Defining Secondary and Degraded Forests in Central America

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Secondary forest in San Carlos, Costa Rica // CATIE

Introduction

The Forestry and Climate Change Fund ("FCCF") is an impact investment fund focused on providing capital for the management of secondary and degraded forests. FCCF's initial country focus is on Costa Rica, Nicaragua and Guatemala. FCCF and the associated technical assistance programme ("TAP") are supported by the Luxembourg Development Cooperation, Lux Dev and CATIE.

This paper defines secondary and degraded forests and hence establishes which types of forests are within the scope of FCCF's investments. This document serves as a basis for FCCF's investment decisions. It does not review the multiple definitions academics and practitioners have proposed. The definitions in this document have been refined through the field work undertaken within the framework of the TAP and it has been possible to clarify clearly, under which conditions the FCCF might invest. As an impact investment fund, FCCF pursues multiple objectives: financial returns alongside positive impacts in the environmental and social dimensions of sustainability.

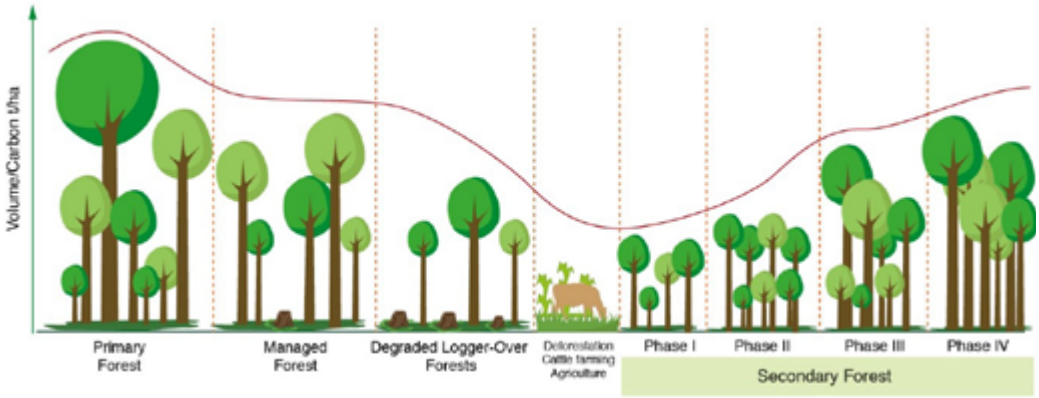
Forest Typologies and the Forest Transition Curve

Natural forests in the tropics have gone through a permanent transition for longer or shorter periods of time. Specialists have defined what is called the Forest Transition Curve (Figure 1), which includes the main phases through which a primary forest transforms from its initial stage until recovery back to a “primary or similar forest”.

The main driver for these transitions are changes in the land use and the natural succession process[1]. The path from one extreme to full recovery takes a long period of time. As an example, the forests impacted by the Mayan civilization in the border region between México, Guatemala and Belize took about 600 – 700 years to transition from agricultural land use to primary forest. Figure 1 illustrates the transition curve proposed by CIFOR and adapted by CATIE.

The terminology used by forest scientists and practitioners may vary for the different stages of degradation and later recovery and Figure 1 does not cover all possibilities. Yet it serves as basis to define the scope of the projects that will be considered for the secondary and degraded forests management initiative of FCCF.

FIGURE 1
THE FOREST TRANSITION CURVE FROM PRIMARY TO SECONDARY FOREST



Defining Secondary Forests

The deforestation for land use change and unsustainable forest exploitation process was the main driver of destruction of primary forests worldwide. Nowadays, secondary forests constitute a large and growing land use component of forest cover, and they have been an important source for the provision of a wide range of goods and ecosystem services. In fact, in the Forest Recourses Assessment Report 2015, the area of naturally regenerated forests amounts to 2337 million of ha globally and constitutes 58% of the overall global forest area. (FAO 2015).

There is considerable ambiguity with regard to the meaning of the term "secondary forest" which, despite its widespread usage, includes very different types of forests. Existing definitions or perceptions of secondary forests concentrate on three main points of contention: (1) whether the cause for the transition is human activity or natural disturbance, (2) the intensity of the disturbance, and (3) the nature of the vegetation development post disturbance.

The statistics of the FAO suggest that secondary forests are the dominant forest type of the planet. However, under the definition adopted in the present document it is likely to be more restrictive and not all the areas counted as naturally regenerated forest by the FAO qualify as secondary forests eligible for FCCF financing.

For the purposes of this paper the following definition has been adopted: *"Secondary forests are forests regenerating largely through natural processes after significant [or even total][2] human and/or natural disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites"* (Chokkalingam and de Jong, 2001).

The change in structure and species follows a successional process, and the time elapsed since the human or natural disturbance plays an important role. As Chazdon (2016) sustains[3]: "Regenerating (secondary) and restored forests are the nexus between conservation and development, between social and natural sciences".

Secondary forests are a great opportunity for initiatives like the Bonn Challenge since they represent restoration in action or even better, productive restoration. The conversion of degraded areas in naturally regenerated forests - assisted by proper management - constitutes an alternative to restore lands and forests. Well managed secondary forests are also important contributors to carbon sequestration and thus to REDD+.

In recent decades, forest conversion to pastures or agricultural fields, followed by land abandonment, has led to large areas of second-growth forest in the Amazon, Central America and many other tropical countries. These forests grow rapidly and sequester large amounts of carbon in their biomass, but they tend to be ignored, as most of the debate on the carbon balance of the Amazon basin tends to revolve around old-growth forests.

Chokkalingham et. al.[4] recognize a typology of secondary forests:

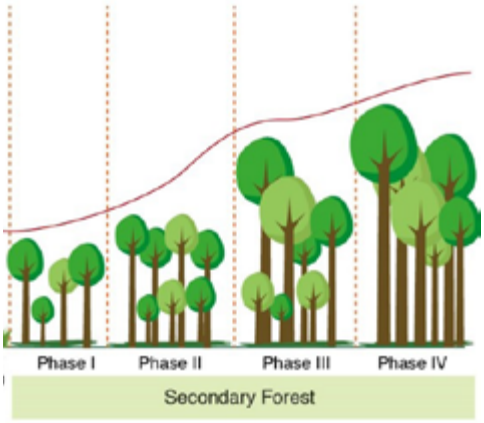
a) post-catastrophic secondary forests;
b) post-extraction secondary forests;
c) secondary forests after slash and burn agriculture;
d) post-abandonment secondary forests; and
e) rehabilitated secondary forests.

The types that best match the objective of the FCCF are of types c), d) and e) since a) and b) correspond to degraded logged- over forests and to forests disturbed by hurricanes covered by the definition for degraded forest. Table 1 illustrates the structural characteristics of forests with reference to the moment when a disturbance occurred.

Table 1 illustrates features in the succession of secondary forests that can be used to determine appropriate management systems for the forest. According to Ruiz (2007)[6] and Guariguata (2011)[7], the categories in Table 1 can also be translated into successional phases. It is also important to state that the variables of structural characteristics in lowland tropical forests are comparable to dry tropical lowland and semi- tropical highland forests.

Yet there are differences in the magnitudes of the variables according to life zones[8]: number of species, basal area, canopy structure, existence of vines, large logs, and large trees. The general picture is that in dry lowlands, most of these variables have lower values and rates, while in the highlands specially the growth rates and number of species are lower, with a trend to natural monocultures such as the Pine or Oak forests of Central America.

FIGURE 2
SUCCESSIONAL PHASES OF SECONDARY FORESTS



The succession in a secondary forest follows a process in the structure and the gremium of species, a pattern that is described below and is shown in Figure 1. We are using as an example the phases derived from a tropical moist forest from Costa Rica according to Finegan (1992, 1997)[9]. There are variations in the case of dry forests, especially in species compositions and the length of the phases. In the case of mountain forests the differences are mostly in the drastic reduction of species up to the extreme of natural monocultures (pine forests, oak forests in the highlands). Independently of the species in different ecosystems (humid, dry, mountain) the species change, but the gremiums not (tolerance to shade).

TABLE 1:
STRUCTURAL CHARACTERISTIC OF LOWLAND TROPICAL RAINFOREST AS A FUNCTION OF AGE SINCE DISTURBANCE (FROM CLARK 1996)[5]

Characteristic	Young secondary forest	Old secondary forest	Old – growth forest
Standal basal area	Lowest	Intermediate	Highest
Distributin of tree stem diameters	Lowest coefficient of variation (CV)	Intermediate CV	Highest CV
Canopy structure	Plain canopy, only a few gaps	Plain canopy, small gaps common	Variable canopy height, gaps more frequent
Lianas/epiphytes	Absent	Rare	Common
Large logs	Present or absent	Usually absent	Always present
Very large trees	Usually absent except as obvious remnants	Usually absent	Always present

Community managed forestry in the RAAN, Nicaragua // CATIE

Smallholder farmers cultivating corn adjacent to secondary forests in Osa, Costa Rica // CATIE

Phase I

FIGURE 3
(MOIST) TROPICAL LOWLAND SECONDARY FOREST IN PHASE I

Phase 1 begins in the first year or within the first years after abandonment. The recently abandoned crops or pastures are colonized by a dense growth of herbs, bushes and vines (e.g. Solanaceae, Pteridofitae, Gramineae). The Phase can last 3 to 5 years. If the regeneration includes valuable commercial species it is important to protect, maintain and clean around the spots of regeneration.

Phase II

FIGURE 4
PHASE II OF THE SECONDARY SUCCESSION WITH SCHIZOLOBIUM PARAHYBA AS DOMINANT SPECIES

Phase II can take from 3 to 15 years. Seedlings of pioneer, light demanding species of rapid growth and short life (ephemeral heliofitae) emerge fast and initiate the second phase. As an example and depending on the Life Zone, genuses such as Cecropia, Ochroma, Schizolobium will appear soon. This trees can form a continuous woody canopy in 3 to 5 years. When this occurs the canopy creates shade which triggers the disappearance of the species of the first phase. Phase II can take from 10 to 30 years, corresponding to the lifetime of the pioneering species of short duration that dominate widely during this phase.

In this phase liberation and refining thinning are necessary. The pioneer species can be harvested before they disappear. The shade under the canopy permit the regeneration of emerging new species, also with relatively short life span. This is also a moment to intervene in the secondary forest in the year 15, 20 or 30 depending on species that emerge in this stage. Figure 4 shows advanced regeneration of Schizolobium that can be removed in a commercial thinning, or even harvested totally while preserving seed trees for a second generation of the species, depending on its dominance.

Phase III

FIGURE 5
SECONDARY FOREST IN PHASE III WITH GOOD DENSITY

Phase III begins 10 to 30 years after the abandonment of the site. In this phase the Pioneer species of quick growth and short life are replaced in dominance by long living species (later Heliophitae). As an example species such as Cordia alliodora, Swietenia macrophylla, Cederella spp, Vochysia spp, Hampea spp, Goethalsia meiantha emerge. Phase III, like Phase II lasts (under natural conditions) as long as the dominant species and up to 75 – 150 years.

In this phase different types of interventions are possible. Commercial thinning need to be done, as well as final harvest of most of the species. Seed trees need to be preserved, as well as protected species. Figure 5 shows a phase III secondary forest, with good density and development, in this case in the absent of management.

Phase IV

FIGURE 6
A PHASE IV SECONDARY FOREST

The population of durable Heliofitase begins to disappear and the area is dominated by species that tolerate shade and that have a long life (Esciofitae), for example: Pentaclethra macroloba, Carapa guianensis, Hirtella triandra, Hieronyma spp, Miconias, Eugenias, Zanthoxylum …

The Esciofitae will dominate the area until a new drastic perturbation happens which renews the successional process. If there is no further perturbation the Forest will continue its development until it takes the form of a primary forest with esciofitae species in the upper canopy of the Forest[10 11].

In Phase IV the harvest cycle can happen between 40 and 60 years depending on the species targeted, the total area of the management unit and the general distribution of the different phases. The structure of the forest will adopt an uneven aged format, or an even aged format (by age classes) depending on the management method (target species mix, dimensions, products).

Special case of Pine forests

FIGURE 7
THE FOUR PHASES OF A SECONDARY PINE FOREST

One of the ecosystems that presents a special case in the management of secondary forest are the pines. Pine forests grow almost as a natural monoculture. Many silvicultural activities can take place in such forests, including natural regeneration through seed trees, enrichment, pruning, non-commercial thinning, commercial thinning, and final harvest with preservation of seed trees.

Special interventions need to be made for the prevention of forest fires, the control of cattle during the regeneration and first phase period and the prevention and control of pests and diseases. Similar to pine forests, other natural monocultures include mangroves, Carapa- and Pine-Oak forests.

Secondary forest in the buffer zone next to the Mayan Biosphere Reserve in Petén, Guatemala // LMDF

Conclusion

The description of the four phases is only one example of the many configurations that are present depending on the ecological zone and the human interventions in the forest. It is clear that each ecosystem is different, but on average successional phases are similar with variation in time frames, species, behavior of the forest areas, as well as the type of species and the length of the phases. Yet all forest types will - in general - follow a similar successional pattern. This includes, in all ecological zones, the transition from Ephemeral Heliofitaea (Phase I) to Late Heliofitae and Esciofitae (Phase IV).

Finally, the management system needs to be adapted to the specific ecosystem and life zone as well as the local context (the “economic” and the “social” system). Examples range from a short cycle forest management of ephemeral species focused on final harvest with preservation of seed trees, to a conversion of the forest to an uneven aged forest. The interventions can vary from low frequency harvest interventions, to more frequent and higher volume interventions.

However, the type and method for the interventions must be in agreement to the criteria of the Forest Stewardship Council (“FSC”), national regulations and scientific evidence regarding the biophysical variables such as growth capacity of the different species, soil condition, slopes and other variables. These variables will drive the decision whether to opt for selective harvesting (polycyclic), multiple monocyclic interventions by species groups, or one monocyclic harvest with preservation of seed trees. In all cases, protected species and areas remain untouched.

Defining Degraded Forests

Logged–over or degraded forests are a very important type of intervened system. It is a forest type in which most or all of the commercial timber has been removed (Soil Conserv. Soc. Amer. 1970)[12]. The extraction in general is done through "conventional logging", without applying the principles of reduced impact logging and the harvest exceeds the natural growth capacity of the system. Such forests can be restored in ways similar to secondary forests by trying to maintain and restore productivity over time. There is no lack of technical methods to achieving this goal[13], in particular with regards to the economic potential of forest management.

Logged-over forests may be in a wide range of conditions according to the degree of direct or indirect disturbance. Among the common causes for logged-over forests are the extraction of valuable species, followed by the exploitation of some of the remaining species some years later, poor logging practices using inappropriate heavy machinery, and bad selection of harvest time and methods including the intensity and frequency of timber extraction and the quality of supervision and control. These are the key elements affecting the degree of degradation of the remaining forest[14]. Figure 8 illustrates the process from a degraded or logged-over forest to a secondary forest. Such forests will over time evolve through the phases I – IV described before.

For the decision-making purposes of the FCCF, it is important to analyze carefully the current stage of development of the forest and the reasons of the logged – over of a particular area before taking a decision to go ahead with to a project or not. There are situations in which the remaining forests have been over exploited to such a degree, that a gradual recovery to a forest similar to a primary forest is no longer feasible.

In some cases, the selective harvesting and extraction of most of the higher value species have degraded forests very heavily. These types of forests have different structures depending on the time that has elapsed since the last exploitation. In most of the cases there are still some big trees of lesser commercial value left with some regeneration of trees of valuable species in the mid stages of growth. In most cases, these have still not reached the diameter limit that the law prescribes (in each country) for harvesting. In some cases, over-exploitation has led to harvesting of trees that are of intermediate diameter. Generally, the canopy is open enough and has permitted regeneration establishment of most of the species, including those with commercial value.

In this case, sustainable forest management will favor the middle size trees of the most valuable species, harvesting carefully part of the valuable and lesser value individuals of the remaining canopy. Additionally, the path and time to recover a healthy forest depends on the time elapsed since the last unsustainable exploitation and the overall conditions in the area. The establishment of natural regeneration of 5 to 15 or 20 years require silvicultural interventions such as enrichment planting, thinning (liberation and refining), liana cutting to improve the forest conditions. This in turn improves the canopy and creates the conditions for a commercial harvest.

In the case of logged-over forests where some commercial and trees with large diameters remain, the possibility of profitable management exists. Initial harvesting of larger trees will convert the forest into a secondary forest. The FCCF may not finance management of logged-over forests with low volume and size of commercial trees because of the significant time required to restore a forest to conditions similar to a primary forest. The extensive time horizon is likely to make the operation unsustainable from a financial point of view in a limited investment horizon.

FIGURE 8
TRANSITION FROM DEGRADED LOGGED-OVER FOREST TO SECONDARY FOREST

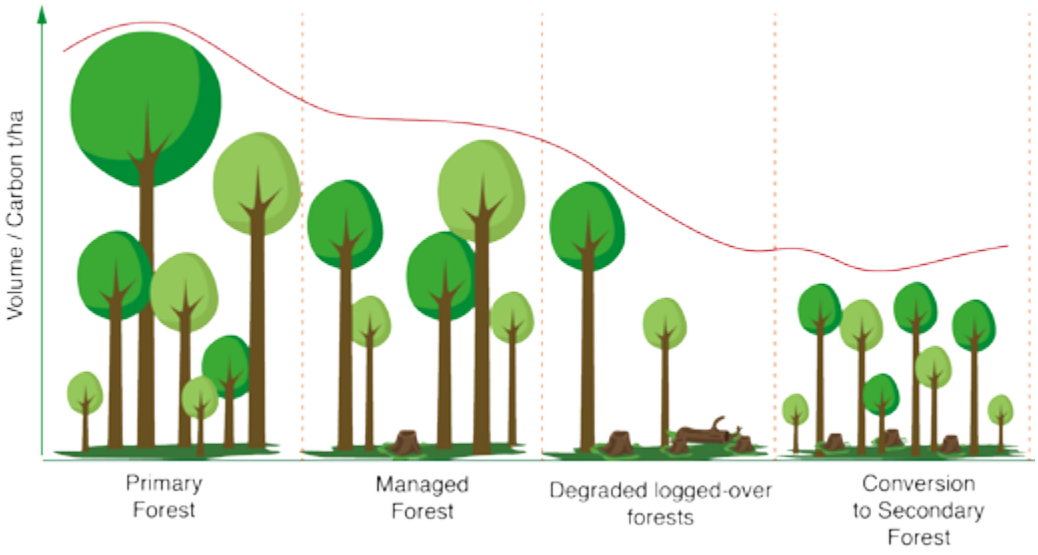


FIGURE 9
HIGH INTENSITY LOGGED-OVER FOREST

Differentiating degraded from natural forest

It is extremely important to understand that Secondary and Degraded Forests differ significantly from primary forests and sustainably managed natural forests.

The definitions of degraded or logged-over forests established above are based on the concept of "unsustainable" human intervention in the forest leading to a state of degradation when the forest characteristics differ significantly from a natural stage. A number of indicators may be used to objectively differentiate degraded forests from primary forests or sustainably managed natural forests. The following scientific criteria might be used for characterizing the degraded forests:

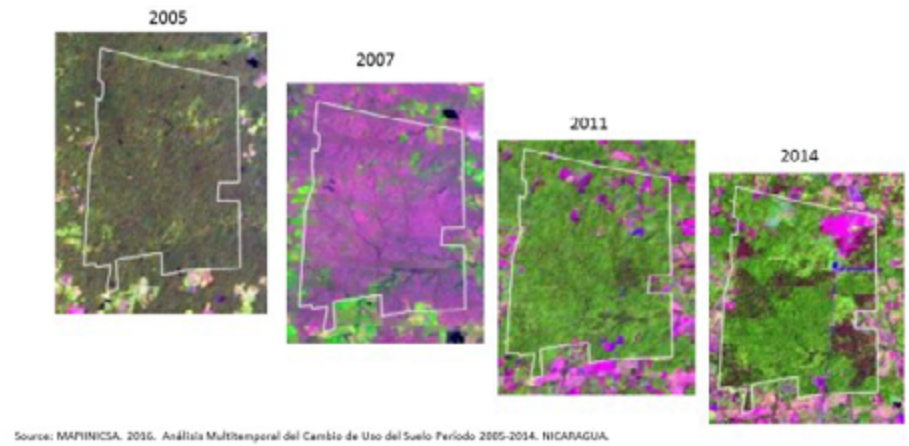
- Basal area (lower);
- Diameter distribution (even);
- Species composition and/or frequency (fewer).

According to local conditions, the importance of each criteria may vary. Yet these criteria allow the FCCF to avoid that primary forests or ecosystems close to primary forests are included.
An additional element in differentiating degraded or secondary from natural forests is the availability of historic data on any given forest area:

- The history of the forest in the last 20 years;
- The geographical information system with the images of the evolution of the forest.

The example in figure 10 shows the evolution of a forest in Nicaragua. In 2005, the property was a logged-over forest. In 2007 a hurricane destroyed large part of the forest and between 2007 and 2014 a secondary forest developed. This information, together with the historic narrative clarifies the situation and allows decision to be taken. Given the current state of technology, the multi-temporal analysis is available for most of the situations and the information from local population can complete or complement the information of contain in the images.

FIGURE 10
EXAMPLE OF MULTITEMPORAL ANALYSIS OF LAND USE CHANGE



Source: MAFINICSA. 2016. Análisis Multitemporal del Cambio de Uso del Suelo Período 2005-2014. NICARAGUA.

Naturally degraded forests due to hurricanes and forest fires

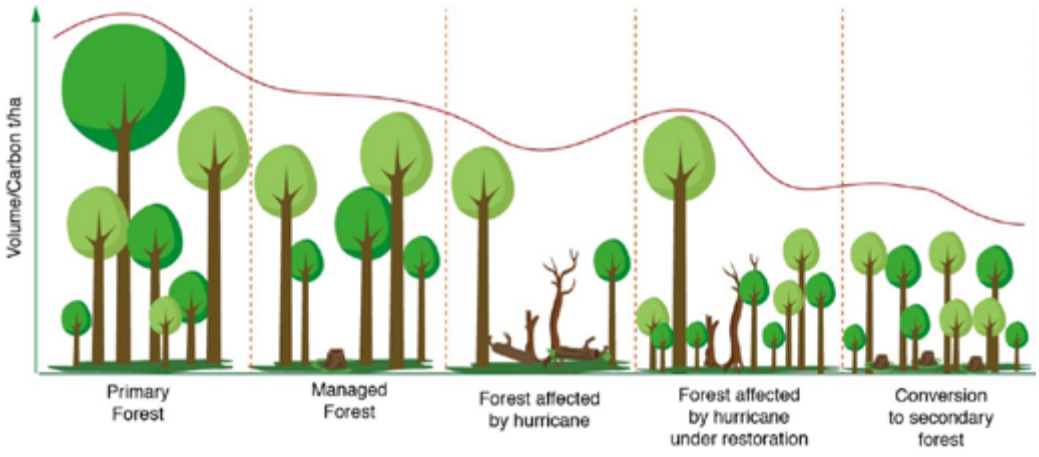
Mexico and Central America, with the exception of Costa Rica and Panamá are areas prone to be impacted by tropical hurricanes. The occurrence of such storms affect the population and nature. Hurricanes affects the forest depending on their intensity and duration and may provoke different degrees of degradation.

Hurricanes also change the dynamics of the forest and it is necessary to recognize these changes for an adequate and sustainable forest management. It appears that global warming and climate change is increasing the frequency and intensity of both hurricanes and forest fires.

Figure 11 illustrates the transition curve of a forest affected by a hurricane to a state similar to a secondary forest.

The effect of a hurricane is first to devastate the main canopy destroying totally or partially the bigger trees. Depending on the intensity, forestry interventions will differ, from a sanitary harvest (immediately after the hurricane when possible, otherwise wood will rot and the danger of fires will increase) of the commercial trees to the tending of the regeneration. In the thinning phase a hurricane forest (after 10 to 15 years after the event) is similar to a secondary forest.

FIGURE 11
FROM HURRICANE DEGRADED TO SECONDARY FOREST



In the case of hurricane Felix in Nicaragua in 2007, the delay between the hurricane and the start of forestry interventions to harvest fallen trees was too long and most of the wood was lost. In big gaps with no remaining tree coverage some enrichment planting might be necessary.

In the case of Nicaragua, and in the context of the FCCF, it is possible to find forests where commercial thinning is feasible during the building phase and the thinning phase of the forest.

Hurricane affected areas are often impacted by settling activities with land use change towards cattle farming and agriculture. The conversion process to secondary forest will protect the areas from land use change. Some of the existing secondary forests may be direct result of the hurricanes.

FIGURE 12
HURRICANE AFFECTED FORESTS WITH BROKEN AND UPROOTED TREES

Land use change in Costa Rica // UNIQUE

Annex 1: Opportunities and risks associated with different forest types

Forest Type	Opportunities	Risks
Secondary Forests	• Abundance • Relatively better access • Growth rate that can be comparable to plantations • Good age classes distribution (abandonment date) • Scattered forest stands (but all located at economic distances from each other). • No need of heavy machinery • Existence of organizations • Ecologic knowledge available	• Emergence of markets for lesser known species • High levels of fragmentation • Few examples of good management experiences • Represents a high level of change for the private sector, communities and government institutions • If abandonment date is too recent, there is a delay in the cash flow • Pressure to convert to agriculture and cattle farming
Degraded Forests	• Bigger areas available • Existence of old growth remaining trees that can be immediately harvested • Existing of dead trees of durable woods that can be immediately harvested • Good conditions for regeneration • In logged –over forests, existing infrastructure • Experienced workers (but need to be trained in sustainable low impact processes)	• Possibilities to create markets for lesser known species • Possibility that the risk to certain agents (fires, diseases) appears frequently • Higher risk of land invasion by poachers • Pressure to convert to agriculture and cattle farming even higher than in secondary forests

Degraded dry forest in Guanacaste, Costa Rica // LMDF

Annex 2: Decisions Making

There is not only one description that covers all the possible events that exist in nature or provoked by men, like storms, forest fires, over-exploitation, agriculture, cattle farming, pests and diseases, etc. The Technical Committee of the LUXDEV/FCCF/CATIE Project defined that the previous described following forest conditions can be subject to analysis to be considered as potential investments.

Secondary and Degraded Forests, classified after their evolutionary history:

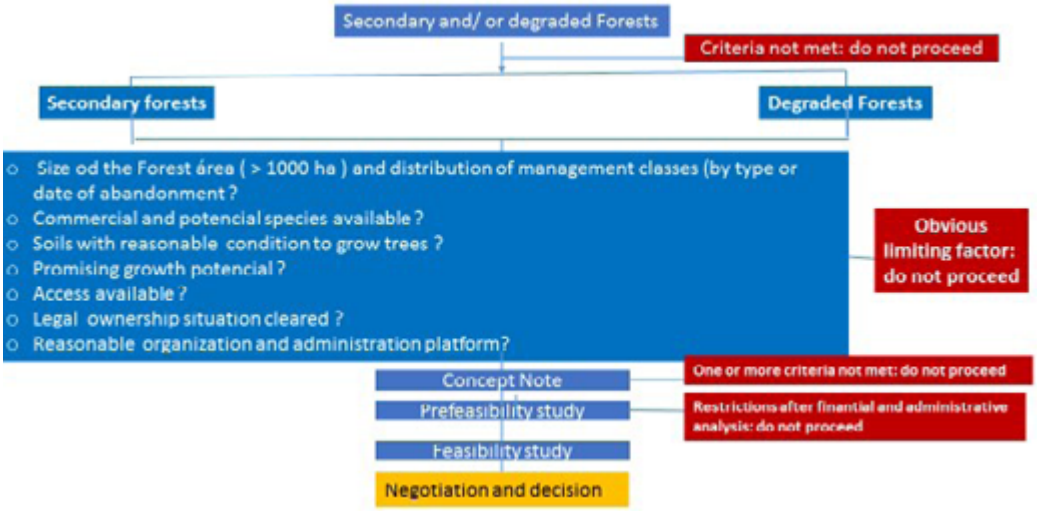
- Naturally regenerated forests after human intervention in agriculture and cattle farming that cleared the former forest;
- Naturally regenerated forests after natural full disturbance (forest fires, pests and diseases that fully destroyed the previous forest).

Degraded forests:

- Degraded logged-over forests;
- Forest damaged partially by hurricanes, fires and pests and diseases with remains of the old structure and the original trees.

Please refer to the below flow chart of decision making

FIGURE 13
DECISION TREE TO DEVELOP MANAGEMENT INITIATIVES BY THE FCCF



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2. The words “even total” has been added by the authors of this paper to clearly include the forests regenerating in former pastures and livestock

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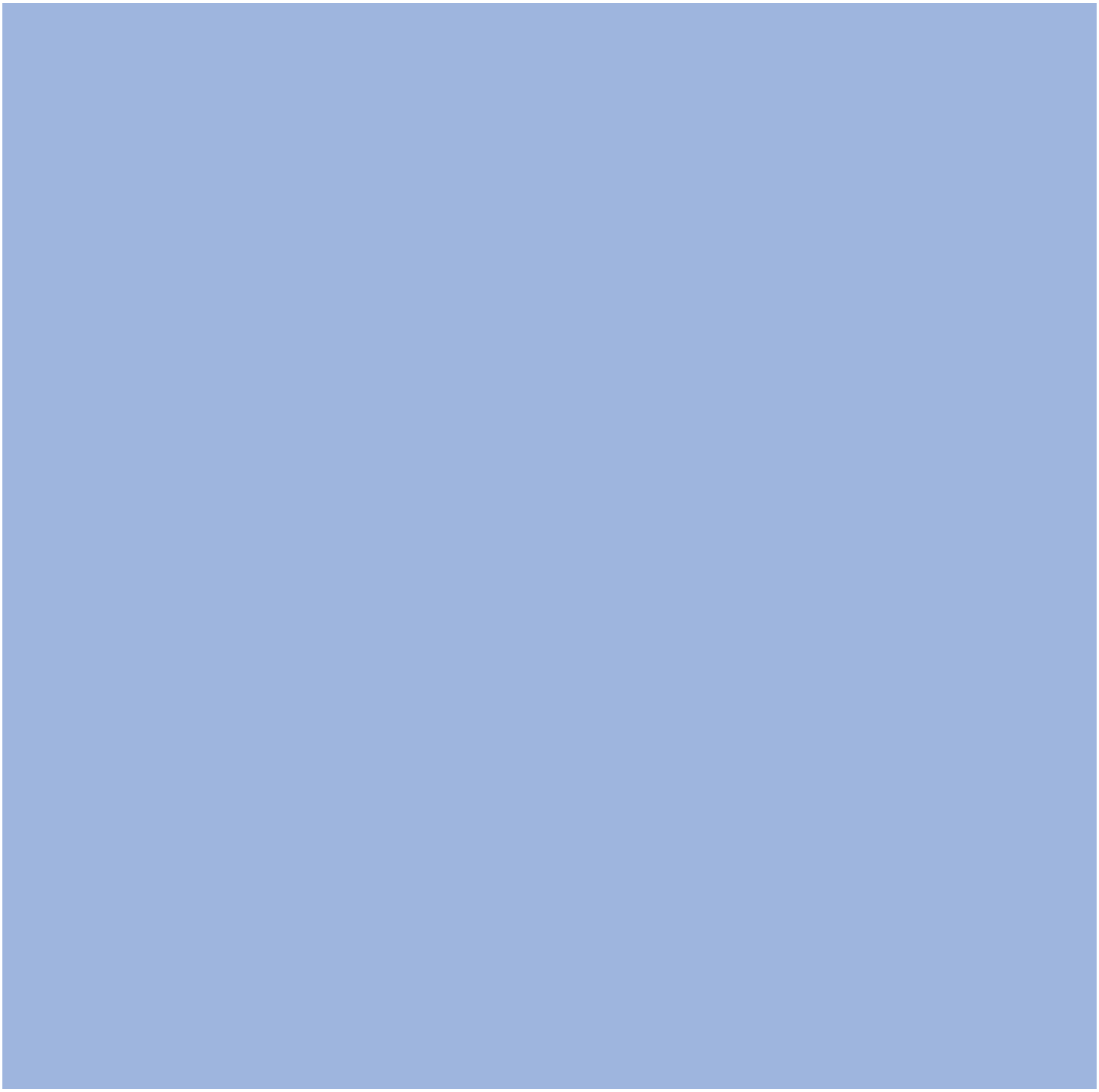

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