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Review

Forest Degradation: When Is a Forest Degraded?

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Abstract: The concept of forest degradation tends to be addressed in broad terms, and existing definitions are difficult to apply in practice. These definitions are based on a reduction in the production of ecosystem goods and services, but fail to address how, when and to what degree this reduction—which ultimately leads to degradation of a forest—occurs. Generally speaking, degradation is the result of a progressive decline in the structure, composition and functions upon which the vigor and RESILIENCE of a forest is based. A degraded forest is one whose structure, function, species composition, or productivity have been severely modified or permanently lost as a result of damaging human activities. So far, no guidelines have been developed for classification and evaluation of a degraded forest at the stand level, nor are there methodologies for assessing the degree of degradation found. The present work proposes stand-level guidelines for identification of a degraded forest according to a list of structural, compositional and regeneration criteria and characteristics. Emphasis is put on the need for local definitions of forest degradation, and identification of thresholds that determine the points where the processes of degradation finalize into degraded forests. Finally, the present work makes a call to move forwards in sustainable management in order to prevent degradation, and in implementation of restoration or rehabilitation practices in degraded forests.

Keywords: disturbances; selective logging; cattle grazing; conservation; degradation process; rehabilitation

1. Introduction

A degraded forest is the result of a process of degradation which negatively affects the structural and functional characteristics of that forest. Forest degradation occurs as a result of human activities, which in turn are driven by a variety of macroeconomic, demographic, technological, institutional and political factors [1,2]. This process may take place over a long period and only become evident gradually [3], implying that the forest degrades over time [1,4–6]. In the majority of cases, the process involves a reduction in biomass and changes to the structure and species composition (biodiversity) of the forest, as well as in its natural regeneration. These changes in the system's biotic components may also lead to alterations in soil and water, and in the interactions between these components, ultimately affecting forest functioning and diminishing the provision of ecosystem goods and services [4,7–9]. Thus, forest degradation refers to situations involving long-term and severe environmental changes, and does not cover short-term changes or variability such as those associated with forest management for silvicultural purposes [6,10].

The primary causes of forest degradation are unsustainable exploitation (in the form of excessive harvesting of forest products), overgrazing, wildfires, and the spread of invasive species or pests [11–16]. Hosonuma et al. [14] analyze the direct drivers of degradation in 46 developing countries, and show that the main causes are harvesting for timber (52%), harvesting for firewood and charcoal (31%), uncontrolled forest fires (9%), and grazing (7%). Considering this variety of drivers, the process of degradation can be rapid, or may occur more slowly, such as the selective harvesting of the best trees in a forest, which may be conducted in few or through several occasions [1].

It is estimated that more than 2000 million hectares of the world's forest have been degraded [2,8]. As a result, forest degradation is recognized globally as a serious environmental, social and economic problem [1,10,17]. The effects of forest degradation are harmful both to the ecosystems themselves and to society, as they have the potential to negatively affect millions of people who depend—wholly or partially—on the goods and services that forests generate on a local, regional or global scale [10].

Given the manifold negative effects and impacts of forest degradation, the concepts of degraded forest and forest degradation have been defined from a variety of perspectives, in accordance with the interests and objectives of the various programs, international conventions and global policies that address biodiversity, climate change and forest management [6,8,10,17,18].

There are currently more than 50 definitions of the concepts of degraded forest and forest degradation [1,19], with emphasis ranging from soil degradation [20] to, more recently, loss of carbon stock and mitigation of climate change [8,21,22]. A central aim of international negotiations and discussions surrounding forest degradation has therefore been to reach a consensus on these definitions [23–25]. International audiences continue to use the generic definition of "forest degradation" from FAO [26]: "the reduction in the capacity of a forest to provide goods and services". This definition is used to compare and monitor statistics across multiple countries, but does not include aspects such as a reference state or different degrees of degradation. As a consequence, Ghazoul et al. [27] state that interpreting degradation as a loss of attributes or functions, although intuitive, is not sufficient to establish the degree of degradation of a forest.

Overall, it continues to be extremely difficult to establish a clear and practical definition of a degraded forest. This is in part due to the inherent level of uncertainty surrounding the degradation process but also stems from the high degree of variability in the capacity of forests to recover to their original, undisturbed state (i.e., resilience). Sasaki and Putz [3] claim that given the need to reach agreements to address the challenges posed by climate change, the definition of forest degradation should take into account the full range of biophysical and social conditions under which forests develop, and the variety of ways in which they can degrade. This effort should be accompanied by parameters that may be easily monitored [6]. In short, reversing forest degradation is a global challenge, but one which requires local answers, and therefore operational definitions. However, there are as yet no widely approved operational methods to guide assessment of whether or not a forest is in a state of degradation.

Once a consensus has been reached on the definition of a degraded forest, it will become clear that such a forest must be treated differently to a deforested area, and indeed to a non-degraded forest in which proven silviculture practices may be applied. The ability to identify a degraded forest is the first step towards development of silvicultural approaches and techniques to restore forest cover and structure, as well as species composition and the forest's own capacity for regeneration. It will also form the practical foundation on which to establish systems for monitoring forest degradation and the restoration of degraded forests [25].

The objective of the present work is to develop a conceptual framework for the evaluation and categorization of a forest as degraded. This contribution is based upon a review and discussion of literature concerning the degradation process which gives rise to this state.

2. Loss of Resilience and the Degradation of Forests

Changes within a forest are associated with autogenic alterations or disturbances, such as treefalls, or allogenic disturbances, for example landslides or windstorms [28,29]. Forests are highly dynamic ecosystems which, with the exception of allogenic disturbances, naturally undergo small-scale changes in their composition, structure and function. These fluctuations occur within certain relatively constant limits that are maintained by the forest ecosystem, and the forest remains in a stable state [30]. Certain types of disturbance may shift an ecosystem from its stable state to one of instability, but provided these disturbances do not occur frequently, the forest will tend to return to its original stable state through succession [27]. If an ecosystem suffers disturbances such as these, and reacts to them by regulating the variation of its structure and ecological processes, its capacity to maintain a dynamic equilibrium will enable it to return to a stable state [31].

As a rule, the forests of a given region will react appropriately according to the intensity and frequency of the local disturbances with which they have evolved. In doing so, they will potentially pass through multiple stable states depending on the region's natural dynamics [32–34], and respond in different ways to disturbances according to their capacity to cope with the severity of the change.

Ecosystems subject to their natural disturbance regimes are constantly changing, resulting in inherent ecosystem variation over time [18]. Minor changes (autogenic disturbances) and major stand-replacing changes (allogenic disturbances) both result in an ecosystem that cannot be considered a degraded forest. Even forests which suffer a permanent change in species composition, but whose functionality and resilience remain unaffected, are said to be impoverished rather than degraded. However, impoverished forests may degrade if they experience a continuous loss of species—or of functionally important species—as this may increase the ecosystem's vulnerability to future disturbances [27]. By contrast, human-induced disturbances of excessive intensity or frequency may force a forest into a degraded state [35,36] from which transition back to stability is unlikely to be possible.

There is, therefore, a tipping point or ecological threshold (Figure 1) at which the process of degradation becomes irreversible. Beyond this point, the forest is considered degraded [18,26,37] due to the loss of resilience or capacity to recover to a given state following the disturbance or disturbances which triggered the degradation process [34,38,39]. This tipping point represents a critical cut-off in terms of the stability of the forest, i.e., its capacity to maintain a dynamic equilibrium over time, and to resist change to a different state [40]. Once this ecological threshold has been crossed, the forest may become unstable, moving to another stable state from which it is no longer able to completely recover the composition, structure and functions of its original state [36,41,42]. A forest degrades when it enters a state of arrested succession as a result of human activity, in which the ecological processes associated with the dynamics of the forest are reduced or severely limited [32]. Such ecosystems continue to be forests, but the natural recovery process is halted [3,13,43].

An ecosystem may reach its tipping point rapidly, or indeed gradually due to a chronic transformation that consumes its resilience, as is the case with gradual species die-off [18,42]. Human activity may force a forest past the tipping point or ecological threshold, causing a change in the ecosystem (e.g., changes in production and in the dominant species composition of the ecosystem) which may exacerbate other natural disturbances such as mortality resulting from disease or insect attack [36]. Once the tipping point is reached, the forest has become considerably altered from its original stable state. The time elapsed between the original pressures that triggered the changes and the manifestation of these changes may be highly variable [44].

Examples of degradation induced by human activity can be found in forests that have been subject to selective extraction of the most merchantable individuals from commercially valuable species, known as high grading. This process reduces the diversity of tree species, in turn affecting the wildlife which depend on them for food and shelter. This may also result in the disappearance or reduction in number of seed-dispersal agents, therefore complicating the regeneration process [45]. Furthermore, if this type of exploitation is accompanied by cattle grazing within the forest, the situation becomes more severe. The intensity of disturbances to the ecosystem is increased, and the loss of ecosystem resilience may be more rapid [46]. The combined impact of these human activities alters the biodiversity of species and the composition of the forest, and may have a synergistic effect on communities, ecosystem functions [47–49], and the productive capacity of the forest [6,42,50].

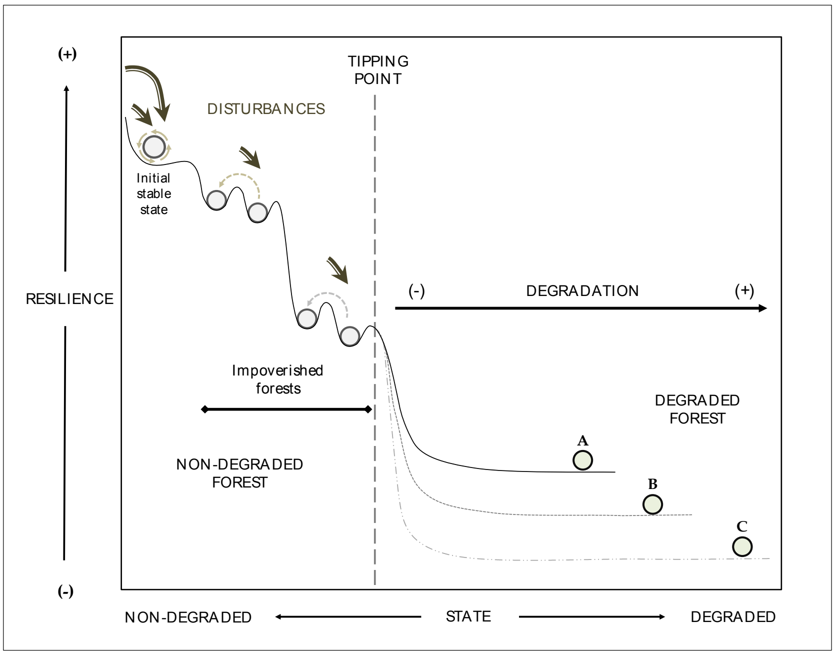

Figure 1. Theoretical illustration of the "tipping point" or "ecological threshold" at which a forest becomes degraded. A forest subjected to pressures—either small but sustained, or brief but highly intense—will at some point lose its capacity to recover. The state of the degraded forest is presented as a degradation gradient, depending on whether the changes to the structural and functional characteristics of the forest were partial or total. The degraded forest may be in an alternative stable state if the changes to composition and structure are stable and the system is simply unable, by itself and in the short term, to return to its original stable state. Examples of different states of degradation are state A, low degradation; state B, medium degradation; and state C, high degradation (modified of diagrams originally formulated by [37,51]).

3. What is a Degraded Forest?

Conceptually, "degraded forest" is a generic term that can be applied to all forests that have been altered beyond the normal effects of natural processes, through unsustainable use [52]. These normal effects refer to those expected under the forest dynamics of the system, either natural or following sustainable management [29,40]. In a degraded forest, the initial forest cover has been affected mainly due to unsustainable exploitation of timber and/or non-timber forest products, to the extent that its structure, processes, functions and dynamics have been altered, and the forest's capacity to recover completely from this exploitation in the short or medium term is compromised. Degraded forests provide a reduced output of products and services for a given area, and a limited degree of biological diversity [1,52].

In practice, the state of a stand is determined according to its dominant floristic composition and structure, including height, strata and density. Thus, a stand which at one point was dominated by a group of species, and as a result of human-induced disturbances changed its state and processes (e.g., regeneration, growth rates, mortality, decomposition), becomes a different type of ecosystem to that expected at that site in any of its successional states [40,44]. These changes derive into a degraded forest if they include at least several characteristics such as loss of the main canopy, dominance of competitive species, loss of functional groups, spread of generalist and invasive species, a generally impoverished biota [35], and a reduction in the source of propagules from the original vegetation. The latter is the most critical for degraded forests, as the capacity of these tree species to regenerate following a disturbance is reduced [8]. A significant reduction in the population of given tree species may trigger the loss of other associated species (e.g., lichens [53]), and a reduction in the provision of specific goods and services (e.g., [54]).

Forests can be considered partially or severely degraded, depending on the degree to which the structural and compositional characteristics of the forest have been modified, the processes that have been affected, and the frequency and intensity of the human-induced impacts. Slightly degraded forests are those suffering only minor changes in structure and composition, but which are nonetheless sufficiently severe to diminish the regeneration capacity of some key functional species due to lack of seed sources or problems relating to successful development of seedlings (e.g., cattle grazing). At the other end of the scale, some forests may have been severely degraded, with competitive shrub and tree species (native or invasive) growing significantly in importance, to the extent that they hinder natural regeneration and result in a state of arrested succession. In the most extreme cases of degradation, changes may occur not only in the biotic environment, but also in the physical environment, such as the soil [1,4,27]. In all cases, the forest regeneration process may be highly indicative of the degree of degradation. The size and diversity of seed banks, shoots and seedlings are inversely proportional to the degree of alteration that the forest has experienced. In other words, as change becomes more serious or frequent, so the reduction in abundance and diversity of sources of propagules becomes greater. In many cases, these sources may be lost completely, creating a major barrier to the regeneration process [55,56].

4. Key Considerations in the Evaluation of Forest Degradation

There are three key elements involved in the evaluation of forest degradation: a reference forest, degradation indicators, and a threshold value to determine the point at which a non-degraded forest becomes a degraded forest.

4.1. Reference Forests

A reference or baseline may be used in the evaluation of degradation, derived from a comparison either with a previous state [1,10,22] or with a point of reference (i.e., contemporaneous reference condition [6]). In each case, the reference contexts must be taken from forests located within the same edaphoclimatic zone and biome type, and be free from significant human-induced disturbances [57]. The first case is similar to the study of deforestation, where forest cover present at the end of the evaluation period is compared to that existing at the beginning of the period [1]; however, it is difficult in many regions to obtain data relevant to a given forest during a prior period, or before the occurrence of any human impact [22]. In the case of comparison against a point of reference, the challenge is to define, identify and measure the state of the non-degraded forest [6,22]. The reference states must represent non-degraded forests with biophysical characteristics that are comparable to the forest being evaluated (i.e., local reference point [22]). These reference forests provide a scale against which to measure the possible degradation of a forest at a local level, or the degree of degradation over time [6,22,24].

In practice, establishing a point of reference is not a straightforward task, as there is always inherent natural variation in forests over space and time [58]. However, the range of variation of a given type of forest provides a level of reference against which to evaluate degradation, and is a prerequisite for measurement of the same [6,10]. Thus, unmanaged primary or old-growth forests may provide a baseline for measuring degradation, even at different stages of succession [10,17,40,59], and a sustainably managed natural forest may also provide a useful reference.

4.2. Degradation Indicators

Multiple indicators are monitored as part of the evaluation of degradation [1,6,19,22], allowing for a comparison of forests and a study of the changes in their structure, composition and regeneration. They must also be capable of expressing degradation in different types of forest [1,10]. Chazdon [60] states that the majority of studies employ indicators that represent rapid and easily-measured changes that take place following a human-induced disturbance, such as structural variables (e.g., [61]). FAO [10] proposes guidelines for degradation assessments which focus on measurement of biophysical and biological effects, and, in some cases, on the direct causes of the degradation. FAO also advocates the use of certain key indicators, for example, stand volume, biomass stock, state and diversity of the ecosystem, functional and invasive species, and lack of or insufficient density of individuals, juveniles and seed trees from commercial species. Similarly, Thompson et al. [6] propose a set of indicators to quantify types of forest degradation according to specific management situations and objectives, including growing stock, ecosystem state, tree species composition, invasive species, tree density, and relative abundance of high wood-density tree species. They claim that stand-level measurements are necessary to evaluate degradation at the local level, but that the indicators are also applicable to larger forest units, and even at the national level. Stanturf et al. [8] propose grouping indicators according to the forest attributes that have been affected by degradation. These include loss of canopy cover, reduction in structural complexity, reduction in growth, increase in mortality, decline in biodiversity (e.g., loss of species of interest, spread of invasive species), diminished protection functions (e.g., soil loss), and diminished production functions (e.g., decline of commercial species, and lack of regeneration).

If the evaluation approach requires categorization of a degraded forest, the integrated Forest Degradation Index (FDI) put forward by Modica et al. [9] is applicable at the stand level, and based on six indicators: Structural index (which measures stratification of trees, i.e., their vertical distribution), canopy cover, natural regeneration density, focal species of degradation (i.e., typical associated species; functional species whose loss results in progressive changes to the forest, affecting a number of other species in turn), coarse woody debris (i.e., volume per hectare) and soil depth. By contrast with the above methodological approach, Ghazoul et al. [27] propose the use of indicators linked to functional forest processes, including variables such as shoot growth in woody plants, seed availability in soil seed banks, abundance of seedlings, and age structure of common species (compared to that expected based on the successional state of the forest and the regeneration strategy of the various species). These indicators provide information regarding forest recovery in response to disturbances, and through analysis of the seedling and young tree community, offer predictions as to the future dynamics of these forests.

4.3. Degradation Threshold

The degradation threshold is a value that marks the boundary between a non-degraded forest and a degraded forest, and may refer to structural variables or indicators of the forest, such as those mentioned above (Figure 2). Pragmatic criteria should be used to determine this threshold based on an understanding of the properties, patterns and processes of forest ecosystems [22]. However, identification of this value is complex and has rarely been attempted [62]. Tucker et al. [57] claim that quantitative measurements should be made of variables that describe the states of forests.

Thompson [18] suggests that the threshold could be a range of values, as some indicators—such as production of goods and services—fluctuate over time, and there is statistical uncertainty associated with insufficient understanding of forest functioning. On the other hand, the threshold could be established based on what would usually be expected in a non-degraded forest, whether unmanaged or sustainably managed [1,6].

Some works have been written that address these thresholds. Baland et al. [63] indicate that forest degradation has several dimensions that are difficult to represent in a single measure. However, they provide threshold values for several forest variables in the Indian Himalayas. Sasaki et al. [64] propose a critical degradation threshold at 10% of forest cover in tropical forests. This is similar to the threshold suggested by Bahamondez and Thompson [36], based on a stocking chart for the temperate forests of Chile. All things considered, literature concerning specific thresholds for forest ecosystems appears to be somewhat scarce.

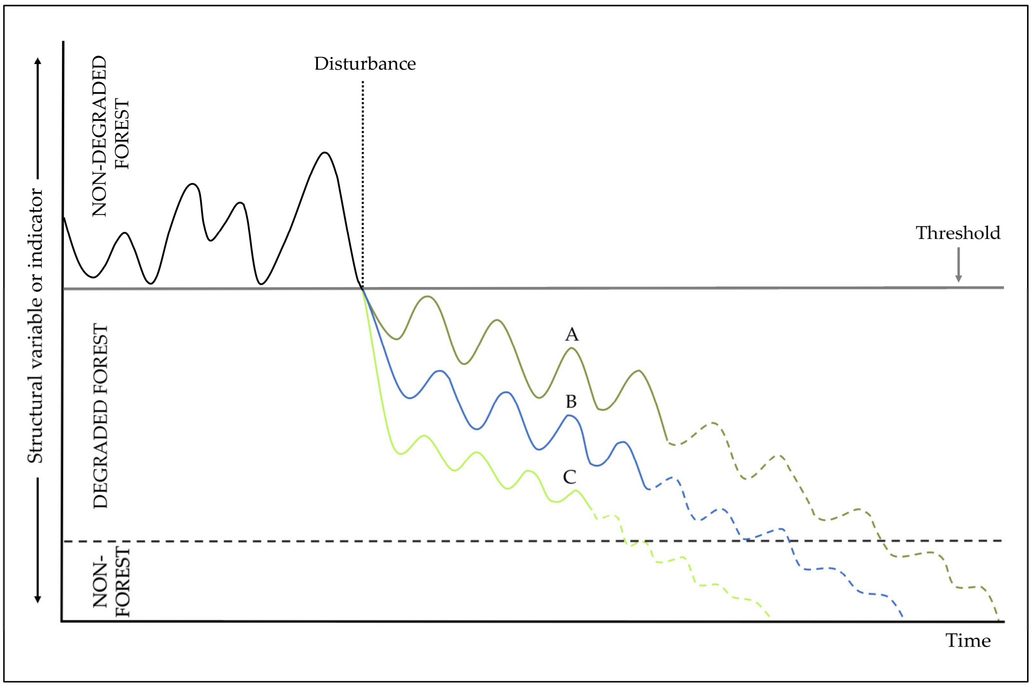

Figure 2. Example of variation in value of the indicator used to evaluate the degradation of a forest (e.g., forest cover, biomass, carbon stock). The upper left-hand side of the graph (above the threshold line) represents natural variation of an indicator in a non-degraded forest. The curves (below the threshold line) illustrate variation of an indicator in a forest subject to human-induced disturbances. Degradation occurs when the indicator value is consistently below an expected level, and the forest is considered to be degraded once it has exceeded the value attributed to the indicator(s) used in the degradation analysis. A, B and C represent different increasing levels of degradation of the forest (modified of diagrams originally formulated by [1,6,51]).

5. Principal Approaches to Identification of a Degraded Forest

All approaches to define forest degradation are linked to the loss of the main forest attributes, i.e., composition, structure and function [65]. We recommend three criteria for use in evaluation of the conditions under which a forest stand could be categorized as degraded: The structure, composition and regeneration of the forest (Table 1). These categories are crucial to the study of the state of an altered forest at any given moment in time, and help with the description and analysis of the forest's condition. They provide valuable information to forest managers, whose objectives are to strengthen the recovery capacity of degraded ecosystems, slow the degradation process, and improve the characteristics of their forests in terms of structure and function.

Based on these three criteria, a number of structural and compositional characteristics of forests subjected to damaging selective extraction—as reported by refs. [52,66,67]—and the guidelines proposed by Vásquez et al. [68], we have created a summary of the criteria and characteristics (Table 1) of a forest that has been altered by human activity. It is an initial framework for stand-level evaluation of whether a forest is genuinely degraded, or rather in a successional phase from which it will recover naturally.

Our approach is applicable to any forest affected by damaging human activity, and does not focus on specific thresholds. According to Ghazoul and Chazdon [69], the setting of thresholds to evaluate degradation is, in the majority of cases, an arbitrary decision taken by the interested parties, with forest biomass thresholds established in the context of changing land use potentially being very different to those thresholds determined to address loss of biodiversity.

In the case of forests affected by damaging human activity (e.g., high grading), the main structural characteristics of a degraded forest are low total basal area (e.g., 20 m^2 ha^{-1} [36]) [70]), high frequency of individuals in the pole and small tree diameter classes (i.e., diameter at breast height, DBH < 20 cm), low density of commercial species individuals with DBH > 65 cm [68], and low density of potential seed trees to establish a new cohort [71].

A reduction in canopy cover that identifies a forest as degraded will continue to occur until the deforestation threshold is reached [23]. The latter is the minimum canopy cover of a forest, defined according to the specific conditions of each region (ecozone), the type of forest, and the legal definition upheld by each country [24]. Sasaki et al. [64] propose a canopy cover of > 20% as the starting point for evaluation of degradation.

Changes in diameter distribution are characteristic of degraded forests. In the case of adult forests with a reverse- J diameter structure that are subjected to high grading, these differences may be significant (i.e., DBH ($\geq$5 cm, $\leq$260 cm)), with potential gaps in some diameter classes over DBH 60 cm, and a low frequency of individuals in the intermediate diameter classes [68]. This is most probably the result of forest interventions involving extraction of larger-diameter trees from commercial species, and the majority of highly degraded forests are composed of trees significantly below an established cut diameter (e.g., DBH < 60 cm) [64].

Degraded forests have low post-intervention stock [72,73]. Basal area reduces with degradation [54], and average basal area is lower than that of a non-degraded forest (e.g., [74]). Long-term total volume tends to be lower due to poor growth rates of residual trees [45], the volume of large individuals from the most valuable species is lower, and the volume of poor-quality trees or those from species of little commercial value is greater. If damaging human activities occur at regular intervals, forest stands may become severely degraded, especially if their stock of commercially low-value species is very low [75].

Composition of the residual forest is significantly affected, as the practice of high grading reduces the diversity of tree species, harming one or more main forest species [68,70,73]. This may eventually lead to the disappearance of certain species, and low Relative importance values (RIV) of the remaining original species found in a given type of forest [68], and the greater the degree of degradation, the more severe the decline in the number of tree species [54]. The result may be an exaggerated presence of non-commercial or secondary species to the detriment of principal forest species, and high density and coverage of competitive arborescent and/or shrub species [54,73]. In severely altered forests, where damaging selective extraction affects the composition and structure of the forest, the density and dominance of non-commercial and secondary species may reach disproportionally high levels (e.g., 90% of the total stand density) [68].

In terms of regeneration, altered forests are characterized by moderate to low levels—or indeed a complete absence—of tree species regeneration, and/or high levels of secondary, arborescent and non-commercial species regeneration, depending on the degree of degradation. Diversity of regeneration is linked to the presence or absence of adult seed trees and to the high coverage of competitive species in the understory. The presence of seed trees in degraded forests does not guarantee a successful process of seedling recruitment and seed harvesting [76], and in highly degraded forests, the density of seedlings of non-commercial and secondary species may represent as much as 80% of the total density of tree regeneration in the stand [68].

In summary, the structural and compositional characteristics of forests subjected to damaging human-induced alterations (with an absence of silvicultural criteria and objectives) of varying intensity and frequency become altered to a greater or lesser extent, as does the density and diversity of the tree species regenerating within the forest. In other words, stands eventually come to reflect the differing degrees of alteration that has taken place.

Table 1. Preliminary guidelines for recognition of a degraded forest: criteria and characteristics for categorization as degraded.

Criteria	Characteristics
Structure	Loss of canopy cover Change in diametric structure (low frequency of intermediate diameter classes, absence of some diameter classes, low density of larger-diameter commercial species) Reduction of growing and biomass stock (basal area and volume)
Composition	Loss of species (composition and biodiversity) High density and dominance of non-commercial or secondary species High density and coverage of competitive species
Regeneration	Very low or lack of tree species regeneration Abundant regeneration of non-commercial and arborescent species

Further and more detailed research is needed into the structural, compositional and regeneration criteria and characteristics put forward in the guidelines proposed in the present work, in order to identify a set of valid and adequate indicators to discern common patterns of degradation in forests, and thus establish a practical approach for description and analysis of a degraded forest. This research should be based on specific field studies, existing forest inventories, and permanent plots.

Finally, these criteria should be used to create an operational definition that details characteristics, measurements or observations of the forests (stands) under evaluation, establishing a practical means of identifying whether or not a forest is degraded.

6. Considerations for the Future

Forest degradation is increasing around the world, and the potential of these ecosystems to continue to provide an array of goods and services of both local and global importance is diminishing. Probably the least contested assertion with regard to the phenomenon is that there are many causes of forest degradation; however, the challenge of defining a degraded forest is far more complex. There is considerable motivation worldwide in reversing the process of forest degradation, at least among scientists and international organizations that focus on forests and biological conservation in general. While this is good news, the challenge is to sustain efforts to define degraded forests locally, and to act upon these definitions in order to restore their key attributes and take the important first step along the path to their recovery as providers of goods and services. This process involves identification of thresholds beyond which a forest can be said to be degraded, followed by the implementation of behaviors and measures that will contribute to the restoration or rehabilitation of these damaged forests. There is a fundamental and urgent need not only to drive the recovery of degraded forests through processes of sustainable forest management, but also to introduce responsible silvicultural practices in forests which are experiencing the process of degradation, but which have not yet crossed the threshold to become degraded.

The present-day reality of ongoing forest degradation, and the severe environmental, social and economic problems that come with it, present a number of challenges to be addressed by future research focusing on the structural, compositional and regeneration characteristics of degraded forests at the stand level, and on the target characteristics of these attributes that we seek to recover. While further research will continue to contribute to solutions, many issues of governance remain to be addressed before we can expect a major reversal of current trends in forest degradation. The research-implementation gap continues to be a major limitation to the achievement of large-scale solutions [77]. Local diagnosis and remedial approaches that consider the specific biophysical, social and political context will be important contributors to the global and urgent need to reverse forest degradation.

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