AN OPERATIONAL APPROACH TO FOREST DEGRADATION

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Meeting on Forest Degradation
FAO Rome
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Why the interest on Forest degradation?

- Is defined as "changes within the forest which negatively affect the structure or function of the stand or site, and thereby lower the capacity to supply products and/or services" FAO-FRA 2005.
- Or "forest degradation is a long-term reduction of tree crown cover towards but not exceeding the minimum accepted 'forest' threshold.". IPCC.
- Notice the definition itself is an issue.
- Forest degradation:
- Is related to REDD+ in Climate Change.
- Is related to Deforestation, because is actually a precursor of Deforestation.
- We may be very effective in avoiding deforestation, but, we may not realize the leakage our actions are producing, i.e., degradation.
- Degradation and deforestation are strongly related and should be treated together.
- Example of this in Chile we have no deforestation, but we have degradation (leakage effect?, which is the reference we are using to arrive to such a conclusion, ancient information may answer this 1944 vs 2000.)

How to face forest degradation measurement?

- One option: giving up
- Or, searching for good scientific solutions like:
  - Taking advantage of "system thinking" to organize the scope of analysis.
  - i.e., Considering the forest ecosystem from a hierachical point of view (Hierarchical theory, Prigogine I.1980) (Allen T. F. H. and T. Hoekstra. 1992. *Toward a unified ecology*).

- Given this approach, forest degradation may be observed at different levels from the:
- Landscape level (genetic implications, fragmentation, reproductive capacity of forest, conectivity, among others)
  - to even,
- chemical reactions level (organism cells, soil minerals)
  - Given our limitations we face with data and resources, we always use to have at most information related to the interval of *landscape level* to *stand development level*.

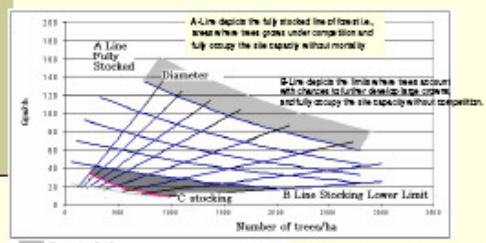
The Chile´s study case

- **Level of analysis:** Stand development
- **Objective:** test an operational approach to identify areas of forest degradation based on stock definition.
- **Measurement tool:** Densitiy, approached by the stocking chart (Gingrich S.F., 1967)
- **The forest:** one the most important forest type in southern forest in Chile: Roble-Rauli-Coihue forest types (MM ha 1,4.)
- **The data:** 290 permanent sampling plots from National Forest Inventory (systhematically located in a grid of 5 km by 7 km., since 2000)

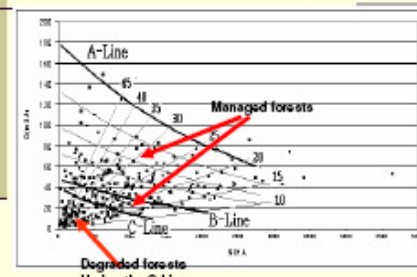
The Stocking chart

- Stock is defined as the "Volume of all living trees more than 'X' cm in diameter at breast height (or above buttress if these are higher) measured over bark from ground or stump height to a top stem diameter of 'Y' cm, excluding or including branches to a minimum diameter of 'Z' cm. Excludes: smaller branches, twigs, foliage, flowers, seeds, stump and roots" (FRA 2005).
- Forest stock is a common term used by forest managers for describing the optimal combination of tree size, growth, and numbers of trees in relation to a particular management objective.
- The stock is closely related to stand density which implies how the growing space is occupied by trees in the forests.
- Forest stocking varies according to company or owner management goals.
- However stocking is flexible enough to include even small trees, (national forest inventory in Chile include from 4 cm DBH trees)

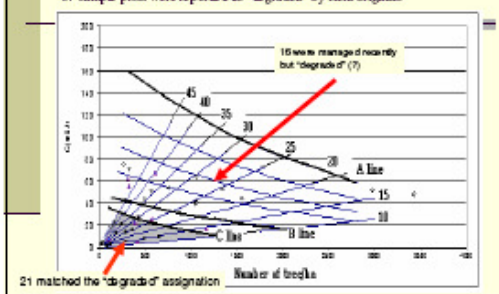
The stocking chart represents the state of the forest by relating, Numbers of trees/ha, Basal Area/ha and, Site space occupation (%)



How does this work for identifying degraded forest? The case of Roble-Rauli-Coihue forest type



Testing against reality
37 sample plots were reported as "degraded" by field brigades



Confusing results?

- The stocking chart is not able to say about 'quality of management', but field observation does.
- Field observations are not able to see stock of forest directly (trees does not let us see the forest)
- Let's recall the 61 sample plots located under the C-Line, field observation only detected 21 of those, 40 were missed !!.

Conclusion & recommendations

- The stocking chart is an useful tool for aiding recognizing degraded forests.
- The stocking chart assume good management practices.
- The field observations and stocking chart acting together improve the identification of degraded forest.
- It is necessary and required the presence of a national forest inventory under permanent bases.
- The stocking chart allows for objetive comparison in time, i.e., monitoring.
- This practice is Tier 3.
- The degradation involves more than stocking, as such hierarchical theory help us to devise suitable tools for measure it.

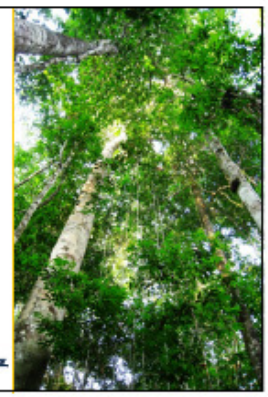
- Capacitation & training is a key issue in recognizing forest degradation from field.
- Operationalizing imply a practical method for checking degradation from the productive perspective.
- We are trying now a quick method for defining in field the degradation status, by using Variable sampling plots (Bitterlich) and Prodan samples.
- We are also trying approaches for the other hierarchical levels of observations, moving toward Landscape level (remote sensing material, spatial analysis-fragmentation).

Instituto Floresta Tropical
Fundação Floresta Tropical

Measuring ecological impacts from logging in natural forests of Eastern Amazônia as a tool to assess forest degradation

Marco W. Lentini
Johan C. Zweede
Thomas P. Holmes

IFT's institutional support



Forest management and reduced impact logging (RIL)

Reduced impact logging

Conventional logging

- ✓ In 1996, an experiment in Paragominas compared costs and benefits of CL and RIL (Holmes *et al.* 2002).
- ✓ Showed a net income from RIL 19% higher than CL
  - > productivity in skidding and log deck operations (39%)
  - < fixed and variable costs (12%)
  - < timber wasted after logging (78%)
- ✓ Main constraints for adopting sound FM are not related to costs.

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Objectives

- ✓ To present a method to assess ecological impacts provoked by logging, based on a study conducted in 1996 at a forest site in Paragominas, Eastern *Amazônia*
- ✓ This method has being intensively replicated in the last 14 years in IFT´s field activities
  - Damage to future crop trees
  - Ground damage
  - Timber waste

Photos: IFT

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Methods

- ✓ The experiment was conducted in three 100 ha forest blocks (1 RIL, 1 CL and 1 unlogged)
- ✓ Before harvesting, IFT conducted censuses of all commercial and potentially commercial trees (> 35 cm D.B.H.) and established permanent plots (1% of the area)
- ✓ In the forest block harvested with RIL, harvesting was planned
  - Liana cutting, planning maps for felling and skidding of logs based on the census, directional felling techniques, skidder with winch and grapple, planning of roads and skid trails as part of the permanent infrastructure.
- ✓ The CL operation was conducted by a logger
  - Harvesting crew with on-the-job-training
  - Sawyers were paid on a piece rate
  - Skidding crews were not provided with precise information from felling crews
  - No census or planning is executed

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Damage to future crop trees

Severity class	Crown damage	Bole damage	Cause of damage	Health class
0	No damage, complete crown	No damage	-	No damage
1	Minor damage, i.e. < 1/5 of crown damaged	Minor damage to < 1,500 cm² of bark	Felling	Clear signs of recovery
2	Moderate damage, i.e. > 1/5, but less than 2/5 of crown destroyed	Minor damage to > 1,500 cm² of bark	Skidding	No signs of recovery or death/decay
3	Severe damage, i.e. crown crushed	Moderate damage, i.e. deeper than bark, but < 1,500 cm² in area	Road building	Clear signs of death or decay (e.g. insect or fungal attack)
4	N/A	Severe damage to area > 1,500 cm², e.g. a major tear or broken branch	Log deck construction	N/A
5	N/A	Irreversible damage (clearly dead or dying), e.g. smashed bole	Natural causes (unrelated to harvest activities)	N/A

-Adapted version of the method proposed by Johns et al. (1996)

- Only commercial and potentially commercial tree species with good form and DBH > 35 cm

- Survey was conducted about 20 months after harvest.

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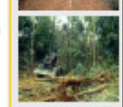
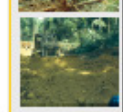
Ground area disturbed by logging

- ✓ It measures the total impact of heavy machinery on the forest floor
- ✓ Assessment is made by measuring in the field the total area of roads, log decks and skid trails established for harvesting
  - A technician used a 50-m tape to measure the length and width of every road, skid trail and log deck in both harvest areas.
  - The direction of every infra-structure measured was recorded with a compass to permit mapping these features in the office.
  - Surface of these features were calculated.
- ✓ Although compaction was not measured, disturbance severity was estimated.
  - Every 30 meters along all skid trails, it was evaluated whether mineral soil was exposed.
  - Sampling unit was a single line across the width of the skid trail.

Photos: IFT





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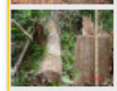
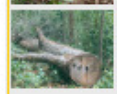
Volume of merchantable timber wasted

- ✓ The volume of timber wasted is the difference between the volume under "ideal" logging and the actual volume recovered
- ✓ Causes of timber wasted
  - timber felled and not found by skidding crew or left in the forest because poor felling caused logs to split and lose merchantability
  - timber left on the log deck
  - timber wasted because cutting stumps were too high or due to poor bucking of felled logs
  - poor felling techniques
- ✓ Volume was measured by a crew of IFT technicians by measuring the area and the length of timber portions which could be harvested but were left in the forest

Photos: IFT

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Results: Damage to future crop trees

Health class	Conventional Logging		Reduced Impact Logging	
	Felling Damage	Damage from other activities	Felling Damage	Damage from other activities
Recovering	0.14 (54)	0.11 (43)	0.24 (80)	0.17 (57)
No sign of change	0.16 (63)	0.05 (21)	0.18 (58)	0.05 (17)
Dying	**0.34 (136)**	**0.04 (16)**	**0.16 (52)**	**0.01 (2)**
Total impacted	**0.64 (253)**	**0.20 (80)**	**0.58 (190)**	**0.23 (76)**

-Felling was revealed as the most important driver of damages to residual trees (> 95% of human-induced damages)

- Damages which provoked the death of residual trees were > 2 x higher in CL than in RIL.

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Results: Ground area disturbed by logging

Activity	Conventional logging		Reduced-impact logging	
	m³ / tree harvested	ha / 100 ha block	m³ / tree harvested	ha / 100 ha block
Secondary roads	34	1.35	20	0.65
Log decks	26	1.05	19	0.63
Skid trails	193	7.66	120	3.90
Total	**253**	**10.05**	**159**	**5.18**

In addition, the experiment showed that 100% of the CL skid trails were cleared to mineral soil, whereas less than 10% of the RIL skid trails had mineral soil exposed.

Cumulative disturbance over time in CL tend to intensify, since forest infrastructure tend to be permanent in RIL

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Results: Wasted merchantable timber

Source	CL waste (m³/ha)	RIL waste (vol./ha)
High stumps	0.28	0.10
Split logs	0.87	0.31
Bucking waste	1.97	0.85
Logs lost	0.96	0.06
Total forest	**4.08**	**1.32**
Log deck	1.97	0.60
Total	**6.05**	**1.92**

Timber wasted in the CL block was almost % (23.9%) of the standard harvest volume. RIL provoked a total wasted of 7.6% of merchantable timber.

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Discussion

- ✓ The main purpose was to present a simple method to assess forest degradation and ecological impacts provoked by logging.
- ✓ Despite current development of remote sensing techniques able to identify in a coarse scale the overall occurrence of sound FM indicators, field based methods are still necessary to evaluate the quality of forest operations and their ecological impacts over the forest.
- ✓ It is still necessary to replicate the method in other regions in *Amazônia*, taking into account the diversity of conditions.

Photos: IFT



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Conclusions

- ✓ The method used to evaluate forest degradation and ecological impacts from logging presented in this paper has a large potential to be disseminated to other regions in *Amazônia* and surrounding countries.
  - As main advantages, we can cite is simplicity and viability to be used in different contexts.
  - Measurement of roads, log decks and skid trails can be improved in large scale enterprises using recent GPS technology
  - Methodology still requires validation in other forest types and technological alternatives, mainly considering CFM operations.
- ✓ The method should be disseminated to other FM centers, training centers, universities and forestry foment organizations and agencies.

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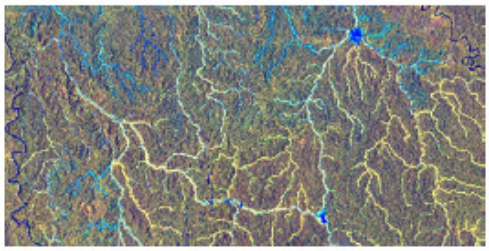
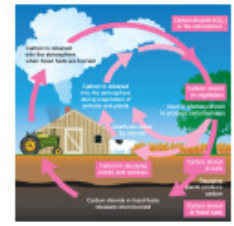
Reporting forest degradation under UNFCCC

Danilo Mollicone, FAO



CONTEXT

- Under UNFCCC: no forest definition and no forest degradation definition with a land based reporting approach



CONTEXT

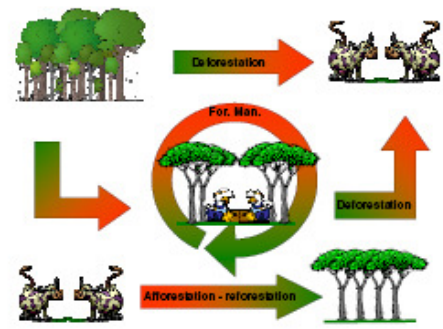
- Under the Kyoto Protocol: a framework forest definition and no forest degradation definition with an activity based approach

- Under the expected REDD mechanism: forest definition ? and forest degradation definition ? with an activity based approach

- In the context of UNFCCC there are no definitions that explain changes occurring within a land use category

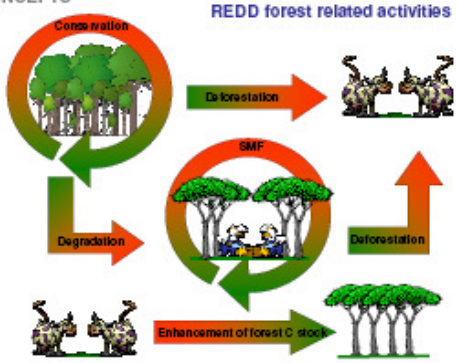
CONCEPTS

KP forest related activities



CONCEPTS

REDD forest related activities



IPCC methodology

KP and REDD activities	=	Forest sector (AFOLU / IPCC)
Deforestation	=	Forest land converted to other land
Forest management Degradation SMF Conservation	=	Forest land remaining forest land
Reforestation Afforestation Enhancement F C S	=	Other land converted to forest land

IPCC methodology

Carbon stock changes: five pools

- Above-ground biomass
- Below-ground biomass

} biomass

- Deadwood
- Litter

} dead organic matter

- Soil

} mineral / organic

$$\Delta C = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO}$$

IPCC methodology

„Stock Difference" method

$$\Delta C = C_2 - C_1$$

ΔC = change of carbon stock

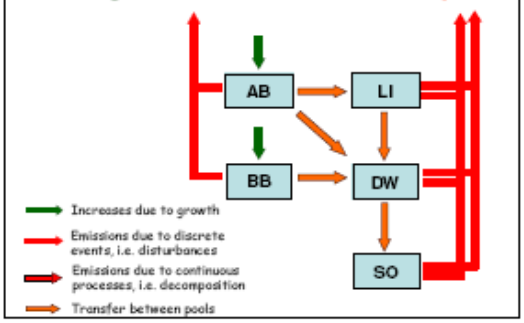
C_2 = carbon stock at **time 2**

C_1 = carbon stock at **time 1**

for one year: $\Delta C = (C_2 - C_1)/(t_2 - t_1)$

IPCC methodology

Changes = Gains – Losses (by pool)



Gain-Loss (default) method for Biomass

$$\Delta C_B = \Delta C_G - \Delta C_L$$

ΔC = change of carbon stocks in biomass

ΔC_G = increase due to biomass **growth**

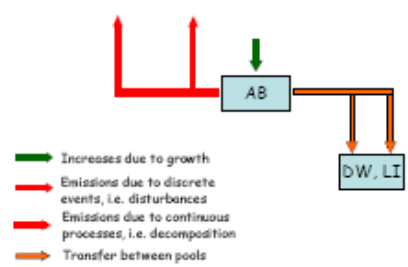
ΔC_L = decrease due to biomass **loss**

Gain-Loss, or default method: consider all processes

$$\Delta C_G = G_{growth}$$

$$\Delta C_L = L_{wood-removals} + L_{fuelwood} + L_{disturbances}$$

IPCC 2006GL



Integrating Forest Transects and Remote Sensing data to Quantify Carbon Loss due to Forest Degradation: a case study of the Brazilian Amazon

Technical meeting on Forest Degradation
FAO FOIM
8-10 September 2009
Rome, Italy

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Remote Sensing Detection of Forest Disturbances

Highly Detectable	Marginally Detectable	Almost Undetectable
· Deforestation · Forest fragmentation · Recent slash-and-burn agriculture · Major canopy fires · Major roads · Conversion to tree monocultures · Hydroelectric dams and other forms of flood disturbances · Large-scale mining	· Selective logging · Forest surface fires · A range of edge effects · Old-slash-and-burn agriculture · Small scale gold-mining · Unpaved secondary roads (8-30-m wide) · Selective thinning of canopy trees · Blowdowns	· Hunting and exploitation of animal products · Harvesting of most non-timber plants products · Old-mechanized selective logging · Narrow cut-canopy roads (<8-m wide) · Understorey thinning and and clear cutting · Invasion of exotic species · Spread of pathogens · Changes in net primary productivity · Community wide shifts in plant species composition · Other cryptic effects of climate changes · Most higher-order effects

Main Sources of C emissions:
- **Deforestation**
- **Selective Logging**
- **Forest fires**
- **Forest fragmentation**

Peres et al., (2006), TREE

Deforestation vs. Forest Degradation

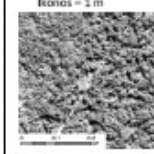
Selectively logged forest, Sinop-MT

Deforested area for plantation, Sinop-MT

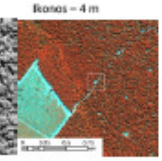
- Forest degradation has been defined as a type of land modification, which means that the original land cover structure and composition is temporarily or permanently changed, but it is not replaced by other type of land cover type (Lambin, 1999).
- For the purpose of REDD, we are interested in monitoring reduction of C stocks.

Monitoring Forest Degradation

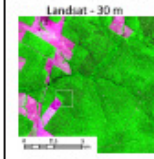
Ikonos – 1 m



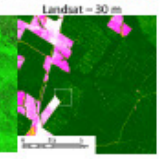
Ikonos – 4 m



Landsat - 30 m



Landsat – 30 m



Souza Jr. (2007)

- More challenge than monitoring deforestation.
- There are several methods to detect and monitor forest degradation (GOFC-GOLD REDD Sourcebook).
- Methods:
  - Visual interpretation can easily detect canopy damage areas in very high spatial resolution imagery.
  - Spectral enhancement is required at lager pixel sizes.

Objetives

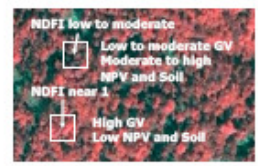
- Present a brief review of how remote sensing has been used to detect and map forest degradation.
- Show how carbon stocks of degraded forests can be characterized using rapid forest transect surveys.
- Demonstrate how field data of forest carbon stocks can be integrated with optical remotely sensed data to regionally characterize forest degradation.
- Discuss the challenges to integrating field-derived carbon estimates with remotely sensed data.

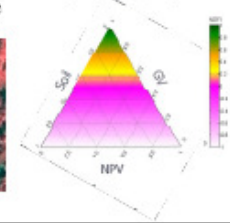
Normalized Difference Fraction Index - NDFI

$$NDFI = \frac{GV_{Shade} - (NPV + Soil)}{GV_{Shade} + NPV + Soil}$$

$$GV_{Shade} = \frac{GV}{100 - Shade}$$

$$-1 \le NDFI \le 1$$

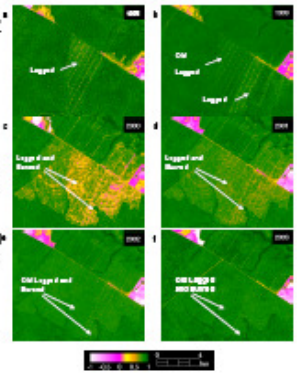




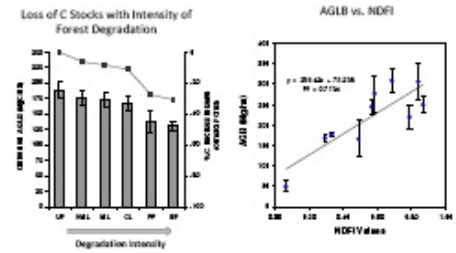
Souza Jr. et al. (2005)

Dynamic of Forest Degradation

- Degrataion signal changes fast.
- There is a synergism of forest degradation processes that can reduces more C stocks of degraded forests.
- Reccurrent forest degratation is expected and creates even more loss of C stocks.
- Annual monitoring is required to keep track of forest degrataion process.



C Stocks Change vs NDFI



Challenges to Monitor Forest Degradation and C Stock Changes

- Monitoring forest degradation requires well-documenting forest disturbance history, specifically recurrent degradation events and time since last disturbance.
- High spatial variability of forest biomass requires site-specific calibration of RS and AGLB.
- Monitoring degradation requires annual acquisition of satellite images because the rapid changes in degraded forests inhibit detection and mask out the intensity of the degradation after one year

Challenges to Monitor Forest Degradation and C Stock Changes

- Optical remote sensing techniques presented in this study cannot be applied in regions with intense cloudy conditions.
- Correlation of NDFI and AGLB of intact forest and forest degradation classes collapses after one year after the degradation event because the NDFI degradation signal disappear fast.