# Ecosystem integrity and forest plantations

Technical Paper

*New Generation Plantations Project*
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## Summary

Forests and plantations are defined as a continuum, with reference to existing international definitions.

Some of the impacts of tree plantations are summarised with respect to four major ecological cycles:

- ✓ **Water**: information on water quantity and quality which provides sufficient understanding about water cycles on a catchment level
- ✓ **Nutrients**: soil attributes which provide sufficient understanding about nutrient cycles
- ✓ **Carbon:** changes in biomass balance
- ✓ **Biodiversity:** HCV's, species and habitats

This Technical Paper then outlines a **conceptual model** for addressing issues of ecological integrity in plantations based on: (1) a determination of the initial settings of the FMU intensity and scale; (2) impact assessment; (3) conservation strategy.

To support an understanding of current best practice a series of **Case Studies** on ecological integrity within plantations, provided by the project participants, conclude the paper.



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## Preface

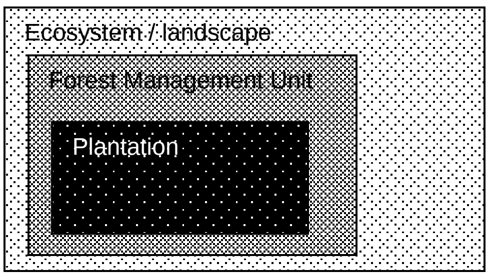
This Technical Paper aims to provide a framework to help ensure that plantations contribute positively to ecosystem integrity at a landscape scale through:

- ✓ Assessing the potential impacts of a range of site-level management practices on the wider ecosystem and analysing the best available information that can maximise benefits and minimise detrimental impacts
- ✓ Presenting a range of planning and management approaches that can help to maintain ecosystem integrity within plantations and between plantations and the wider landscape
- ✓ Relating these analyses with a number of other reviews of ecosystem services
- ✓ Presenting case studies on ecosystem integrity

Measures and concepts are needed to characterise the status and trends in ecosystems and to provide a standard for management. There is no precise description of ecosystem health, however. Ecosystems are loosely defined, dynamically changing associations of biotic and abiotic components. Measures of integrity should, amongst other things, reflect the ability of ecosystems to maintain services of value to humans. Our knowledge of the factors maintaining ecosystem integrity is still incomplete, mainly because of the intrinsic complexity of natural systems. However, this incomplete evidence should not be interpreted as evidence that environmental impacts are absent. Clear yes-no answers are rarely available and decisions must be made in the face of uncertainty.

So, what are the practical implications of these discussions? And how should a manager implement notions of ecosystem integrity? These questions cannot be answered by managers or scientists alone. This is a new and developing area, but one that holds tremendous potential for advancing the science of forest management in a cooperative process.

The conceptual approach to ecosystem integrity used here is based on the model presented below, where a plantation is embedded within a forest management unit (FMU), which is itself embedded in the ecosystem or landscape. There will be cases where the FMU is made up entirely of a plantation although these are unusual situations.




The paper uses the definition of ecological process, adapted from the Millennium Ecosystem Assessment, as the physical, chemical and biological actions or events that link organisms and their environment. Ecological processes include water, nutrient, carbon and biological cycles. This approach relies on data which is already required for compliance with the principles and criteria (P+C) of the Forest Stewardship Council (FSC) along with existing legal frameworks. It therefore does not introduce new requirements. Instead it is a reorganization of the information already required in the FSC P+C and with other existing international processes for responsible forest management.

An intensively managed planted forest can have a role in society, but plantations need to be distinguished from natural forests.

The forest - plantation continuum is a conceptual model which encompasses a variety of ecological systems: from natural forest at one end of the spectrum to intensive exotic short rotation tree plantations at the other. Confining attention to the extremes is simplistic and misleading and in practice a continuum exists between natural forests and plantations, depending on the degree of management and the extent to which composition and ecosystem processes have moved away from the original conditions. This implies a range from low-impact management of natural forests, to high intensity, short-rotation plantations management. The management practices used in forests and plantations do not themselves provide ecosystem integrity but influence ecological processes.

There are different approaches to the question of whether the placement of the forest management practice within the forest - plantations continuum should be based on a discrete or non-discrete system. The non-discrete approach to the forest - plantation continuum acknowledges the difficulties in distinguishing between forests and plantations in many forest ecosystems. It replaces a definition based on a set of different categories to one that instead describes the initial status, intensity and scale of each forest/plantation within the forest management unit in order to describe it more precisely within the continuum.

**Some definitions of forests, ecosystems and plantations**

**Ecosystem:** *A community of all living organisms and their physical environment, constituted by the ecological processes of water, carbon, nutrient and biological cycles, functioning together as an interdependent unit.* (FSC)

**Ecosystem Integrity:** *The status of the natural ecosystem as the baseline for assessing integrity of the ecosystem.*

**Ecosystem health:** *The status of an ecosystem considering its ability to provide services of value to humans*

**Forest ecosystem**: *A forest ecosystem can be defined at a range of scales. It is a dynamic complex of plant, animal and micro-organism communities and their abiotic environment interacting as a functional unit, where trees are a key component of the system. Humans, with their cultural, economic and environmental needs are an integral part of many forest ecosystems*. (Convention on Biological Diversity)

**Forest**: *Forest includes natural forests and forest plantations. It is used to refer to land with a tree canopy cover of more than 10 per cent and area of more than 0.5 ha. Forests are determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young stands that have not yet but are expected to reach a crown density of 10 per cent and tree height of 5 m are included under forest, as are temporarily unstocked areas. The term includes forests used for purposes of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves and other protected areas), as well as forest stands on agricultural lands (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. It also excludes trees planted in agroforestry systems*. (Food and Agriculture Organisation of the United Nations (FAO))

**Forest plantation**: *Forest stands established by planting or/and seeding in the process of afforestation or reforestation. They are either of introduced species (all planted stands), or intensively managed stands of indigenous species, which meet all the following criteria: one or two species at planting, even age class, regular spacing.* (FAO)

**Planted forest**: *Forest in which trees have been established through planting or seeding. Includes all stands established through planting or seeding of both native and introduced species.* (FAO)

**Forest Management Unit:** *A clearly defined forest area with mapped boundaries, managed by a single managerial body to a set of explicit objectives which are expressed in a self-contained multi-year management plan.* (FSC)

**The definitions above can be cross referenced to other contemporary studies on plantations and ecosystem services**

Ecosystem Services Review
UNEP Finance Initiative
The Forest Dialogue secretariat by Yale University
FSC Plantations Review
LEAP
FAO Voluntary Guidelines for Sustainable Management of Planted Forests

## Ecosystem integrity in forest plantations

The Technical Paper addresses how to maintain and enhance ecosystem integrity in forest plantations. It consists of a conceptual approach to forest plantations management and planning to address ecosystem integrity within the forest-plantations continuum. The paper uses some case studies do discuss the applicability of the conceptual approach.

The approach outlines how forest and plantation management can maintain and enhance ecosystem integrity at the site and landscape scale by defining management processes at the forest management unit (FMU) level and carrying out planning in a way that recognises and accommodates landscape-scale issues. It consists of three main dimensions, building on and in some cases expanding standard on Environmental and Social Impact Assessment:

- ✓ **Forest context**: a determination of the intensity, scale and initial status of each forest management practice within the forest management unit, carried out in order to identify where a particular forest practice is placed within the forest - plantation continuum
- ✓ **Impact assessment**: potential impacts of the forest management practices on the ecological process of nutrient, water, carbon and biological cycles, determined in a manner appropriate to the scale, intensity and context of management practices
- ✓ **Conservation strategy**: achievement of ecosystem integrity through the beneficial results of forest management and conservation actions that are based on a conservation strategy that enhances positive impacts in addition to mitigate, prevent and/or remedy the adverse impacts on the ecological processes in a manner appropriate to the level of impacts.

Each step will be described in turn and any associated tools described. A list of existing tools and guidelines relevant to the ecosystem integrity concept is shown in Table 1.

**Examples of guidelines and standards for sustainable plantation management (Marjokorpi & Salo 2007)**

| Standard/guidelines (Abbreviation) | Type | Reference |
|---|---|---|
| Guidelines Shell/WWF Tree Plantation Review (SH) | Guidelines | Guidelines Shell/WWF… 1993 |
| ITTO guidelines for the establishment and sustainable management of planted tropical forests (IP) | Guidelines | ITTO 1993a |
| Linking C&I to a code of practice for industrial tropical tree plantations, CIFOR (CI) | Scientific | Applegate and Raymond 2001[b)], Poulsen and Applegate 2001 |
| The Australian Forestry Standard (AFS)[a)] | Forest certification | AFS 2003a, 2003b[b)] |
| Sistema Brazileiro de Certificação Florestal, CERFLOR – Forest Management – Principles, Criteria and Indicators for Planted Forests (CE) | Forest certification | ABNT 2004 |
| Sistema de Certificación de Manejo Forestal Sustentable, CERTFOR – Standards (CT) | Forest certification | CertforChile 2004 |
| Forest Stewardship Council Principles and Criteria for Forest Stewardship (FSC) | Forest certification | FSC 2004 |
| Lembaga Ekolabel Indonesia – Sustainable plantation forest management (SPFM) system (LEI) | Forest certification | LEI 2005a, 2005b[b)] |

[a)] Applicable to all forest types for wood production. Informative supplement (AFS 2003b) to guide application of the standard in medium and large-scale plantations.
[b)] Supplements to the standards. Included in the analysis.

## Forest context

The forest/plantation in question – whether existing or planned – should be assessed to see where it lies in the forest-plantation continuum. This will serve as the reference/starting point for the interpretation of the level of impacts and conservation actions needed. It cannot be (and need not be) a precise process but rather a guide to the likely opportunities and constraints of management with respect to maintaining ecological integrity.

The approach is based on an assessment of the impact of the scale and intensity of the management practices on ecosystem integrity. This non-discrete approach is necessarily step-wise, due to the complex, multi-dimensional nature of forest management operations around the world (see below). The data used in the assessment are quantitative but the results are influenced by the initial setting, scale and intensity of the forest management practice, which are non-quantitative and non-discrete. The approach is intended to be based on data already required in the existing FSC rules and existing legal frameworks.

### Ecosystem Integrity Approach

A determination of the initial settings of the FMU, intensity and scale of each forest management practice within the forest management unit need to be carried out in order to identify where a forest practice is placed within the forest-plantation continuum.

**Determination of the initial setting** – identifying the type and condition of the ecosystems within the FMU at the time of plantation establishment and for a sufficient period prior to this to provide relevant information to determine the potential impacts on ecosystem integrity.

**Determination of the intensity** – characterising the ways in which the ecosystem is being manipulated. Indicators of intensity could be but are not limited to: rotation; planting density; harvesting volume; and regeneration system. It is necessary to use several of these indicators to determine the intensity, due to the complexity and interrelation of the indictors. For example, the impact of planting density or rotation on intensity is influenced by the tree species selected. The information used is normally already included in the management plan and or forest inventory.

**Determination of scale** – measuring the extent of the FMU in the landscape. Indicators of scale could be but are not limited to: size of FMU; contiguity of planted areas, or percentage and distribution of the FMU in the landscape (e.g. catchments). Information can be obtained in management plans, land use plans, feasibility studies, or have to be calculated or estimated if not available in other sources.

## Impact assessment

Each forest plantation should have a thorough impact assessment, including coverage of issues relevant to ecosystem integrity. The step wise Ecosystem Integrity Approach determines the effort needed to assess the potential impact of a plantation on ecosystem integrity by reference to the initial setting, scale and intensity of the management practices. Conservation actions are then defined depending on the level of impact.

### Ecosystem Integrity Approach

Impacts of forest management practices on the ecological processes related to nutrient, water, carbon and biological cycles should be determined in a manner appropriate to the scale and intensity of management practices.

The following sources normally address ecosystem integrity as defined above and can therefore be used. There is no preference for one source over another.

- ✓ Compliance with national or regional legislation (e.g. forestry or environmental legislation) that addresses ecosystem integrity.
- ✓ If an EIA is conducted, as is often required by legislation, it can also be used for assessment of impacts on ecosystem integrity.
- ✓ Impact assessment can be based on long term monitoring systems, information sharing with comparable FMUs with monitoring system, or research results.

If the sources do not address all aspects of ecosystem integrity as defined above the missing information needs to be acquired and assessed as described below.

### Information needed for assessing impacts on the four elements of ecosystem integrity

- ✓ **Water**: Information on water quality and quantity is needed. Management and monitoring of water resources should preferably be implemented at the water catchment level, which is the scale at which hydrological processes are analyzed.
- ✓ **Nutrients**: Information is needed on soil type, distribution and biological, chemical and physical characteristics that influence soil productivity.
- ✓ **Carbon:** Information is needed on the carbon balance which is determined through changes of biomass and organic soil matter in the long term.
- ✓ **Biodiversity:** information is needed on HCVs and biodiversity at both the site and landscape level as appropriate. This includes among others: representative ecosystems, rare ecosystems and habitats for rare species, riparian zones of native vegetation, conservation corridors and other elements of landscape connectivity.

## Conservation strategy

The case studies demonstrate different strategies to achieve ecosystem integrity. Following the ecosystem integrity approach, the conservation strategy must build on the results of environmental impact assessment, which has identified threats and opportunities resulting from plantations management, maximising the potential and minimises the costs to ecosystem integrity.

### Ecosystem Integrity Approach

Ecosystem integrity shall be achieved through the beneficial results of forest management and conservation actions, based on a conservation strategy to mitigate, prevent and remedy the adverse impacts and enhance the positive impacts on the ecological processes in a manner appropriate to the level of impacts. Each impact should be linked with a description of how and where in the management unit the impact is prevented, mitigated or remedied.

### Examples of guidelines for environmental and social impact assessment

IAIA Principles of Environmental Impact Assessment Best Practice
*http://www.iaia.org/modx/assets/files/Principles%20of%20IA_web.pdf*

IAIA SIA Best Practices
*http://www.iaia.org/modx/assets/files/SP2.pdf*

World Bank Environmental Assessment Sourcebook
*http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTENVASS/0,,contentMDK:20282864~pagePK:148956~piPK:216618~theSitePK:407988,00.html*

World Bank Social Analysis
*http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTSOCIALDEVELOPMENT/EXTSOCIALANALYSIS/0,,menuPK:281319~pagePK:149018~piPK:149093~theSitePK:281314,00.html*

World Bank Participation Sourcebook
http://www.worldbank.org/wbi/sourcebook/sbhome.htm

International Finance Corporation
*http://www.ifc.org/ifcext/sustainability.nsf/Content/EnvSocStandards*

European Investment Bank
*http://www.eib.org/about/news/eib-and-ngos-discuss-the-banks-development-indicators.htm*
*http://www.eib.org/attachments/environmental_and_social_practices_handbook.pdf*

Equator Principles
http://www.equator-principles.com/principles.shtml

## Ecological processes

Forest and plantations management practices influence ecological processes, through impact on the four ecological cycles. Information is required to determine the extent that these cycles will be influenced and changed by the establishment and management of a forest or plantation.

There is no one straight answer to the question of what impacts plantations have on water, nutrient, carbon and biological cycles. If intensive management can have negative impacts on ecological processes, it can also be practiced in a way that maintains and improves some characteristics. The crucial point is to adopt suitable, site specific management systems drawing on a detailed knowledge of the ecosystem functioning. Understanding the processes and properties that affect ecosystem integrity allows the development of management systems adapted to each site and landscape, in a way that can maintain and improve their characteristics and long term productivity in managed plantations. In this context it is very important to recognize sites that are not suitable for intensive management, which will result in a landscape planning mosaic that includes intensive managed plantations and extensive managed or protection forests and other uses.

This paper summarises our current state of understanding about the relationship between forests and plantations and the four cycles, and suggests an approach that managers can take to maximise the benefits and avoid potential problems arising from disturbing ecosystem integrity. Guidance is provided on the conceptual nature of the approach to ecosystem integrity. However this requires further interpretation at the national/regional level.

### Plantations and the water cycle

Hydrological resources are shared by almost all economic sectors, and can be a major driver of development. Water is essential to forestry, agriculture, industry, energy production and for human populations. Due to the high demands on water resources, which mean that it is not always possible to satisfy the total demand, rational management is very important and should preferably be implemented at the water catchment scale. As forests are often located in the upper parts of catchments, where they can influence downstream hydrological resources it is particularly important to understand how they influence the hydrological cycle. A simplified equation of water movement in a catchment is:

Precipitation = runoff + evapotranspiration + water storage

The forest hydrological impacts can occur at each element of the equation.

**Precipitation and annual water catchment** storage can be considered as generally stable. The influence of forests on overall precipitation will only be felt when vegetation changes occur at very large scales, and for practical purposes, we can assume that at the water catchment scale, plantation establishment will not change precipitation. As for the annual water catchment storage, the variation is usually so small that we can consider the variable as stable.

**Evapotranspiration**: forests are generally associated to high values of evapotranspiration. There are two different processes of evapotranspiration:

- ✓ Interception: precipitation water quantity directly evaporated by the canopy;
- ✓ Transpiration: water absorbed by the roots and released by the leaves.

The fact that forests have higher evapotranspiration than other soil uses is due to the high level of fragmentation of the canopy and to the depth of the roots, which can capture water from deep reservoirs. The first factor influences the interception and the second one the transpiration. Evapotranspiration rates are generally greater for evergreen forests than broadleaf forests.

**Water flow**: a primary concern for some stakeholders, particularly in arid or semi-arid regions, is that plantations could reduce the amount of water available in a catchment, leading to drying up of streams or reduced productivity on surrounding lands. The hydrology is complex and hydrologists disagree about the details, but there is now a general consensus that net water surface flow from afforested areas is usually likely to be reduced as compared to most other forms of land use.

Surface water flow from a catchment is the result of the precipitation which is not used in evapotranspiration and does not filter down to recharge the subsoil water storage. High values of forest evapotranspiration will result in low values of water production. This fact is validated by almost all studies done in experimental water catchments. These results are also confirmed by the increase in water runoff after clear cuttings or fires (Hewlett, 1982; Stednick, 1996). However, most studies fail to explain if the reduced runoff is only due to the increased evapotranspiration or whether part of that reduction is due to increased percolation into deeper aquifers.

In some cases the reduction will be too small to have any practical impacts on livelihoods and ecology. Sometimes the changes observed when trees are planted on grazing and agricultural land are probably a return to the hydrological conditions that occurred before historical deforestation. The potential impacts on neighbours and on ecology mean that water balance is becoming an increasingly important issue for many plantation owners and companies.

"*Growing trees quickly, something that is implicit in economically successful plantation forestry, is going to cost water; you cannot have one without the other. In certain places this will cause conflicts*". Scott, 2005

We can say that the higher evapotranspiration values of forests are not based only experimental evidence but are also accepted at a theoretical level. The intensity with which different forest types influence the values of evapotranspiration will depend very much on the characteristics of each forest and site. For the same circumstances, the highest water consumption by evapotranspiration will occur in intensive production forests, with high densities and evergreen leaves (David et al., 2008).

It will be clear from the wide range of different influencing factors listed above that it remains hard to predict what will happen in a particular case. Equally well qualified research groups carrying out careful experiments often come up with different answers. It follows that provision of hard advice remains difficult. Nonetheless, despite this note of caution a competent hydrologist will be able to say a great deal about the likely impacts of a plantation on a watershed if some simple data are available.

"*Different site-specific and often competing processes may be operating and the direction – let alone the magnitude of the impacts – may be difficult to predict for a particular site*". Calder, 2002

The intensity of the hydrologic influence of any forest type depends very much on how the forest is managed over time and space. In the section below, some of the elements of responsible water management presented in the case studies are summarised.

**Responsible water management in plantations**

Some examples of best management practices emerging from the presented case studies regarding plantations influence on water cycle:

**CS1: Glen Affric – UK FC**

- ✓ Encouraging natural regeneration to form a mosaic with a diverse range of woodlands and open space
- ✓ Safeguarded through planning and the establishment of riparian zones containing native species

**CS3: Hafod Boeth Forest - UPM**

- ✓ Mapping all water features
- ✓ Applying water protection measures
- ✓ Developing riparian habitat with native woodland regeneration and open ground

**CS4: West Uruguay - FO**

- ✓ Watercourses and low lying hydromorphic soils are identified and buffered
- ✓ Only about 60 per cent of the total land holding is converted to plantations
- ✓ During heavy rainfall or saturated ground harvesting, transport or land preparation are stoped
- ✓ Application of herbicides and fertilisers is minimised and localised
- ✓ Discharges from drainage of constructed roads are buffered into uncultivated ground

## Plantations and the nutrient cycle

Maintaining nutrient balance and site fertility is one of the key economic and environmental objectives of any sustainable managed plantation. Forests are ecosystems that occur in soils with characteristic physical, chemical and biological properties, which influence erosion and hydrological processes. Natural and long rotation forests build up the organic soil layer through the retention of organic carbon in the soil, which in association with roots and other biological soil elements contribute to soil aggregation, stability and porosity.

Forest ecosystem nutrient cycles are open with both inputs and outputs of nutrients. In forests where no biomass is removed, inputs are related to:

- ✓ Decomposition of primary soil materials
- ✓ Deposition of atmospheric elements and nitrogen fixation

The outputs are mainly related to:

- ✓ Leaching
- ✓ Superficial water runoff
- ✓ Nitrogen loss (volatilization) into the atmosphere

Establishing a plantation can theoretically influence the nutrient cycle by removal of biomass, soil and nutrient loss as a result of mechanical techniques, use of fertilisers and beneficial impacts compared to alternative intensive land uses.

The use of forest ecosystems as source of biomass (wood, fibre or others) modifies the original conditions, changing the nutrient fluxes. The export of nutrients from the system is much lower if only the stem is removed, as this contains lower nutrients as compared with leaves, branches and bark (Fisher and Binkley, 2000).

Forest plantations necessarily result in the intensification and shortening of the temporal cycle of production. Biomass removal is the main export of nutrients from the cycle, because trees are harvested at an age when the consumption of nutrients used in their production has still not been compensated by nutrients from the decomposition of leaves and other system inputs. In intensive forest plantations, soil mobilization and harvesting operations are more frequent, which might further reduce organic matter, modify the soil physical characteristics and increase erosion risk.

For these reasons, a good plantation management system is crucial to soil protection, which will also have a high impact in the plantation's productivity and sustainability (Fox, 2000). Unless soil nutrients are conserved and/or replaced, plantation productivity is likely to decline. However, in most if not all cases nutrient decline can be addressed successfully (Binkley and Stape, 2004)

Some of the techniques used in plantation forestry can increase soil erosion, leading to nutrient losses and more immediate problems of gulleying, landslides and topsoil loss. On the contrary, in some situations presence of plantations can provide fast and effective soil stabilisation in areas where previous poor management, climate impacts or natural disasters have stripped vegetation and left soils denuded.

In particular nitrogen and phosphorus will often need to be applied. In general losses of phosphorus are mainly related to surface runoff and to soil losses processes (Sharpley et al. 2002; Zaimes and Schultz, 2002). Nitrogen enters the soil via biological fixation and fertilization, and is mostly found in organic fractions. Due to the high solubility of the nitrate, nitrogen losses occur mainly through the lixiviation of the soil solution. Nitrogen losses associated with surface runoff are in general negligible, except in conditions of high subsurface flow, although this can occur and affect stream water quality (Delgado 2002).

**Responsible soil management in plantations**

Some examples of best management practices emerging from the presented case studies regarding plantations influence in nutrient cycle:

**CS1: Glen Affric – UK FC**

- ✓ Abandoning the clear fell system
- ✓ Branches and tree tops used to cushion the travel of forest machinery and ground disturbance

**CS3: Hafod Boeth Forest - UPM**

- ✓ Tree species matched to soil type
- ✓ Use of appropriate working methods and buffers to prevent leaching and erosion

**CS4: West Uruguay - FO**

- ✓ In all areas of ownership and prospective interest soils were mapped at high intensity
- ✓ Only one application of fertiliser per rotation, at the time of planting, and placed adjacent to the seedling
- ✓ Mechanised harvesting which de-branches and de-barks in situ to help maintain site fertility
- ✓ During heavy rainfall or saturated ground harvesting, transport or land preparation are stoped

## Plantations and the carbon cycle

Release of carbon into the atmosphere, principally through the burning of fossil fuels and biomass, is the major contributory factor to climate change. Currently around a fifth of greenhouse gas emissions come from deforestation and forest degradation, which although it has slowed a little recently still continues apace in many countries. Reducing forest loss and degradation could play an important role in diminishing levels of greenhouse gases in the atmosphere. As governments look for ways to reduce carbon emissions and also capture (sequester) carbon already in the atmosphere, the role of tree planting has come under increasing attention.

Forest management offers three methods of influence Carbon cycle:

- ✓ Sustainable forest plantations management to increase biomass in timber and soil in existing plantations
- ✓ Increasing carbon storage through afforestation and reforestation
- ✓ Avoiding emissions by maintaining existing carbon storage in trees and soils – the focus of current attention through REDD (Reduce Emissions from Deforestation and Degradation)

Plantations can sequester large amounts of carbon. For example, pine plantations in the Southeast United States have been calculated to accumulate almost 100 tonnes of carbon per acre after 90 years, or roughly one metric ton of carbon per acre per year (Birdsey, 1996). In many cases forest plantations also reduce the amount of cattle in the subject area, which reduces methane emissions, having a double effect.

The amounts sequestered vary between species, climatic and geographical conditions and forest management regimes. Optimising carbon sequestration will require careful management depending on species, rotation length and a range of other climatic and environmental factors (Diaz-Balteiro and Rodriuez, 2006). Lengthening the harvest-regeneration cycle will generally result in less carbon sequestration on a per hectare basis. A more comprehensive picture of the climate effects of these practices also needs to consider possible nitrous oxide ($N_2O$) and methane ($CH_4$) emissions; these are also important greenhouse gases and vary in their response to management regimes.

Carbon accumulation in forests and soils eventually reaches a saturation point, beyond which additional sequestration is no longer possible. This happens, for example, when trees reach maturity, or when the organic matter in soils builds back up to original levels before losses occurred – at this stage forests become important carbon repositories but are no longer active. The stage when this happens is subject to considerable debate and some researchers believe that more sequestration takes place in mature forests than has previously been assumed.

Plantations could thus sequester a proportionately large amount of carbon because the bulk of stored above-ground carbon is removed every few years and new growth occurs. However, the net carbon balance depends to a large extent on the timber use: if it is used in short-life paper products that are burnt or degrade quickly then no net gains have been made. If plantation establishment disturbs soil and results in release of long-held carbon (for example from peat deposits) then a net loss in carbon will have occurred. If a plantation is established on a low productive pasture site and is managed for solid wood products it can sequester much more significant amounts of carbon than the previous land use. There are still gaps in understanding of the links between intensively-managed plantations and carbon sequestration, including the quantity and long-term fate of carbon in litter, below-ground tissues and exudates and soil.

Currently there is also a great deal of debate about the long term implications of carbon sequestration and few studies factor in the impact of future climate change on tree growth and carbon sequestration: some studies suggest that sequestration could be negatively affected by rising carbon dioxide levels in the atmosphere (e.g. Oren at al, 2001). It is probably still too early to say for certain what role plantations will be able to play in stabilising climate change in the future.

**Responsible biomass management in plantations**

Some examples of best management practices emerging from the presented case studies regarding plantations influence in carbon cycle:

**CS2: Asset creation through investment in SFM – FSA China**

- ✓ Assessment of the economic value of forest carbon storage assets at landscape scale

**CS3: Hafod Boeth Forest - UPM**

- ✓ Restructuring the forests to achieve sustained yield
- ✓ Areas of ancient deep peat and woodland restored and protected

**CS4: West Uruguay - FO**

- ✓ Minimising the area cultivated

## Plantations and the biodiversity cycle

Well managed and designed plantations can be beneficial to biodiversity in degraded landscapes. A determination of the initial settings of each site within the forest management unit is important, serving as the reference/starting point for the interpretation of the level of impacts and conservation actions needed.

Based on this, plantations have potential impacts on biodiversity mainly through:

- ✓ Replacement of natural or semi-natural habitats, cultural habitats and creating new habitats.
- ✓ Changes in net biodiversity carrying-capacity and connectivity at landscape level
- ✓ Potential impacts of agrochemicals, invasive species and other elements introduced

The most immediate and obvious impact of plantations are implications for biodiversity depending on the type and quality of the habitat being replaced. Where plantations are established in place of natural forests, areas of peat, natural grasslands then the impacts on the number and type of species occurring is generally negative. If plantations are placed on former agricultural land, various forms of degraded land or to halt desertification, the impacts can be neutral or positive, even through the creation of new habitats.

In such cases plantations can have important positive impacts on biodiversity by, creating suitable conditions for natural regeneration, changing land use dynamics (e.g. eliminating degrading factors), stabilization of land use (e.g. reduced grazing, shifting cultivation, encroachment to the natural forest remnants within the plantation area) or active restoration by the companies.

More difficult to measure, are the impacts that plantations can have on biodiversity at landscape-scale; i.e. whether the presence of a plantation in part of a landscape increases or decreases the chances of wild plant and animal species surviving elsewhere. Landscape-scale responses are influenced by a range of factors including the total amount of plantation, connectivity, whether or not it replaces key natural or semi-natural habitats and management.

The location of the plantation in the landscape is critical to whether it helps or hinders biodiversity at a landscape scale (Montagnini, 2005). Plantations can provide linkages (corridors, buffer zones and stepping stones), allowing animal dispersers (particularly birds and bats) to travel further between natural forest patches, thereby also dispersing more forest seeds (Carnus et al, 2003, Parrish and Petit, 1996). Badly managed and designed plantations have the potential to further fragment ecosystems and to isolate native flora and fauna (Gill and Williams, 1996; Estades and Temple, 1999).

**Responsible biodiversity management in plantations**

Some examples of best management practices emerging from the presented case studies regarding plantations influence in carbon cycle:

**CS1: Glen Affric – UK FC**

- ✓ Removal of non-native trees and planting of native species
- ✓ Monitoring the condition of species to conserve the welfare of wildlife and the condition of vegetation
- ✓ Increasing the proportion of deadwood
- ✓ Managing deer and other grazers populations

**CS2: Asset creation through investment in SFM – FSA China**

- ✓ Assessment of the economic value of biodiversity assets at landscape scale

**CS3: Hafod Boeth Forest - UPM**

- ✓ Protection of habitats of threatened species and restoration of native woodland habitat
- ✓ Removal and control of invasive species
- ✓ Provide connectivity to valuable habitats through removal of crops and habitat restoration
- ✓ Restructuring at FMU level, selective felling at compartment level for structural and age class diversity

**CS4: West Uruguay - FO**

- ✓ Avoiding planting on wetter areas has provided some natural site level connectivity
- ✓ EIAs provided a basis to designate specific ecosystems and habitats as rare or valuable
- ✓ One site has now acquired both international Ramsar and Uruguayan SNAP (protected area) status

**CS17: South Africa - Mondi**

- ✓ Increasing the size of the iSimangaliso Wetland Park by facilitating the inclusion of 9 000 ha into the park, plus 15 000 ha forming a buffer zone between the World Heritage Site and adjoining commercial farming areas.

## Case Studies

The case studies below demonstrate different strategies to achieve ecosystem integrity; and show how the organisations involved have had to respond to a wide diversity of pre-existing circumstances. These case studies introduce a wide diversity of initial settings and ecological, social and economic contexts which face common challenges regarding plantations management and maintaining ecosystem integrity. The cases present us public planted forests side to side with private intensively managed planted forests. The ecosystem integrity approach intends to be a flexible tool that could assist practitioners to systematise their approach to this important aspect of land use change in such different contexts.

### CASE STUDY 1 - Pinewood restoration and conservation in an existing plantation in Glen Affric, Scotland: UK Forestry Commission

Location: Glen Affric is situated in northern highlands of Scotland (see map below).
Organisation: UK Forestry Commission
Contact person: Steve Smith (steve.smith@forestry.gsi.gov.uk )

#### 1. Summary of the main operation and surrounding conditions:

The long-term aim is to establish a large and diverse native Scots Pine ecosystem within Glen Affric, incorporating the National Nature Reserve. From the 1780's, there was forced removal of people from the Scottish Highlands as the introduction of sheep was deemed a more economic use of the land. This was followed by a large increase in the deer population for sport during the Victorian era. One consequence of increased grazing by sheep and deer was a major decline in the native woodland. Glen Affric is home to one of the largest remnants of the ancient Caledonian Pine Forest that once covered much of the Highlands. Recognising the importance of Glen Affric to the nation, the Forestry Commission purchased a large part of the Glen in 1951 – including the majority of the native pinewood (over 3,000 ha), comprising mainly Scots pine (*Pinus sylvestris*) and birch (*Betula pendula* and *Betula pubescens*). Plantations were established over much of the area, including Scots pine but also various non-native conifer species e.g. lodgepole pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*). The population in the glen is relatively small, but many local businesses depend on visitors to Glen Affric. Therefore, community consultation is also a very high priority.

#### 2. Description of best management practices (ecosystem integrity)

a) Silviculture

- removing non-native trees from the Reserve
- abandoning the clearfell system within the Reserve
- thinning plantations of native species to make them appear more natural
- monitoring the condition of all species within the Reserve to conserve the welfare of all wildlife and the condition of all vegetation
- encouraging natural regeneration of trees to form a healthy woodland mosaic with a diverse range of woodlands and open space
- some planting of native species
- increase the proportion of deadwood within the Reserve

b) Managing deer and other grazers

- maintenance of perimeter deer fences to provide buffer against adjacent deer herds
- removal of internal fences or marking fences to reduce risk to forest birds, such as the capercaillie
- developing a Deer Management Plan with neighbours
- eliminating sheep or general cattle grazing within the Reserve

c) Water and soil quality

- safeguarded through sensitive planning and the establishment of riparian zones containing native species

- branches and tree tops will be used to cushion the travel of forest machinery and ground disturbance will be minimised

The proposals also required extensive consultation with stakeholders and there is an ongoing provision of a Ranger service to both manage recreation and increase understanding of management being carried out.

### 3. Challenges and difficulties

Non-native tree species within the Reserve area will be removed entirely. Their removal will be prioritised according to the perceived threat to remnant native vegetation through shading. Where native vegetation is present the ideal would have been to remove the overstorey gradually, but the windy climate and unstable conditions don't always allow this.

Implementation of the plan is costly, and Forestry Commission Scotland has been grateful to belong to successful partnership projects in recent years. In more recent times the charity Trees For Life has played a major role in carrying on the conservation role. They organize volunteer workweeks periodically throughout the year, allowing interested individuals from near and far to play a vital role in the restoration process.
Many people come each year to enjoy the beauty of Glen Affric, which requires a careful balance between the needs of visitors and the sensitive environment. Managing this on the ground is one of the tasks of the Ranger Service.

There has been a lot of forest research activity in Glen Affric that has contributed to the development of modelling and decision support tools for forest planning. However, it has been difficult to link this with practical forest planning. It was decided that there was need for better incorporation of these modelling approaches into the forest planning process. Over the last year ecological modelling tools BEETLE (Biological and Environmental Evaluation Tools for Biodiversity), ESC (Ecological Site Classification) and ForestGales have been used in the first stages of the 5-year review of the management plan.

### 4. Outputs, results, lessons learned

Glen Affric has been designated a Caledonian Forest Reserve, a National Scenic Area and now is a National Nature Reserve (NNR). Despite the years of conservation work, the pinewood is still only a fraction of its original size. However it provides a wide range of habitats that in turn ensure varied populations of flora, fauna, mammals, insects and birds.

The bulk of non-native trees have now been removed from the NNR. Ideally, this would have been achieved more gradually to help retain native flora but scale of working and market conditions negated this. Regeneration of native woodland is very slow, and supplementary planting in key areas has been necessary. Having a dedicated Recreation Ranger has helped interaction with the public and the community. Visitor numbers have been on a steady increase – overseas visitors in particular seem to be very aware of the NNR status. A welcome progression during the first Plan period was greater consultation with all stakeholders and in particular the involvement and engagement of the local community through the Community Council. This is represented by their nominated sub-group, the Strathglass Community Development Group, who have a Concordat with the Forestry Commission to embrace mutual values and aspirations. Greater use of modelling tools and decision support systems will enable forest planning to prioritise actions and make interventions more effective.

### 5. References

http://www.forestry.gov.uk/website/recreation.nsf/LUWebDocsByKey/ScotlandHighlandNoForestGlenAffric
http://www.snh.org.uk/nnr-scotland/reserve.asp?NNRId=17
http://www.snh.org.uk/publications/on-line/designatedareas/nnrs/glenaffric/default.html
http://www.glenaffric.org/glen_affric.html

## CASE STUDY 2 - Asset creation through investments in sustainable forest management in Guangong Province, southern China: SFA China

Location: Guangdong province, Southern China
Organisation: SFA China
Contact person:

### 1. Summary of the main operation and surrounding conditions:

Sinoforest International Co. Ltd, a listed company on the Canadian stock market, is one of the first foreign companies to invest in forestry in China. It has established several enterprises, forming an integrated entity engaged in tree planting and cultivation, management, processing and trade. Sinoforest recognizes that improvement of ecology and environment, and harmonious development of the human society and nature is a major goal of modern forest management. Management should try to meet not only the demands of current generation but also the social, economic, cultural and spiritual needs of the generations to come. Therefore, Sinoforest puts sustainable forestry as its development strategy, giving equal importance to environment and social responsibility along with economic benefits. It uses the international environment management system and the FSC system to guide practical operations and management. The company was recently awarded the FSC certificate, being the first company in China to do so.

Since the 1990s, and more particularly with the beginning of natural forest protection program in 1998, the timber demand and supply gap has been enlarging. In order to mitigate this timber demand-supply gap, the Chinese government launched an ambitious programme of establishing large fast-growing and high-yielding plantations in southern China encouraging private investment. As a result many domestic companies began establishing fast-growing and high-yielding plantations. Over 2 million ha have been planted, making a significant contribution to improving ecology and environment, mitigating the shortage of timber supply and meeting timber requirements for national economic development. Nearly a hundred such forestry companies have been taking part including APP, APRIL, Sinoforest, Stora Enso, Weyerhaeuser, Oji Paper etc.

According to Guangdong provincial development plan, Heyuan municipality is the central area of development of Eucalyptus plantations for industrial raw materials. However, Heyuan is located in the upper reaches of the Dongjiang River, and feeds water to the Pearl River Delta (Guangzhou, Shenzhen and Hong Kong). Therefore, plantation development for industrial raw materials in Heyuan must ensure the protection and sustainable management of the ecologically rich forests of the province, particularly the natural vegetation in Heyuan, in order to safeguard the lifeline of the economically developed region of Guangdong province and Hong Kong.

Heyuan is one of the forest bases of Sinoforest. Recognizing that a well-managed natural forest is superior to plantations in providing ecological services, it decided to protect existing natural forests as it continued its plantation efforts. The company purchased 6 blocks of secondary natural forests with high ecological value and managed them to enhance their ecological attributes through protection and management.

### 2. Description of best management practices

Sinoforest bought the management rights of 6 blocks of natural secondary forests with good ecological and social attributes, and in collaboration with the villages and townships, carried out regular activities such as forest patrol, fire prevention, and illegal wood cutting and destruction of its natural forest resources. In addition, the company undertook a number of management measures to maintain and improve the integrated benefits of forest ecological functions. The locations of the natural secondary forests are presented in Table 1.

### 3. Outputs, results, lessons learned:

1) The structure and functions of protected natural forests were improved

Since the involvement of Sinoforestin forest management of these forests, and with greater clarity on the responsibilities for the protection and management of these forests, the rights of stakeholders and the benefits that they can legitimately expect, the sense of responsibility felt was significantly strengthened, no evident illegal cutting of trees happened in the protected natural forests, and the functions of forests have been continually restored and enhanced.

Table 1 Basic information on each of the 6 natural secondary forests protected by Sinoforest

| Code | Location | Area(ha) | Volume(m3) | Vegetation type |
|---|---|---|---|---|
| 1 | Yangmei Villag, Xingang Township, Dongyuan County | 259 | 12309.4 | Broad-leaved/Mixed conifer and broadleaved |
| 2 | Kenkou Village, Huangtian Township, Dongyuan County | 261.1 | 15441.0 | Conifer/Mixed conifer and broadleaved |
| 3 | Shangdun and Xiangxi Villages, Yihe Township, Dongyuang County | 223.4 | 7609.1 | Conifer/Mixed conifer and broadleaved/shrub |
| 4 | Zhengchang Village, HuangcunTownship, Dongyuan County | 275.2 | 11778.9 | Broad-leaved/Mixed conifer and broadleaved |
| 5 | Baipuyi, Zijin County | 196.1 | 7573.2 | Broad-leaved |
| 6 | Luojing Village, Dahu Township, Lianping County | 147.5 | 2004.5 | Broad-leaved/Mixed conifer and broadleaved |
| **Total** | | **1362.3** | **56716.1** | |

2) The integrated benefits of protected forests are significant

Recently, the Chinese Academy of Forestry has conducted an assessment of the six natural secondary forests managed by Sinoforest, including assessment of the assets of forestland, standing trees, ecological assets (including landscape assets, forest carbon storage and biodiversity). The total value of the assets of the protected natural vegetation over the total forest area of 1362 ha has been assessed at RMB 86 million, of which the value of forestlands is assessed at about RMB 3.9 million, standing trees RMB 16.53 million, carbon storage RMB 9.10 million and the biodiversity at RMB 56.46 million. The natural vegetation produces integrated benefits of about RMB 32.31 million annually excluding other ecological services the values of which could not be estimated because of lack of acceptable assessment techniques. Of this RMB 0.7 million is the accrual due to the growth of standing trees, accounting for merely 2.2 per cent of the total benefit. The rest RMB 31.61 million are all due to ecological services, accounting for 97.8 per cent of the total benefit. The value of water conservation is estimated at RMB 23.69 million which alone accounts for 72.5 per cent of the total benefits. Next is the value of climate regulation and air purification which, at RMB 4.307 million, accounts for 13.2 per cent of the total benefits. Thus the total annual ecological benefit of the protected natural vegetation is 46.7 times of the benefit produced by timber production.

The total value of the natural secondary forests protected by Sinoforest is RMB 86.019 million, an average of RMB 63,143 per ha. The total annual production value of the protected natural secondary forests is RMB 32.31 million, an average of RMB 24,000 per ha. Of the total production value, about RMB 0.7 million are of the annual timber production, an average of RMB 517 per ha; and RMB 31.61 million are of annual ecological services, averaged at RMB 23,206 per ha.

The participation in natural forest protection and management by large forestry companies can help mitigate the difficulties in managing natural forests encountered due to lack of funding and access to technology. The example cited above provides a good demonstration to regions where large scale plantations for industrial raw materials are to be established, and has significant implications for sustainable development of China's forestry and the socioeconomics of local communities, and is thus worthy of extended applications.

(Note: Assessment agency: Institute of Forestry Policy and Information, Chinese Academy of Forestry).

## Case Study 3: Management of biodiversity and natural forest fragments in a commercial plantation in Wales: UPM Tilhill

Location: Gwynedd, Wales
Organisation: UPM Tilhill
Contact persons: phil.johnson@upm-kymmene.com robert.taylor@upm-kymmene.com

### 1 - Main operation and surrounding conditions

Hafod Boeth Forest is a plantation of 423 ha established in the 1960s and 80s on former agricultural grazing land. The plantation is located within the Snowdonia National Park and is an example of how existing even aged plantations can be managed to preserve ecosystem integrity at FMU and landscape level and provide economic, environmental and social benefits to the local community. The owners' objectives are to:

- ✓ Maximize financial return through sound silviculture
- ✓ Maintain and enhance the amenity and conservation value
- ✓ Preserve scheduled ancient monuments
- ✓ Develop and maintain biodiversity
- ✓ Safeguard water quality

The commercial crop is composed of Sitka spruce, Lodgepole pine, Japanese larch, Western red cedar and Douglas fir. The biodiversity interest includes ancient semi-natural woodland, Atlantic oakwoods (EU*), water voles (UK SAP*), nightjars (RDB*), lesser horseshoe bats (EU*) and a valley mire system. A water supply originates in the plantation and there are several natural watercourses and open water bodies. An estimated 30,000 visitors per year use the forest, car park and 17km of paths for walking, orienteering and environmental studies. The property is regularly used by the local outdoor centre, college and university and is bordered by the popular Ffestiniog tourist railway. The cairn and the old mine shafts are archaeologically and culturally important.

### 2 - Best management practices

**Stakeholder consultation**: The existing legal and regulatory framework requires that the forest plan is subject to extensive consultation with local stakeholders and approval by the forestry authorities. The stakeholders include local Parish Councils, neighbouring landowners, forest and environmental authorities, external experts and NGOs. Stakeholder contributions were provided in writing and via a formal stakeholder scoping meeting. This process determined and evaluated all aspects of ecosystem integrity related to the "intensity, context and impacts" of the plantation at FMU and landscape level.

**Ecological audit**: An ecological audit by UPM's own expert described the conservation value of the plantation and prioritized and defined management requirements so as to maintain and, where possible, enhance the conservation values of the site.

**Constraints and opportunities mapping**: Constraints and opportunities mapping brought together all environmental and social issues identified by stakeholder consultation and the ecological audit. This map forms a key part of the management plan and guides the forest manager in the future development of the plantation. The table below lists the key aspects related to biodiversity, water, nutrients and carbon identified and the compartment level prescriptions for addressing ecosystem integrity.

### 3 - Challenges and difficulties

- ✓ Few stakeholders submitted formal comments in the consultation process
- ✓ Managing the high level of public access to safeguard ecosystem integrity
- ✓ Staff changes and information transfer: the manager responsible for the consultation process is no longer managing the forest and despite best efforts, some valuable knowledge and experience is lost

| | | |
|---|---|---|
| | | with seedlings grown from seeds collected on the property<br>Selective felling to create age diversity |
| | Planted ancient woodland sites | Remove crop at economic rotation age and regenerate as native woodland.<br>Remove crop from under canopy of remnant trees. |
| | Lesser horseshoe bats habitat | Map hibernacula and maternity roost sites<br>Leave 15-20 metre unplanted area around the mine shafts and permit low density broadleaf regeneration for cover<br>Create broadleaf corridors linking hibernation sites, including to areas outwith property boundary |
| | Valley mire system | Maintain existing area of mire habitat and identify those suitable for restoration<br>Ensure second rotation crops around the fen are not established on peat with depth greater than 0.5 metres<br>Removal of conifers, blocking drains and linking to similar areas outwith the property |
| | Water voles | Manage riparian habitats to favour the water vole by creating areas of unforested bankside habitat and careful management of all watercourses during operational periods. |
| | Nightjars | Cycle of fell and replant will favour nightjar by creating favoured scrub habitat.<br>Undertake breeding bird survey prior to potentially disruptive operations |
| Water | Water supply<br>Watercourses<br>Water bodies | Map all water features<br>Apply water protection guidelines e.g. working methods, buffer zones, crossing points, fuelling and maintenance areas etc<br>Develop riparian habitat with native woodland regeneration and open ground |
| Nutrients | Plantation area | Tree species matched to soil type.<br>Use of appropriate working methods and the use of buffer zones to prevent nutrient leaching and erosion |
| Carbon | Plantation area | Restructuring the forests to achieve sustained yield will maintain the forest as an sustainable and effective carbon sink<br>Areas of deep peat and ancient woodland will be restored and protected. |

### 4 - Outputs, results, lessons learned:

### Outputs:

- ✓ Ecological Audit identifying HCVA and setting management objectives
- ✓ Successful stakeholder scoping exercise
- ✓ 20 year forest management plan including compartment level prescriptions for ecosystem integrity
- ✓ Key species level management prescriptions
- ✓ Ecosystem integrity safeguarded at FMU and landscape level

### Results:

- ✓ A committed forest plantation owner
- ✓ Stakeholder approval for the forest management plan
- ✓ Cooperation and commitment of experts and local interest groups
- ✓ Support from local community
- ✓ Protection, maintenance, restoration and enhancement of HCVA and key species
- ✓ Linkage of HCVA to similar habitats beyond the ownership boundary
- ✓ Water quality safeguarded
- ✓ State grant aid towards cost of maintaining ecosystem integrity

### Lessons learned

- ✓ It is possible to protect and enhance ecosystem integrity as part of good plantation design
- ✓ Ecological audit is the start point for evaluating HCVA and defining prescriptions
- ✓ Constraints and opportunities mapping brings all elements of ecosystem integrity together and is a useful planning tool for forest managers
- ✓ Involving experts and stakeholders is time consuming and costly, often with little formal feedback.
- ✓ However, it secures goodwill and support.
- ✓ HCVA management and restoration works are not financially possible without targeted state grant aid

### References

Hafod Boeth Forest plan draft
Meirionnydd Oakwoods Habitat Management Project
http://www.meirionnyddoakwoods.org.uk/english/partners.asp

## CASE STUDY 4 - Maintaining ecosystem integrity and protecting habitat in a Eucalyptus plantation in Western Uruguay: Forestal Oriental

Location: West Uruguay
Organisation: Forestal Oriental S. A.
Contact person: Matthew Rivers (mrivers@forestaloriental.com.uy)

### 1. Summary of the main operation and surrounding conditions

Forestal Oriental has responsibility for 3.5 million $m^3$/year of wood supply for the Botnia pulp mill. The company owns about 180,000 ha of which 110,000 are classed as plantable. There have been several voluntary Environment Impact Assessments, and monitoring including soils and site investigation and climate date, best silviculture practices, an advanced breeding programme and biodiversity monitoring.

### 2 - Best management practices

Detailed policies and guidance exist to minimise environmental impacts of the plantation. These are developed by a team that includes two full time environmental specialists and which has also drawn on the international networks available to the business. The process started from a pre-acquisition evaluation of new areas to plant and extends through detailed site planning and operational controls. The guidance is currently being revised into a better integrated format which will also compatible with the ISO standards 9001, 14000 and OHSAS 18000. The following are some examples of how information and good operational practice have been used to assess and manage the four specific dimensions of ecosystem integrity cited.

**Water**: Uruguay is in the mid latitude, humid sub tropical climate group. Rainfall is fairly evenly distributed with a mean annual precipitation of 1200-1500 mm – this relative abundance formed part of the original decision for the project. At a site scale all watercourses and low lying hydromorphic soils are identified by detailed survey and extensively buffered. In practice only about 60% of the total land holding is converted to plantations. Water quality is protected by management that stops harvesting, transport or land preparation during heavy rainfall or when the ground is saturated (which also protects soil), and minimised and targeted application of herbicides and fertilisers. The provision of drainage for constructed roads is important with discharges buffered into uncultivated ground to ensure that silt does not find its way to watercourses.

**Nutrients**: As Uruguay is highly dependent on agriculture there is a good national soil classification system. FO has supplemented this for areas of ownership (and prospective interest) with more detailed mapping to inform management. The natural fertility of sites has thus far allowed FO to only use one fertiliser application per rotation, at the time of planting. Rate of application has been halved following monitoring and second rotation crops are out-performing the first in wood yield. Natural fertility and soil structure is protected by, e.g., micro-planning followed by mechanised harvesting, which removes branches and bark at the point of felling, using this material to protect soil structure from damage by machines and retaining biomass *in situ* to maintain fertility. Area of cultivation is minimised by maximising inter-row spacing (now 1100 stems/ha) and all ploughing is carried out across contours and with periodic breaks to minimise soil damage and loss.

**Carbon**: No detailed studies have been undertaken on soil carbon impacts but the company's baseline data provides a good starting point. The fact that the plantations substitute for extensive cattle rearing (and thus methane production) will be interesting to evaluate. It is clear from international research that the average C carrying capacity (stock) under forest plantations is higher than under pasture/grassland. A key objective of the project is to provide a sustainable wood supply to the newly commissioned pulp mill. To this end the owned and controlled land base, in combination with a successful out-growers scheme has secured a total area adequate to achieve self sufficiency. Attention is focused on normalising the age class structure to an optimal rotation – and thereby sustained yield.

**Biodiversity**: The early EIAs provided a strong basis to designate and protect specific ecosystems and habitats (some of which have subsequently been designated; as HCV in the certification process , and one in particular now has both international Ramsar and Uruguayan SNAP (Sistema Nacional de Areas Protegidas; or protected areas) status. Uruguayan legislation protects fragments of native woodland and some species, such as the palm *Butia yatay*. The distribution of the low hydromorphic areas has provided some natural site level connectivity of this habitat type and a significant diversity. The management of the protected areas includes removal of woody invader species and improved protection from illegal activity.

### 3 - Challenges and difficulties

**Landscape scale integrity**: FO purchased and planted its forest estate over an extended period (now 18 years) from a multitude of owners in a competitive private market. The holdings are now widely dispersed (over a gross area of more than 3.5 million hectares of forest priority soils) and fragmented. Simultaneously others legitimately developed plantations were established in the same zones, along with intensive production of soya. Nutrient and carbon issues can be managed at a site level. The same is not true of water and biodiversity issues where cumulative and landscape level issues apply in addition.

**Water**: Groundwater systems in Uruguay are complex with little baseline data available for river flow and groundwater dynamics. The department of forestry commissioned and published a review on possible impacts caused by converting extensive areas to plantations. This did not result in any imposed constraints on proportion of catchments planted and gave reassurance that water balance was unlikely to be drastically altered. Recent work by FO has, however, highlighted the cumulative effects of land use change in certain sub areas. In the most extreme case one catchment is nearly 50 per cent afforested (by more than three different owners). One consequence is that FO has now decided to increase monitoring of water flows and quality: to install at least one more paired catchment experiment, establish monitoring of re-charge rates in mature crops and extend the borehole monitoring programme; along with undertaking a comprehensive water risk assessment across all holdings – looking for third party assets that could be at risk.

**Biodiversity**: A similar picture arises in respect of the history of the development of the FO project and opportunities to broaden the scope for conservatio. FO does not control land at the landscape level. So while unilateral actions to identify, protect or enhance biological corridors and stepping stones can be valuable, they would be better integrated in a co-ordinated response with neighbours. Such advances are a whole level of complexity more difficult to broker and sustain as individual owner objectives and constraints differ and can change. DINAMA (the authority responsible for the environment) published a classification (Prioridad Geograficas para la Consevacion de la Biodiversidad Terrestre de Uruguay – August 2008) that can be a precursor to imposing additional statutory constraints to protect priority biodiversity.

### 4 - Outputs, results and lessons learned.

The evolution and testing of practices to minimise negative impacts from plantations has resulted in a suite of best practices at site level. Research will continue to evaluate technologies, techniques and products. A precautionary approach to the proportion of a catchment that might be planted (say the 20% 'rule' for planting without measurable impact on hydrology) is neither prescriptive enough nor capable of voluntary application when there are multiple land units. Where a developer does not control the "landscape" others' actions may prejudice unilateral good practice. It is not clear how businesses, buying land in fragmented units over a long time and in competition with others can best contribute to precautionary actions in an equitable way without statutory guidance. Such guidance presumes a pre-existing body of knowledge.

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www.ForestalOriental.com.uy

## Case Study 17: Mondi in South Africa

Location: KwaZula-Natal, South Africa
Organization: SiyaQhubeka Forests (SQF), part of Mondi, outh Africa
Contact: Leonard Magagula (leonard.magagula@mondigroup.com)

### Summary of main operating and surrounding conditions

SiyaQhubeka Forests (SQF) is a partnership between Mondi and its Black Empowerment partners, Government and communities. It borders on the World Heritage Site of iSimangaliso Wetland Park in South Africa and illustrates many attributes of a successful NGP.

SQF has also played a leading role in increasing the size of the iSimangaliso Wetland Park by facilitating the inclusion of 9 000 ha into the park. In addition the consortium has supported moving the boundary fence of the park to include a sizeable portion of its plantations, allowing for better management and freer movement of animals. This has increased the park by some 15 000 ha forming a buffer zone between the World Heritage Site and adjoining commercial farming areas. SQF consists of approximately 26,000 ha of land, of which approximately 20 per cent is natural vegetation managed primarily for conservation. These herbaceous communities can be broadly categorised into dwarf shrublands and hydromorphic grasslands/ sedgelands. The woody communities can be divided into coastal lowland thickets and swamp forest.

With “symbiotic forestry” as SQF’s fundamental philosophy, the company proudly upholds its slogan, “Forestry for Life” and strives for the establishment of sustainable and mutually beneficial relationships between the forestry sector, the community and the environment.

### Description of best management practices and challenges faced

A world first for commercial plantation forestry and a World Heritage Site has been the positioning of a 158km 'eco-boundary’ between the iSimangaliso Wetland Park and commercial plantation areas. This line delineates 4,000 ha of previously afforested, significant conservation area from highly productive commercial forestry areas. These sensitive previously afforested areas have been rehabilitated to wetlands and grasslands, thereby improving the overall biodiversity value of the area. The positioning of the eco-boundary line was agreed following a participative approach based on a scientific ecosystem assessment involving Mondi, SQF, the government, environmental NGOs and the Park Authority, transforming a long history of passionate dispute between local forestry operations and environmentalists into a true partnership. The recommended criteria included the presence of important communities, water source areas and wetlands for the Natural Zone; and the presence of soils most suitable for afforestation, for the commercial afforestation zone. The study suggested that a boundary following natural features would best satisfy these aims. The solution adopted was to create a natural boundary that separates broad soil groupings (essentially the interface between dryland soils and wetland or hydromorphic soils), by use of soil augurs.

A fundamental decision was to revise and change the plantation layout which, in many cases, had been in conflict with modern environmental and plantation forestry principles. The concept of site-specific plantation forestry within an integrated land-use plan was implemented. This minimised the adverse environmental impacts and optimised the commercial forestry aspects – the commercial plantations have been laid out to fit into the existing landscape rather than trying to alter the landscape features to suit the forestry operational requirements. SQF regards the communities in which it operates as important stakeholders in this venture. This symbiotic relationship will not only boost the economy in the region but also foster environmental sustainability. It will also bring about upliftment in rural communities through the transfer of skills and the ownership of forestry assets and eco-tourism also stands to benefit significantly.

Elephant, rhino, buffalo, cheetah and other game now roam freely within the commercial plantation forestry area, which forms a buffer between the Park, local communities and commercial farming areas.

### Outputs, results and lessons learned

SQF has demonstrated that the social, environmental and economic needs of present and future generations can be met by transforming inappropriate and outdated forestry practices into progressive and profitable land-use management, incorporating commercial plantations and natural ecosystems in a culture of symbiotic forestry.

SQF illustrates 5 key principles pertaining to "new generation plantations"

1. Good Governance, consultation with relevant stakeholders and participation of local stakeholders.
2. Detailed planning including an Environmental Impact Assessment, soil survey, integrated land use plan, delineation of High Conservation Value (HCV) ecosystems and site classifications to regulate future forestry operations.
3. Best-practice silviculture and harvesting, including site specific recommendations supported by a world class plant breeding programme, and applied research and development. The safety and health of all workers must however remain the highest priority.
4. Protection of forest areas and associated ecosystems from fire, pests and diseases using internal and industry research resources and facilitating the participation of small and medium forest owners.
5. Sound socio-environmental management and participation of stakeholders – Mondi and SQF engage with a wide range of relevant stakeholders via their Socio-Economic Assessment Tool (SEAT) and dedicated Community Engagement Facilitators at all Business Units. This ensures healthy relations with local communities and local government. SQF, through Mondi, is also well represented at national and global forestry forums and is a leader in terms of integrating local communities into the business. Transparency and co-operation with NGOs is evident in projects such as the Mondi Wetlands Programme, Biodiversity Stewardship Programme and Ecosystem Services Review. Mondi reinforces its commitment to conservation and responsible forestry management through the certification of their plantation holdings under the principles of the internationally recognised Forest Stewardship Council (FSC). SQF enthusiastically supports the same approach and has converted its forests to economically sustainable hardwood plantations in line with the FSC requirements.

The benefits of this approach at SQF are numerous, covering a variety of areas including:

- ✓ The change in land-use has benefitted the iSimangaliso Wetland Park World Heritage Site by improving crucial freshwater supplies into the lake, following removal of the timber plantations; and by the provision of access for tourists for the first time to the western portions of the lake.
- ✓ The changes have also benefitted the wilderness areas since the excised area forms an additional buffer within the park to protect the wildernesses from development in the western peripheries of the park.
- ✓ The remaining plantations, with a total area of about 15,000 ha, form an economically viable enterprise, and constitute sustainable land use in the peripheries of the park.
- ✓ Small and medium enterprise development in the Zululand region has been stimulated through SQF's activities, including timber farming support schemes, honey production and firewood collection.
- ✓ Business, NGOs and government have cooperated in a sustainable "win-win" solution that has set new conservation norms for commercial forestry plantations.

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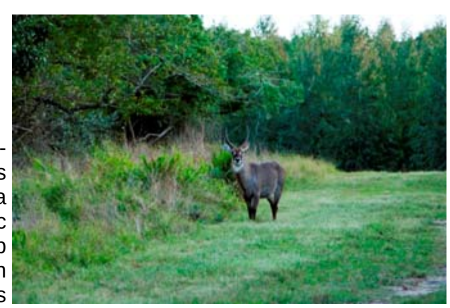
www.siyaqhubeka.co.za
www.mondigroup.com

Zenzele Gumede, SQF's social investment facilitator (right) with Musa Zikhali, one of the owners of the Dukuduku Indigenous Nursery in the Khulu Village

Accurate eco-boundaries enable a symbiotic relationship between plantations



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