Forest Integrity Assessment

A simple and user-friendly tool for assessing and monitoring biodiversity conditions in forests and forest remnants

Foreword

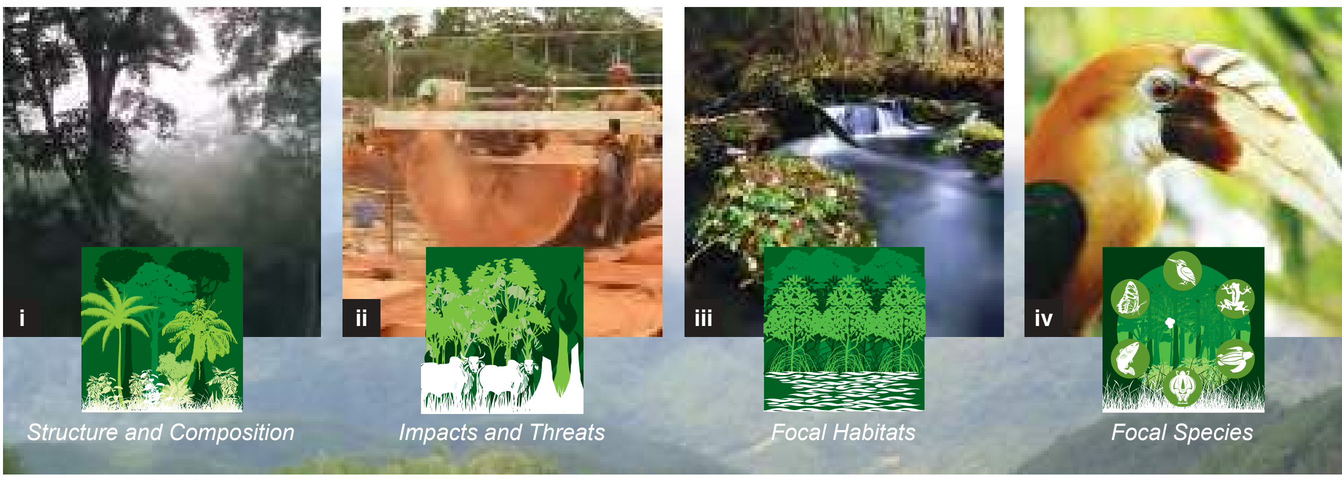
The first steps towards the Forest Integrity Assessment methodology date back to work done in the early 1990s, sparked by the need for an 'ecological assessment tool for use by non-ecologists'. Staying true to that basic concept, we have since developed numerous iterations and tested and modified the approach based on experiences from forests in many parts of the world – boreal, temperate and tropical. We are convinced that there are many uses for this simple but versatile tool, now added to the SHARP / HCV Resource Network toolbox, and we encourage people to adopt it, adapt it to regional conditions and use it in line with this guidance.

Anders Lindhe and Börje Drakenberg

*The **SHARP** Programme is a multi-stakeholder partnership working with the private sector to promote to sustainable smallholder development and crop production. Partners include smallholders and their representatives and a range of producer and supply chain companies, financiers, governments and non-governmental and civil society organisations.*

*The **HCV Resource Network** is an independent membership organisation that strives to identify, maintain and enhance critically important ecological, social and cultural values, by bringing together and helping stakeholders to consistently use the High Conservation Value approach. Members include a range sustainability certification schemes, financial institutions, multilateral organisations, non-governmental organisations and HCV practitioners.*

proforest HCV RESOURCE NETWORK WWF



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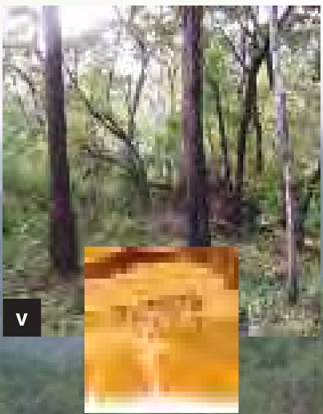

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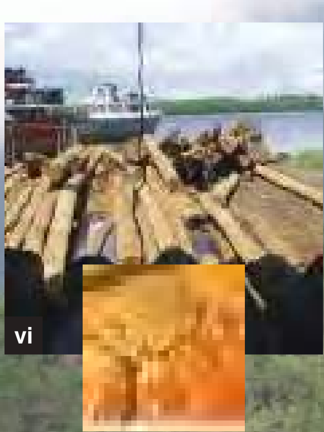

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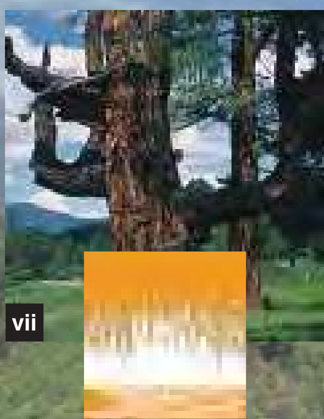

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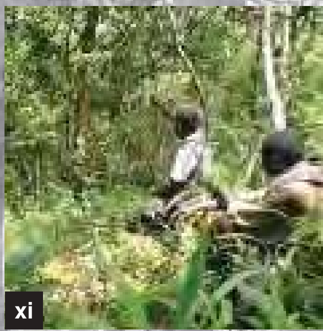

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1. Introduction

Assessing and monitoring forest biodiversity is a huge challenge, particularly for smallholders, communities and medium-sized entities. Populations of large, conspicuous and easily identified animal species, particularly those that are active during daytime, build characteristic nests, or leave large droppings, may be monitored through surveys in the field. However, organising, conducting and interpreting such surveys is beyond the capacity of smaller operators. In fact, broader inventories of invertebrates, fungi, mosses and lichens – the bulk of forest biodiversity in terms of numbers – are very challenging even for well-resourced, large organisations, as is evaluating the results and using them to adapt and improve management.

The Forest Integrity Assessment (FIA) tool is a simple and user-friendly check-list approach designed to overcome these constraints. Assessments focus on habitats as indirect proxies for biodiversity rather than on species, using natural forest types little affected by large scale human activities as reference. The approach is applicable both to larger forests and to remnant forest patches interspersed in agricultural and forestry landscapes. The tool can be used for monitoring by companies, for self-assessment by smallholders and for participatory monitoring with community members – in fact almost anyone with an interest can learn how to apply the approach. Some basic training is necessary to achieve reasonably consistent results: smallholders may learn how to assess and monitor their woodlots during a day of field training, while a couple of days may be needed to train people to consistently sample and monitor larger forests.

Forest Integrity Assessments may serve one or all of the following purposes:

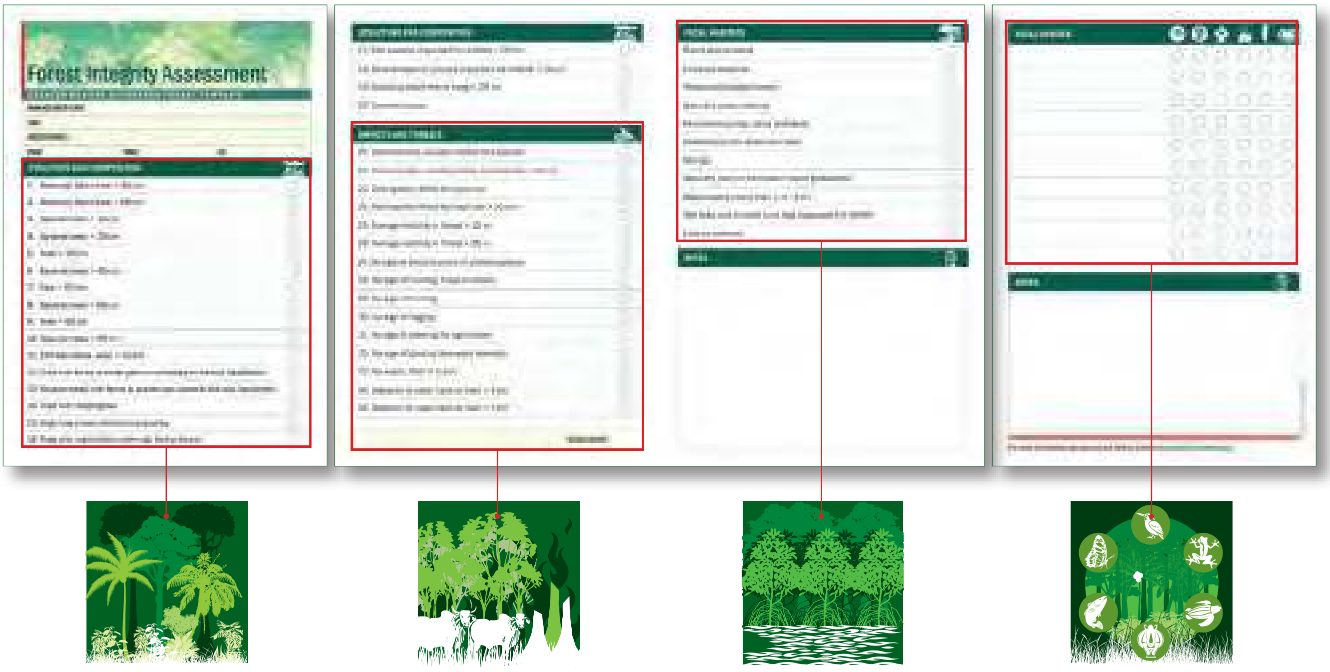
- **Self- or participatory assessment and monitoring** over time of forest conditions for biodiversity in managed forests and/or in HCV areas or set-aside reserves.
- **Guiding responsible forest management and forest restoration** by identifying features and elements that are currently missing (gap-analysis). This helps managers to identify what they can do (or abstain from doing) in order to recreate such structures and so score better in the future.
- **Raising awareness and educating** non-biologists about forest conditions important for biodiversity.

2. Methodology

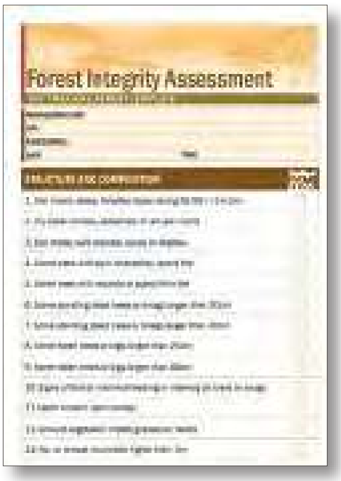
2.1 Background and rationale

The FIA approach assumes that most organisms depend on particular natural habitats and forest conditions for successful survival and reproduction. This is a simplification: wide-roaming carnivores and other generalists often thrive in a broad range of circumstances where there is plenty of food and absence of persecution, and some species are regulated more by predators, competitors, parasites or diseases than by habitat quality. Habitat size is obviously also very important – everything else being equal, larger areas have the capacity to host larger numbers of species than smaller areas, and recently fragmented forest patches usually lose species as new equilibrium conditions are established over time. Small forest remnants may also suffer from negative edge effects due to, for example, less humidity or increased predation. Still, vast numbers of species are closely linked to particular forest elements and habitats, and assessing these is the only feasible option for monitoring where capacity and resources for quality species surveys are lacking.

Forest characteristics may be recorded by counting and measuring certain parameters, (e.g. diameter distributions of tree species, cubic metres of dead wood, percentage of canopy cover or thickness of litter layer) in delineated plots. Such rigorous procedures are taxing in terms of capacity, time and logistics, and are most often used in research where there is a need for very precise data. Estimates, the approach adopted for forest integrity assessments, are obviously less precise at the level of the individual plot. However, as estimates are more rapid and require less training and capacity, the relative lack of precision at each plot may be offset by larger samples. This is important, as larger amounts of less precise samples usually generate more accurate descriptions of average forest conditions than a few intensively studied plots.



Structure and Composition *Impacts and Threats* *Focal Habitats* *Focal Species*

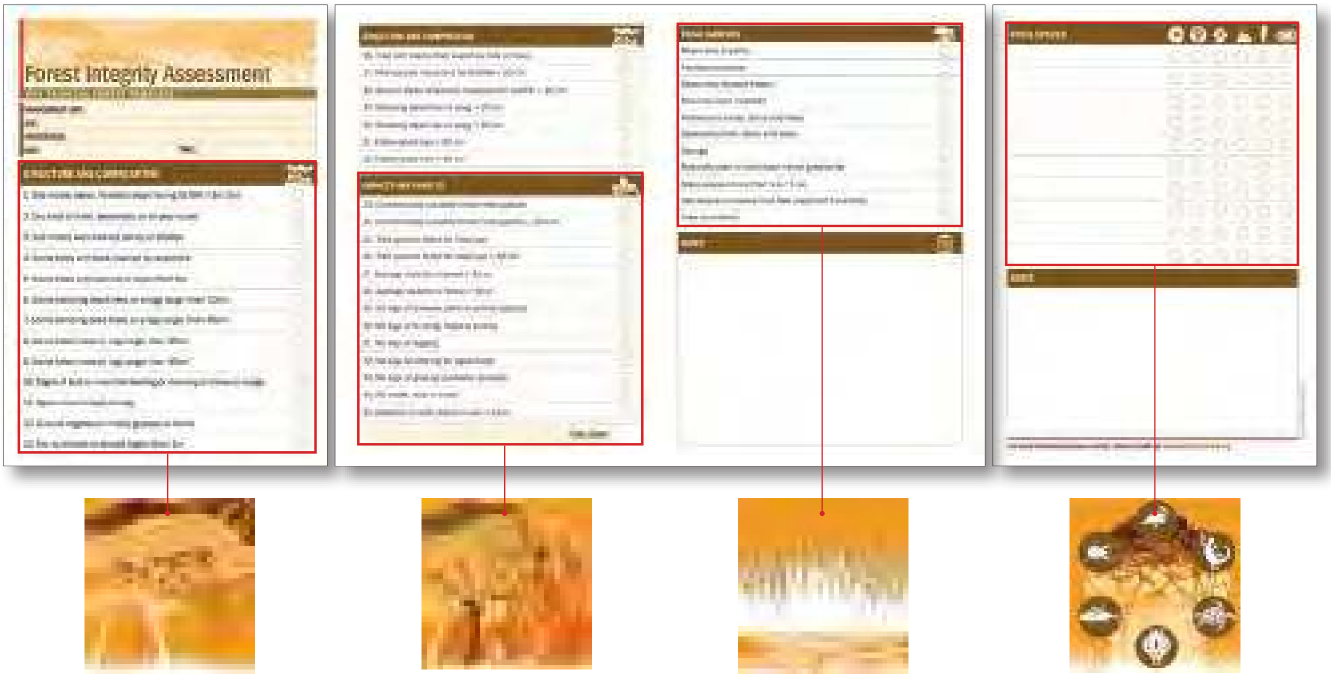


2.2 Scoring

Field forms with sets of yes/no scoring questions guide and standardise the assessments, adding up to a numerical value of forest integrity. Some questions address biodiversity directly (e.g. presence of trees with epiphytes), others serve as indicators of natural conditions or low human pressure (e.g. presence of very large trees and presence of trees of high commercial value). Recent field forms divide scoring questions into two sections: *Structure and Composition*, and *Impacts and Threats.*

Questions are formulated so as to address forest elements and features as they occur on a relatively limited assessment area, typically plots of 0.25-1 hectare (the actual size depends on the visibility in the particular forest). The word ‘several’ is used to characterise components found in larger numbers, as opposed to just one or two. In practice, these are components or features that occur in such quantities that the assessor *will notice them without specifically looking for them*. Biases of human perception make us note the presence of large and conspicuous components more readily than we register smaller things. As a result, 3 to 4 big trees in a plot may be enough to trigger ‘several’ while it may take 10 to 15 smaller trees to give a similar impression. This relativity doesn’t matter for purposes of monitoring as long as it doesn’t change over time.

Each question in the field form is to be answered independently of the others, ticking the boxes where the answer is *yes* (no numbers or figures!) and leaving blank the boxes for which the answer is *no*. A number of components are addressed by two successive, paired questions. The first asks about presence in any quantity, large or small: e.g. *tree…*, while the second specifically asks about presence in higher numbers: e.g. *several trees…* The intention is to generate double scores where there are more than just one or two individuals of a certain category of trees – a first yes for presence, and an additional tick for *several*.

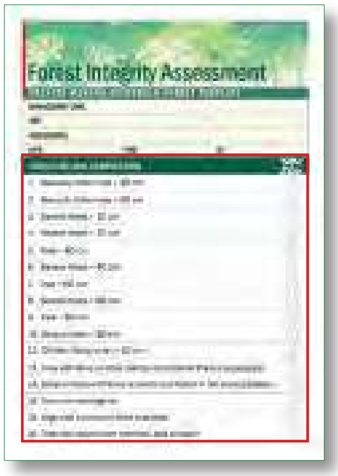


Structure and Composition *Impacts and Threats* *Focal Habitats* *Focal Species*

3. Field form

3.1 Structure and composition

3.1.1 Tree size



Large diameter trees serve as both direct and indirect indicators of forest biodiversity potential. Experience demonstrates that classes of stem diameters (at breast height or above buttress roots, where necessary) separated by 20 cm intervals are distinct enough to be robustly estimated in the field without measuring. Big, old trees are fundamental ecological elements of old-growth forests (and good indicators of naturalness), and field forms are designed to give them heavy weight through a set of linked, accumulative questions.
As an example, in the field form for tropical evergreen forests in the Greater Mekong region, a plot with several trees with diameters larger than 80 cm may score a total of eight ‘diameter points’, as positive answers could be given for the following criteria: several trees > 10 cm, several trees > 20 cm, as well as ‘tree’ and ‘several trees’ > 40, 60 and 80 cm diameter.

1 *Tropical forest, Sabah, Malaysia*

3.1.2 Regeneration

In healthy forest ecosystems, trees regenerate so that forests maintain or revert to their natural state after disturbances. In (typically boreal and temperate) forests that consist of relatively few, easily identified tree species, regeneration may be assessed through the presence of saplings with capacity to reach the canopy – a height of more than 3 m serves as an indicator that saplings have survived the bottleneck seedling stage. In (typically tropical evergreen) forests that are composed of large numbers of tree species which are difficult to identify at the sapling stage, conditions for regeneration may be addressed indirectly through the presence of fallen big trees. These are assumed to create gaps suitable for generation for a couple of years after the tree fall.

2 *Fire-driven forest regeneration, Sweden*

3 *Nest of Steller's sea eagle, Russian Federation*

4 *Plant epiphytes, Malaysia*

5 *Large-diameter lianas, Republic of the Congo*

3.1.3 Trees important for biodiversity

Some trees are more important for biodiversity than others. These include trees that host epiphytic plants (which may form small ecosystems in their own right in some tropical rainforests), tree species that are particularly good nesting trees for birds, predictable providers of edible fruits, nuts or berries for birds and mammals, or sought-after sources of nectar for birds, bats and butterflies. Lianas and woody parasites may also be sorted under this heading, for their contribution to structural diversity as well as for their fruits or berries.

3.1.4 Coarse woody debris

Most ‘dead’ wood is in fact very much alive and plays an important, or even crucial, role as habitat for a variety of wood-living fungi and insects, as hiding or hibernation places for a multitude of small vertebrates and invertebrates, and as substrate for mosses. Dead wood is particularly important in the cold and dry boreal where decomposition is slow compared to moist temperate and tropical forests. In such settings, even small diameter fallen trees may sustain diverse communities of organisms for decades before their nutrients are exhausted, so it makes sense to allocate quite a number of questions to this aspect and distinguish between various sizes and kinds of dead wood. In the moist tropics on the other hand, wood may decompose so fast that trees disappear within years. In such forests dead wood is a proportionally less important component of the ecosystem and just a few questions on large diameter dead trees may be more appropriate.

6 *Stag beetle on dead oak, Sweden*

7 *Bracket fungus on fallen tree, Indonesia*

8 *Recently burnt forest, Sweden*

3.1.5 Fire

Field forms for use in dry forests are designed to score positively for signs of recent and/or recurrent fires. This may raise some eyebrows, as forest fires are often associated with haze, forest clearing and devastation, but many dry forests need periodic fire to create habitats and conditions for fire-dependent organisms and for the long term maintenance of forest structure and composition. Such fires tend to open up the canopy and burn away shrubs and smaller trees to the benefit of grasses, herbs and many ground-living animals. Consequently, a dry local climate that increases the likelihood of wildfire scores ecologically positively in such settings. However, combined pressures from frequent burning, logging and intense grazing may push dry forests past a tipping point to become (very fire-prone) scrublands, particularly in regions with seasonally dry climates, where fires may be severe threats to human lives and infrastructure. Fire intervals may also be lengthened through active fire suppression and combating of wildfire, in which case forests accumulate combustible litter and, when fire eventually hits, burn intensively leaving few if any surviving trees. .

Natural fire frequencies vary – some dry subtropical Southeast African forests burn (or are burnt!) almost every year, dry temperate pine forests in the Southeastern US may burn naturally once or twice every decade, while dry boreal pine forests may be affected by fire once or twice a century. Natural fire intervals may be shortened by human clearing and burning for temporary crop cultivation or to promote livestock grazing, or, as in most managed forests, lengthened through active fire suppression and combating wildfire. Forests in the latter category accumulate combustible litter and, when fire eventually hits, often burn intensively leaving few if any surviving trees.

9 Clearing for shifting agriculture, Peru

10 Lung lichen growing on maple tree, Canada

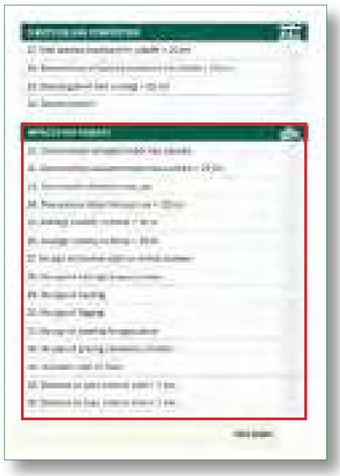
3.1.6 Other elements

Forest differ also in many other aspects, and other structural elements may be added as part of the *structure and composition* scoring section where appropriate.

Examples include:

- Tree trunks with mosses *(indicating relatively moist conditions).*
- Tree covered with lichens *(for their contribution to biodiversity).*
- Tree with top broken by snow *(slows growth and creates conditions for certain wood-living insects).*
- Trees with signs of pollarding/coppicing (cut branches and subsequent healing may create inroads and habitats for insects and fungi)
- Tree with signs of pollarding/coppicing *(indicator of positive human impacts in culturally modified woodlands and parklands).*
- Solitary, sun-exposed tree with wide crown and thick branches *(indicator of positive human management regimes in culturally modified woodlands and parklands).*
- Hollow tree *(large cavities are used by many vertebrates and the resultant mixture of faeces, feathers and decaying wood may host a rich insect fauna).*
- Anthill *(ants constitute staple food for numbers of bird species in some regions).*

3.2 Impacts and threats



This section addresses anthropogenic pressure, based on the assumption that human impacts generally reduce forest naturalness and diversity. This is often a reasonable approximation outside woodlands with a long history of livestock grazing and/or harvesting of winter fodder, particularly where human pressure is severe, unregulated and mediated through multiple factors. However, human activities may also enrich forests through low intensity shifting agriculture that increases the amount of food for herbivores on the forest floor and allows some regeneration of shade-intolerant trees species, or through 'gardening' that spreads and promotes growth of trees with edible fruits and nuts. Moreover, just setting aside the forest does not necessarily create optimal conditions for biodiversity, particularly in secondary forests and in forests where natural fires are suppressed. Such forests may be responsibly managed and harvested and still score high on integrity, provided that enough natural elements and characteristics are retained, mimicked or restored. FIAs may help managers to strike a reasonable balance between ecology and economy.

Obviously, the character and magnitude of human impacts on forests depend very much on the context. Encroachment, unauthorised logging and poaching may be massive problems in regions affected by poverty and weak governance, and non-issues in other situations. The *Impacts and Threats* section should be adapted accordingly, taking care that all questions finally included are meaningful and relevant.

Negative impacts are addressed through 'no' questions in order to generate positive scores compatible with those of the *Structure and Composition* section.

11 Herding goats in the forest, Greece

3.2.1 Trees of high commercial or local value

Regions where (once more common), high market value trees have become rare or absent (e.g. mahogany in parts of Latin America) bear witness to past pressure, often several waves of logging successively smaller diameter trees. In addition to changing the forest composition and structure, loggers may also have left residual roads, tracks and other types of infrastructure that facilitate access for hunters and poachers.

Tree species sought out and cut down for local use (charcoaling, building, fencing, wood-carving etc.) may also serve as impact indicators. Where such trees have become rare, forests may be degraded in other respects as well, for example through over-hunting, over-collection of non-timber forest products or the persecution of species that pose threats to domestic animals or crops.

12 Truck with mahogany logs, Brazil

3.2.2 Visibility and absence of disturbance-favoured undergrowth

Forests often have denser patches of regenerating saplings or disturbance-favoured undergrowth (e.g. climbing bamboos in some tropical rainforests) where trees have fallen or been logged. However, the amount of undergrowth is usually less, and visibility (how far you can see in the forest off-trail) considerably better where a closed canopy shades the ground. Thus, average visibility is quite an effective indicator of overall disturbance. Visibility also works as a positive indicator in dry forests where dense shrubs are cleared away by periodic fires.

3.2.3 Invasive species

Species intentionally or accidentally introduced to new regions where they lack co-evolved predators or competitors may expand and invade natural ecosystems, sometimes causing massive environmental and economic damage. Consequences are often most severe where the regions of origin and destiny have been separated for long periods of time – the impacts of alien animals on the ecosystems of Australia and islands in the Pacific are illustrative examples. Other examples of problematic invasive species include the infestation of riparian zones in South Africa by acacia, introduced as plantation trees, and damage to trees in Western Europe from the, originally North American, grey squirrel (which is also locally outcompeting the native red squirrel).

3.2.4 Illegal hunting, poisoning, capturing or collecting

These are all activities with potentially negative impacts on local ecosystems, sometimes depleting structurally diverse, and therefore 'healthy-looking', forests of a significant proportion of their original species. Drivers range from selling local bush meat (signs in the forest include empty cartridges, traps and paths), to supplying illegal traders of ivory, rhino horns and other extremely high-value animal body parts. There are also very lucrative illegal markets for captured live animals (e.g. raptors, parrots, snakes and large cats) kept as pets or for 'sport', as well as for birds' eggs, butterflies, orchids and other species coveted by unscrupulous collectors. Use of poisoned baits to kill mammals and birds that prey on domestic animals (or are perceived to be competitors for game) may have severe unintended consequences, by killing scavengers and other non-target species.

13 A black-casqued hornbill killed for bushmeat, Gabon

14 A civet cat and red-capped mangabey killed for bushmeat, Gabon

15 Confiscated jaguar skins, Brazil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16 Tree felling, Indonesia

17 Shifting cultivation, Peru

3.2.5 Logging

Logging often (but not always!) impacts negatively on the naturalness and integrity of forest ecosystems. Exceptions include forest management practises that mimic some effects of natural fire in regions, such as much of US, Canada and Scandinavia, where fire-alerts and fire-fighting have effectively eliminated much of the natural disturbance regime. In regions with limited logging for local needs by communities, or where legal and responsible forestry practices (e.g. low impact logging) is the norm, it is more appropriate to focus on Ilegal (un-authorised, non-regulated etc.) tree felling. Focusing on the more damaging illegal and irresponsible practices will also facilitate a constructive dialogue with community members and forest managers.

3.2.6 Human forest clearing

Similar to logging, it may be argued that human forest clearing is often negative in forests moulded by natural disturbances. However, shifting agriculture followed by long periods of fallow that allow trees to grow back may in fact make the forest a richer mosaic of different successional stages, and in some areas low-intensive shifting agriculture has been practised for so long that it makes little sense to imagine a primeval forest 'before man' as a point of reference. Clearing for permanent fields is obviously another matter (as is unsustainably intensive, short rotational shifting agriculture) – where such practises are common, FIA questions may be formulated so as to consider all clearing for agriculture a negative impact.

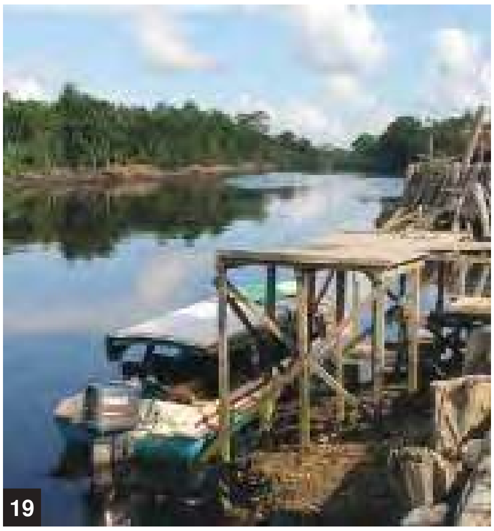
3.2.7 Accessibility

A generic indicator, assuming that human pressure on forests and forest resources (and associated risks of negative impacts) are higher closer to points that are easy to access by vehicles, motorbikes or boats. The distance that people will be willing to walk to attain certain resources varies depending on a number of factors, including the value of the resource, character of terrain and availability of alternative resources or substitutes. However, research indicates that almost all illegal logging occurs within 5 km from a road and 1 km from a river and these distances are used as defaults in the template.

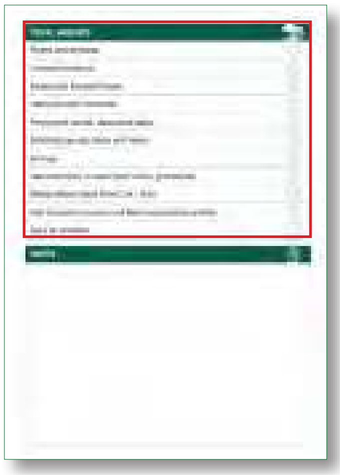
18 Forest track, Ghana

19 Access by boat, Kalimantan, Indonesia

20 Road building, Yabassi, Cameroon



3.3 Focal habitats



The purpose of this section is to highlight forest and forest-mosaic sites of particular importance for biodiversity – for shelter, feeding or reproduction. In forestry contexts, this section serves as a checklist of habitats for which responsible managers should have in place specific standard operating procedures (SOPs) to maintain their character, implemented by trained staff and with systematic follow up. Where feasible, local people utilising resources from the forest should also be made aware of focal habitats, and rules for acceptable and not acceptable activities should be agreed. Presence of focal habitats in an area may also serve as additional indicators of value for biodiversity, helping to prioritise areas to be set aside and/or managed for conservation.

Wetlands, springs, ponds and lakes are focal habitats in most settings, including bogs and other peat lands, marshes and fens with or without tree cover. Seasonal and permanent streams and rivers are also important and, where relevant, may be distinguished further based on size, materials and characteristics of river beds and river beds and river banks, presence of rapids and falls etc.

Other kinds of focal habitats result from particular topography or geomorphology: steep slopes, cliffs and ravines, boulders and scree, sinkholes and caves. Further examples include areas of bare bedrock and/or shallow soils, and patches of exposed sand or silt suitable for digging nests and burrows – for vertebrates as well as for bees, wasps and other insects. Biodiversity also usually benefits from patches of open natural or semi-natural vegetation like heath, meadow and other grassland mixed in with the forest.

21 Temperate rainforest stream, Canada

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3.4 Focal species

The focal species concept (included in recent templates) builds on selecting a shortlist of species of regional conservation concern, normally a subset of nationally protected or IUCN-classified *Rare, Threatened or Endangered* species. Ideally, focal species should be chosen so as to represent not only birds and mammals, but also reptiles, amphibians, fish, insects and plants. Preference should be given to familiar and widely recognised species – particularly species with names in local languages. In cases where whole genera or larger taxonomic units are under threat, or where species of conservation concern are difficult to distinguish from other visually similar species, larger taxa such as *hornbills, salamanders* or *turtles* may serve as collective focal species. Symbols refer to the nature of observations, whether by sight (eye), or sound (ear). Direct encounters may be rare though: observations of nests, tracks or markings, faeces or shed feathers may be more common ways of detecting species presence.

Focal species are included in the FIA methodology mainly to facilitate outreach and awareness raising about the aims and needs of biodiversity conservation. Where people with good species knowledge spend considerable time doing FIAs in the field, observations may also help to monitor changes, but the approach is not intended as a substitute for more in-depth species surveys.

22 Jaguar footprint, Brazil

23 Poison dart frog, French Guiana

24 Tree pangolin, Democratic Republic of the Congo

25 Lineated woodpecker, Brazil

26 Young sunbear, Indonesia


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4. Regional adaptation

FIA field forms and templates have been developed for a number of purposes and forest types around the world: value assessment prior to operations, prioritisation of areas for conservation and monitoring of forest integrity over time. Regional or national adaptation aims to further modify a generic template or adapt an already existing version for use in another region or country with similar forest types. This is most effectively done by a group of people, including a forester or a forest ecologist, a botanist and a zoologist, in a 3-4 day workshop that includes visits to the field.

Questions in particular need of regional consideration are highlighted through use of italics in the templates. Other questions may also need to be reworded or removed or new questions added, as regionally appropriate. When adapting the field forms or templates it is important to aim for concise formulations that encourage consistent interpretation (quite a challenge given the one-liner format!). As a general rule, elements and indicators addressed should meet the following criteria:

- **Relate, directly or indirectly,** to conditions for forest-dependent flora and/or fauna.
- **Be easy to detect** in the field during all seasons assessments are feasible.
- **Be easy to identify** with a minimum of training (effectively limiting questions on specific species to a small number in most contexts).

27 Old-growth boreal pine forest, Sweden

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Moist temperate forest: the field forms for the Valdivia region in Chile

Step 1: Identify relevant disturbance regimes

Natural forests are moulded by natural disturbances. In gap-dynamic forest types, regeneration is largely associated with small gaps from fallen trees where the competition for nutrients is reduced, accelerating the growth of seedlings and releasing suppressed understory trees. In other forests, fires, hurricanes, landslides or deposition of volcanic ash can create large, sometimes very large, open areas where new generations of pioneer, shade-intolerant tree species germinate or sprout. There are also forests that fall outside this nature-as-reference scenario, particularly woodlands and parklands where grazing or hay-moving inhibits regeneration outside pockets not reached by scythes or livestock, and where older trees often bear witness to pollarding or coppicing for fencing, fodder, fuel or charcoaling.

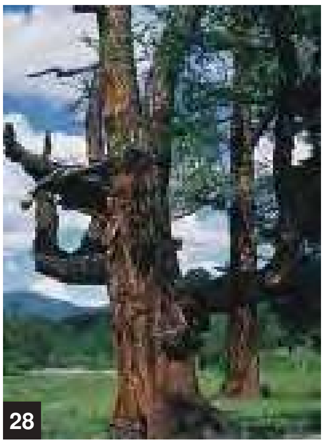
While many questions apply equally to all three forest categories, some are only relevant for one or two. Others, such as maximum tree diameters, may differ between forest types. There are also features that are specific for a certain forest category and other indicators, such as fire, that may be considered positive in dry forests where fire is a natural factor, but negative in moist forests where burning is usually associated with human clearing. Different categories of forests may be addressed either by developing separate FIA field forms, as exemplified by the different templates for evergreen and dry forests in the Greater Mekong region (an approach that makes sense where each management unit rarely contains more than one category of forests), or through separate columns in the same form (see e.g. the field forms for Scandinavia or the versions developed for Northwestern and Southeastern US). The latter approach may be preferable to avoid handling multiple forms in regions where forests of different categories are often found in close proximity.

Step 2: Identify appropriate tree diameter classes

The largest diameters to be incorporated in the scoring form should reflect the size of the largest, relatively common size class in the type of natural forest used as a regional reference – old trees in warm and humid forests normally grow much bigger than old trees in colder, seasonally dry forests. In forests where earlier logging has left occasional very big and old trees (e.g. because they didn't meet high quality standards), it may be relevant to include a specific 'veteran' tree category, in addition to a number of 20 cm increment diameter classes.

28 Grazed parkland, Kazakhstan

29 Cloud forest tree with epiphytes, Ecuador



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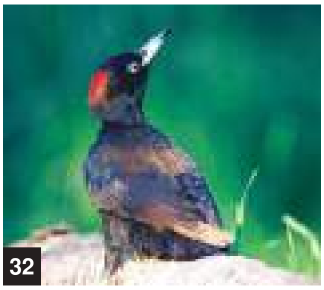
Step 3: Identify regionally relevant:

- **Trees important for wildlife.** Most tree species sustain a host of other organisms and in many forests lists of trees important for wildlife (if taken literally!) would be long indeed. The task at hand is to select a handful of readily identifiable tree species of particular importance for biodiversity, preferably those with names in local languages. If there are more readily identifiable 'biodiversity tree species' than match the one-liner format, we recommend adding another set of paired questions. In such cases it may make sense to divide the two subsets based on some shared feature, e.g. one subset that is important for birds, and one of particular importance for other organisms.
- **Indicators of regeneration.** As mentioned, targeting specific tree species assumes that the canopy is composed of a relatively limited number of species (or several species of groups like *oaks* that may be collectively identified as such), and that these have readily identifiable saplings. Where this is not the case, regeneration is more effectively addressed through questions related to the underlying dynamics, e.g. the presence of canopy gaps that reflect or mimic natural disturbances.
- **Tree species with wood of high commercial value.**
- **Tree species sought after and felled for local use.**
- **Invasive species** (where relevant).

30 Tree fall gap with regeneration, French Guiana



31 Fallen pine tree with longhorn beetle larvae, Sweden

32 Black woodpecker, Sweden

Step 4: Identify regionally relevant habitats and microhabitats

Once identified, decide which to include in the scoring sections, and which to address as focal habitats. The focal habitat subsection lists habitats of particular importance for biodiversity – areas that are too large, unevenly distributed or too rare to be meaningfully addressed by scoring plots. Examples are given in section 2.4, but regional climate, geology and geomorphology differ so much that it is impossible to list all potentially relevant candidates. Which of these are small and common enough to be included as 'microhabitats' in the *structure and composition* section, and which are better considered as separate focal habitats are matters of judgement. Additional microhabitats and indicators used for scoring in some field forms include the following:

- Large nest of twigs or branches.
- Big tree with hollow trunk or large cavity.
- Burrow or den of mammal or reptile.
- Conspicuous signs of woodpecker activity on tree, snag, log or stump.
- Signs of beaver activity.
- Large boulder with mosses/lichens.

Step 5: Cross-check the scoring section

To make sure no important element is missing from the scoring section, cross-check with field forms developed for other regions.

Step 6: Identify a set of regionally relevant focal species.

www.hcvnetwork.org/resources/forest-integrity-assessment-tool

Step 7: Develop a customised user guide

Where feasible, it may be desirable to create a user customised guide with pictures of focal habitats and species – see the website for examples.

33 Beaver-felled tree, Russian Federation

5. Sampling

5.1 Assessing small woodlots

Forest patches, stands and woodlots that are small enough to be surveyed in their entirety may be assessed on a single field form and, if so, no sampling is needed. *The upper size limit for the 'single field form' approach varies with the character of the forest, from maybe half a hectare of very heterogeneous forest, up to perhaps five hectares of homogenous forest with good visibility.* Applying single field forms to sites larger than a hectare tends to inflate scores, as the probability of encountering most indicators increases as a function of the area surveyed. This doesn't matter so much for purposes of monitoring as long as subsequent assessments are done on areas of similar size, but the bias should be kept in mind if results are compared with scores from other assessments.

5.2 Stratification

Assessments of forests too large to be walked through and assessed in their entirety require some form of sampling, where each sample plot is scored on a *separate field form.* For sampling to yield reliable and robust results, plots must be as representative of the larger forest unit as possible.

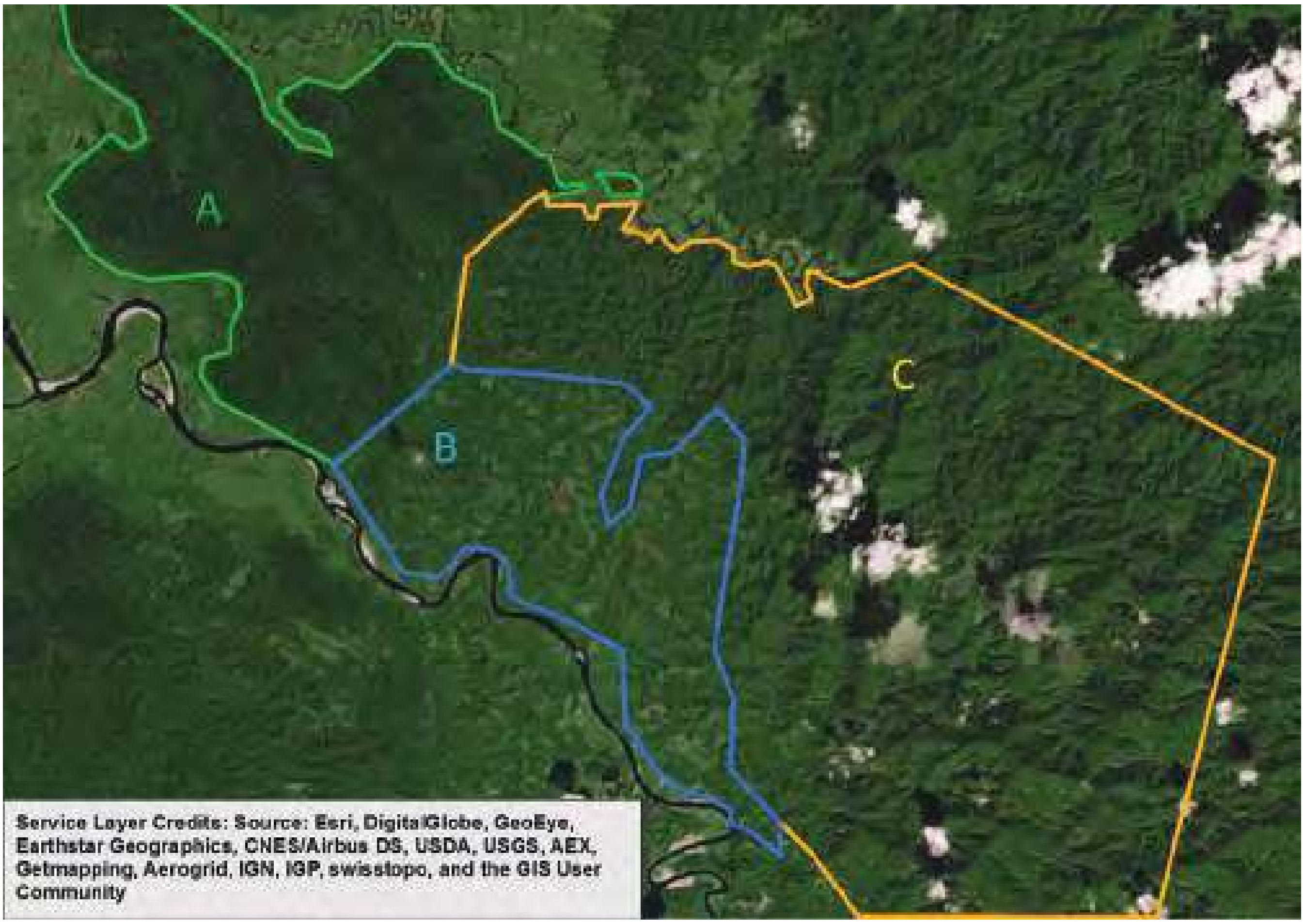


Figure 1: Stratification. *Forest area tentatively divided into three subunits based on visual interpretation of remote sensing imagery.*

www.google.com/earth

Larger forest areas are often heterogeneous, reflecting, for example, different topography, altitude, soils or proximity to villages. Where such areas can be divided into smaller, more homogenous parts, it is usually more efficient to consider and sample these as separate subunits. Such units may be identified based on prior knowledge or by using Google Earth (free, downloadable software offering relatively high resolution images of most of the Earth's surface, typically 10-30 metres per pixel). The downside is that images outside urban areas may be several years old (check 'Imagery Date' at the bottom of the page). The purpose of this initial subdivision, called stratification, is to *adapt the long-term sampling intensity* of each subunit to its level of variation, and to *prioritise* areas for more frequent monitoring. If in doubt, it is better to assume that subunits do differ and to stratify accordingly – units that are then found to be more similar in the field than expected can always be merged together for the next round of assessments.

34 Giant rainforest tree, Gabon

5.3 Distribution of sampling plots

Ideally, the best way to decide where to sample is by randomly selecting plots. However, this is rarely cost-efficient given the time it takes to locate and reach each plot if these are scattered in a larger tract of forest. A more frequently used approach is to do line transects. In this scenario, more or less straight lines are drawn on a map of each subunit. The assessors walk along these virtual lines in the field using a compass (and GPS if available), slowing to make assessments of a 100 metre stretch of forest (an effective plot size of approximately 0.2–1 hectare, depending on the visibility) at certain predetermined intervals, e.g. every 300, 500 or 1,000 metre. Each plot is scored on a separate field form. *Observations of focal habitats and focal species are recorded at all times, including when moving in between plot areas*, to make maximum use of time spent in the field. Working in pairs or small teams provides safety in case of injuries and facilitates alignment. Engaging the same pool of people year after year (with brief calibration and recap exercises now and then) promotes consistency and reduces the need to train new assessors from scratch.

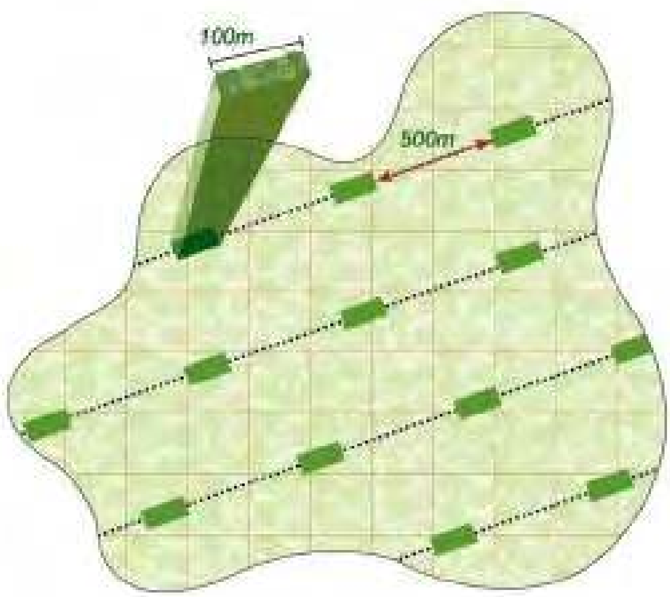


Figure 2: Line transects. *Idealised example, showing sampling a new 100-metre-long section every 500 metres. Other distances between plots and between different transects may be chosen to suit the size and heterogeneity of the particular forest unit and the amount of available resources.*

Annual monitoring programs should be designed to sample *new plots* rather than revisit previously assessed ones. This may appear counter-intuitive – surely reassessing the same sites would be less influenced by chance? However, there are at least three good reasons not to resample the same plots. Firstly, we do not know to what extent a certain set of plots is really representative of the larger forest – given this uncertainty changing plots between rounds is a safer bet. Secondly, returning to and locating exactly the same plot every year is likely to be more time-consuming than choosing new ones. Thirdly, most people find it difficult to reassess previously visited plots with the same curiosity and diligence as the first time, which may bias the scoring.

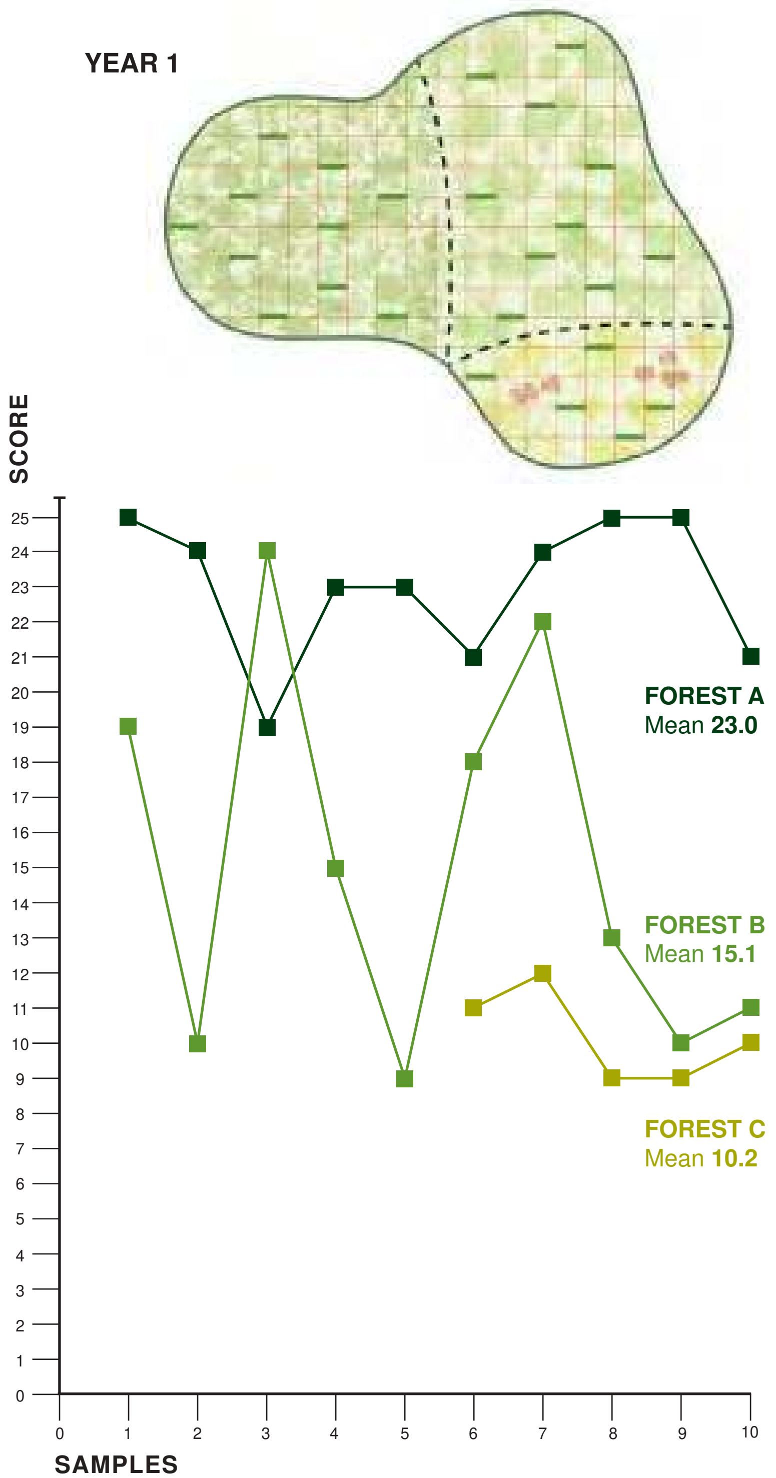
Transects can be designed as parallel lines with equal distances between them. This allows for the starting point of the first transect to be chosen randomly, which is preferable as (if repeated prior to each new round) it makes successive rounds of monitoring more independent. However, lines do not have to be equidistant and starting points can be chosen based on factors such as, for example, accessibility. Transects can also be non-parallel or curved, designed to cover a certain forest or subunit as effectively as possible – this may be the best option if the shape of forest area is very irregular. In reality long straight lines may not be very practical anyway, as assessors often need to return to the point of origin by the end of the day. If so, transects can be shaped like rectangles or triangles rather than straight lines, taking people back to where they started from in the morning.

Strategically placed roads, tracks, rivers and other 'linear' landscape elements can also be used as transects, allowing stretches between plots to be travelled using a motorcycle, car or boat. The downside is that forest conditions along accessible parts of the forests, e.g. in the vicinity of roads, often deviate from conditions in less accessible parts and so may not be representative of the area at large. Similarly, forest edges bordering watercourses or open areas are usually not representative of conditions in the forest interior. If roads and rivers are used to ease access, sites should be localised at some distance from these, for example by walking a couple of hundred meters into the forest before sampling, in order to reduce biases from edge effects.

35 Old-growth Korean pine, Russian Federation

5.4 Sampling intensity

In principle, the number of plots (in a forest unit or subunit) that needs to be assessed in order to generate a robust overall integrity score depends on the variation between plots. The more variation in a forest unit, the larger the range of observed scores, prompting a need for more plots. As the variation is rarely known beforehand, a rough rule of thumb is to initially assess at least ten separate plots in each stratified subunit (unless the unit is very small).



	FOREST A	FOREST B	FOREST C
	25	19	
	24	10	
	19	24	
	23	15	
	23	9	
	21	18	11
	24	22	12
	25	13	9
	25	10	9
	21	11	10
MEAN	**23.0**	**15.1**	**10.2**

Figure 3: Estimating forest heterogeneity. *In the first year, each subunit is sampled with the same amount of effort per area (same plot density). When the observed variation is visualised in a diagram, it is obvious that subunit B is much more heterogeneous than subunits A and C.*

Comparing the first year *range* of scores from each different subunit, e.g. by plotting them in a simple diagram, helps to estimate and compare levels of heterogeneity. The purpose is to adapt the intensity of next year's sampling to the observed variation in each subunit, shifting some sampling effort from units of lower heterogeneity to areas of more variation. This process can be repeated after each round of monitoring to further fine tune the sampling intensity.

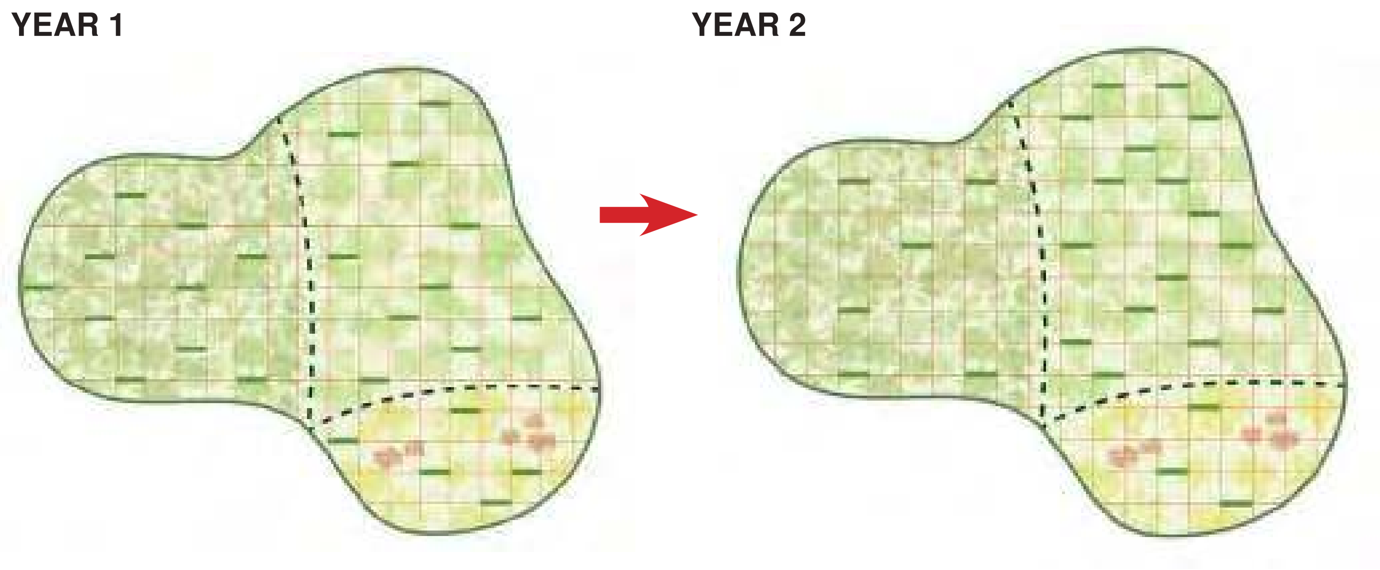


Figure 4: Adjusting the intensity of sampling. *In the second year, some sampling effort is shifted from subunits A and C to subunit B in order to match the higher heterogeneity of B observed during the first year of sampling.*

5.5 Frequency of sampling

As a general rule, the frequency of monitoring should be adapted to the pace of change in the monitored system. An annual round of monitoring makes ecological sense in most forest contexts. Yearly monitoring also fits well with the auditing cycle of certification schemes. As forest conditions like ground water tables and presence or detectability of focal species may vary with seasons, annual monitoring should be conducted during roughly the same time period each year, preferably by the same assessors or assessor teams.

If forest areas are large and resources scarce it may not be possible to do enough sampling to robustly monitor all stratified subunits every year. If that is the case, we recommend focusing annual sampling on those subunits expected to be most impacted, sampling other areas at a lower frequency, e.g. every second year.

6. Monitoring and evaluation

6.1 Evaluating the results

The scores from all plots in a forest subunit are collated into a table (see fig.1). The integrity of a certain subunit is then calculated as the mean (average) score from that unit (in other words, the sum of all plot scores from the unit divided by the number of plots sampled in that unit).

Means from successive years are compared to monitor change over time. As new sites will be assessed each year, and as the methodology builds on estimates rather than absolute measurements, there is likely to be some variation between years purely as a result of chance, even if nothing has changed in the forests. Thus, mean scores that jump up or down a point or two from year to year do not necessarily reflect real changes on the ground.

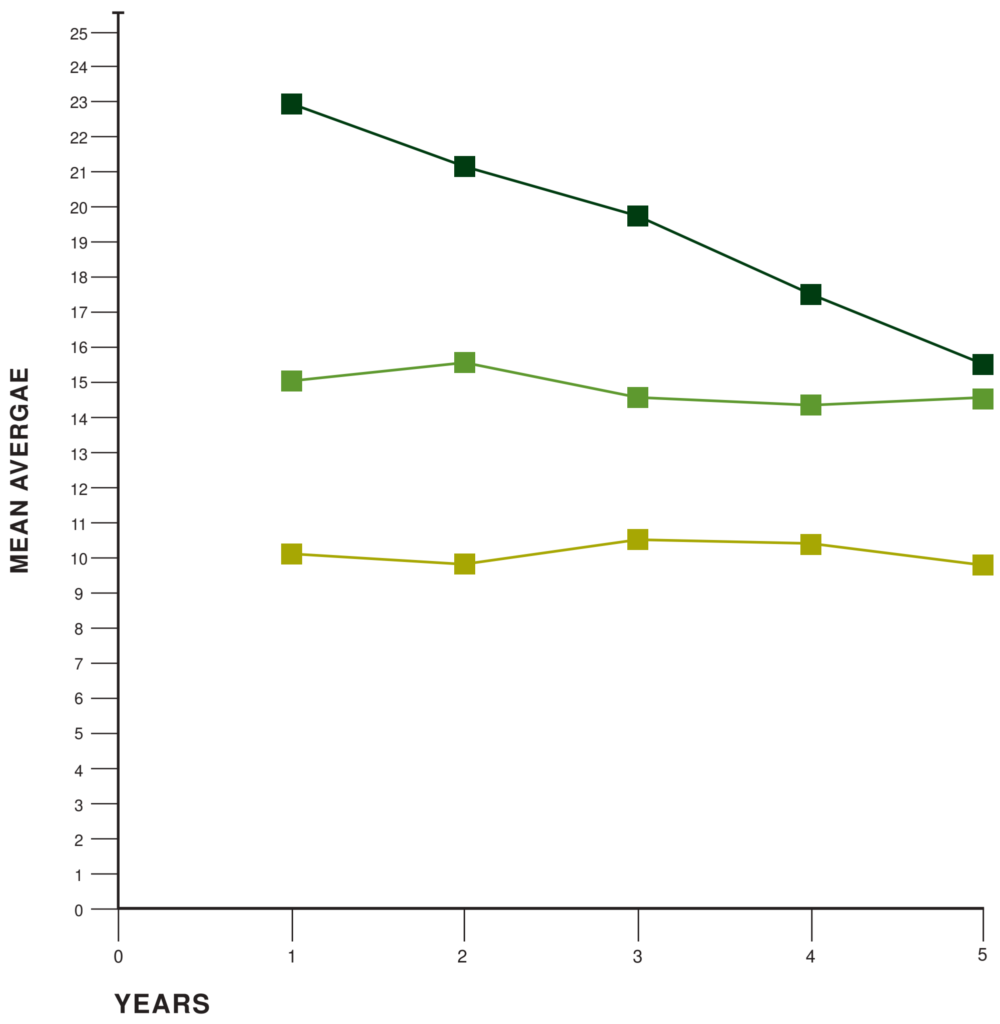


Figure 5: Monitoring change over time. *Diagram displaying mean scores from five consecutive years of sampling of subunits A, B and C. While the graphs of B and C seem to reflect random variation around a more or less stable mean, the slope of graph A is likely to reflect real forest degradation. Managers would need to urgently identify the cause and take remedial action.*

However, negative trends over time (means that get lower and lower), and means that suddenly decrease more than may be attributed to chance alone, need to be detected, evaluated and addressed (see fig. 5). In such cases, all field forms should be examined to identify what changes have caused scores to drop. If no clear patterns emerge, the next step is to calculate *mean scores for each question in turn*, counting each 'yes' tick as 1 and 'no' tick as 0 (adding all ones and zeros and dividing the sum with the number of plots).

An example of this could be that question number 22 (in the template for moist evergreen forests in the Mekong region) scored 'yes' for 7 plots out of a total of 10 plots in unit A in the first year, but only 2 out of 10 plots in the same unit the second year. If so, the mean for this specific question has suddenly decreased from 0.7 to 0.2 – quite a drastic decrease of commercially valuable trees that should prompt actions to stop further loss (unless a temporary outcome of planned and regulated responsible logging).

Means for different years are compared for each question in turn. Making a simple diagram where mean scores for each question (on the y-axis) are plotted against year of assessment (on the x-axis) helps to visualise changes. As results accumulate over time, a glance should suffice to distinguish questions characterised by saw-teeth, random variation around a long term constant mean, from questions where scores are genuinely decreasing.

Over time, these simple calculations should allow managers to detect significant losses of forest integrity, and to identify more precisely what is going on. Knowledge must lead to action – exactly what needs to be done depends on the nature of the problem. If it is a matter of poaching or illegal logging, information campaigns, sign-posting and more intensive patrolling may be part of the solution. If the issue is substantial forest degradation and loss of structure due to forestry operations, managers may consider amending standard operating procedures (SOPs) to lower annually harvested volumes of timber and/or target different tree species or diameter classes.

Of course there may also be positive change over time, and in well-managed or well-protected areas there should be! In contrast to deforestation and degradation (which may be rapid and dramatic), positive changes are likely to be more gradual, simply because it takes much more time for trees to grow big than it takes to cut them down. Consequently, annual means that suddenly increase should be considered suspicious, particularly if they reflect scores in the *structure and composition* section. Such changes are likely to be artefacts due to heterogeneous forest conditions (prompting more accurate stratification!), too few sampling sites, or both.

6.2 Summary of calculations

To sum up, there are three ways of evaluating the scores:

a) Calculating annual means of scores from *all plots* in a certain forest or subunit, i.e. the grand sum of scores from all plots in the unit, divided by the number of plots. This figure, an annual mean for each subunit, is monitored over time to detect changes – negative impacts that need to be addressed, and/or positive changes due to better management or protection.

b) Visualising the spread (range) of scores from different plots in the same unit and year. This spread, best illustrated in a diagram, reflects the level of heterogeneity (variation) within that particular forest unit. Comparing the spread found in different forest units may help to improve next year's monitoring by shifting some sampling efforts from units with little heterogeneity to units with more variation.

c) Calculating separate, annual means for *each question* in the scoring sections from a certain unit, counting 'yes' as 1 and no as 0, (adding all ones and zeros and dividing the sum with the number of plots in the unit). Visualising in a diagram how means for each question change over time helps to detect what is happening to the forest in more detail and what problems need to be addressed.

36 Boreal mire, Finland

7. Species, sites and landscapes

Forest diversity exists at a number of different scales, nested like Russian dolls: species, within sites, within landscapes. As negative changes in one of these scales may not be easily detected in the others, monitoring programs should be designed to address different spatial scales.

The Forest Integrity Assessment tool focuses on the site level. Species are partly addressed in the Focal Species section (where complementary, more in-depth species monitoring is feasible we recommend using SMART, a tool developed by a partnership of organisations coordinated by Zoological Society of London). However, sampling plots in the forest is not an ideal method for detecting e.g. a new patch of encroachment, a new mining spot, a new dirt track, or spots of illegal logging. True, assessors may stumble upon signs of such activities along transects, or even within sample plots, but the probability of detecting rare and localised events within a larger landscape through transects is low.

www.zsl.org/smart

Thus, managers and project leaders in charge of larger forest units (a couple of hundred hectares and upwards) are recommended to complement FIA monitoring with annual 'bird's eye' inspections of the whole unit using remote sensing satellite data. Currently, the best tool available for free is the World Resources Institute's Global Forest Watch (GFW). This site contains a navigable global map of forest change from year 2000 until one year before the present with 30 m resolution: click on 'map' at the top of the page and 'tree cover loss' loads automatically. Then set the bar at the bottom to the relevant period of time (latest year available if you do annual monitoring). The 30 m resolution does not allow for detecting small scale changes, but any more significant clearing should be visible.

commodities.globalforestwatch.org

GFW also has a website with 'real time' data on forest fires in South East Asia but so far accumulated fire data suitable for annual monitoring programs is only available for Indonesia. However, remote sensing applications suitable for monitoring forests and land use are rapidly evolving with higher resolution satellite imagery likely to become more readily available. Land surveillance by use of drones is another promising monitoring tool.

fires.globalforestwatch.org

37 Blue and Yellow Macaw, Brazil

Annex

The below field form was designed as a basis for further national adaptation and use in moist forests in the Greater Mekong region. It is included here as an example – forms from other regions may be downloaded from the HCVRN website. Note that the field forms are usually printed with all four pages in A5 format fitting into the front and back of one single, folded A4 sheet.

Forest Integrity Assessment

GREATER MEKONG EVERGREEN FOREST TEMPLATE

MANAGEMENT UNIT:		
SITE:		
ASSESSOR(S):		
DATE:	TIME:	ID:

STRUCTURE AND COMPOSITION

1. Naturally fallen tree > 40 cm	◯
2. Naturally fallen tree > 60 cm	◯
3. Several trees > 10 cm	◯
4. Several trees > 20 cm	◯
5. Tree > 40 cm	◯
6. Several trees > 40 cm	◯
7. Tree > 60 cm	◯
8. Several trees > 60 cm	◯
9. Tree > 80 cm	◯
10. Several trees > 80 cm	◯
11. Climber (liana, vine) > 10 cm	◯
12. Tree with ferns or other plants not rooted in the soil (epiphytes)	◯
13. Several trees with ferns or plants not rooted in the soil (epiphytes)	◯
14. Tree with nestinghole	◯
15. High tree crown with thick branches	◯
16. Tree with marks from mammal, bird or lizard	◯

STRUCTURE AND COMPOSITION	
17. Tree species important for wildlife > 20 cm	○
18. Several trees of species important for wildlife > 20 cm	○
19. Standing dead tree or snag > 20 cm	○
20. Termite mound	○

IMPACTS AND THREATS	
21. Commercially valuable timber tree species	○
22. Commercially valuable timber tree species > 20 cm	○
23. Tree species felled for local use	○
24. Tree species felled for local use > 20 cm	○
25. Average visibility in forest > 10 m	○
26. Average visibility in forest > 20 m	○
27. No sign of invasive plant or animal species	○
28. No sign of hunting, traps or snares	○
29. No sign of burning	○
30. No sign of logging	○
31. No sign of clearing for agriculture	○
32. No sign of grazing (domestic animals)	○
33. No waste, litter or trash	○
34. Distance to road, track or river > 1 km	○
35. Distance to road, track or river > 5 km	○

TOTAL SCORE:	

FOCAL HABITATS	
Rivers and streams	◯
Forested wetlands	◯
Seasonally flooded forests	◯
Naturally open wetlands	◯
Permanent ponds, dams and lakes	◯
Seasonal ponds, dams and lakes	◯
Springs	◯
Naturally open or semi-open native grasslands	◯
Steep slopes (more than 1 m : 3 m)	◯
Salt licks and mineral mud flats important for wildlife	◯
Cave or sinkhole	◯

NOTES

FOCAL SPECIES						

NOTES

For more information please contact, Anders Lindhe at anders@hcvnetwork.org

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	Moist forest: structure and composition	Fern Lee/Proforest	Foreword page
	Moist forest: impacts and threats	Fern Lee/Proforest	Foreword page
	Moist forest: focal habitats	Fern Lee/Proforest	Foreword page
	Moist forest: focal species	Fern Lee/Proforest	Foreword page
	Dry forest: structure and composition	Fern Lee/Proforest	Table of contents
	Dry forest: impacts and threats	Fern Lee/Proforest	Table of contents
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iii	Stream flowing through temperate rainforest. British Columbia, Canada.	Mike Ambach/WWF-Canada	Foreword page
iv	Blyth's hornbill (*Aceros plicatus*). Port Moresby, Papua New Guinea.	Brent Stirton/Getty Images/ WWF-UK	Foreword page
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