

A hierarchical terminology for more or less natural forests in relation to sustainable management and biodiversity conservation

Erik Buchwald
Danish Forest and Nature Agency

Abstract

Existing terminologies since the late 1980's are reviewed revealing gaps, inconsistencies and overlapping definitions. Many terms have been used very differently by different organisations with semi-natural forest being the worst example. It has variously been used for any kind of forest except exotic plantation. A new hierarchical terminology is proposed based on the work of many authors, persons and organisations working with this issue during the 1990's. Fourteen mutually exclusive levels of naturalness are delimited, defined, named and grouped, including virgin forest, old-growth, newly untouched forest, exploited natural forest, native plantation, exotic plantation and exotic self-sown forest. Consistent definitions for groups of levels and for qualifying features are also presented, e.g. for natural forest, planted forest, native forest, exotic forest, primary forest, minimum-intervention forest, ancient woodland and grazed forest. The definition of natural forest follows UNCED, FAO, EU and the World Bank. For other terms official sources like FAO's Forest Resources Assessment have been followed as far as possible.

Key words: Natural forest; Terminology; Management; Grazing; Conservation; Biodiversity; Old-Growth;

1. Introduction - the need for common terms

Especially since the UNCED Rio summit 1992 there has been much interest in protecting the natural qualities of forests including their biodiversity and ecological functions. This has led to many meetings and papers dealing with issues related to more or less natural forests and their biodiversity.

It has been clear in the political processes derived from UNCED that no commonly accepted terminology exists on forests relating to their management and conservation. This has given rise to lengthy debates about the words and long texts explaining local/regional definitions, most of which have no general acceptance. Some papers have not defined their words, paving the way for misunderstandings.

The lack of a generally accepted terminology is a problem both domestically in many countries and even more so internationally – especially in legal/political negotiations and in scientific work. Both inside and between continents there are problems with misunderstandings (IUFRO 1997 & 2002, COST E4 2000, Lund 2001, FAO 2002 a, FAO 2002 b).

In this paper I use forest as defined in FAO (2001b), and native tree species as defined in FAO (2001a) for indigenous tree species. When using "predominantly consisting of" about tree species ratios, I mean ratios of vertical crown projections. I focus on the terminologies used during the past ten years, including single works of major importance a few years older.

The main aim of this review is to improve understanding of existing terminologies and to suggest a possible consistent terminology – not to monopolise the terms. The general public often uses some of the words in a broad sense or with a different meaning than any published definition (Peterken 96). This cannot be avoided.

The choice of terms and definitions is affected by the objectives of the setting. If definitions are well-documented, logical and hierarchical it should be possible to translate and relate them to other objectives and

settings. First I explore some of the background for why inconsistencies develop, and then set out a new hierarchical approach.

1.1. Earlier attempts at a mutual terminology

Several authors have provided overviews of how the international terminology has been used (Broekmeyer & Vos 1993, Schuck et al. 1994, Peterken 1996, COST E4 2000, Lund 2001).

On the basis of these and other works, international attempts have been made to address the problem of a lacking mutual terminology. Precision is especially important in international research, statistics and political negotiations where definitions have therefore been elaborated (MCPF 1996, UN-ECE/FAO 1997 & 2000, FAO 2001a, IUFRO 2002).

1.2. Problems with the existing terminologies and definitions

Analysing the definitions of the commonly used terms referring to more or less natural forests reveals that one reason for the lack of mutual acceptance could be that most of the terms are not defined logically or precisely enough. Overlaps and gaps are common. It is often impossible from the published definitions to understand where the limits or even the typical range of the features in question are (Peterken 1996, Lund 2001).

A further general problem is that many sets of definitions are vague in places, and leave undefined gaps in others – see appendix 1.

There seems to be a need for a more stringent, logical and precise approach to defining a terminology. This might enable common use of terminology in international work in the future. It might also inspire national organisations to define national terminology more precisely. Improved terminology has for example been recommended in the Lisbon resolutions of the Ministerial Conference on Protection of Forests in Europe in 1998 (MCPF3 1998).

1.2.1. Etymology - are humans part of nature?

One set of problems arises around the concept of naturalness because humans have been an integral part of nature until some time in the past. However most people do not accept the major impacts of modern humans as natural - meaning as an integral part of nature.

Therefore we need to consider a level of impact where the transition happens from humans being a part of nature to being something apart from nature impacting on it. Unfortunately there is no simple logical way of discerning when or why human impact on (forest) ecosystems became too large to be accepted as natural.

The wordpairs nature \times culture and natural \times artificial are antonyms. The words are derived from Latin *natura* nature (from *natus* born), *cultura* cultivation of plants (from *colere* to till) and *arte factum* art work (Henderson 1979). These antonyms of general acceptance may help in deciding where to set logical limits compatible with the understanding of most people.

From these words it can be seen that some of the features which set humans definitely apart from nature are the *cultivation of plants* (tilling, sowing and planting) and the production of *art*. This is supported by the fact that no animals cultivate plants or produce art. From archaeological evidence the departure from nature can thus be taken as happening in the time period after the first art works and before Neolithic farming started. That would be between 5.000 and 25.000 years ago in much of the World depending on location.

Human activities such as hunting and the use of fire were already widespread ten thousands of years earlier. This indicates that humans had impacts on nature before ceasing to be part of it.

In reality it is not the artworks/artefacts themselves that disturb our notion of people as part of nature, but the escalated impacts on wildlife and landscape which often occurred more-or-less simultaneously. For example

evidence from isolated islands and continents shows a close correspondence between prehistoric human colonisation and extinctions of large animals (Stuart 1991, Bradshaw & Mitchell 1999). Extinctions especially hit megaherbivores, which are herbivorous animal species that grow larger than 1000 kg. In several continents these went extinct roughly 10-20.000 years ago. Megaherbivores have major influence on the dynamics of ecosystems and landscapes, and thus their disappearance must have had large impacts (Owen-Smith 1988).

In the light of such archaeological information it can be seen that the idea in the head of many people that forests until a few thousands of years ago were totally unimpacted by humans is a misconception.

This misconception is reflected in numerous published definitions of terms like primeval, pristine and virgin forest. These terms – and in a few cases also natural forest and old-growth (Lund 2001) - have often been defined in a way excluding any human impact ever (WWF/IUCN 1996, MCPF 1996, COST E4 2000). Such definitions are *a priori* problematical because humans have been present for hundreds of thousands of years with great potential impact already from the start of use of fire more than 200.000 years ago (Andersson & Appelquist 1990).

2. Developing a new hierarchical approach

A hierarchical logic is already partly inherent in many of the features covered by commonly used terms, without being appropriately incorporated or delimited in the published definitions.

The following fundamental forest features can be described in a hierarchical manner:

1. More or less natural *origin/genesis* >< More or less artificially created/regenerated
2. More or less natural *flora, fauna and genepool* >< More or less modified by human activities
3. More or less natural *processes and structures* >< More or less modified by human activities
4. Timespan of *continuity* of features >< History of change including human influence
5. Type and intensity of *management operations and utilisation*

In practice, although each of these features is a continuum, breaks in continual distribution tend to be present. The features are also interrelated and can be combined in a multi-dimensional matrix. From such a matrix sections can be grouped and identified to develop a logical hierarchic terminology.

2.1. Logical breaking points in the continual distribution of features

There is a logical breaking point in the continuum of **origin/genesis** when human action changes the existing /spontaneous vegetation of a site to an artificial stock of trees (by planting or seeding). This is also a breaking point in the continuum of the four other features and is therefore fundamental. The breaking point between natural and artificial regeneration can also occur when planted stands later regenerate naturally.

For **flora, fauna and genepool** there is a major breaking point in the continuum when native vegetation of a site loses its dominant role to non-native vegetation (e.g. to invasive non-native species). The fauna can be with or without key species of large wide-ranging animals. A usually prehistorical breaking point was at the first human-induced extinctions. It is not deemed feasible to incorporate breaking points relating to lower than species level, even though such impacts on the genepool can be of great importance.

Important breaking points in the continuum of **processes and structures** are presence/absence of significant native/aboriginal human modification and presence/absence of significant modern/western civilised human modification (e.g. logging). In sites with discontinued modification a breaking point in the reverse direction is when signs of the former human modification can no longer be seen/measured. Other breaking points relate to size (landscape-, forest- or stand-scale) and to seral stages of forest dynamics – which is especially relevant for old-growth versus younger seral stages. A last breaking point refers to presence/absence of a plantation-like structure.

A logical breaking point for **continuity** is when humans clear forest for other types of land-use, e.g. agriculture. Many hundreds of years of woodland continuity is of prime importance for many elements of flora and fauna (Peterken 1996, Graae 2000). Sites with forest continuity back to the oldest maps often also have continuity much further back in time.

Major logical breaking points in the continuum of **management** are if sites mainly serve industrial wood production purposes, are left untouched or have special management (e.g. old-time traditional management types, biodiversity protection, hunting estates, grazing, water protection or recreation).

2.2. Levels of naturalness

In order to overview the existing terminology I developed an array of levels of naturalness each with a corresponding definition labelled with a number instead of a name. For each new terminology reviewed, levels were added if necessary to incorporate details of definitions.

When the process was finished, 14 mutually exclusive levels emerged. The most logical and generally accepted parts of existing definitions were reused and incorporated in the definitions of levels. Amendments and adjustments were generally necessary in order to make the definitions more universally useful, consistent and without gaps. Appendix 1 shows the results of the review, while appendix 2 gives the level definitions. Level names have been added to both – see below.

In cases where the references use the words without defining them, there are uncertainties regarding the limits of terms, even though the context often gives a quite clear clue. In other cases definitions are vague or unprecise. Uncertainties are displayed with questionmarks in appendix 1.

Often it can be difficult to document historical and other features, e.g. whether a 200 years old forest stand is planted or not. I propose different solutions to such documentation problems at different levels, including the documentation topic in each relevant level definition. Any forest stand should be referable to the appropriate level by a field visit supplemented by general historical and biological knowledge of the area.

2.3. Names for the levels

I have tried to match the levels with the most commonly used and directly meaningful terms at hand in order to obtain logical hierarchy and best chances of communication with minimal misunderstandings. See fig. 1.

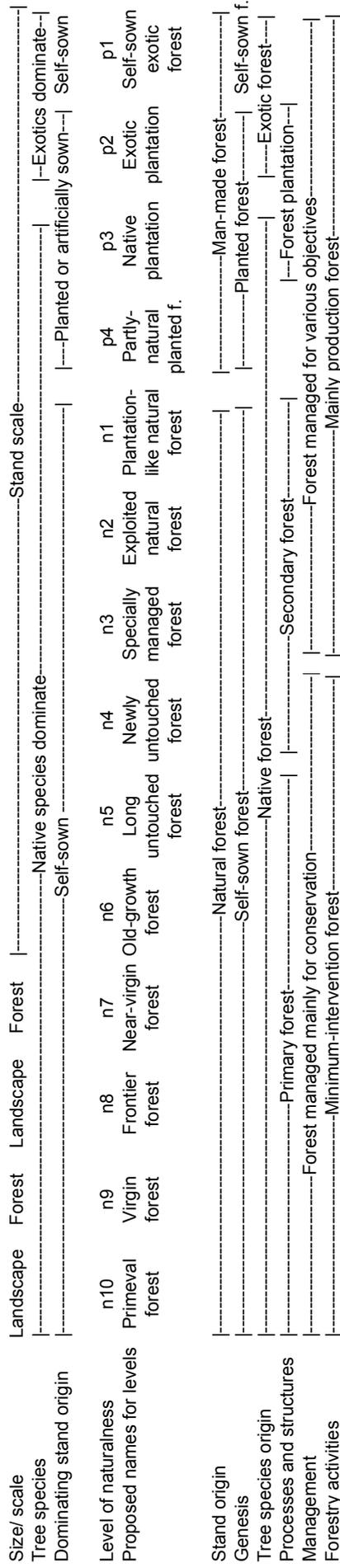
The words **primeval** and **virgin** have traditionally been connected to forest of an ultimately natural character – with some differentiation. **Primeval** bears in the word itself the reference to "the earliest ages (as of the world or human history)" (Lund 2001) making it useful for denoting the ultimately natural situation before human impacts (in most cases a very prehistoric situation).

The term **virgin** on the other hand denotes a situation that during the generations repeatedly can occur, but where the qualities cannot be restored once lost. It should be acceptable that virgin forest can still develop nowadays under certain ultimately natural conditions. This would be in line with the countries still claiming to have at least some virgin forest. Peterken (1996) supplements with Near-virgin Forest and World Resources Institute (1997) uses Frontier Forest which can be relevant in certain cases – see definitions of these in appendix 2.

For forest with a very high degree of naturalness but not as ultimate as the four abovementioned levels several continents use **Old-growth** – especially America, Australia and Asia (Russia) (Lund 2001). The term has been the issue of a separate working group to discuss definitions (IUFRO 1997). Many local definitions are very specific, but most can be encapsulated by the more generic definitions used at national scale in Russia, Australia, Canada and the US, which are fairly similar (Lund 2001). The main part of the level n6 definition is unchanged from the United States Forest Service 1989 definition of old-growth (via Lund 2001). An almost identical wording is used and recommended in Canada (Wells et al. 1998).

Figure 1

Levels of naturalness



f. = forest

Alongside the abovementioned terms the following ones are sometimes defined almost identically as synonyms dealing with forests of ultimate to high degree of naturalness: Pristine, primary, antique, climax, ancient and natural forest (COST E4 2000, Lund 2001). These terms are less suited for these levels because they either have a very limited and not generally accepted use and/or do not communicate the correct/precise inherent meaning in them and/or have been used widely with other definitions better relating to the inherent meaning of the words.

This leaves us with the lower levels of naturalness, where it is not possible to find good and broadly accepted names or definitions. The terms Semi-natural Forest, Secondary forest, Modified Forest, Man-made Forest, Planted Forest, Plantation and Plantation Forest are much used, with definitions varying between authors and countries. They are often inconsistent (see Appendix 1). Artificial Forest is also sometimes used.

The range of forest naturalness between levels n6 and n1 is particularly important because such forests cover large areas in many countries. They often have a complex balance between conservation and use, and raise a lot of debate about sustainability. I have proposed names for the levels which as far as possible directly reflect their content. See figure 1 and appendix 2.

2.4. Names for groups of levels

On the basis of the analysis of the word **natural** (etymology and antonyms) and of the logical breaking points, I support the many organisations and authors who have used or defined Natural Forest rather broadly covering many levels of naturalness (e.g. UNCED 1992, EU 1996, Peterken 1996, COST E4 2000, Lund 2001, FAO 2001b, IUFRO SilvaVoc 2002). The minimum level of naturalness in these definitions is mostly at naturally regenerated native forest - regardless of intensity of human use.

Natural Forest should thus be used broadly for relatively to ultimately natural situations, encompassing a broad range of naturalness from level n1 through n10. This matches the international definitions of e.g. UNCED, FAO, IUFRO and World Bank (see appendix 1) and national definitions used in many countries e.g. China, Iran, Vietnam, New Zealand, Brasil (Lund 2001), Sweden (Selander 1969) and Japan (IUFRO 2002). See appendix 3 for definition.

Semi-natural Forest is used in Europe, especially Great Britain, about forests that are more or less natural or resemble such forests enough to make it difficult to tell the difference. Inventory and statistical purposes have been the main reasons for this rather unprecise term, e.g. for sites where it is difficult or impossible to find out if the stand was planted or not - maybe 200 years ago (Peterken 1996). Different works have set up quite different limits for what semi-natural forest is – see appendix 1.

The word semi-natural is more difficult to translate to other languages than most other terms and is not directly meaningful to most people. It has been used for any level of naturalness except p2, Exotic plantation (see appendix 1). I therefore recommend it used as little as possible in international work.

Care must also be taken in translation of the other terms to national tongues. In numerous cases a "direct" translation will give useless and confusing results. This problem has been known for years and will continue, no doubt.

See figure 1 and appendix 3 for other names for groups of levels of naturalness.

2.5. Qualifying features (continuity, grazing, protection status)

The breaking points of the fundamental features cover important divisions, but distinctions along another axis of the matrix can be worthwhile for some purposes. Qualifying features can be used to describe and rank sites in a more detailed manner or as determinants of management, when biodiversity is an important objective. Ellenberg (1988), Peterken (1996) and Vera (2000) can be consulted for details on the features.

I recommend the use of a terminology for continuity, grazing and protection regime in combination with the terminology outlined in appendix 2 and appendix 3, because of the importance and management implications of these qualifying features.

2.5.1 Continuity

Woodland continuity is of such prime importance for biodiversity, that it is worthwhile using it across the whole terminology, discerning between ancient woodland and recent woodland, see box 1. Further specification can be made, e.g. continuity of old trees, dead wood, tree species presence, undisturbed soil or of elements developed by grazing at moderate levels. Regardless of level there can be important differences in biodiversity between ancient and recent woodland. Sometimes the terms primary versus secondary forest are used to indicate if non-forest land-use has occurred, but this leads to confusion with another use of the same wordpair, see appendix 1 and figure 1.

Box 1 Terms on continuity of forest.

Ancient woodland – Forest sites which have been continuously wooded for several hundred years, at least since the time where reliable maps were first made (eg. 1600 or 1750 AD). Some may have continuity back to primeval forests whilst others arose as secondary woodland on ground cleared at some time in the far past. Continuity is not broken by felling, coppicing, planting nor any other forestry operation, provided that woodland of some kind regenerates immediately. Continuity is broken by an alternative land use, such as pasturage (unwooded) or agriculture/cultivation (after Peterken 1996).

Recent woodland – Forest sites which have shorter continuity than ancient woodland. (Peterken 1996).

2.5.2 Grazing regime

The original natural grazing pressure by wild animals in the Pleistocene and early Holocene is an issue of much debate (Vera 2000, Svenning 2002). Since those prehistoric times grazing levels have oscillated in complex manners with domesticated herbivores being very important in most continents for hundreds to thousands of years (Bradshaw & Mitchell 1999). Today, breaking points are presence/absence of fencing and of wild/domestic large herbivores (deer, antelope, kangaroo, beaver, buffalo, pigs, oxen, horses etc.) and whether grazing impact is significantly lower, higher or thought to be near the originally natural situation with intact wildlife. Absence of grazing by large herbivores is unnatural from a biodiversity and evolutionary point of view, while intensive domestic livestock grazing is also unnatural and detrimental to forest. See box 2 for proposed terminology.

2.5.3 Protection regime

The protection regime of forest reserves can take on three principally different forms: 1) Minimum-intervention, 2) Traditional Management or 3) Designed Management (NFNA 1994, Peterken 1996 & 2000), see box 3. A code of practice can detail the specific management principles and prescriptions of a reserve or of sub-types of the three forms (e.g. NFNA 1994). Minimum-intervention reserves are often called Strict Forest Reserves, Strictly Protected Forests or Scientific Forest Reserves (COST E4 2000).

Peterken (2000) has elaborated on Minimum-intervention, which he sub-divides into a) Non-intervention and b) Protective Intervention. Typically some human activities are accepted even in Non-intervention reserves, e.g. access, research, grazing regulation, recreation, restoration of natural hydrology or felling trees for security reasons along roads. In Protective Intervention non-native species are controlled also. Minimum-intervention as management prescription is synonymous with untouched forest as prescription (NFNA 1994).

IUCN codings of protected areas are not well suited for stand- or forest-scale assessments because the IUCN class definitions work at protected area scale. Very often at that scale there are multiple habitat types and/or levels of protection regimes, e.g. zones, which cannot be accounted for by the IUCN system (IUCN 1994, EUROPARC & IUCN 1999, COST E27 2001).

Box 2 Terms on grazing regime

Ungrazed forest - Woodland showing no structural signs of the presence of large herbivores. This can be because of very low herbivore density or because there are only small herbivores present. In many regions this is an unnatural situation for woodland seen from a biodiversity and evolutionary perspective (Owen-Smith 1988, Vera 2000). Roe deer (*Capreolus capreolus*) at c. 25 kg is here defined as a "small" herbivore, while all heavier species are defined as being "large".

Grazed forest – Woodland showing structural signs of the presence of large wild/non-domestic herbivores. The signs are often in the form of changes in flora composition and tree regeneration rates, but can also be wallow sites, trampling effects or large trees wounded or even killed by wildlife. The effects on the forest ecosystem are highly dependent on species composition of grazers and on grazing pressure. Roe deer (*Capreolus capreolus*) at c. 25 kg is here defined as a "small" herbivore, while all heavier species are defined as being "large". *Comment: Large herbivores were an important part of prehistoric and primeval natural woodland ecosystems. The herbivore composition was quite diverse in most continents including different megaherbivores with large potential impacts on the forest (Owen-Smith 1988). In many regions extant large herbivores have relict, patchy distributions, e.g. confined to national parks and other refuges (Buffalo, elephants etc.).*

Pasture forest – Woodland showing structural signs of being used for pasturage of domestic livestock either herded or fenced (cattle, horses, pigs, sheep, goats and similar). The forest structure often attains some of the characteristics of grasslands and can include flora and fauna elements from these.

Box 3 Terms on protection regime of forest

Minimum-intervention forest – Site specifically set aside by administrative or legal order as Minimum-intervention (=untouched) woodland from a specified time. Sub-types are Non-intervention and Protective Intervention. Protection and restoration of free dynamics and processes, ideally including natural hydrology, are top priorities. (NFNA 1994, Peterken 2000).

Traditional management – Site managed as it was in the past, preserving historic forms of interaction between people and nature. Due to prolongation of continuity this type often maintains a great diversity of species which would be threatened by a shift to other management or protection regimes. Important sub-types are coppice, wood-pasture and pre-industrial type selective cutting (NFNA 1994, Peterken 1996).

Designed management – Management is designed to meet some explicit nature conservation objective, such as maximising diversity, providing for a particular species, creating a mature stand or providing facilities for research and demonstration. (Peterken 1996).

Special management – Traditional and Designed Management can be grouped with similar low-intensity management types (e.g. for environmental protection) into Special Management. One purpose of this grouping is discerning these forest stands from stands with normal economically based forestry (NFNA 1994).

Gene-resource protection forest – Forest stands specifically designated for gene-resource protection of tree or shrub species. Management measures usually include buffer-zones in order to minimise risks of unwanted pollen incursion.

3. Discussion

3.1. The role of differing objectives

Many stakeholders use words regarding the naturalness of a forest in relation to their different objectives such as forest policy, statistics, research and biodiversity protection as well as to the general objective of sustainable development. Appendix 1 illustrates the many risks of misunderstandings brought about by different organisations using the same words differently.

Differing objectives can be the reason of some of the variation. But in many cases chance, tradition and historical background seem to be the main reasons, e.g. level n1–n10 being called native forest, natural forest and semi-natural forest in Australia, China and the UK respectively. Similarly, plantation, plantation forest and forest plantation are used synonymously for level p2-p4.

There are tendencies for there to be different "Schools" of terminology. The use of the word semi-natural has spread from the UK to European organisations (MCPF and UN-ECE/FAO), but not in a consistent manner. This may be because semi-natural has been used with differing definitions even inside the UK (Peterken 1996). In North America Canada and the US use more or less the same terminology, and from here the word "old-growth" has spread to other continents.

As can be seen in appendix 1, the World Bank, UNCED, IUFRO and FAO represent another school of terminology. It is of major importance, since it has been used internationally in many contexts both before and after the Rio summit in 1992, and because it is used in more or less legally binding documents of UNCED and EU regarding natural forests and primary forests.

3.2. Documentation problems

The genetic level of biodiversity has not been incorporated in the main terminology, mainly because it is almost never included in the reviewed terminologies, but also because inclusion would give rise to documentation problems. Pollen of trees mix over large and uncontrollable distances in a dynamic way. This makes definitions focused on "clean" local provenances and strains/races almost impossible to use in practice.

Dynamic evolution of species, strains and their distributions continues. This makes it necessary also to reflect on how native range is defined and on when species are deemed exotic. Native range should not be seen statically in relation to political boundaries, but dynamically in relation to soil, climate, dispersal barriers, rate of historical change, potential future changes etc.

Ideally Natural Forest might be defined as forest which has always been naturally regenerated and never artificially regenerated. Such a definition has been attempted (NFNA 1994) but has proven problematical because it is very difficult to know whether a generation preceding the extant stand was planted/sown, e.g. oak and beech forests where planting has been used for hundreds of years at least in Europe.

When a planted stand of native species has later regenerated naturally, the planted origin of the previous generation can usually only be determined by studies of archives or by genetic studies of the trees. Often archives do not exist and they cannot prove whether a pre-archive stand was planted or not. The other method is tedious and cannot give a certain answer either. This seems to be the reason why all other reviewed definitions which call levels n1-n10 natural forest, only employ features of the extant stand.

The abovementioned documentation problems have been attempted solved in the proposed terminology by incorporating different levels of necessary documentation at the various levels. This should be a help when referring a forest stand to a level, e.g. for inventory purposes.

3.3. Organisms as indicators

Ellenberg (1988) attempted to use field layer flora combined with forest management as determinants of a forest terminology. He found that his system works quite well in intensively investigated parts of Central

Europe, but not quite so well in southern and eastern parts of Central Europe where investigations of forest vegetation are somewhat fewer. The requirement for detailed knowledge on flora makes the system less useful internationally.

Even so, field layer flora can be of great importance as indicator of naturalness of forests by having certain plant species absent, present or common. Different indicators can be identified for different levels of naturalness. The same goes for other groups having indicator species for more or less natural forests (e.g. lichens, saproxylic fungi and insects). Sets of indicator species are necessarily local/regional, because of limited distributions of indicator species (Hermy et al 1999). Using all species matching specific forest-related traits as indicators instead of using just a few listed species, might be worthwhile in order to widen the geographical scope (Graae & Sunde 2000).

Certain sites at a specific level of naturalness can happen to have a more rare or typical biodiversity than some sites of a higher level. This can especially be the case when looking at limited sections of biodiversity and when comparing ancient woodland with recent woodland. For instance soil organisms and saproxylic organisms react very differently to forest management operations which break continuity of old trees and dead wood.

4. Recommendations - Conservation importance

The main use of terminologies on naturalness of forests relates to discussions of priorities relating to conservation of biodiversity. A sustainable balance between use and protection is an important factor in such discussions.

14 levels of forest naturalness have been identified in this review. Some levels, e.g. Primeval, Virgin and Old-growth Forest, are mainly retrospective and the appeal is to protect them. Other levels, e.g. Newly Untouched and Near-virgin Forest, have relevance in nature restoration activities and give hope for the future of biodiversity alongside wise management of the less natural levels. I find that it is of importance to understand all 14 levels when dealing with sustainable development and biodiversity protection, although aggregate levels will be enough for most reporting purposes.

Much work on forest conservation relates to the setting up of networks of protected areas. Site selection for conservation should benefit from using a stringent terminology and analysing which types of sites have high priority for inclusion in a reserve network. Many countries have so little forest with high levels of naturalness left that reserves need to be selected also in disturbed forests in order to represent ecological variation or just to reach adopted area targets. In such selection schemes Ancient Woodland should be given high priority because of the importance of continuity for biodiversity.

Other selection criteria for reserve networks include hydrological regime, which is very important for biodiversity. Sites with restored or intact natural hydrology should be ranked higher than sites with modified hydrology. Old stands and trees should be ranked higher than younger ones. In general sites with a rich, typical, unusual or fairly intact biodiversity should be ranked higher than sites with less well-developed biodiversity.

When sites are selected, protection regimes need to be settled. Continuity of management system can be very important for biodiversity, so that changing Specially Managed Forest, e.g. ancient coppice or wood pasture, to Untouched Forest can be detrimental to important parts of site biodiversity. For other site types, the flora and fauna – especially saproxylic species - can benefit by a change to untouched status. Restored or natural hydrology, natural species composition and wildlife including large herbivores are important for the natural structures and functions of the ecosystem to redevelop optimally (Peterken 1996, Vera 2000).

Recommendations on how much forest should be protected in reserves usually range below 10 – 15 % of the forest area. For the remaining at least 85 % of forest areas Natural Forests with forestry and Man-made Forests (levels n3 through p1) are highly relevant in discussions of sustainable management. All production

forests sustain some biodiversity. How much depends on how near-to-natural the management and the forest is. The proposed terminology can hopefully enhance and clarify discussions.

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Review of used terminology on forests

Year	Reference	Stakeholder	Size/ scale	Tree species	Dominating stand origin	Level of naturalness	Proposed name for level (this study)	Landscape	Forest	Landscape	Forest	Native species dominate	Stand scale	Exotics dominate							
								n10	n9	n8	n7	n6	n5	n4	n3	n2	n1	p4	p3	p2	p1
1990	FRA1990, (report FAO1995)	FAO						Primeval forest	Virgin forest	Frontier forest	Near-virgin forest	Old-growth forest	Long forest	Newly untouched forest	Specially managed forest	Exploited natural forest	Plantation-like natural forest	Partly-natural planted f.	Native plantation	Exotic plantation	Self-sown forest
1992	UNCED - Agenda 21	UNCED								Primary old-growth forests		Natural forest	???						Planted forest		Undefined
1992	UNCED - Agenda 21	UNCED								Primary/old-growth forests		Natural forest	???						Planted forest		???
1992	UNCED - Forest principles	UNCED										Natural forest	???						Planted forest		???
1992	UNCED - Forest principles	UNCED										Natural forest	???						Planted forest		???
1997	UN report of IPF 4. session	Intergov. panel on Forests								Forest undisturbed by man		Natural forest	???						Planted forest		???
2000	Forest resources (TBFRA)	UN-ECE/FAO								Natural forest undisturbed by humans		Natural forest	???						Planted forest		???
2000	Forest resources (TBFRA)	UN-ECE/FAO								Natural forest undisturbed by humans		Natural forest	???						Planted forest		???
2001a	Global FRA2000	FAO								Primeval f = Virgin f. = Primary forest		Natural forest	???						Planted forest		???
2001b	Global FRA2000	FAO								Primeval f = Virgin f. = Primary forest		Natural forest	???						Planted forest		???
2002	Silva Termi/SilvaVoc	IUFRO								Natural forest		Natural forest	???						Planted forest		???
2002	Silva Termi/SilvaVoc	IUFRO								Natural forest		Natural forest	???						Planted forest		???
1991	Forest Strategy	World Bank								Primary forest		Natural forest	???						Planted forest		???
1991	Forest Strategy	World Bank								Primary forest		Natural forest	???						Planted forest		???
1992	Aird	CANADA										Natural forest	???						Planted forest		???
1994	Aird	CANADA										Natural forest	???						Planted forest		???
1998	Wells et al	CANADA								Virgin forest	?	Old-growth	Unclear / variable						Planted forest		Undefined
2001	David South (in Lund 2001)	US Pacific Coast region								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Natural stands
1995	Rosson	Southern F. Exp. St., USA								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Undefined
2001	Lund	USA, various authors								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Undefined
2001	Lund	Australia								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Undefined
1999	Wenning	China										Natural forest	???						Planted forest		Undefined
1994	Forest Practice Guide no. 1-8	Forestry Authority, UK								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Natural stands
1994	Strategy for Natural Forests	NFNA, Denmark								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Undefined
1994	Strategy for Natural Forests	NFNA, Denmark								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Undefined
1995	MCPE (Followup)	Minis. Conf. Prot. F. Europ								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Undefined
1995	MCPE (Followup)	Minis. Conf. Prot. F. Europ								Virgin f.	?	Old-growth	Unclear / variable						Planted forest		Undefined
1998	MCPE3 resolutions, Lisbon	Minis. Conf. Prot. F. Europ								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Undefined
1996	Forests in sustainable develop	EU Commission								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Undefined
1996	Forests in sustainable develop	EU Commission								Virgin f.		Virgin-like forest	Unclear / variable						Planted forest		Undefined
1991	Corine Biotopes Manual	EU Commission										Natural forest	???						Planted forest		Undefined
1999	Interpretation Manual habitats	EU Habitats Directive										Natural forest	???						Planted forest		Undefined
1999	Interpretation Manual habitats	EU Habitats Directive										Natural forest	???						Planted forest		Undefined
2000	Final report	EU COST E4										Natural forest	???						Planted forest		Undefined
1991	Caring for the Earth	WWF/Dudley										Natural forest	???						Planted forest		Undefined
1992	Forests in trouble	WWF/Dudley										Natural forest	???						Planted forest		Undefined
1992	Forests in trouble	WWF/Dudley										Natural forest	???						Planted forest		Undefined
1996	Forests for life	IUCN/WWF										Natural forest	???						Planted forest		Undefined
1996	Forests for life	IUCN/WWF										Natural forest	???						Planted forest		Undefined
1997	Last Frontier Forests	World Resources Institute										Natural forest	???						Planted forest		Undefined
2000	FSC Principles & Criteria	Forest Stewardship Council										Natural forest	???						Planted forest		Undefined
1988	Vegetation Ecology	Ellenberg										Natural forest	???						Planted forest		Undefined
1988	Vegetation Ecology	Ellenberg										Natural forest	???						Planted forest		Undefined
1996	Natural Woodland	Peterken										Natural forest	???						Planted forest		Undefined
1996	Natural Woodland	Peterken										Natural forest	???						Planted forest		Undefined

FRA = Forest Resources Assessment
 TB = Temperate and Boreal
 ? = Cannot be inferred with certainty
 n = None of the terms are defined in the reference, but can be inferred from context
 x = All relevant terms are defined in the reference
 p = Partly
 f. = Forest
 P. old-g. = Partly Old-growth
 Semi-n.f. = Semi-natural forest
 Spec. man = Special management

14 levels of forest naturalness with definitions:**Appendix 2**

n10 Ultimate degree of naturalness – **Primeval Forest** – Forest ecosystems never modified by modern man/civilisation even indirectly, where the degree of impact on the ecosystem by indigenous people has not been significantly higher than the impacts of natural wildfire and of large wild animals (e.g. beaver (*Castor spp.*) or megaherbivores). The fauna includes a rich host of large animal species and is not significantly affected by human-induced extinctions or changes to animal population densities. Size is landscape-scale. *Comm: In Europe and America this type belongs in prehistorical times (before megaherbivore extinctions in stoneage), while examples might still occur in other parts of the world (e.g. perhaps some African National Parks). For prehistoric forests the time-period can be specified, e.g. Pleistocene forest or early-Holocene forest.*

n9 Extremely high degree of naturalness - **Virgin Forest** - Forest ecosystems virtually unmodified by man, and where the degree of former human impact on the forest - including soil and hydrology - has been only slightly more significant than the impacts of wildfire and animals (e.g. beaver (*Castor spp.*) or megaherbivores), and is no longer obvious. Wildlife inhabits the area with a fairly natural density and species composition including large herbivores and carnivores. Size is forest-scale. *Comm: In Europe this term has been used by many authors and lay people for the most extremely natural forests of Europe (Bialowieza and several others, see Peterken 1996) well knowing that they have been impacted somewhat by people in former times (grazing, selective cutting, fires etc).*

n8 Very high degree of naturalness - **Frontier forest** – A frontier forest is an area meeting the following criteria: It is primarily forested and predominantly consists of indigenous tree species. It is big enough to support viable populations of all indigenous species associated with that forest type -- measured by the forest's ability to support wide-ranging animal species (such as elephants, harpy eagles or brown bears). It is large enough to keep these species' populations viable even in the face of the natural disasters -- such as hurricanes, fires, and pest or disease outbreaks -- that might occur there in a century. It is home to most, if not all, of the other plant and animal species that typically live in this type of forest. Its structure and composition are determined mainly by natural events, though limited human disturbance by traditional activities of the sort that have shaped forests for thousands of years -- such as low-density shifting cultivation -- is acceptable. As such, it remains relatively unmanaged by humans, and natural disturbances (such as fire) are permitted to shape much of the forest. In forests where patches of trees of different ages would naturally occur, the landscape exhibits this type of heterogeneity. (Rearranged/shortened from World Res. Inst.:<http://www.wri.org/ffi/lff-eng/>).

n7 Very high degree of naturalness - **Near-virgin forest** – Forest ecosystems (forest scale) untouched long enough to have attained structures, dynamics and species composition similar to virgin forest, even though they may have been significantly modified, e.g. by clearcutting or agriculture at some time in the past. They are distinguished by a mixture in time and space between different seral stages, e.g. between old-growth stages and younger stages. Human impact on the forest structures is not obvious to see. The time necessary in untouched development before this level can be reached depends on how modified the situation was at the start. It is at least several hundred years if the starting point is a plantation-like forest.

n6 High degree of naturalness - **Old-growth forest** – Ecosystems (stand scale) distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function. The age at which old-growth develops and the specific structural attributes that characterise old-growth will vary widely according to forest type, climate, site conditions, and disturbance regime. For example, old-growth in fire-dependent forest types may not differ from younger forests in the number of canopy layers or accumulation of down woody material. However, old-growth is typically distinguished from younger growth by several of the following attributes: 1) large trees for species and site, 2) wide variation in tree sizes and spacing, 3) accumulations of large-size dead standing and fallen trees that are high relative to earlier stages, 4) decadence in the form of broken or deformed tops or bole and root decay, 5) multiple canopy layers, and 6) canopy gaps and understory patchiness. Old-growth is not necessarily "virgin" or "primeval." Old-growth can develop following human disturbances. (USFS 1989, Wells et al 1998). If the stand is known to be planted/sown or predominantly consists of exotics it is referred to level p4, Partly-natural planted forest or p1/p2, Exotic forests.

Continued on next page

Appendix 2 continued

n5 Quite high degree of naturalness - **Long untouched forest** – Relatively intact forest (stand level) that has been essentially unmodified by human activity for the past sixty to eighty years or for an unknown, but relatively long time. Signs of former human impacts may still be visible, but strongly blurred due to the decades without forestry operations. The time limit depends on how modified the forest was at the starting point. If the stand is known to be planted/sown or predominantly consists of exotics it is referred to level p4, Partly-natural planted forest or p1/p2, Exotic forests.

n4 Moderately high degree of naturalness – **Newly untouched forest** – Forest stands where forestry operations have been discontinued or never occurred since stand establishment, and which are known to have been left untouched for less than sixty to eighty years. Signs of former human management are usually easily visible, becoming more blurred with time. In principle any stand would belong here between forestry operations. If discontinuation of operations is only because of long management intervals, the stand is referred to lower levels. If the stand is known to be planted/sown or predominantly consists of exotics it is referred to level p4, Partly-natural planted forest or p1/p2, Exotic forests.

n3 Medium degree of naturalness – **Specially managed forest** – Forest stands with low-intensity use (allowing for presence of significant old-growth attributes) or where long continuity of pre-industrial type traditional use has given rise to a more or less characteristic forest structure, often with an interesting biodiversity and also often of cultural value. Examples are coppice, pasture forest, non-industrial selective logging and various stands of low accessibility or with protective or recreational functions. Excludes stands where the characteristic structures and attributes have been lost due to discontinuation or to large changes in the traditional use. If the stand is known to be planted/sown or predominantly consists of exotics it is referred to level p4, Partly-natural planted forest or p1/p2, Exotic forests.

n2 Fairly low degree of naturalness – **Exploited natural forest** – Forest stands used and modified by humans so that the forest structure and species composition is more or less heavily changed from the originally natural situation, but still predominantly consisting of self-sown native trees, and without a plantation-like structure. Can be exploitation without preceding silviculture (e.g. modifying old-growth forest), or stands with medium-intensity forest management (e.g. near-to-nature forestry). If a significant proportion of the stand is known to be planted/sown it is referred to level p4, Partly-natural planted forest.

n1 Low degree of naturalness – **Plantation-like natural forest** – Forest stands predominantly consisting of self-sown native trees with high-intensity forest management, so that the forest structure has become plantation-like by being even-aged, having relatively low tree ages, fairly regular tree spacing and only one or two tree species in the canopy layer. If it is not certain that the stand is self-sown it is referred to level p3, Native plantation.

p4 Low degree of naturalness – **Partly-natural planted forest** - Forest stands predominantly consisting of planted or sown native trees, and having somewhat natural structure by being un-evenaged, with mixed species or having significant ingrowth of self-sown trees (e.g. because multiple species have been planted and not intensively managed for timber and/or because of old age and low intensity of forestry). In certain cases such stands are left untouched long enough to correspond to levels n4, n5 or n6. They may be called newly untouched, long untouched and old-growth planted forest respectively.

p3 Extremely low degree of naturalness – **Native plantation** – Intensively managed, basically even-aged forest stands predominantly consisting of native trees, established artificially by planting or sowing with regular spacing. Often monocultures, but sometimes two or more species are established together. Usually the genetic variety of the plantation trees differs from the original genetic variety of the locality.

p2 Almost no degree of naturalness – **Exotic plantation** – Forest predominantly consisting of non-native tree species, where the stand origin is artificial by planting or sowing. In certain cases such stands (or p1) might be left untouched long enough to correspond to levels n4, n5 or n6. Such stands may be called newly untouched, long untouched and old-growth exotic forest respectively.

p1 Variably low degree of naturalness – **Exotic self-sown forest** - Forest stands predominantly consisting of self-sown non-native tree species. In certain cases this category can spread at an undesirable scale, e.g. to the extent that it has replaced or seriously suppressed the species previously occupying the specific area. Such cases can be called forest of invasive species. If it is not certain that the stand is self-sown it is referred to level p2, Exotic plantation.

Any forest stand should be possible to refer to level by a field visit supplemented by general historical and biological knowledge of the area.

Definitions of terms covering multiple levels:**Appendix 3**

N1-n10 = **Natural forest** – Forest stands predominantly composed of self-sown native trees. They are in other words naturally regenerated and complementary to planted/sown stands and exotic self-sown stands. (After FAO 2001a).

Comm: They range from undisturbed by humans (e.g. virgin forest) to heavily utilised for grazing, wood production etc. The degree of naturalness can be described by referring to more detailed levels or subclasses of natural forest. Stands that have natural processes or structures present are taken to be self-sown if no information indicates otherwise. "Natural forest dynamics" refer to the natural dynamics of natural forest undisturbed by humans. They often include a cycle of seral stages of growth.

P3,4+n1-n10 = **Native forest** – Forest stands predominantly consisting of native trees. These can be planted, sown by man or self-sown. They can be used/managed or not. *Comm: Native trees means species which have evolved in the same area, region or biotope where the forest stand is growing and are adapted to the specific ecological conditions predominant at the time of the establishment of the stand (FAO 2001a).*

P1,2 = **Exotic forest** – Forest stands predominantly consisting of non-native trees. These can be planted, sown by man or self-sown. They can be used/managed or not.

P2 + p3 **Forest plantation** – Intensively managed forest stands established artificially by planting or seeding and having regular spacing and even-aged structure. Usually only one tree-species is planted, but sometimes two or more are planted together. (After FAO 2001a). *Comm: They can be either native or exotic species or mixed. Excludes native stands which were established as plantations but which have lost the specific structure of plantation later, e.g. because of long time without intensive management or because many of the planted trees have been cut and self-sown trees have been allowed to take their place.*

P2-p4 = **Planted forest** – Forest stands established artificially by planting or seeding. (After ITTO 2002).

p1+n1-n10 = **Self-sown forest** – Forest stands predominantly consisting of trees which have germinated and grown from spontaneous seedfall, either wholly naturally or influenced by various silvicultural activities, e.g. scarification.

P1-p4 = **Man-made forest** - Forest stands which are either predominantly consisting of non-native (introduced, exotic) tree species or which have been established artificially by planting or seeding.

N4-n1 = **Secondary forest** – Forest stands of native species regenerated largely through natural processes after significant human and/or natural disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to primary forests on similar sites. (After Chokkalingam & Jong 2001). *Comm: Typical disturbance types are clearcutting, logging, flood, fire and deforestation in general. Continued modification often takes place, e.g. forestry. Can revert to primary forest if untouched natural development proceeds for a sufficiently long time.*

N5-n10 = **Primary forest** - Relatively intact forest areas that have always or at least for the past sixty to eighty years been essentially unmodified by human activity. Human impacts in such forest areas have normally been limited to low levels of hunting, fishing and harvesting of forest products, and, in some cases, to historical or pre-historical low intensity agriculture. (After World Bank 1991, EU 1996)

N4, n5, n7, n9, n10, most of n8 and n6 and minor parts of p1, p2, p4. = **Untouched forest** (since specified year/decade/time) – A common denomination of forests uninfluenced by forestry activities (felling, planting etc.) from a specified time. Is not affected by research, hunting or recreational activities etc. Usually the length of time is minor except in woods designated as untouched (=minimum-intervention) forest by administrative or legal order.