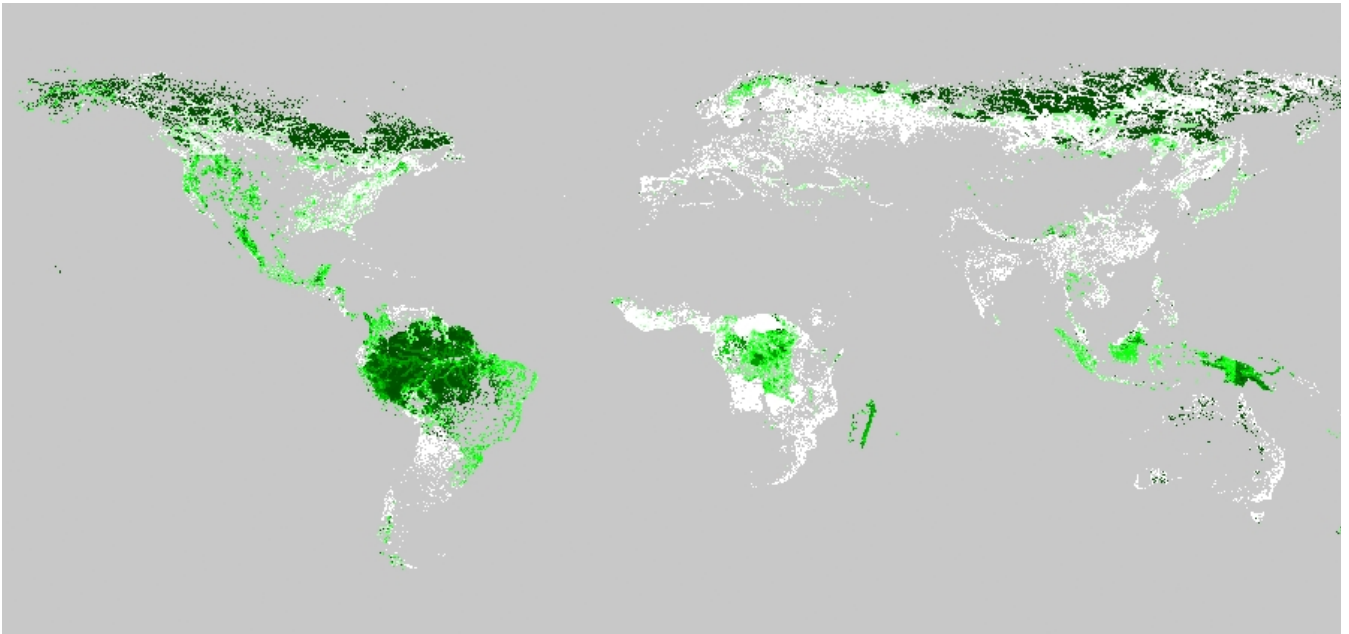


Figure 9 The Global Landcover 2000 Project map

What can be seen in the maps?	
Map 1, Figure 6	All potential land for forests
Map 2, Figure 7	Overview of various biodiversity conservation priorities
Map 3, Figure 8	Productivity in filtered set of potential areas; i.e. a map showing the productivity in potential forest areas excluding already existing ones
Map 4, Figure 9	Overview of the current managed and unmanaged forests

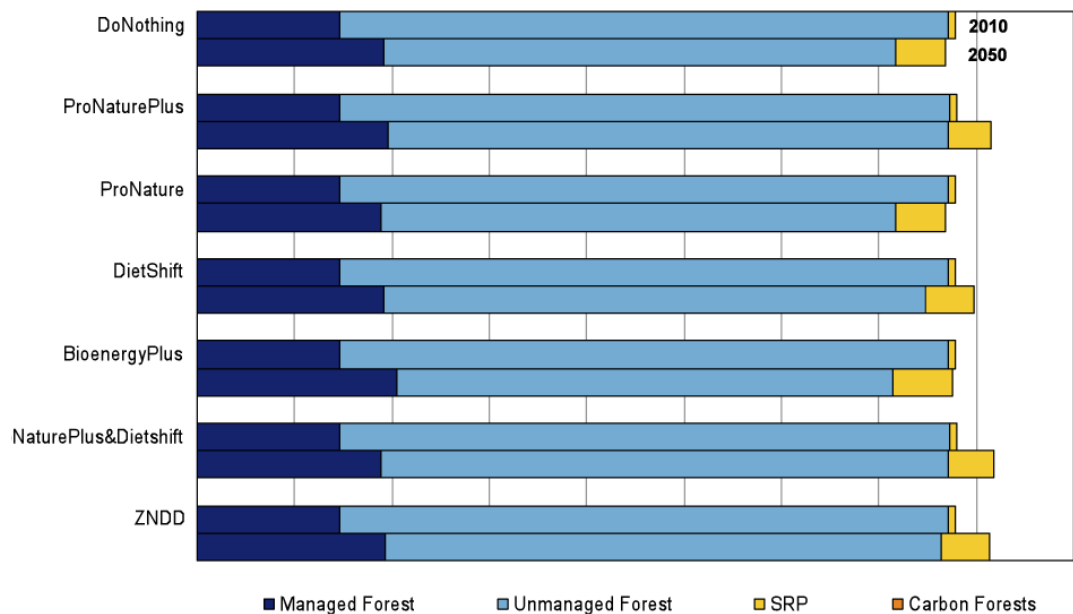
The WHERE, WHAT and HOW above give a glimpse into the crucial question of sustainably providing the forest biomass for current and coming generations' needs. The overall suitability of lands for forest cover, the biodiversity protection aspect and the productivity of the land are three key issues that must be balanced, and a solution without plantation forests is very, very hard to find. Now, deeper interpretation of these maps and all underlying information as regards e.g. expansion of plantation zones is a quite extensive and complex topic. It deserves a whole track of its own, not just this stop. Hence, for the purposes of the storyline, we have gone far enough; we have given a rough picture of forest biomass and biodiversity, so that we can continue to further topics on the road to 2050.

Break-up of the world's forest estate

Moving from the potential afforestation areas to future forest use scenarios, e.g. the "Living Forest Model" by IIASA can be used to produce scenarios on how the world's forest estate is broken up into different forest types in the future. Figure 10 shows the break-up in 2010 and 2050 in different scenarios. The forest type alternatives are managed forest, unmanaged forest, short rotation plantations (SRP) and carbon forests.

One of the key messages would seem to be the strong role of short rotation plantations in ensuring sustainable sourcing and transition to renewable materials.

Figure 10 Break-up of the world's forest estate in 2010 and 2050



The key assumptions behind the different scenarios⁶ are listed in the following:

Scenario description from WWF Living Forests Report			
Do Nothing scenario	Diet Shift scenario	Bioenergy Plus scenario	Pro-Nature scenario
<p>A projection of what the world could look like if our behaviour continues in line with historical trends (see below). The Do Nothing Scenario anticipates land-use change due to: (a) demands for land to supply a growing global human population with food, fibre and fuel; and (b) continuation of historical patterns of poorly planned and governed exploitation of forest resources. Key assumptions in this scenario are:</p> <ul style="list-style-type: none"> by 2050, world population reaches 9.1 billion and per-capita GDP almost triples demand for commodities is driven by changes in affluence (measured by GDP) and human population growth aggregate historical trends in agricultural productivity gains continue the average human diet in a country changes according to historically observed relationships with per-capita GDP forestry and agricultural production does not expand into, but unprotected natural habitats can be converted to timber plantations, cropland and pasture total primary energy use from land-based feedstocks doubles between 2010 and 2050 due to projected energy demand and the competitiveness of technologies and supply chains 	<p>The total global consumption of animal calories is maintained at the 2010 global average with convergence in per capita consumption across regions (i.e., those now below the global average consume more in the future, while those now above the global average consume less). This scenario means less future demand for animal calories than the Do Nothing Scenario.</p>	<p>Bioenergy feedstock demand is consistent with the 100% renewable energy vision calculated by the Ecofys Energy Model. This contrasts with the Do Nothing Scenario in that it assumes a higher carbon price. This makes bioenergy more competitive relative to fossil fuels, although this is tempered by higher bioenergy feedstock prices as more bioenergy is used.</p>	<p>Remaining natural ecosystems are protected (i.e., no further conversion of these ecosystems to cropland, grazing land, plantations or urban settlement) in areas identified as important for biodiversity by at least three separate conservation mapping processes. This scenario assumes that current land uses (e.g., cropland or forestry) in these areas remain constant and continue to produce food or timber.</p>
		<p>Zero Net Deforestation and Forest Degradation (ZNDD) scenario</p> <p>Target Scenario: ZNDD (with near zero gross rate of loss of natural and semi-natural forest) by 2020 and maintained at that level indefinitely.</p>	<p>Pro-Nature plus scenario</p> <p>Remaining natural ecosystems are protected (as defined in the Pro-Nature Scenario) in areas identified by any one of the conservation mapping processes.</p>

CONCLUSION

At this stop, the great difference between theoretical and actual afforestation potential became clear. Now, for the source of forest biomass, there is a global view of possible locations in different scenarios.

⁶ WWF Living Forests Report: Chapter 1

SECOND STOP: SPECIAL BIOMASS AND BIODIVERSITY-RELATED ISSUES

The messages
at this stop:
correcting
misconceptions,
resource efficiency,
long time horizon.

WHY VISIT THIS STOP? IT IS A SHORTER STOP, REMINDING OF SOME ISSUES OF KEY COMPLEMENTARY IMPORTANCE WHEN ENJOYING THE SIGHT OF FOREST BIOMASS AND BIODIVERSITY.

The view of forest as growing stands of otherwise static raw material has received additional nuances with the discussion of ecosystem services. For human services, the discussion has in the industrial age swung between the extremes of

- just building larger and larger bulk production installations, with no service provision
- moving to pure service provision and forgetting manufacturing with all its emissions and raw material needs

A balance is obviously needed, and lately even some most production-outsourcing-friendly instances have begun to realise that to have a functional value chain to the consumer, one has to be able to innovate from raw material harvesting and production to consumer services. Ecosystem services is a term introduced to denote the critical and dynamic work done by ecosystems to keep systems running – work that far, far outperforms anything humans have engineered.

Ecosystem services in general

Forest ecosystems provide several services for the well-being of human beings.

These include e.g.:

- Watershed services
- Soil stabilization and erosion control
- Air quality
- Climate regulation and carbon sequestration
- Biodiversity
- Recreation and tourism
- Non-timber products
- Cultural values

Typically, these services benefit the whole general public regardless of the public or private ownership of forests. Since most of the ecosystem services do not have an established monetary value and do not directly benefit private landowners, they are not accounted for in private land use decisions. This results in low attractiveness of forest preservation compared to e.g. converting the land to agricultural use. By estimating the monetary value of forest ecosystem services and paying the landowners for the services provided, the conservation of forest ecosystems could be promoted. Different methods to estimate the value of forest ecosystem services have been proposed. Establishing the value of a given forest where it faces other potential land uses is in many cases

a significant step. However, no consensus exists on any important detailed issue in this area – except that forests do provide absolutely necessary services for our survival.

Water is a priority area of WBCSD and WWF; thus, an example of a watershed service can be used as illustration.

Concrete example of watershed services

In Manitoba in Canada, **The Manitoba Model Forest Inc.**⁷ is a not-for-profit, nongovernment organisation, aiming to “provide a place where people from different backgrounds can work together to learn about and appreciate all the values of the forest and help ensure those values are conserved for future generations.”

There is concrete action; one part being building watershed management capacity. To protect water quality and quantity when biomass resources are harvested, it is necessary to study the action and interaction of soils, vegetation, fires, animals, agriculture and forestry on water. Manitoba Model Forest has collected baseline water quality data, and with Geographic Information System (GIS) linkages, created a refined watershed map for use in monitoring the levels of forest management activity in the Model Forest area.

CONCLUSION

Here, the growing topic of ecosystem services is attached to forest biomass and biodiversity.

Long before 2050, it is likely that some consensus on dealing with ecosystem services has been reached. Even better: companies and technologies that promote, improve and connect ecosystem services.

⁷ http://www.manitobamodelforest.net/watershed_mf_area.html

THIRD STOP: PRODUCTION PROJECTIONS



WHY VISIT THIS STOP? WHETHER IT IS A MATTER OF PROVIDING THE BULK MATERIALS OR THE BASIS FOR VALUE ADDED, BIO-BASED ENERGY CREATION AT PULP MILLS OR CARBON-BINDING WOODEN CONSTRUCTION, AT THIS STOP THE VOLUME OF ACTIVITY IS ESTABLISHED.

Far too often the habit of the paper industry (and its consultants and researchers) has been to have a very supply-oriented perspective. How much wood is there? Surely it can find a use somewhere. "If you produce it, they will come and buy it". Well, we are fortunately not quite there any longer. The demand side of the forest-based value chain is moving towards balance when wood-based biomass supply/demand in the future is looked at; without consumers and needed end uses there is no production.

Market-based pulp and paper projections

WBCSD Pöyry best estimates presented here are based on input data derived from Pöyry's extensive market, pulp and paper mill, and socio-economic data banks, and are processed through several stages e.g. strictly quantitative modelling and statistical analysis, semi-quantitative assessments and judgmental reviews by an expert panel. The "medium" projection of demand for wood-based fibre needed for papermaking is divided into virgin wood pulp and recovered paper, and presented regionally in Figure 11. The projection covers both market pulp and pulp used in mills where pulp and paper production are integrated.

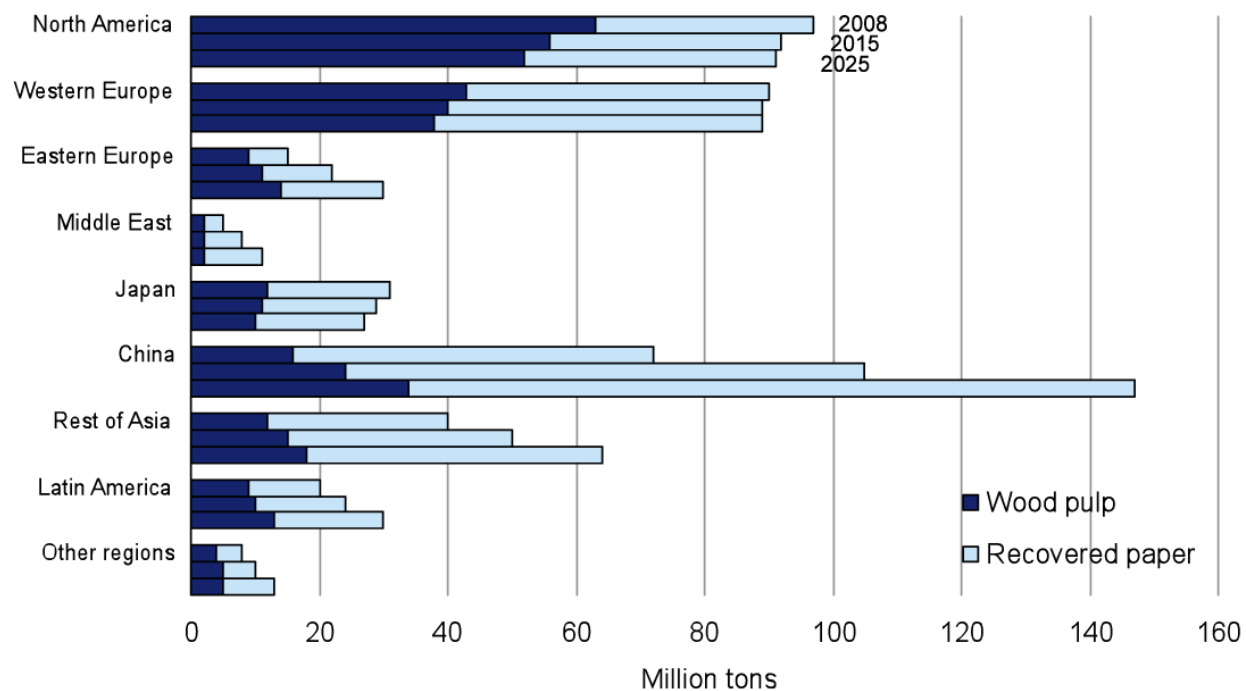


Figure 11 WBCSD Pöyry best estimate for global wood pulp and recovered paper demand by region

Main assumptions behind fibre use in Pöyry's medium scenario

The highest long-term demand growth of paper and board products is in packaging boards (containerboards and cartonboards) and tissue

Demand for printing and writing papers has lower demand growth, in some areas the demand is even declining

Newsprint has the lowest long-term demand growth

According to Pöyry's scenarios, a remarkable part of the growth, especially in the slowly growing paper grades, comes from China, India and Russia

To understand where the fibre is utilised to produce paper and paperboard, and where these products are finally used, Figure 12 shows the global production and consumption of paper and paperboard per region, and presents the expected growth in production by 2025.

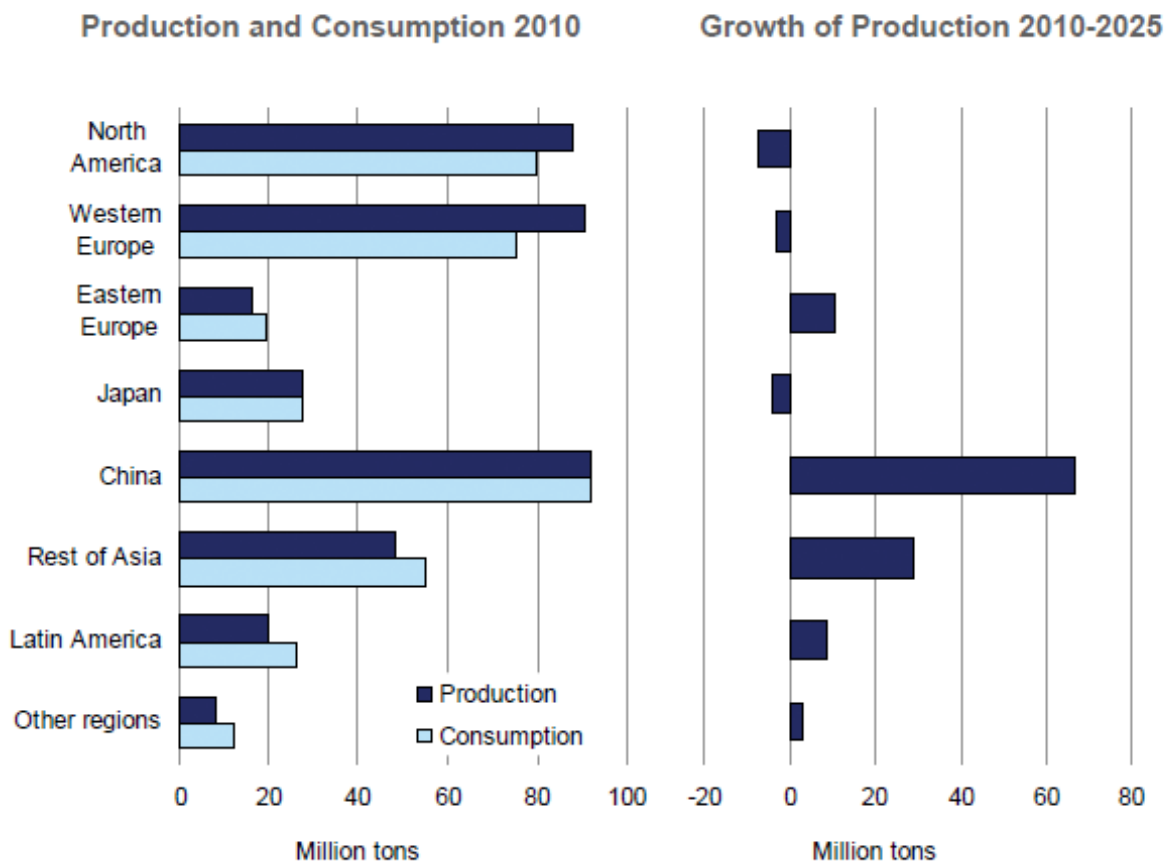


Figure 12 WBCSD Pöyry best estimate for global paper and paperboard production and consumption

Market-based sawnwood and panels projections

Market-based views on the future development of different sawnwood and wood-based panel products by 2025 are described in the following.

Main assumptions behind sawnwood and wood-based panels use in Pöyry's medium scenario

Sawnwood

- Sawnwood demand is growing steadily all over the world. The demand is mainly driven by construction activity and also by the manufacturing industry that requires packaging materials. Softwoods demand is expected to be stronger compared to hardwoods which are substituted to some extent by cheaper materials such as wood based panels
- The growth is focusing on faster developing economies in Asia, Africa and Latin America, but Europe and North America are still the markets in terms of size

Wood-based panels

- Production growth in China has been quick in the 2000's and growth is foreseen to continue. China is globally the biggest wood-based panel producer and consumer
- The highest global long-term demand growth (percentage-wise) is foreseen for oriented strand board (OSB) and medium density fibreboard (MDF)
- Asia and Europe are the largest markets for wood-based panels. Asia is foreseen to further strengthen its role globally
- There are large differences between market sizes of various products in different areas. E.g. softwood, plywood and OSB are widely used for construction in North America, whereas demand for OSB is currently very low e.g. in Asia. On the other hand, MDF demand is relatively small in North America but big in Asia. Europe dominates global particleboard consumption

CONCLUSION

Simply put: fibre use is still on a growth path; variations in end use and end location have occurred and are expected.

FOURTH STOP: TRADE FLOWS

The messages
at this stop:
consumer,
resource efficiency,
long term horizon

WHY VISIT THIS STOP? IN A GLOBALISED WORLD, THE DIRECTION AND SIZE OF TRADE FLOWS IS OF CRUCIAL IMPORTANCE FOR EVERYTHING FROM FINANCIAL CRISES TO EMISSIONS.

WBCSD Pöyry best estimates are presented in the following. The trade flows in 2010 are based on Comtrade (Commodity Trade Statistic Database) data and the future changes have their basis in the Pöyry estimations.

Global fibre flows

Wood-based fibre is traded both in the form of virgin woodpulp and recovered paper. Figure 13 presents the trade flows of wood pulp between the main regions. The triangle symbols show how the 2010 trade flows are projected to change in the future up to 2025. The triangle with "e" indicates that the exports of the area will increase or decrease, depending on the direction of the triangle ("green up" is growth, "red down" decrease), whereas "i" denotes change in the imports in the area.

There are several key drivers that will have an impact on wood pulp production and consumption globally in the medium to long term:

- The industry structure is changing as production is increasingly shifting from Western to developing regions. Most of the new wood pulp production capacity is planned in Russia, Asia and Latin America.

- Asia (China) continues to be a net importer of wood pulp also in the future and will also import wood pulp from other regions.
- Paper consumption is estimated to decrease in mature Western markets and therefore less wood pulp is needed in these regions. Packaging grades will compensate for some of the reduction of wood pulp demand in paper grades. Unless wood pulp production capacity is shut down or new end uses are found, increase in exports /decrease in imports will be seen.
- The availability of recovered fibre is also projected to tighten and therefore, furnish changes in different paper grades might be seen. This will have an effect also on wood pulp trade flows.

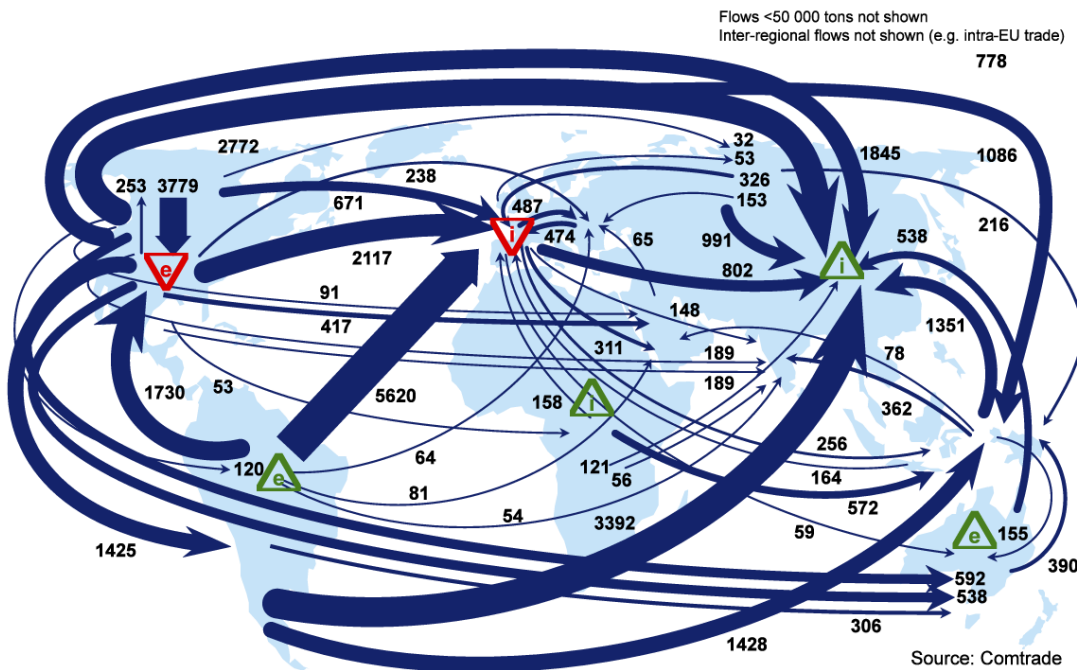


Figure 13 Global wood pulp trade flows in 2010 and WBCSD Pöyry best estimate for main changes in the flows towards 2025

The changes that are expected to change the trade flow map from the 2010 situation are described in the following:

Region	Expected changes
Europe	Exports from Eastern Europe are expected to increase, with the EU as a whole importing less wood pulp in the long term
North America	Exports from North America are projected to decline. Wood pulp is used more commonly in North America for packaging grades than e.g. in Europe or Asia. In North America, there are also plenty of old production assets that are likely to be closed in the medium to long term.
Asia	China is estimated to increasingly import wood pulp from other regions. Other Asian areas, except for the Pacific OECD (Australia, Japan, New Zealand), are also expected to export more wood pulp in the long term. Exports from Oceania are projected to increase in the long term.
Latin America	Exports from Latin America are expected to increase in the future.
Africa	The Middle East and North Africa are seen to continue as importers of wood pulp. Unless new production capacity will be built, Sub-Saharan Africa will turn from a net exporter to a net importer of wood pulp in the long term.

The wood pulp flows are complemented with the recovered paper flows to show the whole landscape of fibre trade for papermaking. The trade flows of recovered paper and the WBCSD Pöyry estimated main changes in the trade flows until 2025 are presented in Figure 14.

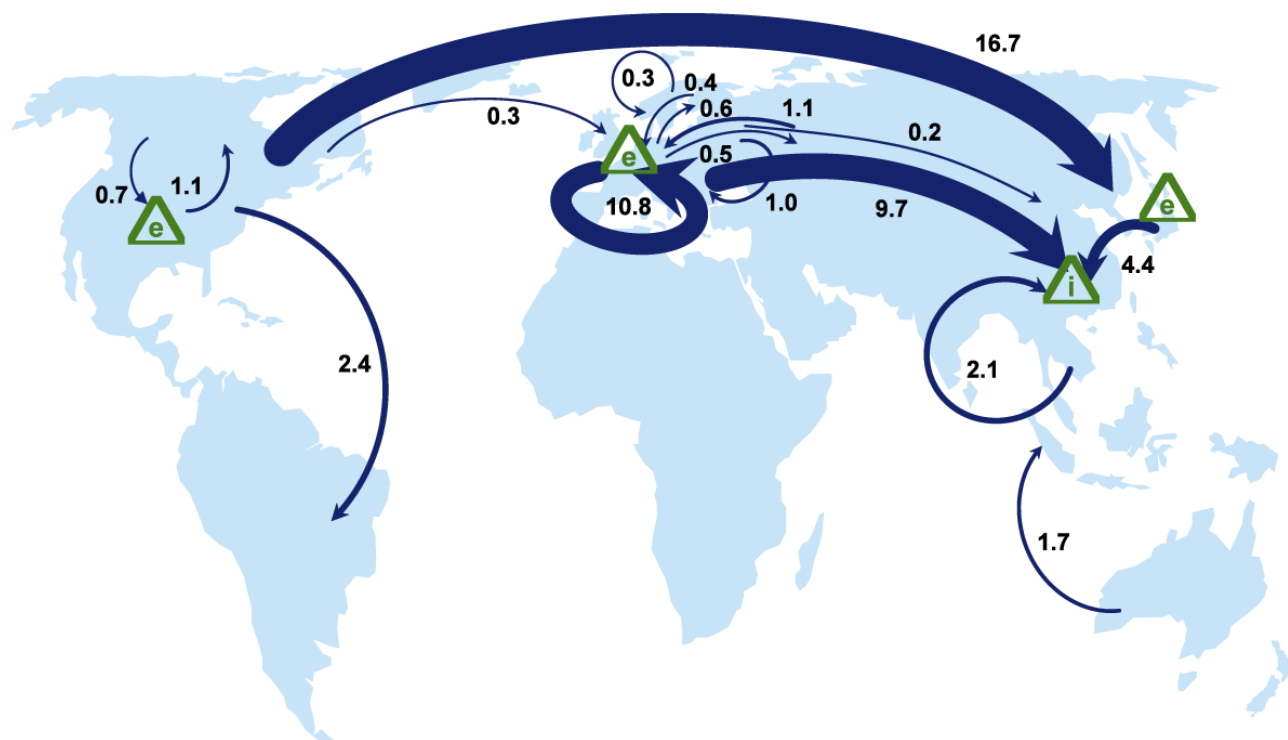


Figure 14 Global recovered paper trade flows in 2010 and WBCSD Pöyry best estimate for main changes in the flows towards 2025

The expected major changes that will shape the trade flow map of recovered paper are explained in the following table:

Region	Expected changes
Europe	The projected growth of exports from Europe to Asia-Pacific does not assume that renewable energy targets would limit the regional paper industry's consumption and offshore demand in Europe. Renewable energy needs could, however, limit the region's net exports, which in the first place would threaten the fibre supply/demand balances in the Asia-Pacific region
North America	Increasing volumes of recovered paper from the USA will become available through increased collection, but the era of abundance is gradually coming to an end, which will likely curb the growth of collection and net exports from the USA in the long term
Asia	The growing deficit in China will be balanced by additional volumes of recovered paper from North America, Europe and Japan

Global paper and paperboard flows

One step further from the fibre trade, we have paper and paperboard products. Figure 15 presents the global trade flows based on the 2010 Comtrade data, and it also describes the major changes that are projected to happen in the paper and paperboard trade until 2025.

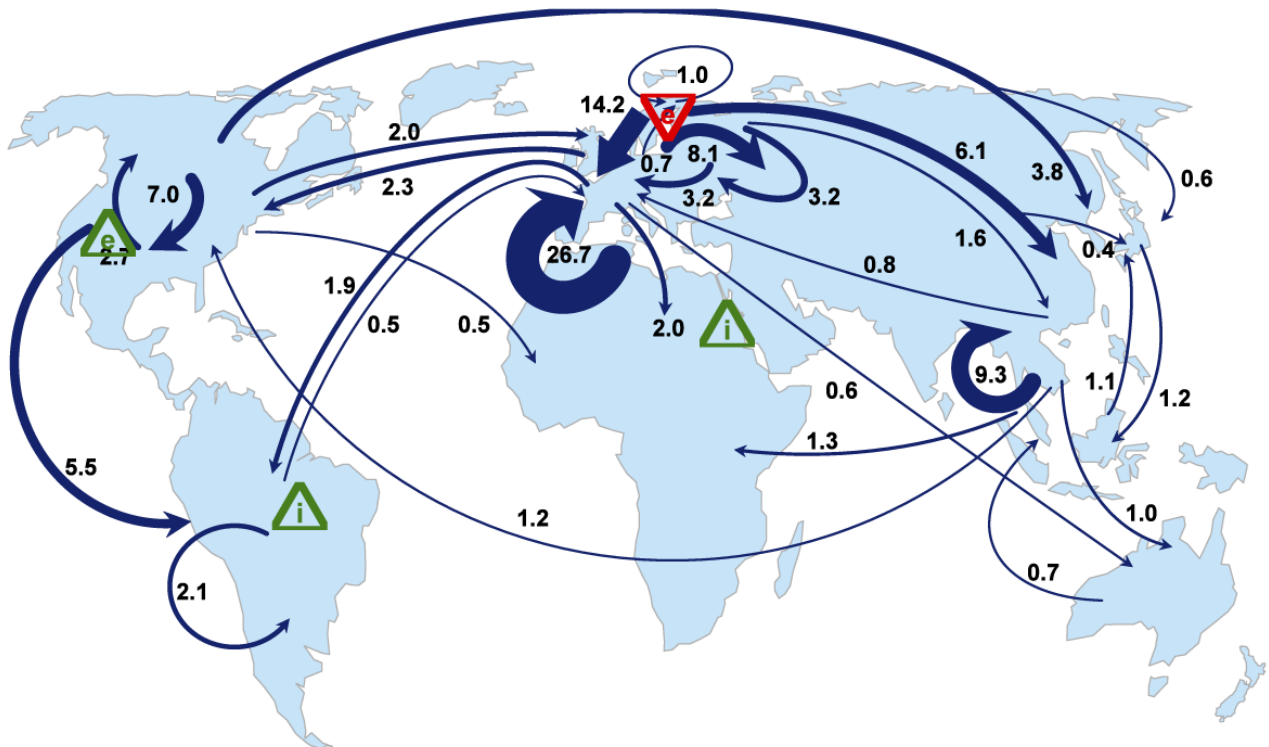


Figure 15 Global paper and paperboard flows 2010 and WBCSD Pöyry best estimate for main changes in the flows towards 2025

The following explains the assumptions behind the expected changes in the paper and paperboard trade flows:

Region	Expected changes
Europe	Net exports from the Nordic region are expected to decline reflecting the weakening export opportunities in the graphic paper sector
North America	The trade surplus in North America is projected to grow mainly as a result of increasing net exports in packaging grades
Asia	China and the rest of Asia will have an increased capacity to produce and export certain grades of paper and paperboard. However, overall paper and paperboard trade balances in Japan, China and the rest of Asia are estimated to remain marginally on deficit due to the chronic lack of virgin and recovered fibre in these regions
Latin America and Africa	Net imports are expected to grow the most in the Middle East, Latin America and Africa

Global wood product flows

The sector of sawnwood and panel products splits into several different product groups. Hardwood sawnwood and plywood are relatively the most traded grades, but in volume softwood sawnwood is the most significant. Figure 16 shows the global softwood sawnwood trade flows in 2010, and indicates the major changes expected in the trade flows by 2025.

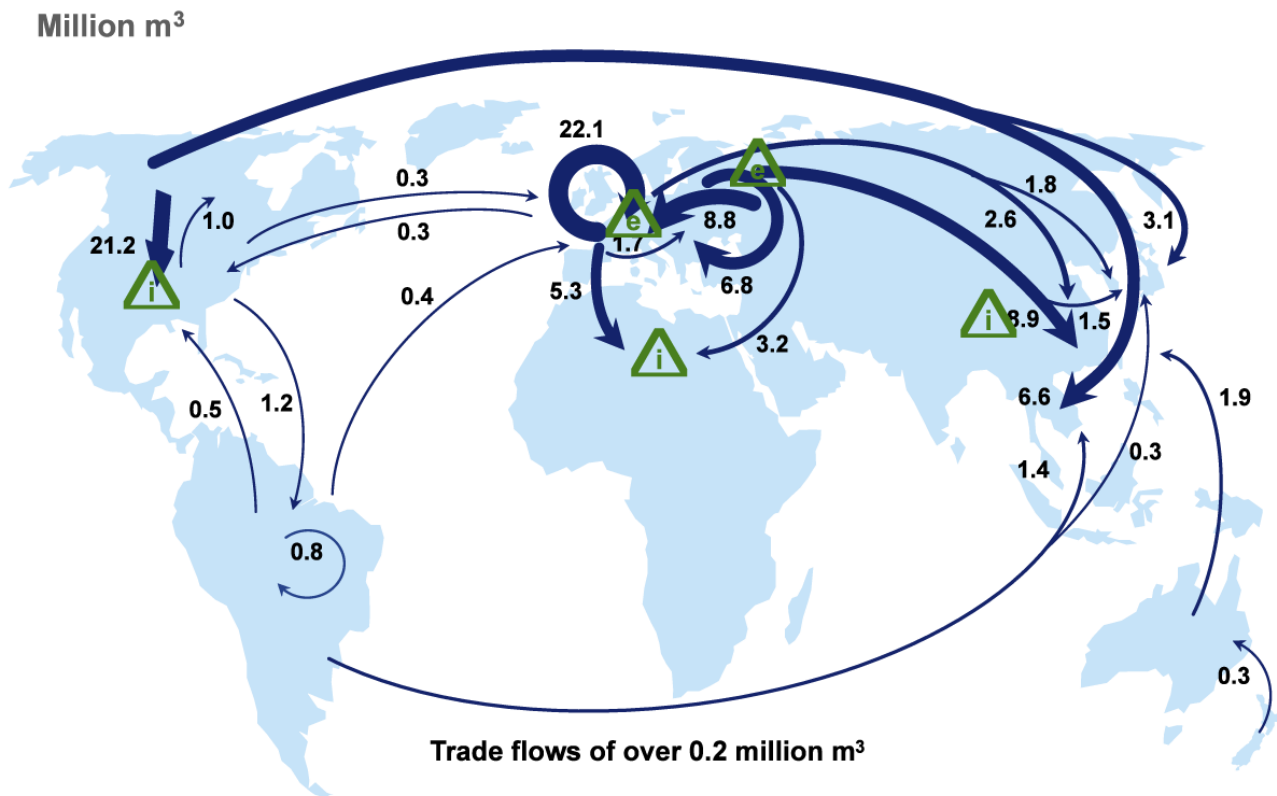


Figure 16 Global softwood sawnwood trade flows in 2010 and WBCSD Pöyry best estimate for main changes in the flows towards 2025

The following describes verbally the expected changes in the softwood sawnwood trade flows:

Region	Expected changes
North America	Imports in the USA are expected to grow, the exporters being Canada, Europe and possibly Russia, too
Asia	The imports in Asia are expected to grow from several regions
Africa and Middle East	Imports in Africa and Middle East will increase from Europe and Russia

Conclusion

The complexity of trade flows, and the amount of drivers that can change them (political, regulatory, financial, resource-related) brings home how fragile individual strands of future scenarios are, even though the general drive and need to use more and more bio-based renewable raw materials would be obvious.

FIFTH STOP: BIOMATERIALS

WHY VISIT THIS STOP? SOME OF THE EARLIER STOPS DEALT WITH ITEMS WHERE LIMITATIONS AND DECLINE WERE PRESENT. FOR BIO-BASED ADVANCED MATERIALS AND BIO-BASED CHEMICALS, THE WORLD IS OPEN, AND A SPREAD ACROSS MANY LARGE NEW CLIENT SECTORS IS POSSIBLE.

Biomass is a renewable raw material to which **value can be added** in ways from pulp, paper and wood products through chemicals to fuels and materials. The gap in many analyses of future biomass use lies in bio-based chemicals and materials; the pulp, paper and wood issue tends to be covered, and bioenergy/biofuel scenarios abound. Moreover, the latter is at least at the moment extremely driven by political decisions and subsidies, and sustainable solutions have to stand on their own feet, eventually.

Renewable and multiply usable

Renewability is, in the case of forest biomass, accompanied by extreme versatility, with uses ranging among others from paper and materials through energy and chemicals to recreation. With such a material, we need more and smarter.

More: the more substitution of non-renewable materials with biomass that occurs, the better for the environment and economy. Increased biomass production does not mean increased overall consumption of goods, at best it means fulfilling material and service needs on a more sustainable basis.

In the generation of additional volumes forest-based biomass, plantation forestry plays a key role, be it in the form of e.g. eucalyptus culture in the South or managed softwood forests in the North. There is a limit on land available, so even with increased forest cover, increased yield for biomass is a necessity. In this, sustainably managed plantations and productivity techniques offer the best chance.

Smarter: resource efficiency is not just a buzzword; getting more value out of a given amount to resources is a goal to pursue in whatever scenario. This, again, does not mean an emphasis on increasing consumption; it means an emphasis on creating real value sustainably with the best techniques and practices from raw materials. Responsible actions imply continuously managing resources better, not leaving resources unmanaged – and leaving the right proportion of forests to protection is also a form of management.

Better also means having better balance in fibre use, including energy usage. The latter, encompassing e.g. solid and liquid biofuels, is a highly politically driven issue, and global legislation including impacts on fuel and electricity prices, and global and regional differences, may have a very significant impact on wood use and fibre flows.

The messages
at this stop:
correcting
misconceptions,
resource efficiency.

At this fifth stop, we hence examine **bio-based chemicals** and **bio-based new materials** and their impact on world fibre flows.

- Bio-based chemicals are chemicals where the raw material is (at least partly) bio-based. Bio-substitution of fossil raw materials with bio-based ones is a rising trend in the chemical and petrochemical industry
- The advanced bio-based materials sector can be seen as a “club that many members don’t realise they are in”. This is because there are so many end uses.

“Bio-based chemicals” is better than “biochemicals”. Otherwise, there is a risk of confusing a bio-based raw material sourcing with biotechnology in production.

The dynamics of bio-based chemicals and advanced bio-based materials

Drawing a line between current pulp, paper and wood products and advanced bio-based materials is not a simple task. We have used the definition in the box below:

Advanced bio-based materials expand the current or recent use of bio-based materials into new directions, either by new functionality or new properties enabling substitution. This definition includes e.g. current products from installations that qualify as refineries processing biomass.

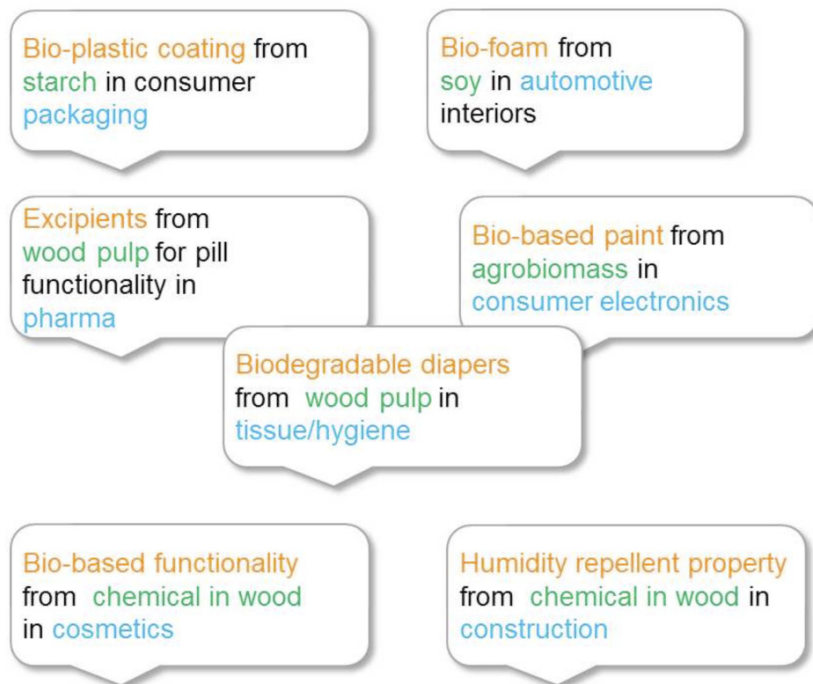


Figure 17 Examples of advanced bio-based material products

In Figure 17, we give some examples of advanced bio-based material products from the sectors packaging, automotive, pharma⁸, consumer electronics, tissue/hygiene, cosmetics and construction.

Bio-based chemicals and advanced bio-based materials from wood have a very interesting dynamic: because of

- intricate linkages between end uses and multi-purpose materials,
- existing supply chains tuned for mass distribution and
- no competition with food use (except for land): one can put minute fractions of wood into food, but wood is not food

Innovations on the markets can quickly spread from sector to sector – which is a strong incentive for R&D investment. As a current example, Figure 18 shows key players capable of spreading forest products industry innovations into many important end use sectors.

⁸ N.B. "Excipient" in the figure means "any more or less inert substance added to a drug to give it suitable consistency or form", i.e. pulp that holds a pill together as long as it needs to be held together and makes it possible to release medicine over a predefined period of time.

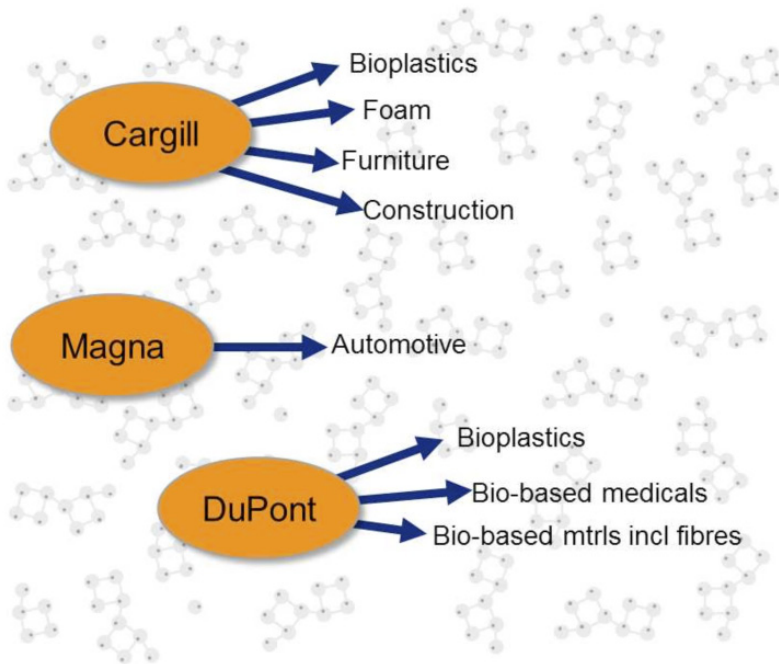


Figure 18 Examples of current supply chain dynamics promoting advanced bio-based materials

Names change and companies come and go, but at the moment, the three below typify a ready-made infrastructure for spreading advanced bio-based materials and bio-based chemicals.

- **Cargill**, which is active in very many areas including bio-plastics, foam, furniture and construction has the power to change many sectors
- **Magna**, as a powerful, global and diversified automotive supplier, purchasing materials and assembling them, and with bio-based entries in its catalog is able to propagate bio-based solutions in the global automotive industry
- **DuPont**, the truly influential chemical giant, with an Applied BioSciences division (\$1 billion in revenue) of two primary businesses: bio-based materials, and biofuels.

The dynamics of classifying new bio-based materials and chemicals

There is a large variety of new materials that can be made of wood, or commonly known materials with new uses.

These products could be classified as

- **Natural:** composites, used in e.g. construction and automotive
- **Modified:** e.g. films and viscose, in packaging and other end uses
- **Bio-based synthetic polymers:** bio-based plastics, in e.g. consumer electronics, automotive

It should be noted that the amount of chemicals from wood with varying end use potential is so large, that one can either stay on a higher level, or dive into very detailed exposition – which is not the task here.

The dynamics of production: Biomaterial flows integrated into existing plants

Wood-based chemicals and advanced biomaterials are mostly based on tiny fractions of the total composition of woody biomass. Analysing the logistics and economics of production, only one general conclusion is possible (at least with current prices and technology): **bio-based chemicals and materials need to be produced at an integrate to be viable, rather than at stand-alone plants.**

There is already a significant amount of integrates in the pulp and paper industry, and more can be created. What all this means for fibre flows is

- bio-based chemicals and advanced bio-based materials will most likely have a fairly negligible impact on fibre use as such.
- what goes to new bio-based products can be taken from a small sidestream of e.g. a pulp mill
- the small addition to wood use that these products bring is probably more than offset by e.g. decrease in certain existing paper products

As an example, polylactic acid (PLA) is a bio-based polymer that can be made from sugars extracted from the hemicellulose of wood. It can be used in e.g. packaging, teabags, medical uses, and shirts.

Wood-based PLA is produced from the side product flow of the pulp mill. In case of a sulphate pulp mill the **feasible amount for PLA production is around 4 % of sulphate pulp production – a reasonable rule of thumb for understanding the impact on fibre flows (but not to be taken too precisely or as a generic constant)**. If more sugars are extracted from hemicellulose, the efficiency of the PLA production decreases, as the extract is relatively more diluted which leads among other things to relatively greater water consumption. The quality of the pulp suffers from too little hemicellulose left for production.

The integrated production has a minor impact on wood consumption. Figure 19 describes this. When part of the pulpwood is used to produce PLA, less wood is left for energy production. The deficit in raw material can be filled with energy wood (i.e. wood not suitable for pulp use), and the amount needed is relatively small compared to total wood input.

Sulphate pulp production



Integrated sulphate pulp and polylactic acid (PLA) production

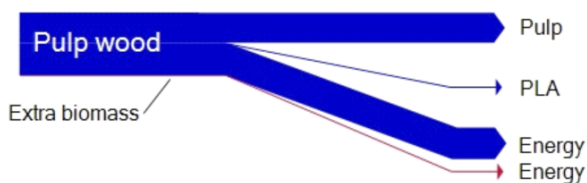


Figure 19 Example of the wood use of sulphate pulp production without and with integrated polylactic acid (PLA) production

This PLA example shows that it is beneficial to produce new bio-based material linked to pulp production, because only limited part of wood can be utilised for PLA. Sulphite pulp production has some more side product flows, thus the potential for new bio-based materials is somewhat bigger. If all parts of wood could be utilised to produce new materials, then it could be feasible to produce them independently from the traditional forest industry, but the near-future technologies and the existing capacity do not support that.

CONCLUSION

Bio-based chemicals and advanced bio-based materials offer superb promise in flow of income and value added – but not in increased usage of fibre. Which makes this a very good area in terms of value/raw material, on the condition that integrates (e.g. pulp mills) with logistics and main flows exist.

SIXTH STOP: FUTURE PRODUCTS

WHY VISIT THIS STOP? WHAT ISN'T BUT COULD BE", POTENTIAL FUTURE FOREST PRODUCTS IN PEOPLE'S EVERYDAY LIVES IN 2050 ARE OBVIOUSLY IMPOSSIBLE TO PREDICT WITH ANY CERTAINTY, BUT MANY DIRECTIONS AND PROMISE CAN BE BROUGHT TOGETHER.



Guideline

The task given for this stop is

- a list of potential future forest products in people's everyday lives in 2050 that do not exist today

As the task is open-ended, for good and bad, we have thought that the following boundaries would serve the purpose well:

Base analogy for good luck	Adaptation 2050
Something old,	Something related to existing products but evolved,
something new,	something out of left field,
something borrowed,	something from another sphere/sector,
something blue.	something related to solving environmental problems ("a mood of environmental blues") with renewable solutions (green).

Thus, the goals have been;

- not making everything completely alien
- trying to bring in surprises
- showing that the forest industry can expand
- keeping awareness of problems present.

have been the goal.

Fundamental storyline

Two main threads are used in the plot:

- the products are placed in the consumer's 24-hr day (24 hr clock)
- there are two main characters, a couple, one working in the **biomaterials industry** (an expansion of the forest industry domain) and the significant other in the **biocleaning sector**, (an expansion of forestry to waste management)

Hence, the two key concepts, the clock and the double-ended tree in Figure 20 are key.

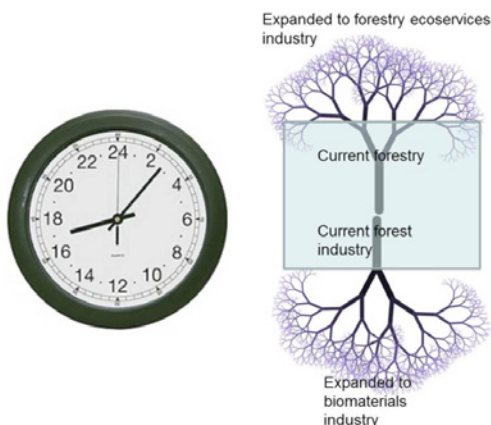


Figure 20 2050 - The Clock and the Tree

Sectors and categories

In the ideal case, e.g. the following categories appear

- **Pharmacology** The expansion of the forest industry into the bio-based medical industry
- **Composites** The expansion of bio-based composites in construction, printed and grown organic electronics, everyday objects and utensils
- **Ecoservices** (see also SECOND STOP: BIOMASS AND BIODIVERSITY-RELATED ISSUES)
Health, wellness and safety
Soil reclamation
"Next-next-next-gen plantation"
Sensors
- **Communication** Printing and writing papers moving towards fibre and fibre-based communication hybrids
- **Active packaging** Packaging as expanded protector, freezer, food cooker etc.
- **Active hygiene** Expanded function of tissue and hygiene sector
- **Active entertainment and senses** Forest and food, taste etc.
- **Textiles** Fibres for all purposes
- **Energy** An option in a balanced use portfolio. Maximising value from fibre naturally involves taking advantage of its structural unique properties, Please note that since we are focussing on "products in everyday lives in 2050 that do not exist today", we haven't included current products. This does not mean that there wouldn't be any left, the focus is simply on new or evolved versions.

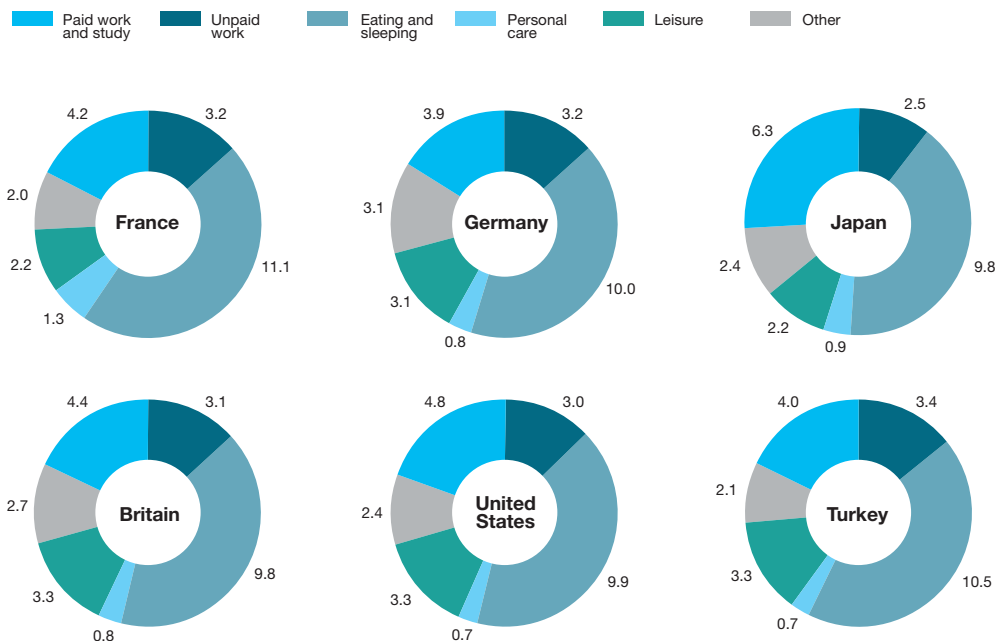
Fundamental storyline: 2050 A.D. DAY

"A day in the life" is a popular metaphor for illustrating everyday activities. What and when people do differs even in developed neighbouring countries, as Figure 21⁹ shows.

We will divide the day into four segments of six hours, starting from the "Night Watch".

Time spent per activity

Hours per day by people aged 15-64, 1998-2009



Source: OECD

*Totals may not add up to 24 due to rounding

Figure 21 Days in Lives 1998-2009, published in The Economist online¹⁰


We also happily acknowledge any prediction for 2050 now, in 2011, is hopelessly bound to what we know today, but we have to make an effort – and do not want the whole thing to appear pure science fiction for the reader that matters: today's individual.

⁹Based on http://www.economist.com/blogs/dailychart/2011/04/time_use

¹⁰http://www.economist.com/blogs/dailychart/2011/04/time_use



2050 A.D. DAY: "Night watch", 00:00 – 06:00

In the introduction, Rembrandt's "Night watch"-painting crystallises key messages in this report. That night watch consisted of civic militia doing rounds. The wood fibre-based "night watch 2050" would not commission a painting of itself, neither does it care about its clothing- but it does its duty.

Time	Forest product/service	Category
	"Night watch"	Nanocellulose filters built into the house structure watch the air, water, weather and other significant items. They actually do it 24/7/365, but at night they are at heightened alert for storms, viral matter, fungi, toxics, oxygen levels, bacterial agents etc. in incoming air/water/solids.



2050 A.D. DAY: "AM shift", 06:00 – 12:00

After "Night watch", presuming that day rhythms are about as they are know (which is in itself a bold prediction), the example couple activates.

Time	Forest product/service	Category
	<p>Wake on fibre mattress</p> <p>Wake in nature (shown on fibre-based displays on the walls)</p> <p>Morning cleaning</p> <p>Breakfast</p> <p>News: organic reader</p>	<p>Textiles: latest generation fibre comfort</p> <p>Nature: Health and wellness; live forest bio-based display; forest VOCs (Volatile Organic Compounds, bio-based chemicals. incl.) with health effect</p> <p>Forest rhythm: house lives in rhythm of nature</p> <p>Mirror as example of everyday object: bio-based composite, bio-based plastics with nanocrystals giving reflection. Bio-optics a growing field.</p> <p>Self-cleaning plates: no water for dishes. Bio-based material.</p> <p>Grown organic electronics: current printed electronics in evolved form. All parts (display, electronics, substrate etc.) biomass, non-toxic-recyclable</p>
	<p>Biotransport: feeder walk to main transport paths through "Wellness"-designed health garden</p> <p>Work in company making customised biomaterials from base biomass products: at end of value chain.</p> <p>Work in company using Next-next-gen plantations for soil reclamation-> specialised in shantytowns</p>	<p>Health and wellness: city gardens become designer bio-based medicine gardens. Anti-allergenic preventive treatment through fungi etc., wood VOC health aromas (science, not belief-based issue)</p> <p>Biocomposite cars/trains</p> <p>New value chain:</p> <p>forest, forest ecoservices, harvesting, pulp -> fibre modification, paper -> making fibre-based surfaces for printing, packaging, hygiene, bio-based materials of all persuasion</p> <p>Logoes for companies our couple works at below.</p>



2050 A.D. DAY: "PM shift", 12:00 – 18:00

The afternoon shift includes jogging, work and getting home.

Time	Forest product/service	Category
	<p>Jog during lunch in biotextiles that store heat (no sweat) and release it to keep one warm</p> <p>Energy: from wind, solar, geothermal, not from biomass (unless toxic-reclaim-biomass, which has to be incinerated). Biomass in storage: woven batteries</p>	<p>Textiles: biostorage of energy -> apply to textiles, also to batteries etc: woven batteries for energy storage.</p> <p>Textile has biosensors: smells your health (see recent article http://blogs.discovermagazine.com/80beats/2011/08/22/dogs-can-smell-lung-cancer-on-your-breath-even-if-youve-just-had-lunch/)</p>
	<p>Take fibre-packaged dinner from room-temperature cabinet and use package to heat it and, possibly, eat out of it</p>	<p>Active hygiene: food safe through packaging</p> <p>Reduce waste: multi-purpose packaging</p> <p>Taste: forest-based spices</p>

2050 A.D. DAY: "Pleasant journey towards night", 18:00 – 00:00

The afternoon shift includes jogging, work and getting home.

Time	Forest product/service	Category
 	<p>Entertainment, homework, socialising</p>	<p>Pick up the carton of "Multipurpose Live Paper" and use it for</p> <ul style="list-style-type: none"> homework: take as many sheets as you need; put them in the layout you want; write/ calculate/ visualise living wall: part of room wall changes according to schedule or people's moods; part of room wall acts as display for entertainment (games, interactive soap operas, live participatory concerts) Interacting with friends and family not in the immediate physical vicinity: different levels of privacy and access rights for different types of friends and family. <p>Fixing things</p> <ul style="list-style-type: none"> Nobody wants robots to do everything; in the biotoolshed, active bio-based materials for everything from scraped knees to bike repair (yes, bikes are fashionable)

Roles for the expanded forest industry

In the above, the expanded forest industry is playing a key role e.g. in

- Reducing gadget- and appliance mania:

Less electronic gadgets

Less kitchen appliances

- The medicine cabinet
- Recreation/sports/entertainment
- Construction

These are but a few possible roles, and even more roles are actually present in the text, if one cares to dig them out.

Visual moments: Snapshots from 2050

Below, the further illustrate points above, five snapshots are given: on the new kitchen, new living room, forest@work, forest pharmacy and biotoolshed.

NOTE Illustrations here could certainly be improved with designers having a specific style as a goal. However, as one picture = 103 words, the illustrations should serve their purpose.

Snapshot 2050: Kitchen



Figure 22 The Truly Nouvelle Cuisine: The Package-Based Kitchen

Image: Kitchen with new design - no freezer, microwave, oven. More room for enjoyment, social life around kitchen table.

No freezer, no microwave, no oven (Figure 22): completely new design, since food storage and preparation chain based on packaging that safeguards, stores, prepares food. Enter innovative new kitchen design, centered on social enjoyment, not production line for nutrition. Customised food preparation services with local food sources replace "Restaurant takeout". Cooking for entertainment of course still present.

Snapshot 2050: Forest@work

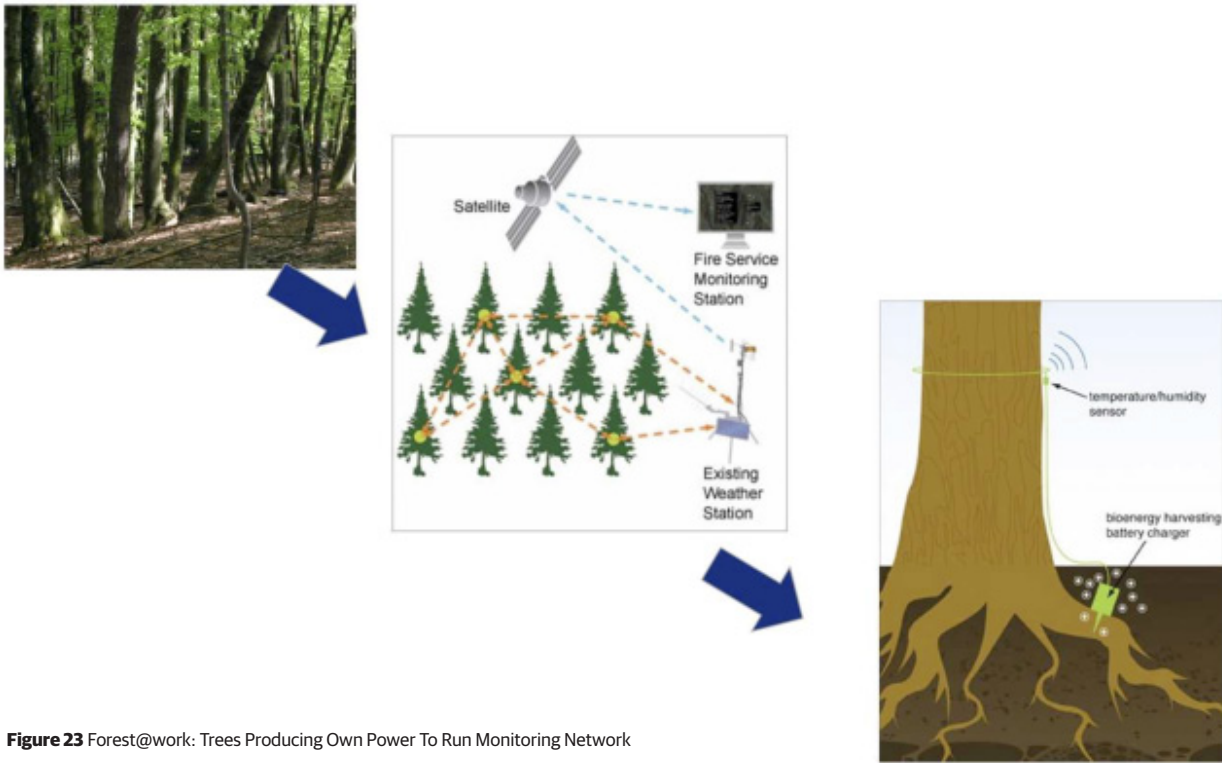


Figure 23 Forest@work: Trees Producing Own Power To Run Monitoring Network

Image: Forest, sensor network shown, power collection and storage pods, soil contaminants collected in pipelines to incineration with energy recovery. Combines healthy green and high-tech

Nextⁿ-plantation at work: taking electricity from soil (example in Figure 23 now MIT's tree-powered network, e.g. <http://www.networkworld.com/community/node/33278>), sensor monitoring, filtering, reclaiming, giving health and wellness services as tools for ecoservice companies.

Snapshot 2050: Forest pharma

Image: Drugstore design, large part "forest-based medicine", aisles with different labels for bio-based items.

Note names of aisles in Figure 24: brought in revolution in emphasis: Preventive, not reactive medicine. Anti-aging, anti-cancer - preventing cancer by preventing disruption of cell suicide cycle instead of doing chemotherapy. Trees are good sources for all of this: as they can't escape by running into isolation, and have a long life span, they have had to develop a chemical/medical arsenal that fortifies their immunity and combats disease.

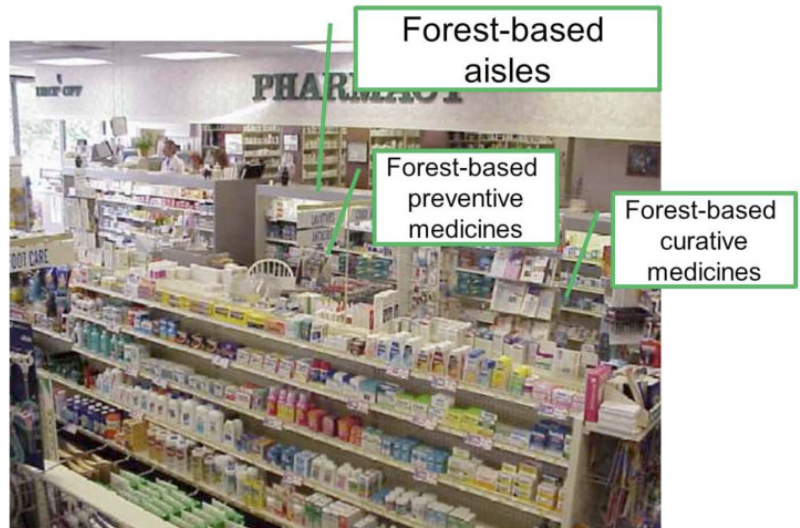


Figure 24 "Forest Pharma" drugstore chain: Aisles seen through mobile display info application

Snapshot 2050: The new, omnipresent multiuse paper

Image: The new copy paper - in living room, a pile of paper sheets. They are active: some are tacked up as temporary displays for gaming, TV, playing with children; others are in work areas as displays; some are used as quick-and-dirty tablet-size pads.

Readers and displays (Figure 25) for all purposes (family tree article): completely organic and printed.



'Printed electronics' is a general term used to describe electronics based on semiconducting organic (i.e. carbon-based) polymeric materials which make it possible to put materials onto a surface using additive or printing techniques.

Figure 25 The new, omnipresent multiuse paper: Living room activities and decoration done through hub of package of "New Copy Paper"

Snapshot 2050: Biotooledshed

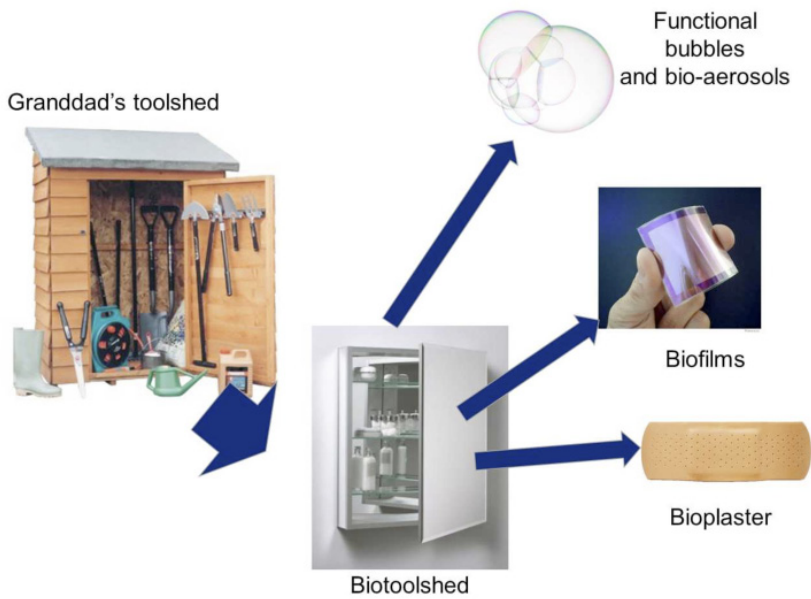


Figure 26 From Granddad's shed to minilab: the biotoolshed

Note names of aisles in Figure 24: brought in revolution in emphasis: Preventive, not reactive medicine. Anti-aging, anti-cancer - preventing cancer by preventing disruption of cell suicide cycle instead of doing chemotherapy. Trees are good sources for all of this: as they can't escape by running into isolation, and have a long life span, they have had to develop a chemical/medical arsenal that fortifies their immunity and combats disease.

CONCLUSION

2050 will probably turn out either much better or much worse than envisioned. However, the potential of fibre-based products to have an impact on an even broader slice of daily life than before is there. In this sense, we might witness a closing of the loop - a development from living in forested areas and off forest abundance, via a more mechanized existence, to a combination of a highly digital yet also highly bio-based lifestyle

Image: toolshed/garage version 2050. From current racks of spanners, hammers etc. to centrifuges, coaters, surface processors. Although self-healing materials already are a fact in 2011, and will presumably be very much more dominant in 2050, something will probably still have to be fixed by people. For this, a biotoolshed (Figure 26) contains the equipment to e.g. biocoat tears in clothing, scratches in cars, reprogram the organic pad, and highly advanced compostor/processors. The raw material: fibre-based.

SEVENTH STOP: CONCLUSION

This report has gone from 17th century paintings to 2050; from night watches of civic militia to night watches of nanofibre-based active filters; from forests and soil to organic electronics reacting to people's moods. The scope may rightly be called broad-ranging.

However, four messages were found in a Rembrandt painting, and those four messages carried the story, and step forth at the conclusion.

- **Correcting misconceptions**
Among many things: fibre-based products are not dying out, they are a promise for the future
- **The growing importance of the consumer**
This message has been repeated ad nauseam, but perhaps, finally, a purely production-oriented viewpoint has reached a turning point towards a balance between consumer's needs and nature's capacity
- **Resource efficiency**
Even though forest products have a strong record on carbon, the element C is not the only resource. Water, energy, metals, chemicals, food, fibre, biodiversity – and time! – are what we need to manage.
- **A long time horizon**
The true horizon of a sustainable forest products and services value chain is far, far longer than even the oldest paper mill in the world. Now, patience is required from every stakeholder in the chain for the truly smart and enduring solutions.

One message we have kept "hidden" on purpose is sustainability. In the current atmosphere the term is used so often as to become almost meaningless. We wanted to emphasise that **sustainability is such a necessary precondition for all activity that it should be a given.** If the term is **conspicuous by its absence** in this report, it is because it is **conspicuous by its constant presence in bio-based products** produced from certifiably sustainable raw materials through sustainable processes and value chains. This is of course not automatic. The forest industry needs to be constantly vigilant in safeguarding and improving the sustainability of bio-based products, whatever the sustainable end use.

