Griffith UNIVERSITY
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Climate Action Beacon

USING ECOSYSTEM INTEGRITY TO MAXIMIZE CLIMATE MITIGATION AND MINIMIZE RISK IN INTERNATIONAL FOREST POLICY

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NOT ALL FORESTS ARE EQUAL

The ecological, social and economic values of forests are widely known and avoiding their loss and degradation has been recognized in national and international policy as critical for helping address the many global problems we face.

Protecting and restoring forests are a key solution for the climate crisis as forest ecosystems remove carbon from the atmosphere and accumulate it in living trees, dead wood and the soil. Forest ecosystems provide the habitat for millions of species found nowhere else, and help regulate local climate conditions and provide our freshest water. They function as natural quarantines against pathogen spillover from wildlife to humans and livestock. Forests are also the customary territories of many of the world's Indigenous and local communities.

However, not all forests are equal, and the benefits they provide us vary according to their ecosystem condition. The differences in their condition are mainly the result of the impacts from human land use and associated activities. Yet little consideration has been given to differentiating forest types and management schemes even though forests in poorer condition are at a greater risk of loss from both human and natural disturbances.

To date, there has not been an agreed framework for assessing, mapping, and reporting on forest condition and therefore to identify forests that have higher/lower values, provide more/less benefits and are at relatively greater/lesser risk of loss.

The concept of 'ecosystem integrity' (which is also referred to as 'ecological integrity') provides the basis for new framework to addresses this gap and help minimize risk in forest-based mitigation policies and maximize forest-related co-benefits.

WHAT IS FOREST ECOSYSTEM INTEGRITY?

Ecosystem integrity integrates different characteristics of an ecosystem that collectively describe its ability to achieve and maintain its 'optimum operating state', given the prevailing environmental conditions and natural disturbances such as wildfires. A high level of ecosystem integrity means that they are entirely self-organizing and self-regenerating; that is, they are not reliant on human management and inputs such as fertilisers.

The integrity of a forest ecosystem can be assessed by considering three factors:

> **Composition** e.g., the dominant canopy tree species, the presence of species found only in mature forests, the lack of invasive weeds and feral animals.
>
> **Structure** e.g., vegetation density, amount of biomass, complexity of food webs – the technical term for this factor is "dissipative structures". Canopy structure is particularly influential in modifying the micro-environmental conditions experiences by other species and processes like nutrient cycling.
>
> **Processes** e.g., ecosystem productivity (i.e., the rate at which new biomass is produced); nutrient cycling between living biomass, dead biomass and the soil; carbon sequestration and storage;

A critical property of ecosystem integrity is stability in the face of external pressures and stresses. There are three kinds of stability:

> **Resistance** - or constancy – which means the ecosystem is not disrupted and does not change in response to an external perturbation. Forest resistance is the result of 'negative feedbacks' (e.g., dense canopies that maintain a moist understory which is fire resistant) and 'buffers' (e.g., water held within the soil that supports plant growth during droughts).
>
> **Resilience** – the ability of an ecosystem to bounce back to a similar condition following being disrupted, at short time scales (months to years). The resulting ecosystem state can be somewhat altered (called 'ecological resilience') but when viewed over an appropriate time span, a resilient forest is able to maintain its 'identity' in terms of composition, structure and function.
>
> **Persistence** - refers to the ability of an ecosystem to persist at the landscape, if not at the same location, over longer time-scales.

Forest resistance and resilience are both the result of an ecosystem's natural adaptive capacity due to its biodiversity which includes genetic diversity, species diversity and phenotypic plasticity. Genetic diversity is the raw material from which species can evolve new traits that are better suited to prevailing climatic conditions. Having a large pool of species increases the chances that there will ones that are best able to cope or even thrive with changing environmental trends and extreme events. Many species have a flexible genetic makeup that enables to modify their shape or functioning in response to environmental drivers.

ECOSYSTEM CONDITION, ECOSYSTEM SERVICES AND RISK OF LOSS

One of the practical applications of ecosystem integrity is that it provides the basis for assessing the ecological condition of a forest which greatly determines the quantity and quality of its ecosystem services. For example, primary forests – that have a high level of ecosystem integrity – store more carbon and yield the cleanest water compared to logged forests and plantations. An important recent policy initiative has been the development of the U.N. System of Environmental-Economic Accounting which provides a robust method for recording the stocks and flows of ecosystems and valuing in economic terms the benefits these provide people. SEEA-EA needs estimates of ecosystem condition in order to have accurate accounts and valuations that can be related to forest policy outcomes and management regimes.

Ecosystem integrity is also of practical value to policy and decision makers because it provides information on the likelihood that a forest will be impacted by natural or human disturbance and at risk of loss and damage of its valued ecosystem services, resulting in, for example, loss of carbon retention and significant CO_2 emissions. Forests with a high level of ecosystem integrity have a low risk of loss. Risk of loss is the inverse of ecosystem stability.

ASSESSING ECOSYSTEM INTEGRITY

Bringing together the scientific concepts discussed above provides the scaffolding for an ecosystem integrity assessment framework (Figure 1):

- Ecosystem integrity is defined here in terms of (i) dissipative structures, (ii) ecosystem processes and (iii) ecosystem stability – risk of loss.
- Underpinning ecosystem integrity is biodiversity operated on by natural selection, which generates a forest's natural adaptive capacity and stability.
- Environmental drivers (including natural disturbances) as well as direct (land use) and indirect (fossil fuel emissions) human impacts affect biodiversity and (both indirectly and directly) ecosystem condition.
- The quality of ecosystem condition – as measured by the level of ecosystem integrity - in turn determines the quantity and quality of ecosystem services (like carbon retention, clean water) and the economic value of their benefits to people.

RECOMMENDATIONS

- The risk of forest carbon loss can be minimized by prioritizing actions that maintain and enhance forest ecosystem integrity. Ecosystem integrity therefore has the potential to be used as an integrating framework for evaluating forest-based mitigation and adaptation actions.
- Given their high level of ecosystem integrity and superior ecosystem service benefits, protecting primary forests would significantly contribute to meeting international climate, biodiversity, and sustainable development goals.
- Protecting primary forests will also be facilitated by changes to current international forest and carbon accounting rules. Existing 'net' forest cover accounting rules, such as the IPCC good practice

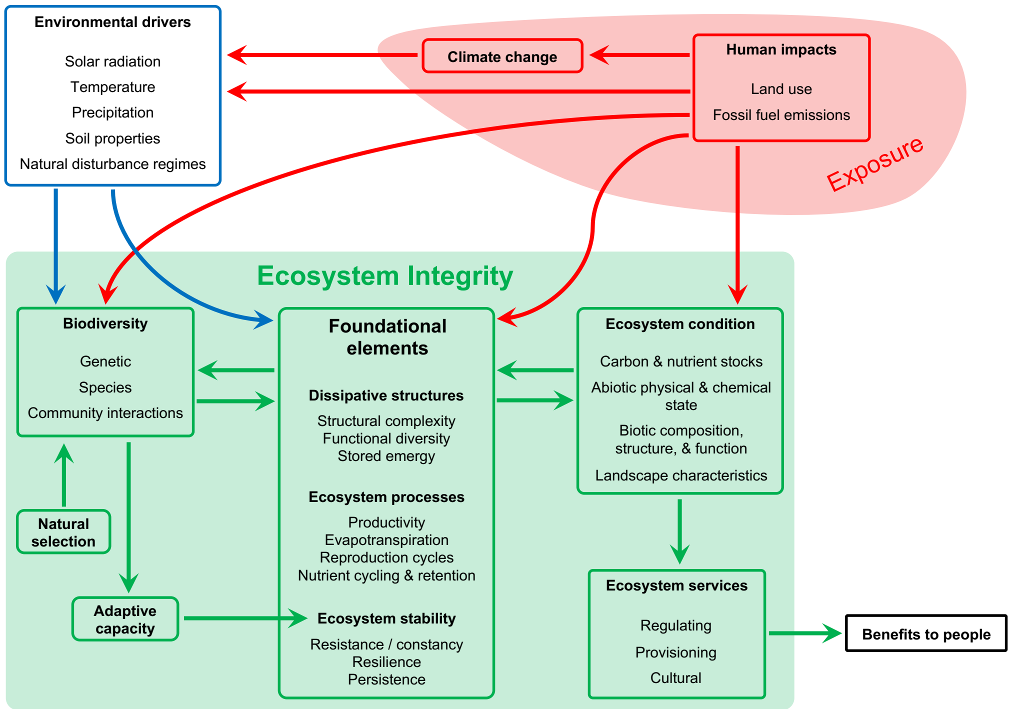
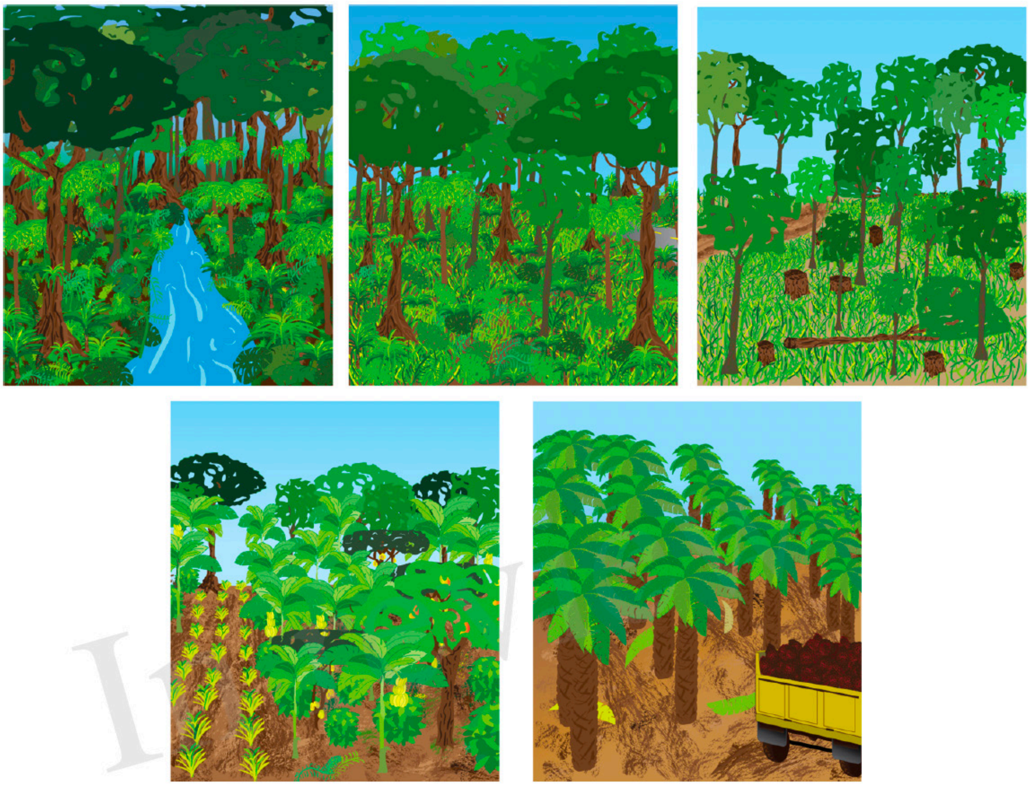


Figure 1. Ecosystem integrity assessment framework.

guidelines for national greenhouse gas inventories and the land sector, are problematic because they report net changes and treat all forests equally, regardless of their level of ecosystem integrity and risk of loss, thereby incentivizing the conversion of primary forests into commodity production forests.

- Management of secondary forests for commodity production, along with tree plantations and agroforestry, can contribute to climate mitigation and other sustainable development goals and reduce pressure on primary forests and other natural forests with high levels of ecosystem integrity. However, the key is to direct these management activities to previously deforested or degraded lands and accompany them with systematic landscape planning and effective governance.
- We strongly recommend an increased focus on integrating climate and biodiversity action to deliver multiple societal goals through ensuring ecosystem integrity. The importance of their nexus for effective action was highlighted by joint IPCC/IPBES workshop of the IPCCC and IPBES which identified priorities, including the protection and restoration of carbon and species rich natural ecosystems such as forests.



Forest type	Definition	Relative level of ecosystem integrity
Primary Forest	Naturally regenerated forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed	High levels for all three factors
Secondary Forest	Natural forests recovering from prior human land use impacts. Canopies dominated by pioneer and secondary growth tree species	Moderate depending on time since disturbance
Production Forest	The consequence of conventional forest management for commodity production (e.g., timber, pulp). Forest predominantly composed of trees established through natural regeneration, but management favors commercially valuable canopy tree species	Low to moderate depending on intensity of logging regimes and biodiversity loss
Agro-forestry	Some level of natural tree species is maintained with subsistence food or commercial crops grown (e.g. shade coffee). Swidden subsistence farming commonly used by traditional communities. Utilizes a mix of natural and assisted regeneration	Low to moderate given sufficient management inputs
Commercial plantations	Forest predominantly composed of trees established through planting and/or seeding and intensely managed for commodity production (timber, pulp, plant oil)	Low

Figure 2. Comparison of ecosystem integrity between five main forest types based on the foundational elements of: (1) dissipative structures; (2) ecosystem processes; and (3) stability and risk profiles

SOURCE REFERENCE

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