Biofuels and Degraded Land

The potential role of intensive agriculture in landscape restoration

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Summary

While historically degraded lands have been considered an environmental problem, many groups and sectors are increasingly targeting such areas as an opportunity for biodiversity conservation and ecological restoration, climate change mitigation and adaptation, as well as agricultural expansion, such as for biofuel production. Globally more than 2 billion hectares of degraded land could potentially be restored, but the term remains poorly understood and poorly defined. Not only can degraded land mean different things to different people, but it also hides a multiplicity of complex factors and issues surrounding land-use and land-use change as well as land tenure and natural resource governance.

One over-arching definition of degraded lands is not possible in a meaningful or practical way. The use of degradation and degraded land in international policy are framed quite generally to be inclusive, yet as discussed in this paper, while general terminology is appropriate to guide international policy making, it rarely lends itself to being operationalised on the ground. Similarly, while wide-ranging degradation maps are useful for communicating degradation issues and informing broader policy decisions, such maps are very limited in their support of more operational decision-making on the ground.

All this presents significant risk to governments, companies and farmers wanting to utilise currently degraded lands, as it casts uncertainly over whether lands are, in reality, suitable and, importantly, available for agricultural production. When conflicts over land use arise and are linked to biofuel producers, the social acceptance of the biofuel market as a whole is threatened. If we do not address this risk of misinterpretation, it also could result in the loss of an opportunity to help farmers bring less productive land back into sustainable production, contribute to socially and environmentally beneficial landscape restoration and help diversify and increase returns to impoverished rural families.

From the preceding it is clear that the answers to questions such as: where should biofuels be grown? or where should efforts aimed at forest restoration be focused? or what should be done to improve the livelihoods of smallholder farmers whose lands are declining in productivity? cannot be simply answered by responding 'on degraded lands', 'in degraded forests' and 'by reversing degradation'. Useful answers are clearly much more complex than this.

This publication represents the outcomes of a dialogue, where the original aim was to come up with a single definition for degraded lands that could be applied across sectors and ecosystems. However, it quickly became apparent that such a definition is neither feasible nor desirable. Instead, this work aims to build on existing experiences both with the agricultural and biofuel sectors, as well as that of landscape restoration more broadly. A tentative, pragmatic framework of considerations is presented that could help decision makers realize the good intention behind investing in biofuel production or other intensive agriculture activities in degraded lands, without the pitfalls of contributing to even greater ecosystem simplification and further marginalising already vulnerable farming communities.

Where concepts of naturalness and human drivers are deemed less useful, resilience theory does bring important lessons for a pragmatic approach on degraded lands. Landscape degradation and restoration have different starting points as well as different end points – and different ways to get from one state to another. It is not realistic to go from a severely degraded to a fully restored, functional landscape in one operation; there is a need to restore different functions at different scales. Taking this logic further, it could be argued that interventions in a landscape regardless the level of degradation (e.g. slightly or severely degraded) are equally valid. This distinction becomes relevant when discussing action for landscape restoration or for agricultural developments – while the wins in terms of increased changes in function are greater, the more severe the degradation of the land, the higher the costs to restore it. In the case of agricultural production, there are clearly differences in where intervention may be preferred in terms of economic and technical viability.

Not all degraded land is suitable for every proposed new land use, and in this way, the potential for a given land use is not solely dependent on environmental indicator of degradation as broader socio-economic factors such as infrastructure and legal access are key to also understanding true potential for a given use(s) of an area of land.

Furthermore, experience in the REDD sector has shown that the best way to optimise social and environmental benefits is not to focus on single issues such as carbon. In a similar way, it is more effective to view biofuel production as one potential facet of an integrated approach to land-use in multi-functional landscapes. This is echoed at the farm level, where direct impacts – both positive and negative – occur, where a farmer is rarely a “biofuel” famer but one who may in one crop rotation produce feedstock that could be used as food, feed and/or fuel (e.g. soy) and in the next rotation, a fibre crop such as cotton.

Arguably then, the challenge is not to define and identify degraded land, but to identify lands with potential for restoration and/or a given sustainable land management.

Given that the biosphere itself is a dynamic system with few fixed internal spatial boundaries and in a constant state of flux, both at spatial and temporal scales, the most useful framework for considering risk and opportunity in this context may be that of ecosystem services, considered at a broad landscape level. Such an approach introduces an important social value component and allows for discussions on trade-offs beyond a site level, and also allows for a mixture of land management and conservation planning. Such an analysis should take into account the needs and aspirations of all stakeholders and should be informed by notions of equity and likely longer-term consequences of any changes. In this context, a very low risk area would be one that is not known to be delivering significant ecosystem goods or services of any kind to any stakeholder group. Any change in land management that increased provision of overall goods or services could then be considered a beneficial change.

This is not to say that biofuel production in itself could restore the land (aside from experiences where biofuel crops could be grown on contaminated land to draw out pollutants). However, the pressure to source biofuels from “lower risk” land could create an incentive to invest in restoring degraded lands. The premium for such action, while not likely to be paid through biofuel supply chains, could be covered through associated carbon sequestration linked to REDD. Mosaic-type restoration, in contrast to wide-scale restoration, allows for this mixture of different land management activities and conservation activities.

Additionally, it should be noted that compliance with sustainability due diligence processes is facilitated in jurisdictions that have comprehensive and participatory land-use planning procedures in place that are also effectively implemented. In the absence of such public policy procedures it can be more difficult and costly to implement sustainability standards, regardless of whether the land is degraded or not.

In such a model, there are implications at multiple levels and for all major stakeholder groups, who have differentiated responsibilities specifically with regard to degraded landscapes as part of a broader sustainable land use management, from economic producers, governments in producer and importing countries, as well as civil society and financial institutions.

Working together, and clearly delineating the different responsibilities of different actors, it should be possible, albeit challenging, to develop land-use plans that optimise social and environmental benefits. In such plans, whether an area of land is deemed to be degraded or not is likely to be of secondary importance to the decision of how to treat it in the present, and what agreed goals for its future state might be, where for example, biofuel markets are but one potential beneficiary.

In the end, we want to use interest from the biofuel sector and other agricultural commodities in untapping potential of degraded lands as a driver for transparent, participatory land-use planning processes. The next steps would be to build on existing methodologies for assessing investment potential in lands and explore examples of this multi-functional landscape planning in action, where biofuel markets are one of the drivers, and to see how this can be done in practice and scaled up to priority agricultural producer countries.

This document is a technical review of the issue drawing on the best available science. Any recommendations it contains reflect the conclusions that of the expert workshop participants, authors and reviewers but do not necessarily represent the policy position of IUCN.

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1. Introduction

While historically degraded lands have been considered an environmental problem due to associated loss of soil organic carbon, nutrients, water storage and regulation, increasingly many groups and sectors are considering "degraded lands" as an opportunity for biodiversity conservation[1], climate change mitigation and adaptation, as well as agricultural expansion. There have only been several attempts to map degraded lands on a global scale, including theGlobal Assessment of Human-induced Soil Degradation (GLASOD), the Global Land Degradation Assessment in Drylands (GLADA) project and the Millennium Ecosystem Assessment (MEA). Each has their own weaknesses including use of old data (GLASAD) or not validated on the ground (GLADA) or limited inclusion of land types (MEA)[2]. Many other assessments have been done but on a national or regional scale. However, in general such studies do not take into account the impact of degradation on future potential benefits of alternative land uses. Another estimate developed by the Global Partnership on Forest Restoration (GPFLR) to generate policy dialogue found that globally more than 2 billion hectares of land could potentially be restored, mostly in tropical and template countries (see figure 1). Of this figure, 1.5 billion hectares are best suited for mosaic restoration, which can accommodate a range of land uses such as protected reserves, ecological corridors, regenerating forests, agriculture, well-managed plantations, agroforestry systems, and riparian plantings to protect waterways[3].

It is this seemingly untapped opportunity in degraded lands that is driving interest from a number of groups and sectors for a range of activities related to biodiversity conservation and landscape restoration, climate change mitigation and adaptation, as well as agricultural expansion, such as for biofuel production[4]. For example, in a recent study, it was estimated that worldwide some 25-30 EJ/year can be produced by perennial biofuel crops on degraded lands, many of which were found in China, West USA, Brazil, West Africa, East Africa, Russia and India (Nijsen et al. 2012). Indeed, such earmarking is increasingly often made with good intentions and is regularly portrayed as a win-win scenario. The assumption is that by targeting degraded sites, biofuel production will not compete with or displace food production or other land uses such as ecological restoration, or place additional pressure on existing cultivated land or land with high carbon or biodiversity value, such as forests or peatlands.

However degradation is not a precise term. Not only can it mean different things to different people (a single species pine plantation may be degraded to an ecologist but not its owner) but it also hides a multiplicity of complex factors and issues surrounding land-use and land-use change as well as land tenure and natural resource governance. All this presents significant risk to governments, companies and farmers as it casts uncertainly over whether lands are, in reality, suitable and importantly available for agricultural production. When conflicts arise linked to biofuel producers, the social acceptance of the biofuel market as a whole is threatened. Yet, if we do not address this risk of misinterpretation, it also could result in the loss of an opportunity to help farmers, governments and the private sector bring less productive land back into sustainable production, contribute to socially and environmentally beneficial landscape restoration and help diversify and increase returns to impoverished rural families.

1 The CBD Aichi target 15 calls on Parties to restore at least 15% of degraded ecosystems to enhance ecosystem resilience and the contribution of biodiversity to carbon stocks.
2 See Nijsen et al, 2012 for further discussion.
3 Global Partnership on Forest Landscape Restoration, World Resources Institute, South Dakota State University, International Union for Conservation of Nature. September, 2011.
4 Biofuels are liquid fuels derived from non-fossil biomass (recently living organisms and their metabolic by-products). While biofuels are generally thought of as vehicle fuels, they can be used in any application that currently uses liquid fuels, e.g. in generators or cooking stoves. Ethanol is currently produced from sugar crops such as sugar beet and sugarcane, or starch crops such as corn and wheat. Biodiesel is made from plant oils such as soybean oil, palm oil and rapeseed oil. See IUCN Factsheet on Biofuels, 2008 https://cmsdata.iucn.org/downloads/biofuels_fact_sheet_wcc_30_sep_web.pdf

This publication represents the outcomes of a dialogue, where the original aim was to come up with a single definition for degraded lands that could be applied across sectors and ecosystems. However, it quickly became apparent that this is neither feasible nor desirable. Instead, this work aims to present a tentative, pragmatic framework of considerations that could help decision makers realize the good intention behind investing in degraded lands without the pitfalls of contributing to even greater ecosystem simplification through monoculture cultivation and further marginalising already vulnerable farming communities.

This document is a technical review of the issue drawing on the best available science. Any recommendations it contains reflect the conclusions that of the expert workshop participants, authors and reviewers but do not necessarily represent the policy position of IUCN.

The first part of this paper examines how the terms "degradation" and "degraded" are used in biophysical or environmental contexts, specifically on land (as opposed to aquatic systems). While the complexity and lack of precision in definitions of degradation is a recurrent theme, the next section will attempt to work beyond the complexity and select those concepts that are more robust and could actually contribute to a pragmatic operational framework from those that tend to be esoteric and inconclusive. The following section will then adapt the building blocks specifically for identifying where and when biofuels could make a useful contribution to the improved management of lands whose productivity is currently sub-optimal and, just as importantly, to the livelihoods of farmers and communities who cultivate or control those lands as well as the overall management of the broader landscape.

2. Key concepts and terms

This introductory section begins by exploring the operational limitations that different understandings of degradation present as well as clarifying the key concepts that could prove useful in identifying when and where biofuels on degraded lands might make sense.

2.1. Defining the terms degradation and degraded

As with many words that have taken on technical (or quasi-technical) meanings, a good place to start is with an examination of how they are used in a broader context.

Degradation: *'Becoming degraded; disgrace; degeneration; abortive structural development; a lowering in dignity; decomposition (chem.); wearing down; erosion.*

Degraded: *reduced in rank; base, degenerate, declined in quality (or standard); low.*
(Chambers Dictionary, 2003).

The terms 'degradation' and 'degraded' are applicable in many different contexts, not merely the world of environmental management. They are, of course, intimately related to each other but quite different in their use, in that the first describes a process, the second a state.

Like virtually all descriptive words 'degradation' and 'degraded' have a commonly used, recurrent meaning that ascribes a particular value judgment. Labelling something as degraded goes well beyond simply conveying that an entity has lost certain qualities but also that it is in a less desirable condition to that which persisted beforehand – in other words degradation is judged to be negative. This sense is clearly retained when the words are used to describe the condition of land or an ecosystem and in thereof lies a practical problem for public policy, for the use of the word "degraded" implies that land in question is something that is of lesser value to society regardless of the context and local use, essentially meaning that the land is "ruined". The rest of this chapter along with chapters 3 and 4 will attempt to explain why that can be a problematic assumption and one that could possibly lead to unintended or counterproductive policies.

2.2. Current international use of the terms "degradation" and "degraded lands"

Despite their subjective nature, the terms "degradation" and "degraded" are widely used in environmental policy and decision making. "Degradation" is enshrined in the text of at least one multilateral environmental agreement (the UN Convention to Combat Desertification (UNCCD)) and in the acronym for a major outcome and process developed under another (REDD – reducing emissions from deforestation and forest degradation – under the UN Framework Convention on Climate Change (UNFCCC)). The terms also feature prominently in formal and informal discussions related to food production and food security, approaches to sustainable land management such as climate-smart agriculture, and conservation and restoration, including the Aichi Targets under the Convention on Biological Diversity (CBD) (see Annex 1 for more a more detailed analysis of additional examples).

While these terms represent contestable value judgements they also reflect a shared understanding among particular communities of practice about the absence of particular qualities which they consider as rendering an entity degraded. For example, grassland ecologists will all understand that if a highly productive, well fertilised field is called degraded it refers to the lack of diversity of flowering plants that might otherwise occur under low input management. On other occasions, definitions assume shared understanding and values where none actually exists.

Realistically, none of the definitions of degradation found in international environmental and land-use agreements are likely to be universally accepted or even widely applicable across all kinds of landscape and land-use. Many also face major challenges in delivering a set of objectively verifiable metrics that could consistently indicate to what degree degradation is taking place.

The difficulty in applying these terms in practice becomes clear, as soon as an attempt is made to sharpen definitions in order that they become operational. In this way, the world map of restoration potential developed by the GPLFR (see figure 1) is useful for communicating degradation issues and informing broader policy decisions, though such maps are very limited in their support of more operational decision-making and as shall we discussed in section 5, need to be complemented by landscape level participatory assessments.

Another example of discrepancy between political and operational definitions is found in the Renewable Energy Directive (2008) of the European Union, which legislates for the award of a greenhouse gas "bonus" for biofuel feedstock produced on "severely degraded or contaminated lands"[5]. To date, no economic operator has requested this bonus, suggesting that the working definition is not technically or operationally applicable and hence is likely to be dropped in the review of the Renewable Energy Directive in 2014 by the European Commission. However, this would represent a missed opportunity for directing investment in less productive landscapes, as mentioned previously. Similarly, an explicit definition of degradation under REDD+ was proposed some years ago but has yet to be adopted (see section 7 below), and one outcome of Rio+20, prompted by input from UNCCD, was an agreement to strive to achieve a land degradation neutral world[6], although without any explicit definition of what this entails[7].

[5] Annex V of the Renewable Energy Directive: "(a) 'severely degraded land' means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded; (b) 'heavily contaminated land' means land that is unfit for the cultivation of food and feed due to soil contamination."

[6] The exact text of para 206 of the outcome document of Rio+20 is. "*We recognize the need for urgent action to reverse land degradation. In view of this we will strive to achieve a land degradation neutral world in the context of sustainable development. This should act to catalyze financial resources from a range of public and private sources*." See

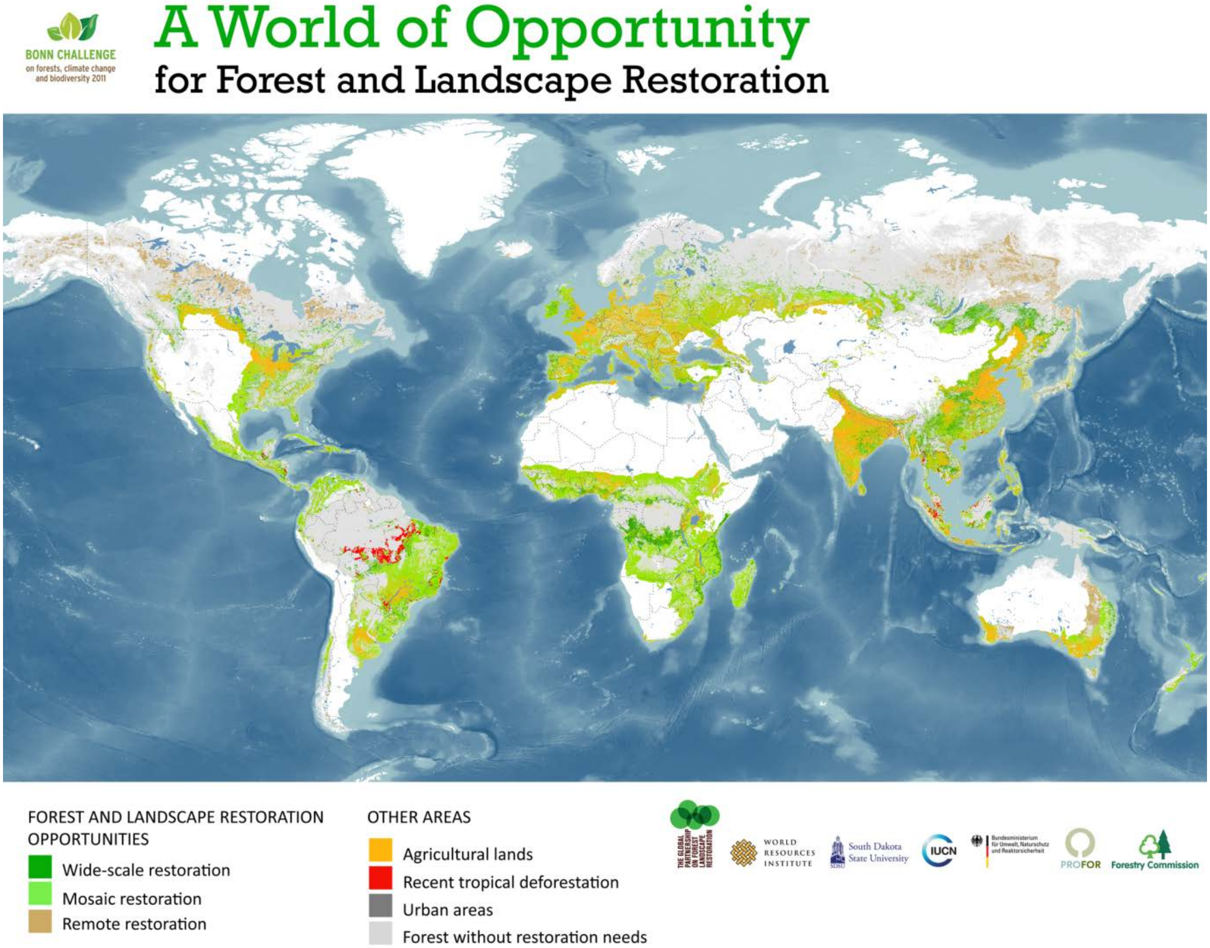

Figure 1: world map of areas with potential for forest restoration (GPLFR, 2010)

In conclusion, the use of degradation and degraded land in international agreements and policy frameworks are often framed in general, even vague, terms in order to be inclusive and avoid negotiation deadlock. Herein lies the problem, for while general terminology is appropriate to guide international policy making, it rarely lends itself to targeted and effective action on the ground.

2.3. Differing perceptions of "degradation" and "degraded"

In the cases highlighted above, the use of the terms "degradation" or "degraded" is based on an implicit assumption that all those who encounter them in that particular context will share a common understanding of the specific qualities a site has lost in order that it qualifies as degraded. This is seldom the case and is further complicated by the fact that related concepts[8] such as desertification are often used inter-changeably even though each term is different in its weight of meaning and carries its own in-built assumptions. In reality, those who use the land at present may have a very different view from other parties on such basic matters as whether degradation is taking place or not, or whether the area in question is actually in need of restoration. This is echoed in forest assessment linked to deforestation, where forest quality is assessed under three criteria: authenticity;

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http://www.un.org/en/sustainablefuture/ See the UNCCD Secretariat Policy Brief (2012) Zero Net Land Degradation A Sustainable Development Goal for Rio+20 at http://www.unccd.int/en/resources/publication for more detail.

[7] See relevant discussion with regard to REDD+: Putz, F. E. and K. H. Redford. 2010.

[8] Degradation is linked to terms such as 'desertification', 'deforestation', 'pollution', 'impoverishment' and 'contamination'. Sometimes these are thought of as forms of degradation, or phenomena that might lead to degradation. Sometimes, as with 'desertification' they may be regarded as a consequence of degradation. In describing land, terms such as 'abandoned', 'idle', 'low-value', 'unused', 'underused', 'marginal' and 'waste' are frequently used; habitats and ecosystems are often described as 'secondary', 'poor quality', 'fragmented', 'unhealthy' or 'stressed'.

environmental benefits; and social and economic benefits (Dudley et al, 2006). Moreover, different stakeholders may have very different views as to the most effective measures that could be deployed to halt degradation or which values or qualities should be prioritised in subsequent action plans for restoration or rehabilitation.

Clarity of assumptions and definitions is important because decisions regarding whether degradation is taking place, or whether a specific area is degraded or not, can have a direct and significant impact on land use, land management decisions and investment flows. These policies and actions have important implications for livelihoods and for the environment. These are not just theoretical issues, but have been sources of real conflict, affecting livelihoods and environments in many parts of the world. They have an impact on land-tenure and land-use rights: occupants of land classified as degraded (or, often, 'marginal' or ‘waste’) may be considered to have forfeited any rights to the land, and those whose activities are considered to be leading to degradation may be relocated, forcibly or otherwise[9]. Groups of people affected in this way include pastoralists in arid and semi-arid lands[10]; shifting cultivators in much of the humid tropics[11]; hunter-gatherers in Southern Africa and Australia; of hill farmers in the British Isles. Conflicts may concern opposing forms of land use (for example, shifting cultivation versus plantation forestry) but may also arise in protected area management, where various kinds of human activities may conflict, or be perceived to conflict with, conservation goals.

However, as shall be discussed, clearer definitions do not automatically lead to better land-use; the process through which decisions are made, by who and on what basis, is arguably more important. More generally, use of the term “degraded land” or related terms, can have impacts on perceived rights and notions of land tenure and ownership: in some circumstances land that is classified as degraded may be deemed to be open for appropriation by individuals or groups who propose new uses for it.

2.4. Natural versus human causes of degradation

As can be seen from the definitions discussed in the Annex, where the terms degraded or degradation are used, an attempt is often made to distinguish the cause of the degraded state, from unused, or underused, to deforested, desertification, contaminated, etc. Implicit and sometimes explicit is the notion of whether the cause of degradation is natural (e.g. flooding) or whether the impacts are caused by human actions (e.g. over use of chemical inputs). There is a view that natural events do not lead to long term degradation, whereas the latter may. However, this distinction is problematic.

Even where it is possible to distinguish unambiguously between the two, the effects on the system in question may be indistinguishable. Fire, for example, may have essentially the same effect on a system whether it is started deliberately by people, or accidentally, or is the product of a lightning strike. The effects of a storm on a forest may be similar to those of logging or clear-felling.

Moreover, it may no longer be very helpful, or even meaningful, to try to rigidly separate the human from the natural. With human-induced climate change the distinction becomes ever harder to justify. Thus, one major predicted impact of climate-change is a growing frequency and severity of extreme weather events of the kinds that themselves have a major impact on terrestrial systems. It becomes a moot point whether the effects of any one storm, for example, can be thought of as natural or a consequence of human actions.

[9] See Gaia Foundation *et al.* (2008) for a briefing on this from the perspective of biofuel production in Africa
[10] Fernandez-Gimenez (2000); Ho and Azadi (2010); Yeh (2005);
[11] Chazdon and Arroyo (2013).

Therefore the cause of degradation is not an important feature in an eventual framework for considering degradation or restoration potential. However, it should be noted that ecosystem or landscape restoration should not be considered as a substitute for conservation, nor a conduit for allowing intentional destruction or unsustainable use[12].

3. What is 'degraded': why precision on the scale of degradation matters

The terms degradation and degraded, when applied from a land management or environmental perspective are generally used to describe change that diminishes particular biophysical attributes of a site or area. More specifically, area-based degradation is usually qualified in terms of **land, habitat** or **ecosystem** degradation. These three qualifiers are not however synonymous; neither is there a completely straightforward relationship between them, nor indeed a consistent way in which each is used. All three can be thought of as different ways of looking at parts of the biosphere – the thin and irregular envelope around the earth's surface that sustains life.

- **Land** is a word with a range of different meanings. At its broadest it means the terrestrial rather than the hydrological part of the biosphere. It also means a geographic area, with connotations of ownership, tenure or use rights and is used at many scales, from a small piece of ground to a large region or even whole nation. At large scales it may implicitly incorporate river systems and wetlands. However when used to qualify degradation, it most often refers implicitly or explicitly to the substrate or material of which the ground is made, and particularly to the soil. In many cases the intention behind the use is not made fully explicit.

- **Habitat** is another word that can be used in different ways. Usually when it is used to qualify degradation it refers to distinct, usually "natural", vegetation types, usually combining structural descriptors with some indication of the plants assemblages that are predominant. Habitat descriptions can vary greatly in detail and precision, from very general (e.g. grassland, forest) to very specific (e.g. North American tall grass prairie; ancient Scots Pine *Pinus sylvestris* woodland); detailed descriptions often include reference to predominant species or species groups.

- **Ecosystem** is perhaps the most elusive of the three terms when used to qualify degradation. Strictly speaking it is the dynamic complex of other organisms and the physical environment of which a particular species or population formed a part. In other words when the term ecosystem was first coined it was not intended to be an identifiable spatial entity in its own right. Increasingly, however, an ecosystem is broadly considered as a dynamic system that can be spatially circumscribed and is somehow separable from other such systems, with its own distinct flows of energy and matter. The CBD reinforces this view of a spatially bound entity defining the term "ecosystem" as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment ***interacting as a functional unit***". For practical purposes, ecosystem is regularly co-opted in public policy documents and guidance as generic shorthand for a relatively large area that is bound by co-dependent plant, animal and abiotic relationships. Just to complicate matter further the terms "ecosystem" and "habitat" can still be used interchangeably.

[12] This is reflected in the approach on "cut-off dates" by when baseline data applies in many sustainability schemes, linked to their respective launch such as 1st January 2008 for the EU RED, and November 1994 for the Forestry Stewardship Scheme (FSC) scheme. See the RSB's GHG reporting tool http://rsb.org/pdfs/12-03-07-RSB-GHG-Tool-Manual.pdf for further examples.

In sum, although the term "land" can refer to anything from a field to the entire national territory and "habitat" and "ecosystem" are used in different and interchangeable ways there is nevertheless a useful emergent framework that could help improve how we think about and practically address degradation. The terms "land", "habitat" and "ecosystem", as already alluded to above, are sometimes, often unconsciously, used to convey how degradation manifests itself at different scales: land degradation tends to convey biophysical deterioration of the soil that impacts most immediately on site level productivity; habitat degradation can to be used to represent loss and deterioration of important vegetation types, its associated genetic resources and goods such as fuel-wood and wild-harvested food ; while ecosystem (or sometimes landscape) degradation indicates widespread loss of important functions, i.e. ecosystem services, such as pollination, water quality, soil stabilisation and erosion control, as represented in figure 2).

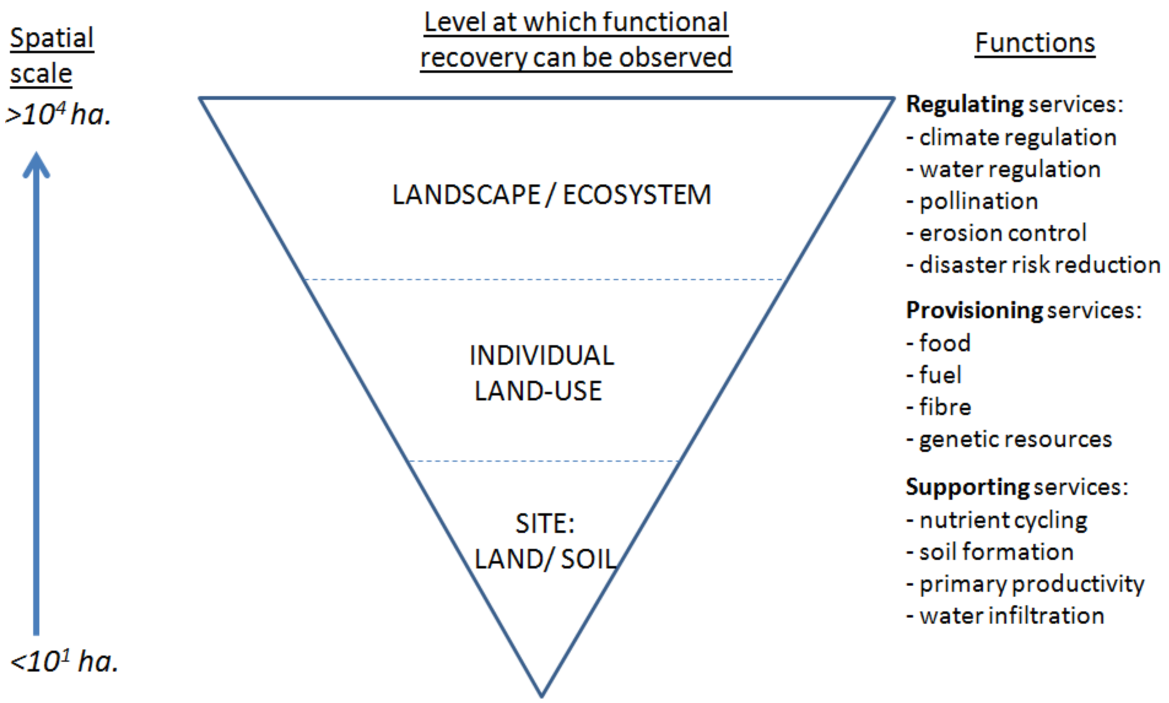

Figure 2: Different spatial scales of degradation based on ecosystem services

The fact that degradation manifests itself in different ways at different scales has important implications for public policy. If degraded lands or soils are targeted for conversion to biofuel crop production, for example, then the outcome ought to be measured and incentivised only in terms of better on-farm productivity. However there are risks here as "horizon-to-horizon" conversion of degraded soils, even if done well and improves land productivity, will do little for and may actually exacerbate current habitat and ecosystem degradation. Therefore, just as importantly, if the scale of intervention is not also considered it leaves the door open to the risk of failure at all levels.

If the establishment of biofuels is to make a positive social and environmental contribution then before we identify the best level of entry we ought to have a clearer idea of what functions are actually missing from degraded areas and where and how best they might be restored. The following chapter explores the types of changes that one tends to encounter with degradation at different scales.

4. Change, scale and degradation: what type of changes are the most reliable indication of degradation

As will already be evident, there are many different ways of looking at degradation, and many different parameters that may be considered under different circumstances as providing indications of degradation. One helpful way of teasing this out is to distinguish changes in more apparent and visible biophysical parameters (section 4.2) that are typically, but not always, experienced as site-based changes, from those, more complex changes at the habitat or ecosystem level in terms of degradation of ecosystem services (section 4.3); loss of ecosystem resilience (section 4.4) and loss of ecosystem naturalness (section 4.5). The following chapter will systematically look at what degradation means from these various perspectives with a view to teasing out useful ideas that could help inform where and when commercial crops such as biofuels on degraded land could make a useful contribution. Not all potential changes associated with degradation are included here, but the ones that are most commonly referred to in technical and policy literature are addressed. However before considering different manifestations of change brought about by degradation we will quickly consider what ultimately unites all these change processes – be it at the field or ecosystem level.

4.1. Changes in ecological processes and shifts in steady states

The earth's biosphere functions as a complex system of dynamic processes involving the cycling and transfer of energy and matter in various forms. When all things are considered these processes are relatively stable and can be expected to maintain a balance over significant periods of time. For most of the earth's history most changes have tended to be gradually driven, for example, by natural shifts in climatic conditions. However the balance can also be disrupted over much shorter periods of time if other, usually anthropogenic, factors divert, disrupt or otherwise alter the flow of inputs to or outputs from the system (whether that system is an individual field or the planet the principle is broadly the same). If this happens then the system will undergo change until a new balance (or equilibrium) is reached.

Over history humans have deliberately manipulated these processes to deliver a beneficial flow of desirable outputs, for example, applying animal manure on agricultural fields to maintain soil nutrients that would otherwise be depleted due to the regular off-take of crop biomass.

Degradation can be considered to take place when the transfer of energy and matter is disrupted in such a way as to shift the balance toward a new equilibrium where expected outputs are delivered at a sub-optimal level. For example, accelerated and sustained removal of above-ground biomass reduces the flow of material available to maintain soil organic matter, which in turn limits the availability of soil nutrients and soil moisture retention, which results in the reduced growth of above-ground biomass. While this may be described as a vicious circle the change process is not actually open-ended; eventually after a period of adjustment a new, albeit sub-optimal balance will be attained. Therefore it is changes in the ecological processes that regulate the flow of energy and matter into and within a system that are more fundamental determinants of degradation rather than the more apparent changes to the structural components of land, habitats and ecosystems.

One of the most central ecological processes whose disruption is relatively easy to understand in terms of degradation is the carbon cycle. This is the conversion of atmospheric carbon dioxide by plants and various kinds of algae and bacteria into organic carbon through photosynthesis. This organic carbon accumulates in the plant's biomass and through a variety of routes is returned to the atmosphere or accumulated in the soil as both organic or inorganic carbon compounds, or becomes dissolved in sea-water and is eventually subsumed into the earth's crust. Other chemicals, most importantly nitrogen, also cycle through the biosphere in both organic and inorganic forms. The entire system is supported by the presence of liquid water both inside and outside living organisms.[13]

The simplest measure of the carbon cycle as it relates to living systems is net primary production – the surplus over time of organic matter accumulated by photosynthesising organisms when their own energetic needs have been met through respiration. A long-term decline in net primary production might result from depletion of nutrients, or loss of soil mass, or repeated disturbance (such as fire) that might be taken as indicative of degradation in some ecosystems. However, declines in primary production might also indicate systems that are undergoing natural succession towards a state where annual energy expenditure is roughly balanced by energy captured locally through photosynthesis.[14]

However, while changes in ecological processes may result in degradation it is both costly and difficult to measure these changes directly. It is therefore easier to look directly at other manifestations of degradation - such as biophysical changes or reduction in ecosystem service - as discussed in the following sections. Nevertheless it should be kept in mind that degradation of land, habitats or ecosystems is ultimately driven by disruption of fundamental ecological processes and is in and of itself simply a manifestation of a shift from one dynamic equilibrium to another. Understanding this fundamental point may ultimately lead us to reframe the central question of this paper – what criteria can be used to identify degraded lands suitable for bio-fuel production – to one that asks under what conditions could biofuel crops contribute to the improved management of degraded lands and ecosystems.

4.2. Site-based changes in structure and composition

Site-level impacts of degradation impact land in two major ways: the structural and compositional attributes of above ground biomass and the physical attributes of the soil that determines and sustains site productivity. Clearly the two are inextricably linked as changes in one kind will be reflected in changes in the other, but there are enough differences, often in practical terms of measurability, to merit looking at the two separately.

Above ground degradation at the site level is typically associated with the following sorts of changes

- declines in overall biomass;
- simplification in structure – for example, site level degradation in natural forests typically witnesses a loss of different canopy layers; in agricultural systems it may come around due to loss of on-farm trees or number of flowering plants;
- a reduction in the number of different species;
- shifts away from ‘optimal' population structures of particular species (for example an absence of recruitment, or a shortage of mature individuals);
- in natural ecosystems, a shift away from a situation where no one species dominates to one where one species, or a small number of species, dominate.

Similarly in considering changes to substrate the following are often considered indications of degradation[15]:

- reductions in soil depth;
- a decrease in soil organic carbon;
- changes in soil structure;
- decreasing concentrations of particular chemicals (nutrients or micronutrients);
- increasing concentrations of particular chemicals (‘pollutants');

[13] See Groombridge and Jenkins (2002) for further elucidation.
[14] See Bai *et al.* (2008) and section 7 below.
[15] For a detailed discussion of soils and the factors that affect them see: http://eusoils.jrc.ec.europa.eu/themes.html and Hannam and Boer (2002, 2004).

- simplification of subsoil communities of organisms.

However, in almost all cases real-world situations are more complicated and sometimes more ambiguous than implied above. For example, in grasslands maintained for livestock production an increase in biomass through invasion of woody or unpalatable herbaceous species is considered as degradation. Similarly, in some circumstances an increase in overall number of species might be considered indicative of degradation if the species are aggressive, nutrient depleting invasives. This difficulty is illustrated further in the case of changes in structural attributes of forests, examined further in box 1.

Box 1: Changes in structural attributes of forests

It might be assumed that the greater the degree of canopy cover and the higher the proportion of large, mature trees the ‘better’, i.e. the higher the quality of the habitat. A decrease in canopy cover, a reduction in average size of trees, or an increase in number or proportion of dead trees might all be considered a decline in quality, that is, an indication of habitat degradation.

However, in most forests, gaps in canopy cover are believed to play an important part in maintaining high levels of species diversity. A forest area with a proportion of gaps is likely to be more diverse than one with no gaps at all. However, different species and groups of species are affected in different ways by the frequency and size of gaps, so that it is not possible to determine a single optimal state. In any event, the forest canopy is by its very nature dynamic, with the frequency, size and location of gaps continuously changing.

Similarly, in considering the age-size distribution of the trees in a forest, or even of trees of one species, the absence or a very low frequency of young trees of a particular species may indicate lack of regeneration of that species and a long-term population decline (e.g. Juniper woodlands in the Netherlands). However, in other circumstances the absence of young of a particular species may be a reflection of the reproductive strategy of that species. Many tropical forest trees have light-demanding seedlings and some, including valuable species such as mahoganies *Swietenia* typically regenerate following large-scale perturbations (from, for example, fire or hurricane damage) forming extensive even-age stands. Even the presence of a significant number of dead trees cannot necessarily be taken as an indication of degradation. In Europe, for example, the reduction in the number of senescent and dead trees as a result of forest management practices has had adverse impacts in many places on populations of saprophytic organisms leading to some declines in overall species diversity measures, i.e. evidence of some form of degradation.[16]

Even in the case of soil, where changes might at first sight be thought to be quite straightforwardly typified as degradation or improvement, the situation may be far from clear-cut given that soil ecosystems are every bit as complex and dynamic as above-ground ecosystems. Degradation can result from having too little or too much of the same physical attribute. For example a reduction in soil nitrates or phosphates that leads to a reduction in productivity is clearly a sign of site-based degradation. However, under other circumstances, an over-abundance of these same elements could also considered indicative of degradation as it contributes to soil eutrophication which not only manifests itself in changes to above ground plant communities but also impacts the wider ecosystem.

Therefore even with the most apparent straightforward of circumstances, site-level structural change, degradation is clearly context specific. This does not mean that public policies targeting areas that have undergone site-level degradation are necessarily impossible to define but it does caution against over-prescribing too much at the general level and assuming that this will always translate into the same sort of site-based activity with a consistent outcome. That said site-based changes are usually a reliable measure of degradation with changes in the biophysical qualities of soil probably the most consistent measure that fundamental degradation processes are underway. However although useful they may also have important limitations in that they will only tend to identify those areas where site

[16] See Chazdon and Arroyo (2013), FAO (2011), Lund (2009), Messier *et al.* (2013) and Sasaki and Putz (2009) for further discussion.

productivity is already in severe decline and this fact alone may limit the options for intervention, such as agricultural development (this will be explored further in the next section). Furthermore, while these types of change do offer a degree of precision at the site level it is less certain whether use of site level biophysical changes could be meaningfully extrapolated to an ecosystem or landscape scale.

4.3. Changes in ecosystem goods and services

4.3.1. Introduction to ecosystem services

The concept of ecosystem services is not new, but has been brought into prominence in recent years as it was the underlying framework of the 2005 Millennium Ecosystem Assessment (MA)[17]. The ecosystem services framework was used in the MA because it was thought to be the best way to convey to a wide audience the fact that humans depend on functioning ecosystems for their wellbeing. In the MA classification, ecosystem services are considered under the broad headings of Provisioning, Regulating, Cultural and Supporting Services. More recently, notably under TEEB (the Economics of Ecosystems and Biodiversity[18]), supporting services have been re-designated as Habitat Services, although the fundamental classification system remains essentially the same.

Under the MEA scheme, provisioning services include food, fibre, genetic resources, natural pharmaceuticals, and water; regulating services include regulation of air quality, climate, water, erosion, pests, diseases and natural hazards, as well as provision of pollination and water purification and waste treatment; cultural services include spiritual and religious values, aesthetic values and recreation and tourism; supporting services are the ecosystem processes that underlie the others, and include nutrient cycling, soil formation and primary production. Drawing on the work of the MEA, a proposed international standard for the classification of ecosystem services was developed, the Common International Classification of Ecosystem Services (CICES) (see table 1)[19].

Theme	Class	Group
Provisioning	Nutrition	Terrestrial plant and animal foodstuffs
		Freshwater plant and animal foodstuffs
		Marine plant and animal foodstuffs
		Potable water
	Materials	Biotic materials
		Abiotic materials
	Energy	Renewable biofuels
		Renewable abiotic energy sources
Regulation and Maintenance	Regulation of wastes	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physical environment	Atmospheric regulation
		Water quality regulation
		Pedogenesis and soil quality regulation
	Regulation of biotic environment	Lifecycle maintenance & habitat protection
		Pest and disease control
		Gene pool protection
Cultural	Symbolic	Aesthetic, Heritage
		Religious and spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

Table 1: The Common International Classification of Ecosystem Services (Haines-Young et al, 2010)

[17] See www.unep.org/maweb
[18] See section 3.3, chapter 1 of the TEEB Foundations (2010) report.
[19] For more detail on the CICES, see Haines–Young, R. (2010)

The concept of a tangible package of goods and services provides a valuable prism through which to consider degradation. Unlike considerations of site-based change which tend to come down to maintaining or enhancing net primary productivity, degradation of the habitat or the ecosystem has the potential to affect not only the immediate landowner but also his or her neighbours and downstream users of particular services such as clean water hundreds of miles away. Consideration of changes at the scale of habitats, landscapes or ecosystems should in theory enable policy makers to identify sizable areas that can be classified as degraded (or at least managed sub-optimally).

The problem is that just because such an area is degraded does not automatically mean that it is then a suitable candidate for a particular land-use such as biofuels. Indeed subjecting a particular landscape that is already supplying sub-optimal levels of goods and services to further concentrations of the same type of land use is almost certain to guarantee a further loss or diminution of at least some of the residual ecosystem services.

4.3.2 Balancing trade-offs in ecosystem goods and services

The mix of goods and services provided from a particular ecosystem is highly variable and determined to a large degree on the scale and time period of assessment. Different people will benefit from a particular set of ecosystem services in very different ways, and this means each individual service may be valued quite differently. The interdependencies between individual goods and services also vary significantly – in some cases maximising the provision of certain services of major goods such as foods, fibres and fuel may have a negative impact on the delivery of another services such as pollination or water purification. Similarly, projects that may not be optimal for the delivery of one particular ecosystem service could still deliver a higher quantity of overall benefits.

Society is regularly faced with choices whether to attempt to maintain a balance between the delivery of different goods and services or simply to forego some in order to maximise others. And given that different parts of society benefit in different ways then these decisions can often fall in favour of those who hold most influence.

This issue is further compounded by the problem with using change at the habitat or ecosystem level to understand and qualify degradation, there is rarely, if ever, a single measure or metric of ecosystem services that all stakeholders can agree on. For example, if public policy provides an incentive to support fertilization of degraded grasslands, or conversion of these grasslands to a crop such as biofuels within a degraded watershed, it is likely that this action would be considered an improvement by those land-owners or investors whose key metric might be maximising returns from their land. However it could equally be judged to be a further setback to downstream municipalities that rely on the watershed for provision of potable water.

The lack of correlation in the delivery of different ecosystem services, and the fact that the way people benefit from these services (and their perceptions of the way that they benefit), differ enormously is one of the chief causes of conflict in management of natural resources. This conflict does not just exist between individuals or groups of people at any one time, but it also extends across generations: one of the most powerful large-scale ideas of degradation is that the current generation is bequeathing to succeeding generations a biosphere that is impoverished in important ways, and will be less capable of delivering the range of services that society ultimately depends on for its survival.

Trying to resolve conflicts, between different services, different users and across generations often leads to the (optimistic) search for so-called 'win-win' solutions, of which genuine examples are rare. More realistic, perhaps, is the acceptance of the need for compromises and trade-offs, or increased overall co-benefits.

The consideration of spatial scale is a crucial aspect of assessing benefits of ecosystem services: it is extremely difficult to manage individual sites so that all ecosystem services are delivered at their maximum potential, all stakeholders are fully satisfied and nothing that anyone would consider to be degradation is taking place. However, if planning and management are implemented at a larger, landscape level, then trade-offs between different uses and users become much more possible to negotiate (see box 2 for principles of a landscape approach to reconciling agriculture, conservation, and other competing land uses). Similarly, if planning is carried out over longer time periods than is normally the case, ecological processes that operate on long timescales (decades or longer), such as soil formation and tree growth, can be better incorporated.

Box 2: Ten Principles of a Landscape Approach

Principle 1: Continual learning and adaptive management; learning from outcomes can improve management.

Principle 2: Shared interest in an issue or problem; build solutions – even to wicked problems where parties have divergent views on possible solutions – around perceptions of common interest.

Principle 3: Multiple scales; awareness of numerous system influences and feedbacks that affect management is essential.

Principle 4: Multifunctionality; landscapes and their components have multiple uses and purposes that require tradeoffs be reconciled.

Principle 5: Multiple stakeholders; engaging them in an equitable manner is needed to ensure optimal and ethical outcomes.

Principle 6: Negotiated and transparent change logic; transparency is the basis of trust needed to avoid or overcome conflict and is helped by good governance.

Principle 7: Clarification of rights and responsibilities; rules on resource access and land use need to be clear to ensure good management and good outcomes.

Principle 8: Participatory and user-friendly monitoring; it is valuable to derive information from multiple sources.

Principle 9: Resilience; increase system-level resilience through recognition of threats and vulnerabilities and actions to reduce them.

Principle 10: Strengthened stakeholder capacity; people require the ability to participate effectively and to accept various roles and responsibilities.

See Sayer et al (2013)
http://www.pnas.org/content/early/2013/05/14/1210595110.full.pdf+html

At whatever scale planning and decision-making are carried out, two factors play a hugely influential role. One is the language or currency in which values are expressed; the second is the power relations between different interested groups.

Attempts have been made to address the first problem by developing economic frameworks for considering goods and services (e.g. The Economics of Ecosystems and Biodiversity (TEEB)[20] and the UK National Ecosystem Assessment[21]), on the basis that, even if there is no one measure for ecosystem services, different ones can at least be considered and weighed against each other in the same currency. This approach may have some use at a high policy level in persuading the world at

[20] See www.teebweb.org
[21] See http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

large that ecosystems have a tangible value, but attempts to apply it operationally often founder because valuations are invariably based on sometimes highly contested assumptions. Relatively small changes in these assumptions can lead to large changes in conclusions. Inherent in the valuing of different goods and services is the potential privatisation benefits and socialising costs in these trade-offs. Local rural poor are often the most compromised in these situations, with little to show as a direct trade-off benefit. This imbalance is linked clearly to the second issue; the large asymmetry in power between different groups remains a besetting problem in decision-making in all spheres. In land-use decisions, those people with insecure land-tenure such as the rural poor and in particular women, are much less capable of influencing decisions than those closer to the seats of power. However, established frameworks do exist that can help to address these issues, such as a Participatory Rural Assessments, of which many techniques and tools exist, broadly including elements on group dynamics, sampling, interviewing and visualisation.[22]

In summary, change in ecosystem goods and services is an important framework for assessing degradation but comes with several challenges. Firstly, it can really only be understood at a landscape level, given the interconnected and dynamic nature of ecosystems. Secondly, that it involves balancing trade-offs between different goods and services; and societies' view on what constitutes the optimal balances is likely to change overtime.

4.4. Loss or decline of 'resilience'

One concept that is featured in some definitions of degradation (see, for example, the GEF definition in the Annex), and that increasingly plays a role in discussions of the place of humans in the biosphere is that of resilience, with a loss of resilience being indicative of degradation. This is defined, very simply, by the Stockholm Resilience Centre as "the capacity of a system to continually change and adapt yet remain within critical thresholds". The Centre defines ecosystem resilience as: "A measure of how much disturbance (like storms, fire or pollutants) an ecosystem can handle without shifting into a qualitatively different state. It is the capacity of a system to both withstand shocks and surprises and to rebuild itself if damaged."[23] In this way, a resilient system is one that can recover naturally (see figure 3)[24].

Resilience thinking is based on two assumptions: the first is that humans and nature are strongly coupled and co-evolving; the second is that the assumptions that systems respond to change in a linear and generally predictable fashion is wrong. In resilience thinking systems are understood to be in a state of constant flux, highly unpredictable and self-organising with feedbacks across multiple scales in time and space. One feature of such systems is that they may organise along a number of different pathways with possible sudden shifts between them (often characterised as 'tipping points', see figure 3) following the introduction of a given input/driver[25].

The basic assumption of resilience thinking, that humans and nature form a highly coupled complex, non-linear system, seems unarguable. It is not so clear, however, how easy it is to move from this to a characterisation of different parts of the global biosphere as more or less resilient, or degraded.

[22] For example, see the World Bank's resources on Participatory Rural Appraisal (PRA) Techniques at http://tinyurl.com/m4n829x . On visualization, see Boedhihartono, AK (2013), Visualizing Sustainable Landscapes: Understanding and Negotiating Conservation and Development Trade-offs Using Visual Techniques. Gland, Switzerland: IUCN. Download at https://portals.iucn.org/library/efiles/edocs/2012-002.pdf.

[23] See http://www.stockholmresilience.org/21/research/what-is-resilience.html

[24] While beyond the scope of this paper to address further, resilience also provides an interesting frame from a socio-economic perspective. It would be interesting to consider what effect degradation can have on the five 'capitals' of a community, i.e. its social, physical, human, financial and natural capital assets. See Derissen S, Quaas M, Baumgärtner S. (2011) for a discussion and an application of this framework.

[25] Folke (2010)

First, at local level at least, the resilience of a system may depend as much on what the system is responding to as on inherent properties of the system. An area of fire-adapted vegetation may return fairly rapidly to something very close to a previous state following a fire but may be very severely and perhaps irreversibly altered by the arrival of a new pathogen.

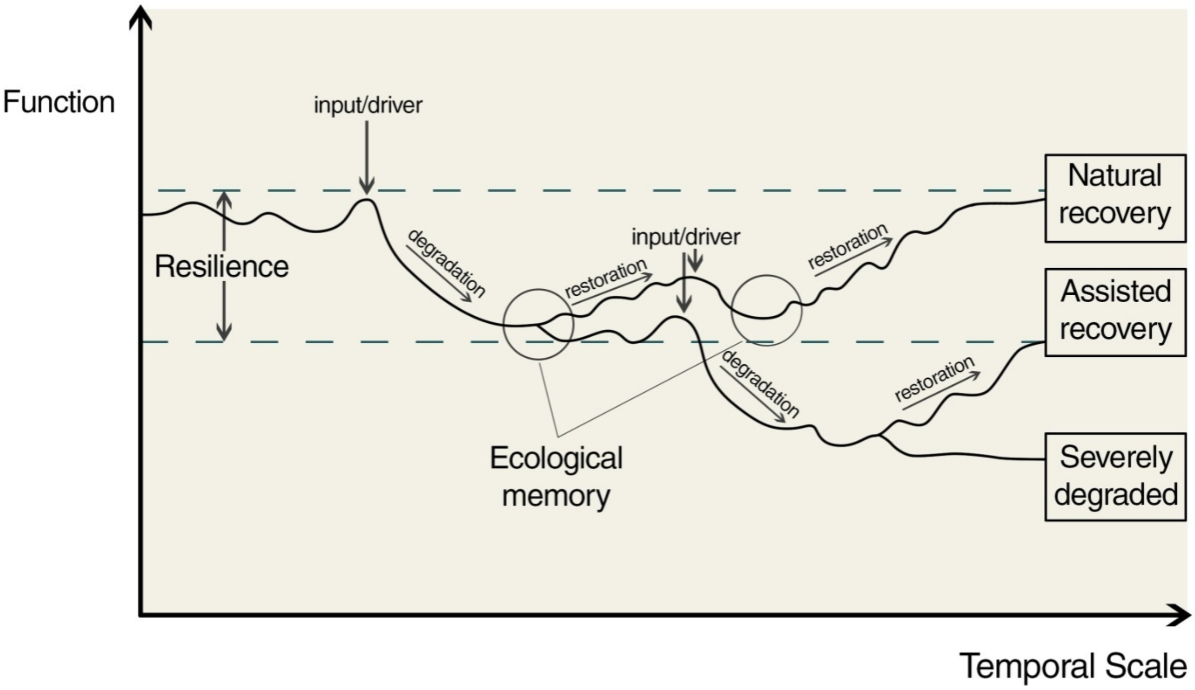

Figure 3: Resilience of the function of an ecosystem over time

More generally, the extent to which different systems (or parts of the global system) may be subject to sudden shifts remains an open question: such changes are well characterised under some conditions (notably more or less closed aquatic systems such as freshwater lakes) but less so in others, including many terrestrial systems. Second, where such phenomena do occur, they are often almost by definition difficult or impossible to predict because of their non-linearity. Thus a system might appear 'non-degraded' but might then undergo a small change that tips it into another state that would then be characterised as highly degraded. It is useful to return to the example of response to fire in terrestrial systems as a case of this. Suppression of fire in areas that are fire-adapted (i.e. they have previously developed in the presence of relatively frequent fires) can lead to an increase in biomass and in structural diversity, and perhaps sometimes in species diversity. By most of the measures discussed in section 4.3 above, such areas would be classified as non-degraded, or as becoming less degraded. In fact, such areas would be becoming increasingly vulnerable to the effects of fire, as when fires occur they will tend to be more intense and destructive than those under a more frequent fire regime. That is, the system would have gradually been losing resilience (Stephens et al, 2013). (This is, of course, well-known to managers of fire-prone areas, and numerous different kinds of fire-management regimes, often involving controlled burning, have developed in different parts of the world).

One possible way of linking concepts of resilience with those of degradation may be to look at those elements of a system whose loss makes it difficult for that system to undergo useful change in the future – that is to return to some previous state, or to change to another state that still delivers benefits in the form of goods or services. When considering the ability of a system to return to some earlier (notionally “undisturbed”) state, this can be thought of as a kind of ecological memory[26], the loss of which may be considered as indicative of some form of degradation.

Furthermore, as degradation and restoration are not linear processes, they are interspersed by “punctuated equilibria” (see figure 4). In this way, degradation and restoration involves incremental changes followed by a period of stability, followed by more incremental change and another period of stability. In practice, landscape restoration therefore needs both long term goals and short-term milestones, where each step needs to be stable and resilient.

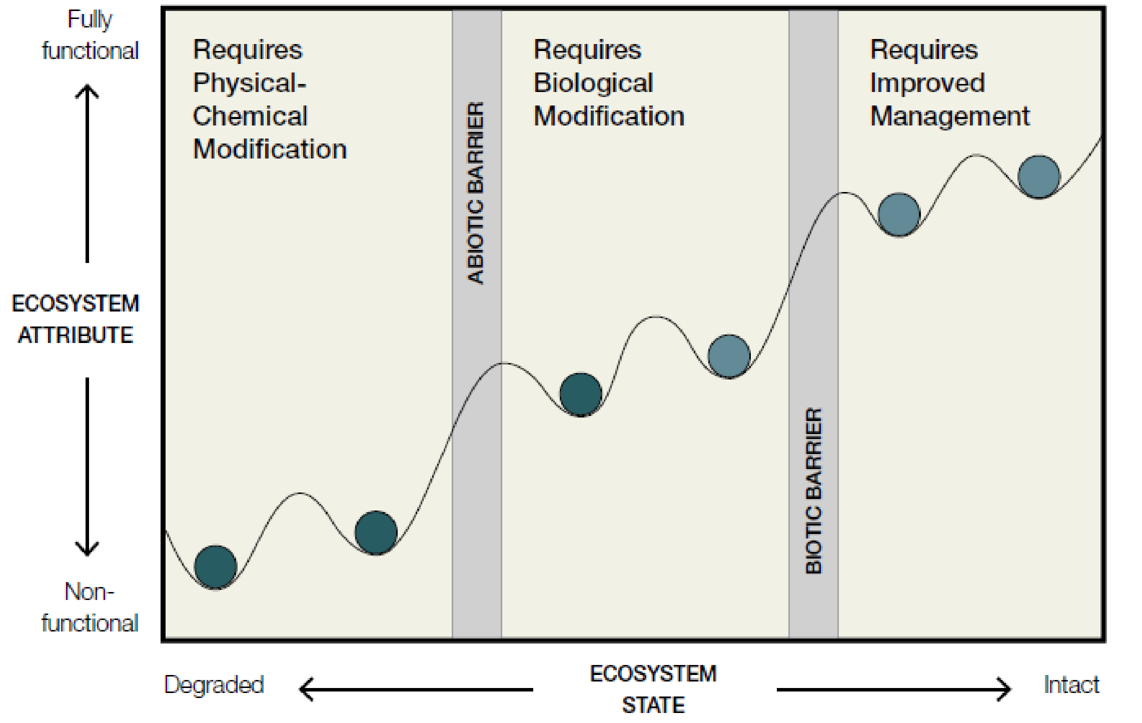

Figure 2: Simplified conceptual model for ecosystem degradation and restoration (Parks Canada and the Canadian Parks Council, 2008; adapted from Whisenant, 1999 and Hobbs & Harris, 2001). The numbered balls represent alternative ecosystem states, with the resilience of the system being represented by the width and depth of the ‘cup’. Disturbance and stress cause transitions towards increasingly degraded states, with 6 being the most degraded. Barriers, or thresholds may also exist between some ecosystem states (e.g., between states 2 and 3) that prevent the system from returning to a less degraded state without management intervention. Restoration attempts to move the ecosystem back towards a more structurally ‘intact’, well functioning state, (i.e., towards state 1). *See* Parks Canada and The Canadian Parks Council (2008) for additional details.

Figure 4. Taken from Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices (Keenleyside et al, 2012) http://data.iucn.org/dbtw-wpd/edocs/PAG-018.pdf

For example, building on the earlier fire-adapted system example, a “simple” afforestation project in a fire-prone landscape may deliver good results in the short term but also comes with a high risk of future degradation as it does not have the grassland basis “ecological memory” to maintain structure during fire.[27]

Another important message is that landscape degradation and restoration have different starting points as well as different end points – and different ways to get from one state to another. It is not realistic to go from severely degraded to a fully restored, functional landscape in one operation. There is a need to work on different functions at different scales across land uses. For example, recovery

[26] The ecological memory of a site includes, among other remnants, the property of the soil, spores, seeds, stem fragments, mycorrizae, species, and populations (Schaefer, 2009)
[27] See case study in Resilience practice: building capacity to absorb disturbance and maintain function (Walker and Salt, 2012)

may need to be assisted in the case of severely degraded landscapes. Taking this logic further, it could be argued that intervention at any level of degradation in a landscape is equally valid.

This becomes relevant whether you are discussing action for ecological restoration or for agricultural developments – while the wins in terms of increased changes in function are greater the more severe the land, the higher the costs to restore the land. In the case of agricultural production, there are clearly differences in where intervention may be preferred in terms of economic and technical viability. It follows then the GHG bonus for biofuel production on severely degraded land under the EU's Renewable Energy Directive (see Section 6.1 for general overview) was never going to be taken up as the upfront costs for restoration were too high relative to the potential benefits. This is reflected in the work of WRI in Indonesia to identify lands suitable for palm oil expansion, where degraded lands were distinguished for their "high potential", "potential" or non-suitability (Gingold et al, 2012).

A lower threshold of degradation may be more appropriate for restoration as part of a mixed landscape, including agriculture and appropriate landscape restoration activities to the area. In Brazil, for example, this approach is encouraged through the Forest Code, which requires conservation or restoration of natural habitat on farm properties, with the portion requirement depending on the size and location of the. As found in a recent IUCN assessment (IUCN, 2013) biodiversity implications of Raízen's implementation of the Bonsucro Standard in Brazil, the potential benefits of ecologically based landscape planning and cost-effective restoration strategies are substantial, though there remains a need to identify the most critical lands and relevant management practices for conservation and restoration.

In short, the resilience paradigm and in particular its concepts of ecological memory and shifts in non-linear, steady states, is clearly a valuable one for framing responses to a rapidly changing world, as is the recognition that different interventions are required at different degradation states.

4.5. Shift away from naturalness

For completeness, this paper will also consider the oft-used term of "naturalness", though as will be explored briefly, this term has very limited practical use in this setting.

Embodied in many notions of degradation is a shift away from naturalness. A degraded forest, for example, is often considered, or defined as, a forest that differs in significant ways from the forest that might be expected to occur there in the absence of human interference (potential forest, or more generally potential vegetation) or that is known or believed to have occurred there before humans had an impact (original forest or vegetation).

This notion, while superficially appealing, is problematic chiefly because in most parts of the world human impacts have been so pervasive for so long that it is not at all clear what the original condition was, nor, given current impacts, is there any realistic prospect of returning to this. Thus, in much of Europe and other high latitude areas, the prevailing conditions before the end of the Pleistocene (i.e. during the last glacial maximum) was several hundred metres of ice. As the ice retreated at the start of the Holocene, humans followed, burning and hunting. Evidence for significant environmental impact accumulates steadily – at no point, as far as we know, have extensive areas of habitat developed without humans present under anything approaching present climatic conditions. For example, it can be argued that all forests have been disturbed in some way[28].

Given this, not only is it difficult – or even meaningless – to try to determine what the original vegetation might have been but it is also difficult to decide what potential vegetation might mean.

[28] For further discussion on this, see Dudley, N. (2011). Authenticity in Nature: making choices about the naturalness of ecosystems. Earthscan.

Does the absence of human interference mean taking into account, or not taking into account, the general absence of large animals or species locally or globally now extinct and which without doubt played a major role in terrestrial communities?

This is not just a theoretical question, but is contested ground amongst conservationists, particularly those engaged in restoration. For example, advocates of the reintroduction of the European Beaver *Castor fiber* to the British Isles, where it was last recorded as a wild species in the 16th century argue that riverine and floodplain habitats, even in areas regarded as natural or semi-natural, are not in fact truly natural because of the absence of a species that has a major impact on these habitats[29].

More generally, in an age of rapid, and accelerating, climate change, it is increasingly difficult to know what the potential vegetation of any given area would be in the absence of other forms of more immediate human intervention.

This is not to say that the concept of naturalness should be abjured entirely: there is a clear and unequivocal difference between, say, an expanse of long-standing tropical moist forest where human activities are at a minimum and a palm oil plantation, or a housing estate, or an expanse of largely bare ground. But between these two lies a huge range of conditions in which the situation is much more ambiguous, and in which notions of naturalness may not be very helpful in determining whether an area is degraded or not.

Moreover, even in these extreme cases of transformation, the use of naturalness, or absence of naturalness, as a sign of degradation would generally only be accepted as applying in cases where the area in question had not been put under some other sort of use. In the three cases above, many people would not consider a palm oil plantation or a housing estate to be degraded in any useful sense of the word, rather this is a form of land use change.

It is evident, therefore that ‘naturalness’ is a concept with limited use when trying to establish definitions or measures of degradation in highly transformed and managed landscapes, such as areas devoted primarily to production, to human habitation or to others forms of infrastructure.

5. Measuring and quantifying aspects of degradation

As discussed thus far, policy driven definitions often have little applicability on the ground. Further, when teasing apart the elements of the biosphere that may be degraded, some concepts are limited in their application to site or landscape level decision-making. In order to be practical, it is essential to also understand the measurement and quantification of degradation and restoration potential.

5.1. Framing

Any definitions of degradation and degraded that are intended to have practical application should ideally be reducible to measurable terms. At the very minimum, these terms should be able to demonstrate in as objective a way as possible that degradation is taking place or has taken place, and be able to indicate whether an area, habitat or ecosystem is degraded or not. This means that the terms or metrics used need to be both objectively verifiable in theory and measurable in practice.

To be verifiable in theory they need to use terms that are as objective as possible, that is they need terms that can be agreed on by all users and that are amenable to at least some form of

[29] See www.scottishbeavers.org.uk and http://www.snh.gov.uk/protecting-scotlands-nature/safeguarding-biodiversity/reintroducing-native-species/scottish-beaver-trial/

quantification. This poses problems for some concepts associated with cultural or aesthetic values of ecosystem services discussed above, such as beauty or spiritual significance. Yet these may be quite powerful drivers of peoples' responses to landscapes when they are assessing whether they consider them degraded or not.

Definitions of degradation and degraded may be agreed on that are essentially arbitrary or subjective in themselves but that can still generate measurable indicators. An example is REDD+ (see Annex), in which some agreement has been reached to define degradation in this context as reduction in forest carbon. This would be acknowledged by those who developed it as an arbitrary and context-dependent definition but it remains one in which it is possible, at least in theory, to measure in practice.

Given the reality stated earlier that degradation is a value judgement, there is an inherent risk involved in measuring degradation in that it tends to be reductionist in order to be specific, and yet for this reason will also be contested. However, this does not mean that we should not try to quantify degradation, rather there is a need to be very explicit what we are quantifying and at what scale – both spatial scale and what time period, as well as the future anticipated change(s) in land use.

5.2. Quantifying

Because the concept of change is inherent in understanding degradation, any measure will require an assessment of the state and use of the unit in question over at least two different points in time, or at least making a plausible reconstruction of some previous state to serve as a baseline for comparison. For many measures, however, historical observations are very limited. Remote-sensing data reach back in useful form only for two or three decades. Field observations and records can in some cases stretch back much further. However, long-term time series are very limited in number, as a rule cover only small areas and are often couched in terms that are not straightforward to relate to present-day measures. Any (arbitrary) historical baseline against which to measure hypothetical degradation has to be reconstructed from modelling, history, ethnography, archaeology, or palaeontology.

Degradation, however defined, could in theory be demonstrated by showing directional change without precise quantification. However, distinguishing 'degraded' from 'undegraded' lands, habitats or ecosystems implies the existence of quite precisely defined thresholds, which would inevitably be at least to some extent arbitrary. In both cases, consideration of spatial and temporal scales is crucial.

In the absence of a clear theoretical foundation for setting particular thresholds for criteria involving declines in area or function, the IUCN Red List of Ecosystems (currently under development) has proposed *decline* threshold values at relatively even intervals for current and future declines: Vulnerable 30%, Endangered 50%, Critically Endangered 80%. This spread of thresholds between zero and 100% "seeks to achieve an informative, rather than highly skewed ranking of ecosystems among the categories". The lowest threshold of 30%, for example, requires evidence of an appreciable decline in ecosystem distribution or function to support listing in a threatened category. For *collapse* thresholds, ecosystems may be generally assumed to have collapsed if their distribution declines to zero (for criteria based on spatial extent), i.e. when the ecosystem has undergone transformation throughout its entire range (Keith et al, 2013).[30] In this case, interventions would be required to assist the recovery of such a system.

From an ecosystem perspective, there are few goods systems to systematically quantify and compare similar systems, i.e. a baseline. In the absence of this, processes are a good way of incorporating best practice. General process indicators example include whether soil content is checked, that the

[30] See Keith el al, 2013 for more information. http://www.iucnredlistofecosystems.org/wp-content/uploads/2013/05/Keith-etal-2013-Scientific-Foundations-Red-List-of-Ecosystems-PLoSONE.pdf

community is involved, that water use is monitored, and specific indicators can be made at the local level. In this way, check lists can provide guidance to local communities and help them and eventual investors/businesses focus on important issues.

5.3. Measuring

The first questions to ask is what are we measuring and for who. In practice, we expect management decisions (e.g. intervention, or not) to be taken. The difficulty in obtaining useful measurements – that is those at an appropriate temporal and spatial scale and with enough precision – is very often overlooked when possible metrics are considered.

There are essentially two ways to make observations on the state of the environment: through remote-sensing and through field observation. Both generate raw data that then require interpretation, and often transformation. The two methods go hand in hand as up-to-date data availability is often limited at higher resolutions, and current land use cannot be accurately ascertained from GIS, particularly over the course of different seasons (for example, in the case of pastoralists). Any remote analysis needs to be ground-truthed and supplemented with socio-economic data to reduce the risks associated with the decision-making for a given land use. Gaps in information can be filled by extrapolation or by modelling as well as participatory mapping and stakeholder assessments. This is best practice for ecological restoration (see Keenleyside et al, 2012) as well as for more intensive land uses, such as palm oil production in Indonesia where WRI developed a methodology for exploring opportunities for palm oil production on degraded lands. The process drew heavily upon sustainable land management practices but had specific environmental criteria related to forest carbon, the main focus of the Indonesian government, yet with a process to ensure that areas with less than 200 tons of carbon but were already under cultivation or locally important were not considered appropriate for palm oil expansion (Gringold et al, 2012).

A similar participatory rural methodology has been adapted to understand REDD+ potential and tested in Ghana and Mexico (see IUCN and WRI, forthcoming). Furthermore, the Low Indirect Impact Biofuels module developed by WWF, EPFL and Ecofys is also based on a stakeholder questionnaire (LIIB, 2012).

5.4. Assessing the end goal(s)

Finally, when assessing whether a restoration project has been a success, it's important to be specific on the end goal, in other words what is the positive change that you want to monitor and measure.

Building on earlier sections, it is clear that not all degraded land is suitable for every proposed new land use. Furthermore, the potential for a given land use is not solely dependent on environmental indicator of degradation, as shall be discussed next in the context of biofuel production.

Arguably then, the challenge is not to define and identify degraded land, but to identify lands with potential for restoration and/or a given sustainable land management.

With this realisation comes the need for new measures for success, which would need to go beyond biophysical details and include social value. One suggestion for a more useful framing definition for degraded land is where there has been a decrease in overall benefits in a landscape. Conversely, restored land is where there is an increase in overall benefits in a landscape.

Questions remain on who monitors compliance, verifies and who is accountable to whom. Sustainability schemes such as the Roundtable on Sustainable Biomaterials (RSB)[31] can offer a

[31] Formally known as the Roundtable on Sustainable Biofuels, until January 2013. See www.rsb.org

framework for this through its auditing procedures, but auditing requirements vary between schemes (see IUCN NL Committee/WWF benchmarking study, forthcoming).

6. Degradation and restoration in the context of biofuel production

A difficulty of definition notwithstanding, it is apparent that many groups and sectors are increasingly targeting what they consider to be degraded lands as priority areas for landscape restoration or various kinds of development. One of the most prominent of these recently is the biofuel sector, which offers an opportunity to explore how the broader degradation and restoration issues raised in this paper apply in the context of such a potentially intensive agriculture land use.

6.1. Overview of the issue

More than 100 countries around the world have renewable energy policies in place. Within that, around 45 countries have specific policies or incentives for bioenergy and biofuels[32]. For example, the EU's Renewable Energy Directive (RED) and Fuel Quality Directives (FQD) are aimed at delivering a public good – the reduction of greenhouse gas emissions[33] – through a mix of incentives and the imposition of legally binding targets to encourage the substitution of fossil fuels with renewable energy sources, including biofuels. Specifically, the Directive 2009/28/EC on renewable energy sets ambitious targets for all Member States, such that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector. The Directive aims to ensure the use of sustainable biofuels only with several criteria relating to a net GHG saving as well as impacts on biodiversity and land use[34]. While biofuel policy is usually framed as energy issue, at its heart biofuel production is a land issue, bound up in the agricultural supply chain. Taking this logic further, where part of a broader sustainable energy and sustainable land use strategies, biofuel production could help to improve natural resource management and reduce poverty.[35]

The impacts of policies such as these may be wide-ranging and may sometimes be unintended. In the case of the EU, Member States cannot meet their biofuel targets through local production so at least a proportion of feedstock has to be sourced from elsewhere. The environmental and social impacts of different biofuels can be highly variable, depending on what is grown to produce the fuel, where it is grown and by whom, and what land-use is being displaced. A major source of biofuels for the EU and other markets is currently (and increasingly expected to come from) the humid tropics. These are primarily found in developing countries in need of rural development opportunities and often in areas of major importance for biodiversity.

There are already established processes that aim to proactively ensure that biofuel production is socially and environmentally sustainable, including sustainability criteria in policy (e.g. in the EU's biofuels policy in RED) and sustainability standards and certification schemes, such as the principles and criteria of the RSB.[36]

In addition to potential direct sustainability impacts, it has already become apparent that some targets, notably those for the proportion of biofuels in transport fuels, may not have the desired impact in reducing greenhouse gases because of the effects of indirect land-use changes. Many approaches

[32] See http://new.ren21.net/REN21Activities/GlobalStatusReport.aspx
[33] It is beyond the scope of this paper to assess the actual GHG mitigation potential of biofuels.
[34] See http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm
[35] IUCN was mandated by its Members at the 4th World Conservation Congress in Barcelona, 2008, through resolution 4.082 Sustainable biomass-based energy "to continue to support efforts to develop sustainable biofuels that conserve biodiversity, bring significant benefits to climate-change mitigation and adaptation, and contribute to social development objectives (especially benefiting the rural poor, women and indigenous peoples".
[36] See http://rsb.org/sustainability/rsb-sustainability-standards/

have been proposed to measure and manage this effect[37]. One approach to reduce the risk of causing this phenomenon through direct action on the ground is to direct investments towards degraded lands. This has been proposed in a number of scientific studies, most recently in the US[38]. Targeting "unused land" (used as a synonym for degraded land) is also one of the approaches to qualify as a "low indirect impact biofuel" (see LIIB, 2012).

6.2. Learning from experiences to date

Experience to date for targeting biofuel production has generally been negative where there is an inherent assumption with those deciding on a change in land use for biofuel production that degraded land has unused or unproductive and therefore biofuel production (or any other development) is better than nothing. There are many cases where governments have allocated so-called marginal or wastelands for biofuel production, from India and China (Plieninger et al, 2011) to Ethiopia (Gaia Foundation, 2008).

However, because of such cases where land has been appropriated under the guise of being "degraded" or "wasteland", there is a danger that the biofuel market loses credibility and social acceptability, and ultimately a license to operate. In this context, an opportunity would be lost of directing investments for biofuel production in lands that are generally viewed as being used sub-optimally, where there is an opportunity for restoration and sustainable land use.

To start with, it should be acknowledged by biofuel decision makers that are targeting degraded lands that it is highly likely that pretty much all land in the world is used (potentially sub-optimally) to some extent at some time by communities[39]. This assertion was demonstrated in a recent case study as part of the development of the "low indirect impact biofuels" certification module in the RSB. The methodology was tested in Mozambique to explore potential production on unused lands, finding very few such lands, particularly lands that could be audited as such[40]. This finding reinforces the point made in section 5.4 that the framing and starting point is important. In such cases, where land has been appropriated, it has led to the displacement of communities and arguably increasing the overall land use (i.e. indirect land use change). The Mozambique case is a real representation of issues already set out within this paper, of targeting degraded lands without taking into account a due process to gauge the local context.

Secondly, biofuel decision makers need to recognise that while it may seem better to maximise biofuel economic value from a site. In reality, it is more effective from an environmental and social (and therefore a long term economic) perspective to view biofuel production as one potential facet of an integrated approach to land-use in multi-functional landscapes. This has been demonstrated in others sectors, such as for REDD, where it has been shown that the best way to maximise social and environmental and therefore economic benefits is not to focus on a single issue such as carbon.

The nature of multiple rather than single benefits is echoed at the farm level (where in reality the majority of impacts – positive and negative – occur) where a farmer is rarely a "biofuel" famer but one who may in one crop rotation produce feedstock that could be used as food, feed and/or fuel (e.g. soy) and in the next rotation, a fibre crop such as cotton. Put simply, the important questions should

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[37] For example, see Biofuels and indirect land use change: the case for mitigation (Ernst & Young, 2011), which identifies a range of ILUC mitigation practices and recommends a market mechanism to encourage such activities through the use of a carbon credit scheme. This study demonstrates that there are a range of activities that, through incentives, could be proactively encouraged to prevent or reduce the risks of ILUC occurring in the first place. http://www.iucn.org/dbtw-wpd/edocs/2011-045.pdf .

[38] Gelfand, I. et al. (2013), Sustainable bioenergy production from marginal lands in the US Midwest, Nature, 2013/01/16/advance online publication, http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11811.html

[39] For case studies see Toulmin, C. & Quan, J. 2000. Evolving land rights, policy and tenure in Africa London, IIED; Wily, L. A. 2012a, Customary land tenure in the modern world. Rights to resources in crisis: reviewing the fate of customary tenure in Africa- Brief #1 of 5, Rights and Resources Initiative, Washington, D.C., 1.

[40] See LIIB (2012) for further discussion.

therefore not only be: “where can we grow our biofuels?” but also first asking: “might production of crops destined solely for biofuel markets be a sensible use of this land?” or “how might we optimise the benefits (environmentally and socially) to multiple stakeholders from crops which could be suitable for fuel, food, feed or fibre?”[41]

In some cases, biofuel production in itself could help improve the quality of degraded lands, such as through nitrogen fixing, stabilising soils by providing cover (which reduces erosion due to wind and rain), as well as some trial experiments where biofuel crops were grown on contaminated land to draw out pollutants. In other cases, the pressure to source biofuels from “lower risk” land could create an incentive to invest more substantively in restoring degraded lands. The premium for such action, while not likely to be paid through biofuel supply chains, could be covered through associated carbon sequestration linked to REDD (see Killeen et al, 2011).

This beneficial assessment is not a theoretical but is also echoed in experiences by a number of organisations that have looked at the potential for using degraded lands for biofuel production including in Indonesia (Gringold et al, 2012) and Brazil (LIIB, 2012). In all cases, identification of such areas depends on a multi-stakeholder process to understand trade-offs between different ecosystem goods and services. It still needs to be determined if there is a viable business case for such an approach, that is, one that directs biofuel production to landscapes that could benefit from increased investment.

In all cases, given poor agricultural practices are one of the drivers of degraded land in the first place, it is imperative that any new land management is sustainable in nature to reduce the risk of degrading the ecosystem again. In any event, continued monitoring is needed wherever biofuels are produced to determine their impacts on land and soil conditions and to determine if indirect land-use change is occurring.

Further, it is interesting to consider the impact of issues beyond the site level in the context of sustainability: natural resource governance and associated land use planning. They not only have implications for negotiations on trade-offs on ecosystem goods and services, but further than that, where policies are in place and enforced, it is easier and lower risk to do business. Similarly, it follows that compliance with sustainability due diligence processes is facilitated in jurisdictions that have comprehensive and participatory land-use planning procedures in place that are also effectively implemented. In the absence of such public policy procedures it can be more difficult and costly to implement sustainability standards, regardless of whether the land is degraded or not.

This risk of implementation difficulty and higher costs to an economic operator is exacerbated particularly where government capacity is limited, natural resource governance standards may be low and stakeholder involvement limited. The onus is then on the standard system and the implementing economic operator to address governance gaps in land-use planning processes (along with other environmental and social aspects)[42]. To be effective, such systems must be consistent with global norms to address social and environmental risks. In this regard, sustainability standards that are comprehensive and include multi-stakeholder consultation mechanisms can potentially help address these risks; however, not all sustainability schemes are equal in this regard.[43]

[41] See Bastos Lima (2012) for a discussion of the different impacts of different biofuel production regimes.
[42] It should be noted that voluntary standards cannot replace sound public policy development processes and regulatory requirements – they must build on, complement, and/or address policy/regulatory gaps.
[43] See forthcoming benchmarking study from WWF/IUCN NL Committee.

6.3. The role of biofuels in the context of landscape restoration – realising the vision

Restoration needs to accommodate, and work with, the reality of current land-use. Mosaic-type restoration activities allow for a mixture of land management and conservation planning. Figure 3 shows how this looks in practice. Such an approach could accommodate areas of intensive agricultural production to achieve economies of scale – though it follows that to have multiple-benefits, the whole landscape would not be comprised of plantations.

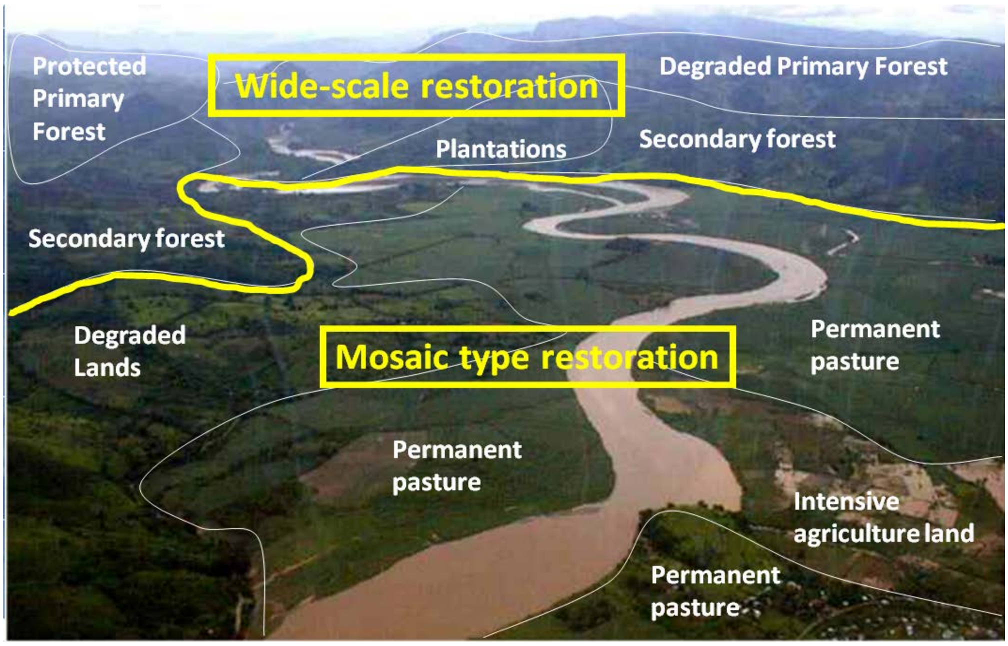

Figure 3: From *The Value and Importance of Forest Landscape Restoration*, IUCN presentation, 2013

From an economic perspective, high potential opportunities might be found in areas where the costs of bringing land back into production are relatively low, though often this might require investment in relevant infrastructure to improve market access. To asses true potential, we need to look beyond biophysical indicators to include broader socio-economic factors. This experience was mirrored in the WRI's work in Indonesia where different potentials for palm oil production where differentiated[44]. Here, they took into account economic considerations, in terms of whether the proposed land use change is feasible both technically (i.e. proximity to access roads) and financial (suggesting a minimum economically viable size of 5,000 hectares), coupled with legal (is that the land available) and social considerations, in terms of potential workforce. Interesting to note is that these issues broadly feature in the frameworks of many agricultural sustainability processes.

In short, it follows that governments should direct companies to invest in landscapes with the highest increase in potential in terms of increased goods and services, beyond the individual company, in the landscape. In such a model, there are implications at multiple levels and for all major stakeholder groups, who have differentiated responsibilities specifically with regard to degraded landscapes as part of a broader sustainable land use management[45]:

[44] While approximately only 5% of palm oil production goes towards the production of biodiesel, this case still presents an interesting case study in the context of biofuel production, particularly as in illustration that many crops are not market-specific but have multiple uses.
[45] The following points were one of the main outputs from the expert workshop held in IUCN in January 2013.

Operators and producers

Given the current difficulties around misappropriation of so-called degraded lands, an international economic operator can look to reduce their risk by aiming to operate in countries with supportive policy and strong natural resource governance processes. Where this may be lacking, caution is advised as such lands may be actively used, for settlements or grazing, for example and/or could also be areas of high conservation value (as found in the Mozambique case study (LIIB, 2012)). Participatory processes set out in credible certification programmes that have strong social engagement practices can help reduce this risk. In this way, an economic operator who can demonstrate that due process was followed could qualify for bonuses or incentives for contributing to the restoration of a genuinely degraded landscape thereby increasing value for local communities. Furthermore, an economic operator can improve their license to operate and potentially increase their access to financial capital (see later point on financial institutions).

More efforts should be made to engage rather than displace smallholder farmers, and to provide them with relevant training, etc. It is appreciated that more reflection is needed on how this can be done in practice. For example, the "Social Fuel Seal" in Brazil, which encourages companies to include at least 10% of their supply from smallholders, has only been taken up by 3 biodiesel companies as of January 2013.[46]

National governments in producer countries

Rather than focusing on allocation of degraded (or waste or marginal) lands, governments in producer countries should have open and transparent licensing and environmentally based land-planning systems that allow for a wide range of stakeholder input, as well as mechanisms for reporting on compliance. Guidelines for this are available from UN Energy Bioenergy Decision Support Tool[47]. While a national level process is unrealistic from a cost perspective, priority could be given to areas that have been zoned for economic development, such as SAGCOT in Tanzania[48].

With particular regard to issues around land tenure, it is advisable to follow the FAO Voluntary Guidelines on the Responsible Governance of Tenure[49], which serve as a reference and set out principles and internationally accepted standards that States can use when developing their own strategies, policies, legislation, programmes and activities. They allow governments, civil society, the private sector and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices.

Ideally, policies and incentives should be converged so that they are complementary and mutually enforcing, for example in Indonesia, where REDD and palm oil policies where aligned, or Brazil where agricultural and conservation policies go hand in hand. But even well crafted policy is useless if it is not enforced.

National governments in (biofuel) importing countries

Many biofuel importing countries are also major importers (and exporters) of other commodities and an important providers of development assistance, both bilaterally and multilaterally. By coordinating activities in these different sectors more effectively, importing countries could greatly enhance the benefits from interventions. As one example, development assistance could be provided to help countries increase their capacity to implement sustainability standards not just in the production of biofuels but also in other commodities; one aspect of this could be the development of a mechanism in low-capacity countries allowing approval of production as sustainable conditional on agreement of a timeline for full implementation of such standards.

[46] Personal communication during expert workshop, D. Lerda, 11 January, 2013.
[47] See http://www.un-energy.org/publications/1013-decision-support-tool-for-sustainable-bioenergy
[48] See http://www.sagcot.com/
[49] See http://www.fao.org/nr/tenure/voluntary-guidelines/en/

Assistance could also be given through provision of tools (maps, appropriate GIS technology) and training in techniques for multi-stakeholder land-use planning. For example, if framed well, the EU's Renewable Energy Directorates with their focus on reducing GHG emissions could contribute to a broader package to achieve sustainable land use management goals, given the associated carbon and community benefits linked to sustainable land use management.

Civil society

Civil society helps to ensure that cases where land is misappropriated under the guise of degraded land or similar terms are brought to the attention of broader groups. As best practice regarding tenure is improved, civil society can help to provide oversight to identify genuine opportunities for restoring multi-functional landscapes, which may or may not include biofuel crop opportunities. Where lands are allocated, civil society can engage in relevant participatory mapping exercises and, if necessary, dispute mechanisms of relevant commodity schemes.

Financial institutions

Building on the experiences of the Equator Principles[50] and the IFC's Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, financial institutions could chose to offer preferential investments in countries that have implemented sustainable land planning and have strong natural resource governance. Where financial institutions prioritise initiatives for production on degraded lands[51], it is important that whatever definition is used, it is flexible enough to allow for the local context and benefits to be taken into account.

7. Conclusions

7.1. Moving away from the term "degraded"

Degraded lands, and similar terms, are increasingly used in government policies, policies of financial institutions and the strategies of companies as a way to reduce perceived risks associated with particular forms of land use, such as agriculture (for food and fuel production), for landscape restoration, such as REDD. However, there have been several cases where assumptions have been made around the value or use of a land that was so called degraded or waste land, that have lead to the displacement of some communities being displaced and arguably increasing the overall land use (i.e. indirect land use change) and conflict.

We now have an opportunity to seize the potential that biofuel demand presents – to direct investments in degraded landscapes where there is an opportunity for sustainable land use and restoration. Indeed, where framed as part of broader sustainable energy and sustainable land use strategies, biofuel production could help to improve natural resource management and reduce poverty.

Unfortunately, the focus on degraded lands and its supposed antonyms does carry major risks. Degradation and "degraded" part of a whole suite of terms that are not neutral, they are value-laden and convey a belief the process should be halted or reversed or that the area in question could or should be improved.

We have seen that one over-arching definition of degraded lands is not possible in a meaningful or practical way. The use of degradation and degraded land in international policy are framed quite generally to be inclusive, yet as discussed, degradation is a complex issue. While general terminology is appropriate to guide international policy making, it rarely lends itself to being operationalised on the

[50] See http://www.equator-principles.com/

[51] For example, in 2011, the World Bank Group announced a strategy for prioritisting palm oil investments on degraded lands.

ground. While wide-ranging degradation maps are useful for communicating degradation issues and informing broader policy decisions, such maps are very limited in their support of more operational decision-making on the ground.

Ideally, the generalised terms degradation and degraded land should be avoided in technical or policy discussions; if their use proves unavoidable, users should specify the precise context in which they intend them to be applied, and should explain clearly what they understand by the terms.

Investing in lands that are being used sub-optimally as agreed through a multi-stakeholder approach, could be an alternative framework to drive investments in degraded landscapes and source sustainable biomass for a multitude of purposes.

It is clear that the answers to questions such as: where should biofuels be grown? or where should efforts aimed at forest restoration be focused? or what should be done to improve the livelihoods of smallholder farmers whose lands are declining in productivity? cannot be simply answered by responding 'on degraded lands', 'in degraded forests' and 'by reversing degradation'. Useful answers are clearly much more complex than this. In some cases concepts of degradation, even if not explicitly or precisely defined, may be helpful in contributing to the answers; in others they may be less so.

The notion that everything has an impact – sometimes predictable, sometimes unpredictable – on everything else may help us understand the world better but can lead to paralysis or, at least, excessive caution in trying to plan anything intended to have longer term benefits.

In reality, it is impossible to isolate the impacts of decisions made in one sector, such as biofuels, that have an impact on land-use from those made in other sectors. For example, as described earlier, at a farm level, a farmer is rarely a biofuel farmer but one who can produce multiple crops for a multitude of purposes. Nor is it practical when making land-use decisions to isolate one attribute or set of attributes of a particular area (e.g. how 'degraded' it might be, however that is defined) from others (e.g. tenure, biodiversity value, proximity to markets). Furthermore decisions that have a direct impact on one particular area will almost invariably have some kind of indirect impact elsewhere. This linkage is clearly manifested in the major importance now attached to assessing the impact of indirect land-use change (ILUC) in the implementation of the EU's renewable energy directive.

7.2. The changes needed at a landscape level

Crucial to this vision of investing in lands that are being used sub-optimally is the consideration of spatial scale: it is extremely difficult to manage individual sites so that all ecosystem services are delivered at their maximum potential, all stakeholders are fully satisfied and nothing that anyone would consider to be degradation is taking place. However, if planning and management are implemented at a larger, landscape level, then trade-offs between different uses and users become much more possible to negotiate. Similarly, if planning is carried out over longer time periods than is normally the case, ecological processes that operate on long timescales (decades or longer), such as soil formation and tree growth, can be better incorporated.

Given that the biosphere itself is a dynamic system with few fixed internal spatial boundaries and in a constant state of flux, both at spatial and temporal scales, the most useful framework for considering risk and opportunity in this context may be that of ecosystem services, considered at a broad landscape level. Such an approach introduces an important social value component and allows for discussions on trade-offs beyond a site level, and also allows for a mixture of land management and conservation planning. Such an analysis should take into account the needs and aspirations of all stakeholders and should be informed by notions of equity and likely longer-term consequences of any changes. In this context, a very low risk area would be one that is not known to be delivering significant ecosystem goods or services of any kind to any stakeholder group. Any change in land management that increases provision of overall goods or services could then be considered a beneficial change.

Of course, in reality, there may be relatively few such areas – that is, most land has some value for some stakeholders. Exceptions might be some hyperarid areas and heavily contaminated sites. Such areas may not be relevant to wider policy-making, as their potential for other uses is likely to be low (although hyperarid areas with low biodiversity and low human population densities may offer important potential for generation of solar energy, for example). More usually, any given area will deliver a mix of benefits to a range of beneficiaries. Changing land use will alter the mix of benefits and also the way that different stakeholders benefit. The challenge is to tease out these factors to allow trade-offs to be made explicit as the basis for negotiation between different stakeholder groups.

Not all degraded land is suitable for every proposed new land use. Therefore, to operationalise and be useful, the specific aspects of degradation that are important for a given land use need to be identified, as well as recognising that other factors can be important to local stakeholders.

In this context, the question of whether a particular area is degraded becomes less relevant. Rather the questions are "what goods and services is this area delivering now and to whom?"; "what goods and services could be delivered under different management regimes and to whom?" and "what loss of current goods and services (i.e. risk) might result from a change in management regime, and who would suffer as a consequence?" on the risk side. On the opportunity side, how can we optimise benefits across stakeholders?

Working together, and clearly delineating the different responsibilities of different actors, it should be possible, albeit challenging, to develop land-use plans that optimise social and environmental benefits. In such plans, whether an area of land is deemed to be degraded or not is likely to be of secondary importance to the decision of how to treat it in the present, and what agreed goals for its future state might be, where for example, biofuel markets are but one potential beneficiary.

7.3. Considerations for intensive agricultural land use, including biofuel production, in landscape restoration

Applying the recommendations in the earlier parts of the paper, the following considerations emerge that can be applied to biofuels as an example of a potentially intensives agriculture land use in the context of mosaic landscape restoration:

Considerations
Any use of so-called degraded land should:

- Specify the context, including the natural transition phase of the landscape
- Be assessed both at an individual site as well as within a landscape
- Be considered as part of a broader sustainable land use discussion, where multiple functions and benefits are considered
- Not cause further degradation within the broader landscape.

Ideally, rather than focus on degraded land:

- Identify lands with suitable potential for a given land use/restoration objective
- Use a range of biophysical indicator, socio-economic and legal indicators.
- Involve relevant government agencies and local communities, including those with land rights and land uses.

- Combine GIS data alongside participatory assessments to produce enhanced maps as a basis for decision-making.

7.4. Potential next steps

Overall, we want to use interest from the biofuel sector and other agricultural commodities in untapping potential of degraded lands as a driver for transparent, participatory land-use planning processes.

The next steps would be to explore examples of this multi-functional landscape planning in action, where biofuel markets are one of the drivers, and to see how this can be done in practice and scaled up to priority agricultural producer countries.

Firstly, a process needs to be designed to identify land with high potential for restoration to increase functionality and goods and services, in an economic, legally and socially sustainably way. This would involve building on the methodologies that were cited earlier, including that of WRI, WWF, and IUCN and other organisations that are active in this area.

Secondly, the development of guidance checklists and the development of ecosystem baselines in a standardised manner would be beneficial to the promotion of valuing land and land use change.

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Annex 1. Existing definitions of degradation and degraded in international use

The terms degradation and degraded are already well embedded in a range of international treaties, other agreements and guidelines. The following section presents some of the most important of these and examines the implications of the definitions used in the light of the theoretical discussion set out above.

The Global Environment Facility defines **Land degradation** as: *"Any form of deterioration of the natural potential of land that affects ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience."*[52]

This definition uses five terms: 'natural potential', 'ecosystem integrity', 'sustainable ecological productivity', 'native biological richness' and 'maintenance of resilience'. Each of these embodies complex notions, most addressed in the foregoing discussion, that are themselves open to different interpretations and mostly difficult to quantify. Of these, the most straightforward to characterise, in theory, at least, is 'native biological richness', although even this cannot be reduced to a single metric and in practice is difficult to measure on the ground. The relationship between the different terms – for example native biological richness and maintenance of resilience – is also unclear.

The UN Convention to Combat Desertification (UNCCD) defines **Land degradation** as: *Reduction or loss, in [arid, semi-arid and dry sub-humid areas], of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation*[53]*;*

The essentials of this definition are: "reduction or loss of the biological or economic productivity and complexity of various kinds of land arising from various processes". This uses simpler terms than the GEF definition. It may be possible to reach wide agreement on meanings of and measures for some of them, notably biological productivity, biological complexity (a concept related to native biological richness in the GEF definition above) and economic productivity. However, the meaning of economic complexity is less clear.

It is also not clear how these different terms relate to each other and to the overall definition. Does a decline in biological complexity indicate degradation if it is accompanied by an increase in economic productivity? The causal factors cited emphasise human influences but the definition is not confined to them and the examples raise further questions (e.g. are all forms of soil erosion necessarily land degradation; what is specifically meant by 'deterioration' of soil properties; and if natural vegetation is replaced by some other land cover is this degradation?).

The Global Assessment of Land Degradation and Improvement (Bai *et al.* 2008) defined **Land degradation** as "*A long-term decline in ecosystem function and measured in terms of net primary productivity."* [54]

This study looked at long-term (30 year) trends in net primary productivity (NPP) as assessed by remote sensing as a first-order method of identifying areas of the world where degradation might be taking place. The authors explicitly noted that NPP could change for reasons other than (their

[52] GEF Land Degradation Strategy at: http://www.thegef.org/gef/node/1304
[53] UNCCD Article 1: *use of terms.*
[54] Bai *et al. (*2008)

understanding of) degradation and that degradation could take place without large changes in NPP (for example in low productivity arid and hyperarid environments). Their definition of degradation is a very general one, and clearly is not intended to be used as the basis for decision-making.

A definition of **Forest degradation** has been proposed but not adopted in the consideration of REDD+ under the UN Framework Convention on Climate Change as follows: *A direct human-induced long-term loss [persisting for X years or more] of at least Y % of forest carbon stocks [and forest values] since time T and not qualifying as deforestation or an elected activity under Article 3.4 of the Kyoto Protocol*.[55]

This is an attempt at a highly specific, quantified definition of forest degradation for a specific purpose, similar in this sense to that sought under the EU Renewable Energy Directive: essentially it aims to define areas that would become eligible for funding were REDD+ to become formalised as financial mechanism. The wording in square brackets has not been agreed on nor have values for Y and T. A definition that takes into account "forest values" other than forest carbon stocks would be very different from one that does not, and would require agreement as to what those values were and how they could be quantified. It is notable that agreement cannot be reached on values for Y and T above even in the relatively simple matter of forest carbon stocks.

The Subsidiary Body on Scientific, Technical and Technological Affairs (SBSTTA) of the Convention on Biological Diversity has defined **Degraded forest** as *"a secondary forest that has lost, through human activities, the structure, function, species composition or productivity normally associated with a natural forest type expected on that site. Hence, a degraded forest delivers a reduced supply of goods and services from the given site and maintains only limited biological diversity. Biological diversity of degraded forests includes many non-tree components, which may dominate in the under canopy vegetation".*[56]

This definition uses a number of terms or concepts that are themselves not well defined, including 'secondary forest', 'function', 'natural forest type', 'goods and services'. It also refers to loss, normally taken to mean the absence of something, when in this case it seems much more likely that 'reduction' or 'change' is what is meant. The reference to 'limited biological diversity' implies but does not state explicitly that this diversity is less than that 'normally associated with a natural forest expected on that site'. The subsidiary observation has little explanatory value: forests of all kinds may have many non-tree components which may dominate in the under-canopy vegetation.

The International Timber Trade Organisation defined **Degraded forest** as "f*orest that delivers a reduced supply of goods and services from a given site and maintains only limited biological diversity. It has lost the structure, function, species composition and /or productivity normally associated with the natural forest type expected at that site."*[57]

This is simplified version of the SBSTTA definition, which no longer refers to human activities as the cause of degradation, nor to secondary forest, but still refers to 'goods and services,' 'function', and 'natural forest type.'

ITTO further defines **Degraded forest land** as "f*ormer forest land severely damaged by the excessive harvesting of wood and/or non-wood forest products, poor management, repeated fire, grazing or other disturbances or land-uses that damage soil and vegetation to a degree that inhibits or severely delays the re-establishment of forest after abandonment.*[58]

[55] Lund (2009); Mollicone and Souza (2007); Sasaki and Putz (2009); Schoene *et al.* (2007)
[56] UNEP/CBD/SBSTTA (2001*)*
[57] ITTO (2002)
[58] ITTO (2002)

This definition is a description of a particular scenario (former forest land that is subsequently 'abandoned') and uses terms such as 'severely damaged', 'poor management', and 'damage' (to soil and vegetation), which would need to be further defined were this definition to be made operational.

The Bonn Challenge has defined **degradation** in the context of **forests** as "a *process that reduces the volume and canopy cover of trees across a landscape. Degradation leads to reduced biomass, reduced biodiversity, and a reduction in the ecosystem services provided by forests*."[59]

The first part of this defines forest degradation in relatively simple terms as a description of a change in forest structure that is in some of the biophysical properties as outlined in section 3.1. The second part is more ambiguous. It is not clear whether it is assumed that reductions in volume and canopy cover of trees across a landscape have these consequences, or whether degradation is taken to be those reductions in volume and canopy cover that also have these consequences. The subsidiary part of this definition uses terms (biodiversity and ecosystem services), which, as discussed above are themselves difficult to define precisely and very difficult to quantify.

[59] See http://www.iucn.org/?uNewsID=8147

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