

## CASE STUDIES ON MEASURING AND ASSESSING FOREST DEGRADATION

### GLOBAL MAPPING AND MONITORING THE EXTENT OF FOREST ALTERATION: THE INTACT FOREST LANDSCAPES METHOD

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Sustainably managed forests have multiple environmental and socio-economic functions which are important at the global, national and local scales, and they play a vital part in sustainable development. Reliable and up-to-date information on the state of forest resources - not only on area and area change, but also on such variables as growing stock, wood and non-wood products, carbon, protected areas, use of forests for recreation and other services, biological diversity and forests' contribution to national economies - is crucial to support decision-making for policies and programmes in forestry and sustainable development at all levels.

Under the umbrella of the Global Forest Resources Assessment 2010 (FRA 2010) and together with members of the Collaborative Partnership on Forests (CPF) and other partners, FAO has initiated a special study to identify the elements of forest degradation and the best practices for assessing them. The objectives of the initiative are to help strengthen the capacity of countries to assess, monitor and report on forest degradation by:

- Identifying specific elements and indicators of forest degradation and degraded forests;
- Classifying elements and harmonizing definitions;
- Identifying and describing existing and promising assessment methodologies;
- Developing assessment tools and guidelines

Expected outcomes and benefits of the initiative include:

- Better understanding of the concept and components of forest degradation;
- An analysis of definitions of forest degradation and associated terms;
- Guidelines and effective, cost-efficient tools and techniques to help assess and monitor forest degradation; and
- Enhanced ability to meet current and future reporting requirements on forest degradation.

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More information on the Global Forest Resources Assessment programme can be found at: [www.fao.org/forestry/fra](http://www.fao.org/forestry/fra)

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**Forestry Department**  
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**Forest Resources Assessment Working Paper**

**Case Studies on Measuring and Assessing  
Forest Degradation**

Global Mapping and Monitoring the Extent of Forest Alteration:  
The Intact Forest Landscapes Method

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## Abstract

This paper presents the *IFL Method*—a novel approach for mapping and monitoring the extent of forest alteration. High spatial resolution satellite images are used to identify and map large un-degraded areas called Intact Forest Landscapes (IFL), defined as unbroken expanses of natural ecosystems in the zone of current forest landscapes extent without signs of significant human activity and at least 50,000 hectares in size. The method produces an IFL map which shows the boundary between unaltered forest landscapes (where most components, including species and site diversity, dynamics and ecological functions remain intact) and altered or fragmented forests (where some level of timber extraction, species composition change, anthropogenic fragmentation and/or alteration of ecosystem dynamics has taken place).

The paper describes the IFL Method and presents results of its use for a global baseline assessment of the extent of forest alteration along with several examples of regional-level monitoring. The extent of forest alteration (understood in this context as a reduction in ecological integrity across a forest landscape) was measured at the global, biome and national levels based on the distribution and proportion of IFL areas. A detailed boundary between ‘intact’ and ‘non-intact’ forest landscapes was established and used as a baseline. The IFL method represents a practical, rapid, and cost-effective approach for assessing forest intactness, alteration and degradation at the global and regional scales.

In the context of Reduced Emissions from Deforestation and Forest Degradation (REDD), IFLs are strongly associated with issues of permanence, biodiversity, and indigenous peoples. Countries that wish to make an early commitment under REDD that is capable of being monitored, verified, and reported may therefore find that the IFL Method offers interesting opportunities. The method can be elaborated to also measure the depth or intensity of forest alteration. It thus represents an approach that should be of interest to FAO’s Forest Resources Assessment, for example for monitoring of forest degradation.

The IFL method was developed by a group of scientists and environmental non-governmental organizations under the framework of Global Forest Watch, an initiative of the World Resources Institute. IFL maps, monitoring reports and other publications are available on a dedicated web site (<http://www.intactforests.org>).

**Key Words:** Forest degradation, Intact forest landscapes, Global degradation assessment, Global degradation monitoring



## 1. Introduction

Assessing forest degradation is difficult for at least two reasons. Degradation is a complex concept and thus difficult to define. It is also difficult to measure. The human impact on a forest is complex and varies significantly both in kind and in degree. To make matters worse, what little information is available is often inadequate, lacking in detail and richness, and lacking in consistency, particularly across jurisdictional boundaries. The non-productive aspects of forests (for example biodiversity) tend to be particularly poorly quantified, making it difficult to assess rates and patterns of degradation. The information problem is particularly difficult at the regional and global scales.

In the late 1990s, Greenpeace Russia and Global Forest Watch (an initiative of the World Resources Institute) initiated an effort to harness the emerging potential of remote sensing to assess the ecological integrity of large forest landscapes. The work resulted in a rigorous original method and a map at the scale of 1:1 million of the remaining virgin forest landscapes (called *Intact Forest Landscapes* or IFL) of Northern European Russia. The results were presented in a report (Yaroshenko *et al.*, 2001) which, apart from a map, also contains an extensive, illustrated presentation of the concept and definition of an IFL and the mapping method.

In subsequent years (2002–2006), the method was refined and its application extended, first across the boreal region and then to the entire world. The boreal studies were carried out by a group of scientists and environmental non-governmental organizations under the framework of Global Forest Watch (Aksenov *et al.*, 2002, Lee *et al.*, 2002, Stritholt *et al.*, 2006), resulting in a number of regional IFL maps (Russia, Canada, Alaska). A global IFL map was prepared in 2005–2006 under the leadership of Greenpeace, with contributions from Global Forest Watch, Biodiversity Conservation Center, International Socio-Ecological Union (Russia), Transparent World (Russia), Luonto Liitto (Finnish Nature League), and Forest Watch Indonesia (Potapov *et al.*, 2008).

In the following, this method – called *the IFL Method* – is described along with the results of a global assessment of forest landscape alteration and some examples of ongoing, regional-level monitoring initiatives.

## 2. Materials and Methods

### *Approach*

For the purposes of this analysis, forest alteration is defined as a reduction in the ecological integrity of a forest landscape due to human influence (including conversion, alteration and fragmentation of the natural landscape). The alteration varies in intensity within and among forest landscapes. The *IFL method* for mapping and monitoring which is presented below represents a simple and feasible approach to measuring the extent of forest alteration at the global and national scales. The method as presented here does not address the intensity of alteration. It can, however, be elaborated to do so.

### *The IFL Method*

The purpose of the *IFL Method* is to map large, possibly inaccessible forest landscapes at a cost that is non-prohibitive in terms of time and resources. The results are replicable and consistent in time and space (for example for a country, a continent, or the world). The *IFL Method* was developed to map forest landscapes of high ecological integrity using satellite images and publicly available maps.

The method consists of two parts which combine to form an integrated whole: an assessment logic and a set of definitions and criteria. The assessment logic has three major characteristics:

### 1. A binary classification of the landscape

Ecological integrity is measured on a binary scale. Forest landscapes are classified as being either intact (un-degraded) or non-intact (altered, including possibly degraded). The degree of alteration within non-intact landscapes is not captured by this scale.

An *Intact Forest Landscape* (IFL) is an unbroken expanse of natural ecosystems that shows no signs of significant human activity and is large enough to maintain all native biodiversity, including viable populations of wide-ranging species. An IFL may contain significant portions of naturally tree-less ecosystems. The assessments reported below have all used 50,000 hectares as the minimum size of an IFL.

### 2. Criteria of two types

Intact and non-intact landscapes are separated on the basis of two types of criteria: degree of human-caused alteration and anthropogenic fragmentation. The entire area of study is assessed for its eligibility to be a part of an IFL. First, the level of human-caused alteration is determined and ineligible parts are rejected. Remaining eligible parts are then assessed for their degree of fragmentation and ineligible parts rejected. Criteria and indicators for the eligibility assessment are described in Box 1.

#### **Box 1. Criteria and indicators**

##### A. Human-caused alteration

Portions of the study area with evidence of *significant* human-caused alteration are considered disturbed and not eligible for inclusion in an IFL. Such evidence includes:

- (1) Settlements (including a buffer zone of 1 km);
- (2) Infrastructure used for transportation between settlements or for industrial development of natural resources. This includes roads (except unpaved trails), railways, navigable waterways (including seashore), pipelines, and power transmission lines (including in all cases a buffer zone of 1 km on either side);
- (3) Agriculture and forest plantations;
- (4) Industrial activities during the last 30–70 years, such as logging, mining, oil and gas exploration and extraction, peat extraction;
- (5) Areas affected by stand-replacing wildfires during the last 30–70 years if located in the vicinity of infrastructure or developed areas.

Old or low intensity human influence is considered *insignificant*. Portions with such “background” influence remain eligible for inclusion in an IFL. Sources of background influence include diffuse grazing by domestic animals, low-intensity selective logging, and hunting.

##### B. Fragmentation

Portions of the study area that remain eligible for inclusion in an IFL are then assessed for fragmentation. Otherwise eligible portions that are too small or too narrow are eliminated. An IFL must satisfy the following criteria:

- (1) Larger than 50,000 ha;
- (2) At least 10 km wide at the broadest place (measured as a diameter of the largest circle that can be fitted inside the patch);
- (3) At least 2 km wide in narrow parts connecting wider patches and in appendages.



### 3. Intact until proven otherwise

The method finds intact areas by identifying and eliminating their opposites. The reason for this “inverse” logic is that it is easier to spot the evidence of the presence of human-caused alteration and fragmentation than to prove their absence. The initial assumption of the assessment process is therefore that the entire area of study is intact. The method contains a set of well-defined rules for assessing the study area by trying to disprove the initial assumption (see Box 1). These have been designed to be globally applicable and easily replicable, allowing for repeated assessments over time as well as independent verification.

The final result is a map on which intact forest landscapes appear as a residual once all non-intact areas have been eliminated. The intact forest landscapes on this map are those portions of the study area for which no evidence of significant human-caused alteration or fragmentation could be found. The map can be used for targeting of conservation and monitoring efforts if made based on satellite images of sufficient quality and spatial resolution (for example, Landsat TM/ETM+).

The possibilities for refining and adapting the method for other purposes, for example, for assessing the intensity of alteration, are discussed below.

#### *Global assessment of forest alteration*

The *IFL Method* was used to assess the ecological integrity of the world’s forest landscapes within their current global extent (referred to in the following as the forest landscape zone<sup>1</sup>). The concept of a forest landscape, as it is used here, is a mosaic of land cover types that are naturally interspersed. A forest landscape is dominated by forests but may include extensive naturally treeless areas (for example, small lakes, wetlands, rivers, and rocky outcroppings) as these components co-exist naturally within the broader forest ecosystem.

The forest landscape zone boundary was defined using a global tree canopy cover dataset (part of the Vegetation Continuous Fields MODIS 500m product, hereafter referred to as VCF) (Hansen *et al.*, 2003). Forest was defined as an area with a tree canopy cover greater than 20 percent in the year 2000. Forest patches smaller than 4 km<sup>2</sup> were excluded. The forest landscape zone as defined here includes all treeless areas (including lakes and rivers) that occur naturally within forest ecosystems. Forest landscape fragments smaller than 500 km<sup>2</sup> were not considered in the analysis.

The forest landscape zone was assessed in two steps. First, a preliminary fragmentation analysis was carried out for those countries for which GIS datasets on a scale 1:500,000 or finer for transportation infrastructure and settlements were available. Buffer zones were assigned to roads, pipelines, power lines and settlements which were subsequently eliminated from the area of study. Our goal was to identify fragments free from major elements of infrastructure and greater than 50,000 hectares in size. Areas that did not qualify were eliminated from further consideration, while other areas were retained as candidates for IFL.

The second step was to use high spatial resolution Landsat TM (global coverage representing an average date of 1990) and ETM+ (global coverage representing an average date of 2000) imagery to systematically assess all remaining candidate IFL areas for human-caused alteration and to delineate developed and fragmented areas. The Landsat images were obtained free of charge from the GeoCover Landsat Orthorectified image collection (Tucker *et al.*, 2004).

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<sup>1</sup> The *forest landscape zone* is different from what FAO calls the *forest zone* in that it includes treeless areas (such as lakes, wetlands, and rivers) that occur naturally within the broader ecosystem that we call a forest landscape. The term forest landscape zone is used here to make the distinction clear.

The image analysis was conducted through expert-based visual interpretation, using Geographic Information System (GIS) overlays with additional thematic and topographic map layers. The purpose was to detect evidence of significant human-caused alteration and fragmentation (see Box 1). Patches with such evidence were eliminated from the area of study and remaining areas, if large enough, were classified as IFL.

*Regional monitoring of forest alteration*

The IFLs found in the global map were re-assessed, using the same criteria as in the baseline assessment. The work was conducted through expert-based visual interpretation, and could proceed much more quickly than the initial IFL baseline mapping because only areas within already identified IFLs needed to be assessed (no gain in intactness is assumed to be possible on a decadal time scale).

The re-assessment product—an updated IFL map—can be used to measure and differentiate rates of forest alteration and degradation across a landscape. If large-scale changes are mapped separately (e.g. clearcuts, fire scars, and agricultural clearings) the map can also be used to differentiate causes of alteration.

The re-assessment was performed at a regional scale, using satellite imagery from the same (Landsat) or comparable (ASTER, IRS/LISS) sensors that were used for the baseline assessment. The Landsat images for year 2005 were obtained from the Global Land Survey image collection (Gutman *et al.*, 2008), ASTER images were obtained from USGS TerraLook collection (<http://glovis.usgs.gov/>), and IRS/LISS images were provided by R&D center ScanEx.

**3. Results and Discussion**

*Global assessment of forest alteration and intact forest landscapes*

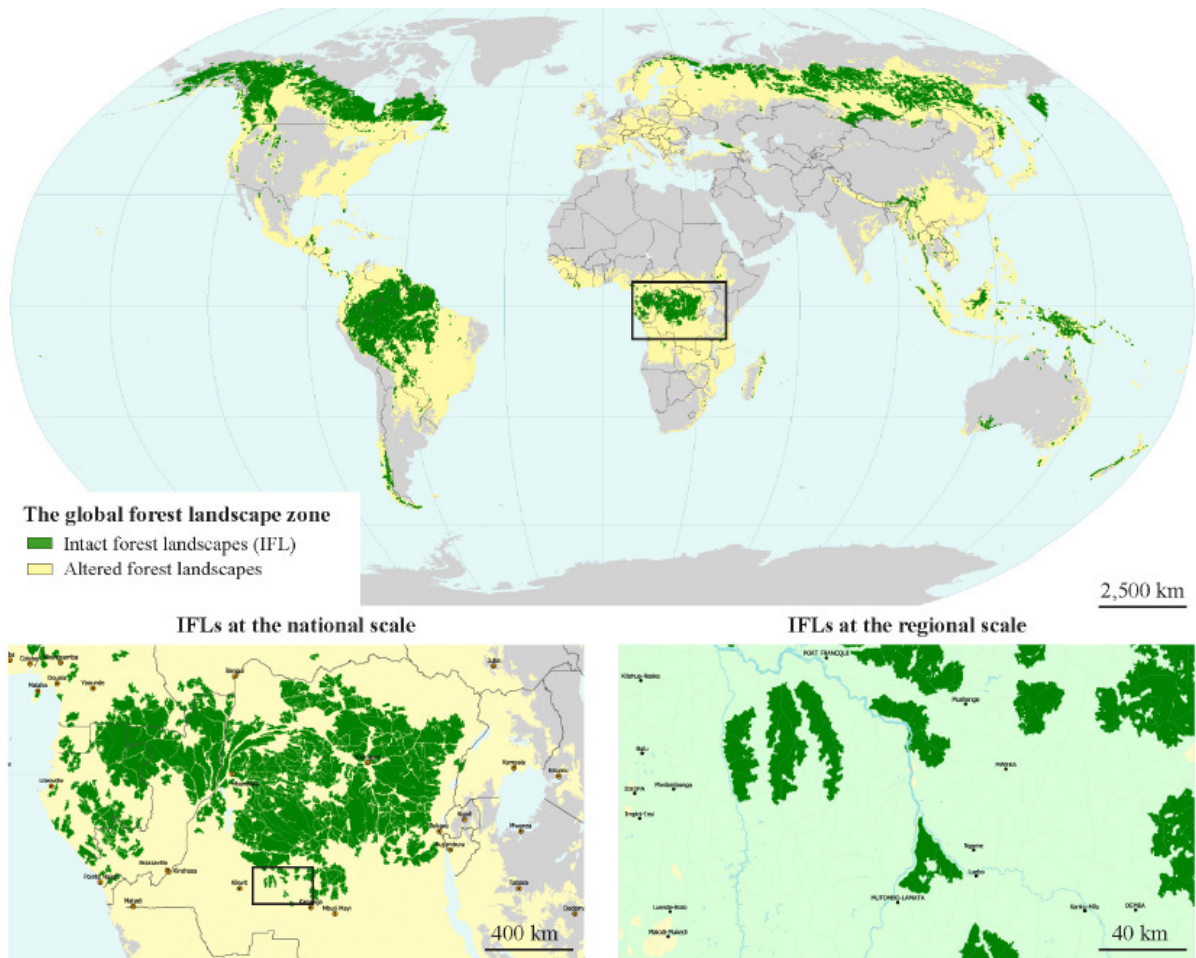
The current extent of the world’s forest landscape zone, as defined above, is 5,587.6 million ha (Mha) or 37.3 percent of the Earth’s total land surface. This area can be divided into three major ecosystem types, based on tree canopy density (Hansen *et al.*, 2003):

- (1) *Closed forests* with a tree canopy density greater than 40 percent (49.2 percent of the forest landscape zone);
- (2) *Open forests and woodlands* with a tree canopy density of 20-40 percent (24.7 percent of the forest landscape zone);
- (3) *Naturally treeless areas* with a tree canopy density below 20 percent, e.g. savannas, grasslands, wetlands, agriculture areas, mountain ecosystems, lakes (26.1 percent of the forest landscape zone).

IFLs make up 23.5 percent of the forest landscape zone (1,312.9 Mha). The remainder of the forest landscape zone (4,274.7 Mha) is affected by development or fragmentation (Figure 1). In the context of the IFL method this part is considered non-intact, i.e. altered, and includes areas that are degraded. The extent of alteration differs for closed, open and non-forest ecosystems (Table 1).

**Table 1.** Altered proportion by forest type

Forest type	Total Area (Mha)	Altered Area (Mha)	Proportion altered (percent)	Intact Area (Mha)	Proportion intact (percent)
Closed forests	2748.4	1901.3	69.2	847.1	30.8
Open forests	1377.6	1108.0	80.4	269.6	19.6
Naturally treeless areas	1461.5	1265.3	86.6	196.2	13.4
Forest landscape zone total	5587.6	4274.7	76.5	1312.9	23.5

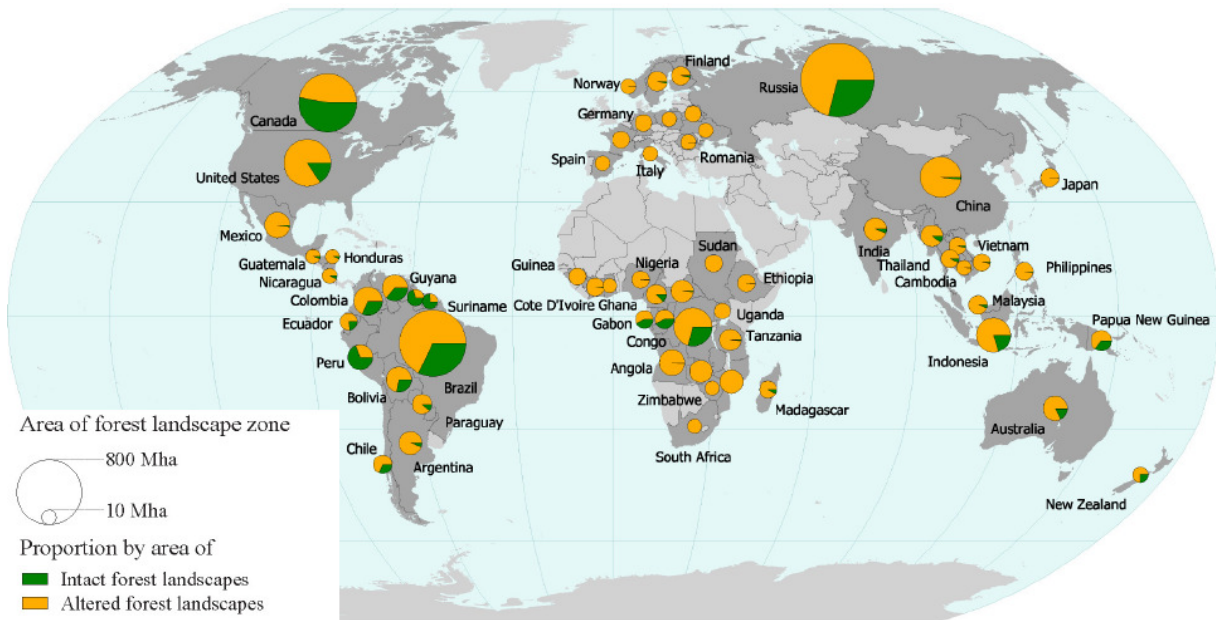


**Figure 1.** The world’s intact and altered forest landscapes. The IFL Method produces maps that are relevant for planning and monitoring at the global, national and regional scales. The regional scale map shows non-intact forests in light green and treeless areas in yellow.

Approximately two-thirds (69.2 percent) of the world’s closed forests are non-intact because of alteration or fragmentation. Within the remaining areas of the forest landscape zone (open canopy and naturally tree-less), IFLs remain in the boreal and subtundra zones of the north but not in the southern regions, where the extent of alteration is significantly greater in these ecosystem types than in the dense forests. A long history of human activities has transformed the original woodlands and savanna-type ecosystems of the tropics and the temperate forest-steppes into croplands, pastures, or pyrogenic shrubland or grassland communities.

### Country level assessment

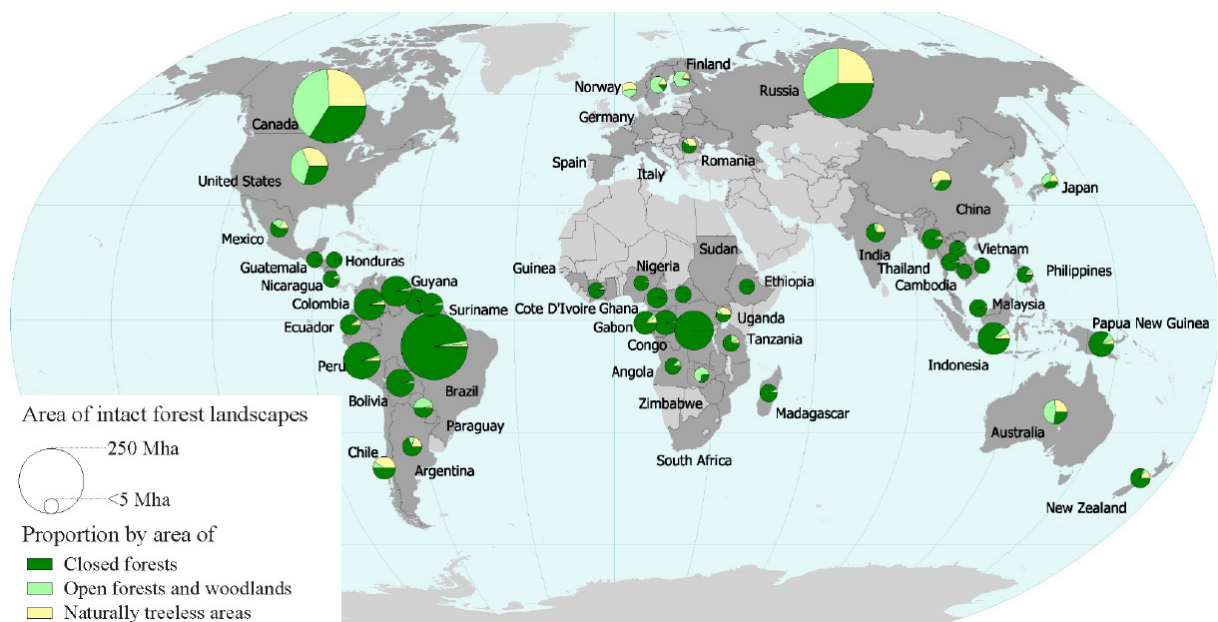
The country-level assessment was limited to countries with at least 10 million hectares of area in the forest landscape zone (Figure 2). Out of these 62 countries, the forest has been almost entirely altered in a group of 19 (less than 1 percent of the forest landscape zone remains as IFL). This group consists of European countries other than Russia, Finland, and Sweden, and African countries outside the Congo Basin. Major levels of alteration are seen in a group of 21 countries, featuring a proportion of remaining IFLs between 1 and 10 percent. This group includes African countries on the edge of the humid tropical forest biome, Central American countries, Northern Europe, and countries in Southeast Asia. China and India also belong to this group. The remaining 22 countries have an IFL proportion that is greater than 10 percent. Only five of them, however, have an IFL proportion greater than 50 percent (Canada, French Guyana, Guyana, Peru and Suriname).



**Figure 2.** Forest alteration, expressed as the proportion of degraded (non-intact) landscapes within the forest landscape zone of selected countries. Countries included in the analysis are shown in dark gray (62 countries total).

A study of different ecosystem types (closed, open, and non-forest ecosystems) within remaining IFLs (see Figure 3) reveals two different groups of countries. The first group is made up of developed countries with industrial forest management, where the densest and most productive forests have been fragmented, altered by management, or converted to plantations. Outside the forest management zone where tree canopy density tends to be low most areas remain intact (for example mountainous regions, wetlands, and the north of the boreal zone).

A different pattern prevails in the second group where accessible forests have been cleared for agriculture or grazing, while inaccessible tracts of dense forests remain largely intact. The least degraded dense forests are found among the countries of Central Africa, in Latin America, and in Papua New Guinea. The large proportion of dense forests within the IFLs of these countries makes them important repositories of carbon and their degradation (either because of deforestation or reduction in tree canopy cover) would lead to significant carbon emissions.

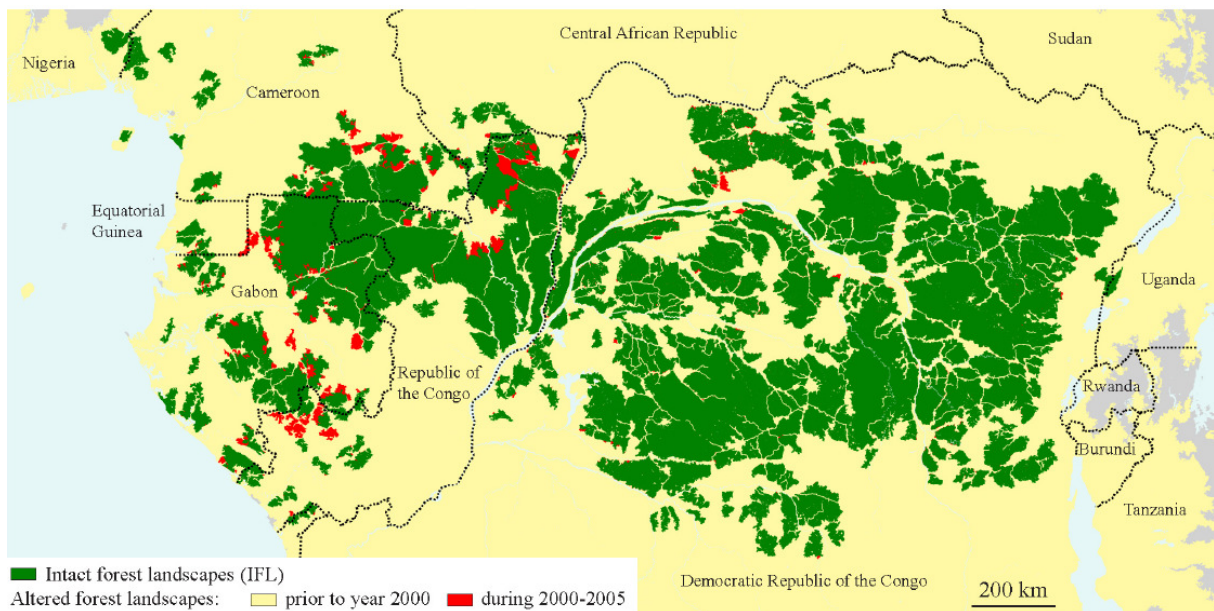


**Figure 3.** Intact forest landscapes in selected countries and their composition by forest canopy density. Countries included in analysis shown in dark gray (62 countries total).

## Regional IFL monitoring

### A. Africa IFL monitoring 2000-2005

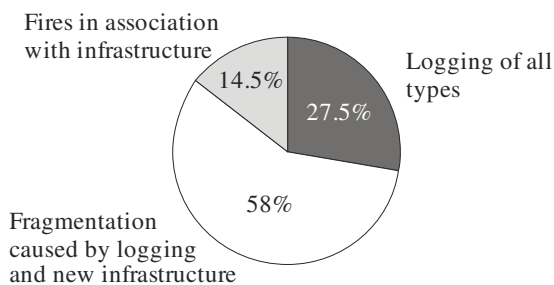
The IFL method was used to assess forest alteration in Africa over the period 2000-2005 (Figure 4). Landsat imagery was used. The analysis was only performed for the 14 countries that had IFLs in the baseline year of 2000. During the five monitored years, the total IFL area in these countries shrank by 3.6 Mha, corresponding to 3.6 percent of the baseline IFL area. Forest alteration was detected within all studied countries except Tanzania and Ethiopia. Most alteration (93 percent by area) took place in four countries: Democratic Republic of the Congo, Republic of the Congo, Gabon, and Cameroon. The per-country alteration rate varied 32 percent (in Liberia) to 0.4 percent (Nigeria) of the baseline IFL area. Democratic Republic of the Congo, the country that alone contains more than a half of Africa's IFLs, lost 1 percent of its intact forests. Our results suggest that the logging activity in this country has increased in recent years after a decade of civil war. The rate of alteration is much higher in other central African countries with more intensive forestry operations: Cameroon lost 10 percent of its IFL during 2000-2005, Gabon lost 8.8 percent and Republic of the Congo lost 8.3 percent.



**Figure 4.** Intact forest landscapes of Central Africa: 2000-2005 monitoring results.

## B. European Russia IFL monitoring 2000-2004

The IFL method was used to monitor forest alteration in European Russia during the period 2000-2004. Landsat, ASTER and IRS/LISS imagery was used. The total IFL area decreased by 19,700 hectares during this period. The reduction was unevenly distributed among remaining IFLs, reaching as high as 1.2 – 1.9 percent per year for individual tracts. The loss of IFL area has two causes: direct transformation and fragmentation. The main cause of the former was clearcutting (cutblocks up to 50 hectares in size) and associated road construction, mainly in the southern and middle zones of the taiga forests (there was very little in the northern taiga). Thinning and other forms of selective felling occurred only rarely. Another cause was forest fires. Most of these occurred in the northeastern part of the area in the vicinity of oil extraction infrastructure. The biggest cause of alteration, however, was fragmentation due to expansion of logged-over area and road construction (Figure 5).



**Figure 5.** Causes of alteration of intact forest landscapes in European Russia.

### *Assessment of the IFL method*

#### Advantages and disadvantages of IFL definitions and criteria

The IFL method has many advantages over field- and expert-based forest alteration assessment approaches for large-area assessments. It is suitable for all countries and continents. It is cheap and quick to apply. Its data needs are fulfilled by satellite imagery, which is available in the public domain at a low and shrinking cost. It is rigorously defined and lends itself to independent replication and verification. It is thereby also suitable for monitoring (i.e. replication at a different point in time in order to measure change). It can be adapted and refined, for example to assess smaller landscapes. Remote and otherwise inaccessible landscapes can be assessed. The result is consistent across the entire area of study (for example a country or the world); and results can therefore be compared. The result is spatially explicit, taking the form of a map which is detailed enough to underpin decisions about conservation priorities and measures. Statistical information can easily be derived from the map. The method is tested and ready to use.

There are also limitations. Skills in GIS and interpretation of remotely sensed data are required. The method is only capable of assessing the presence or absence of human impact, i.e. the degree of ecological integrity of a forest landscape. As described, the method is only suitable for large areas (province, country, region, the world) and not sensitive to variations in the understanding of “intactness” and “disturbance” within the area of study, for example, whether burned areas should be considered the effect of natural disturbance or not, or whether the minimum size of an IFL should be differentiated with regard to biome or natural disturbance regime (for example fire dynamics versus gap dynamics).

A significant limitation of the method as presented here is that it exclusively measures the *extent* of alteration without being sensitive to its *intensity*.

The method can be modified to become more sensitive to the intensity of alteration by introducing more classes into the measuring scale. The scale for human influence can be refined by adding classes that are less strict in terms of what triggers the exclusion of an area, and the patch size threshold can also be further differentiated, for example by inclusion of smaller areas (“fragments of intactness”), thereby making the method more suitable for assessment of small landscapes (Lee *et al.*, 2006, Mollicone *et al.*, 2007).

It is also technically possible to go from a “seamless” assessment to a “quilt” assessment by allowing different criteria to be used in different biomes or countries. A price for this must be paid, however, in terms of loss of consistency and comparability across the area of study. We propose using the presented set of criteria for the global forest alteration analysis, while regional-based criteria can be developed and used for national or biome/ecoregion level assessments if needed.

### Data issues, methods and accuracy

The IFL method was specifically designed to utilize satellite imagery as the main source of information. This makes it possible to assess large, even inaccessible, landscapes at a low cost and a short time. Suitable historical satellite images (Landsat) are available in public archives since approximately 1980, making retrospective assessments possible. The availability and technical quality of satellite images are gradually improving, while the price is gradually going down. The IFL method must be regarded as highly cost-effective in relation to the size of the area assessed.

Monitoring of change takes significantly less time and resources than the initial baseline mapping, as only IFLs that have already been mapped need to be re-assessed. The main data source is visually interpreted satellite imagery of high and medium resolution. The regional monitoring studies presented above suggest that visual interpretation can be effective for rapid and effective re-assessment of IFLs across large regions. Unlike automated satellite image analysis approaches, visual interpretation using our IFL criteria is not sensitive to data gaps (i.e. the use of Landsat SLC-off data), atmospheric effects and differences among sensors. Such IFL monitoring can be supplemented (but not replaced) by analysis of automatically derived forest cover change products.

The IFL method is biased towards under-estimation of alteration (overestimating the area of IFLs). This is because of its basic premise that all landscapes are considered un-degraded until the opposite can be proven. The method may fail to register human influence that is difficult to detect in satellite imagery, such as selective logging, small-scale slash-and-burn agricultural practices, and hunting (for example poaching in Central Africa).

The accuracy of the result benefits from field verification in cases when the interpretation of available satellite imagery is unclear (for example due to poor imagery), when the evidence of human influence is difficult to classify (for example when it is diffuse rather than distinct), or when a landscape is subject to human influence which is invisible from space (for example because it is small scale or happening under the canopy of tree crowns). There is a certain degree of subjectivity in determining IFL boundaries across transition zones from intact to disturbed areas, especially within non-forest territories, savannas, woodlands, and in mountain areas. Resources for field work should be focused on verifying the interpretation at important points of unclarity, rather than on a random or systematic sampling. The method is capable of generating useful results without field verification if applied by experienced analysts with expert knowledge of the landscape they are assessing.



## 4. Conclusions

The IFL method provides a cost-effective way to assess the degree of human influence across a large forest landscape (for example a country or the world). The result is a map that shows the precise location and boundaries of intact forest landscapes, i.e. the remaining patches of un-altered land in the forest landscape zone. The map provides a guide for policy-making and priority setting as well as a baseline for monitoring by recurrent application of the IFL method to remaining intact forest landscapes. The distinction between intact and non-intact forests used here is consistent with experience from satellite-based deforestation measurements and can be used to provide important background data for accounting of carbon loss from forest alteration.

The method can be refined to become more sensitive to the intensity of alteration without changing its logic or data requirements, thus enabling it to measure degrees of alteration.

The method will benefit from improvements in the quality, price, and public access of satellite images, as it is designed to use satellites as the main source of data. The effect of such improvements will be particularly strong in the humid tropics where persistent cloudiness makes image acquisition difficult.

In the context of REDD (Reduction of Deforestation and Degradation in Developing Countries), IFLs are strongly associated with issues of permanence, biodiversity, and indigenous peoples. Countries that wish to make an early commitment under REDD that is capable of being monitored, verified, and reported may therefore find that the IFL Method offers interesting opportunities. It should also be of interest for global monitoring of forest degradation, for example within the Forest Resources Assessment.

The usefulness of the method can be expanded through at least three types of measures:

- *Capacity building.* The method requires from an analyst a combination of two types of expertise: experience in satellite images interpretation and GIS, and knowledge about forest ecology and management. This combination is still rare, particularly in developing countries. Concerted training efforts can certainly help in this regard.
- *Transparency and review of results.* The results of the IFL Method are relatively easy to communicate and understand because they can be articulated on maps. These maps need to be reviewed by regional and local experts as well as by relevant stakeholders but the logistical challenges for a paper based review process are prohibitive, particularly for a regional or global assessment. Fortunately it is possible to let reviewers access the maps and provide feedback via the Internet. Development of a web-based platform for transparency and review is therefore needed.
- *Funding for development and application.* The IFL method has been developed thanks to financial contributions from corporations and foundations in the private sector. Government engagement in the further development and application of the method would be extremely beneficial.

The authors envision that the global IFL map will be periodically updated and improved to reflect changes due to alteration, degradation and deforestation. The continual improvement of satellite-borne sensors and analytical techniques will gradually reduce the necessary effort. A continuous external review process has been organized on a dedicated web site (<http://www.intactforests.org>).

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