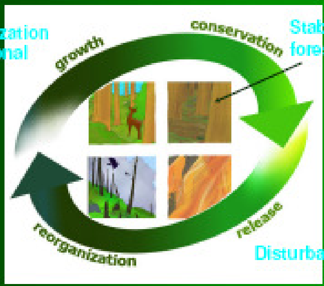
The relationship between forest biodiversity and ecosystem resilience

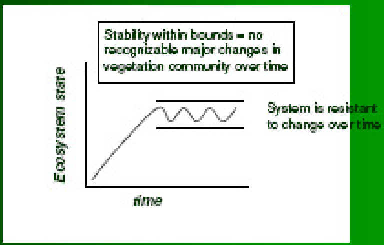
Ian Thompson, Canadian Forest Service
Brendan Mackey, Australian National University
Alex Mosseler, Canadian Forest Service
Steve McNulty, US Forest Service

Rome, Sept. 2009

Resilience is the capacity of an ecosystem to recover after disturbance



Stability of a forest state is a concept related to resilience



Boreal forests are not especially resistant to fire, but they are resilient

This boreal conifer forest will self-replace within 50 years, hence it is highly resilient

Tropical wet forests are resilient and stable gap dynamics forests

Tropical forests undergo gap dynamics in space and time, but the characteristic species remain the same and so these forests exhibit long-term resilience and resistance to change

Resilience is an emergent ecosystem property

- Resilience of a forest is a function of biodiversity at many scales: genes, species, and regional diversity among ecosystems
- Most primary forest ecosystems are resistant and resilient to natural disturbances
- Biodiversity also underpins the ecological goods and services from the forest
- Loss of biodiversity may alter the forest resilience and will result in reduced goods and services
- Loss of resilience means uncertainty about future forest condition

Tipping points exist where the resilience capacity is overcome and the system moves to a new state

- e.g., if a forest becomes dry, it loses species, is subject to increased frequency of fire, and moves to a savannah or grassland state
- this new state is stable and will require considerable change to move to another state
- the biodiversity has been lost and so have most of the goods and services from the ecosystem

Tropical dry forest → Drier climate → savannah

Degraded forest systems may be highly stable or unstable

- In many systems, loss of functional species*, or invasion by superior competitors, can result in new stable and resilient states
- New functional species now 'control' the system by occupying most niches or out-competing endemic species
- Most often, degraded forests are unstable because they lack diversity and functionality
- Degraded forests always provide fewer ecosystem services

** Functional species are key 'drivers' of the system. They are not necessarily the most abundant species.*

Two examples of invasive species forming highly resilient but highly degraded ecosystems

Removing invasive acacia forest in California

Invasive black wattle (*Acacia mearnsii*) in South Africa - a very stable and resilient system

Mechanisms for the linkage between biodiversity and ecosystem stability and resilience

- biodiversity results in strong functional connectivity in the system: e.g., pollinators adapted to plants and vice versa, decomposers adapted to inputs
- diseases and disturbances do not affect all species equally, more diversity = less loss to these factors
- redundancy among species - lose one driver, another previously less important species fills the vacated role
- genetic capacity within species enables adaptation to environmental changes
- general tendency for greater productivity in diverse forest = more goods and services (e.g., carbon storage)

Ecological principles for restoring degraded forests to improve stability and resilience

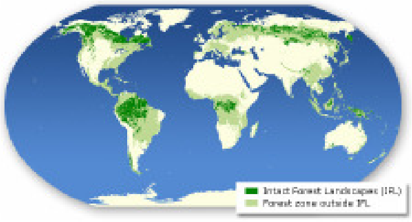
- biologically diverse systems tend to be more productive, stable, and produce more goods and services than simple ecosystems (e.g., monotypic plantations)
- re-forest by using native species and by using natural forests as models
- maintain landscape connectivity
- manage to maintain genetic diversity (e.g., reduce selective harvest of 'best' trees) and plant several seed stocks
- protect primary forests and species at the edges of their ranges
- plan to reduce invasive species

Conclusions

- evidence supports the concept that biodiversity confers resilience within a forest ecosystem at many scales
- mechanisms include redundancy, resistance to disease, increased productivity, genetic capacity to adapt to change
- loss of biodiversity can result in an ecosystem condition that is difficult to change or that provides an uncertain future condition
- biodiversity also provides most ecosystem goods and services
- degraded forests may be stable, although more often they are not, but they will provide reduced goods and services

Global Mapping and Monitoring of Forest Degradation: The Intact Forest Landscapes Method

Peter Potapov, South Dakota State University
Lars Laestadius, World Resources Institute



The IFL Method – Overview

Purpose
To map and monitor forest degradation over large, possibly inaccessible areas (e.g. for a country, a continent, or the world)

Degradation
Defined here as loss of ecological integrity (intactness), or loss of "degrees of freedom" to make trade-offs

Assessment Logic
- A binary classification of the landscape (either intact or not)
- Inverse logic (landscape considered intact until proven otherwise)
- Two types of criteria (alteration and fragmentation)

Data
Satellite images (Landsat or finer), publicly available maps

Characteristics
- Method – whole area (no sampling), tested, ready to use, replicable, suitable for monitoring, adaptable, non-prohibitive cost
- Results - Spatially explicit, consistent in time and space

The IFL Method – Methodology

A Simplified Classification of the Landscape

In reality – a gradient

Degraded — Intact

In the IFL method – either intact or not

Degraded — Intact

NB! Method allows more classes

The IFL Method – Methodology

Definition

An *Intact Forest Landscape* (IFL) is

- an unbroken expanse of natural ecosystems
- with no signs of significant human activity
- and large enough to maintain all native biodiversity, including viable populations of wide-ranging species.

An IFL may contain significant portions of naturally tree-less ecosystems.

Minimum size: 50 000 hectares

Intact – no loss of freedom to make trade-offs

The IFL Method – Methodology

Inverse Logic - Intact Until Proven Otherwise

Step 1: Assume entire study area to be intact

Step 2: Collect evidence of human influence

Step 3: Reject all areas where evidence is sufficient

Step 4: Intact areas appear as a residual

The IFL Method – Methodology

Criteria, Type 1 - Human Caused Alterations

(What's inside a polygon)

- **Settlements** (including a buffer zone of 1 km);
- **Transport infrastructure**, including roads (except unpaved trails), railways, navigable waterways (including seashore), pipelines, and power transmission lines (including in all cases a buffer zone of 1 km on either side);
- **Agriculture and forest plantations**;
- Industrial activities during the last 30–70 years, such as **logging, mining, oil and gas exploration and extraction, peat extraction**, etc.
- **Burned areas** adjacent to infrastructure or developed areas

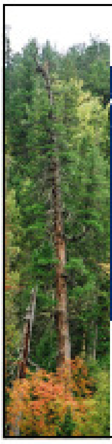
Old or low intensity human influence is considered *insignificant*, e.g. diffuse grazing by domestic animals, low-intensity selective logging, and hunting.

The IFL Method – Methodology

Criteria Type 2 – Fragmentation

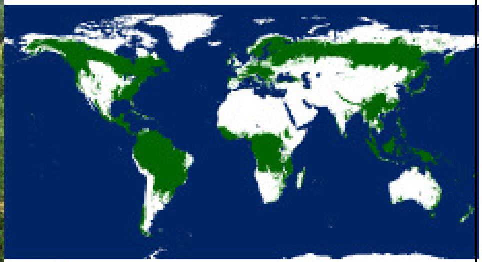
(The geometry of a polygon)

- **Minimal Area** of at least **50,000 hectares (500 km²)**
- **Minimal Width** of at least **10 km** (the diameter of a largest circle that can be fit inside the contour of an area)
- **Corridors or appendages** of areas meeting minimal area and width criteria must have a minimum width of **2 km**



The IFL Method – Methodology

1. Define The Area of Study



Included

Forest landscapes with a canopy density of at least 20%

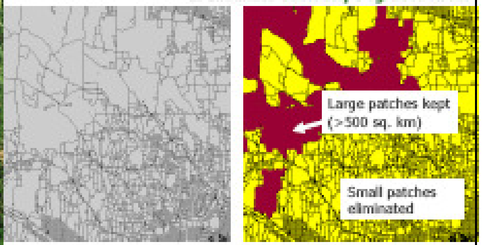
Naturally tree-less areas within forest landscapes

Excluded

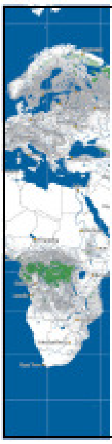
Small remote forest patches (less than 4 sq. km)

The IFL Method – Methodology

2. Eliminate Obviously Degraded Areas



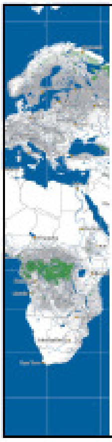
Pre-existing maps are used. Example: TIGER dataset (USA)



The IFL Method – Conclusion

Advantages

- Suitable for all countries and continents.
- Cheap and quick to apply.
- Data from public satellite images
- Rigorously defined, replicable, independently verifiable
- Suitable for monitoring
- Can be adapted and refined, e.g. to assess smaller landscapes.
- Suitable for remote and inaccessible landscapes
- Results are consistent and comparable in time and space
- The result is a map with has many uses
- The method is tested and ready to use
- High level of transparency



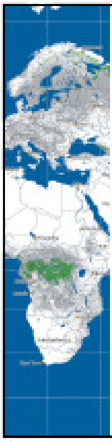
The IFL Method – Conclusion

Limitations

- Skills in GIS and image interpretation are required.
- Measures the presence/absence of human impact
- Current criteria are only suitable for large areas (province, country, region, the world)
- Current criteria are not geographically differentiated
- Fire classification is an issue

Possibilities

- The method can be modified.
- Alteration criteria can admit more human influence
- Fragmentation criteria can admit smaller areas
- Classes of alteration and fragmentation can be created
- Criteria can be geographically differentiated ("quilt" type assessment)
- **But differentiation may cause loss of consistency!**



The IFL Method – Conclusion

Opportunities

- IFL method is ready to use
- IFLs are strongly associated with permanence, biodiversity, indigenous peoples
- IFLs allow countries to make MRV-able commitments in early phases of implementation
- Integrate in emerging "REDD-Plus" mechanism

Recommendations

- Maintain consistency within study area
- Consider adding classes of alteration/fragmentation
- Integrate in FRA (global and/or national assessments)
- Integrate in "REDD-Plus"
- CBD?
- Support additional development and assessment work