

A FOREST CLASSIFICATION BASED ON MANAGEMENT AND TREATMENT

by

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Any sound classification of forests should aim at the selection of a restricted number of basic models, put into a clear systematic order by the use of objective and easily recognizable characteristics.

Most classifications start from structural differences and variations in floristic composition between forest types. They are phytogeographical or phytosociological in their approach, taking into account site variations or differences in climatological and ecological conditions, but they do not consider the direct impact of man as a differentiating characteristic, nor do they assess the degree of change brought about by permanent or temporary use of the forest.

The present classification makes use of the basic relationship between man and the forest: human intervention into the forest (silvicultural manipulation), the organisation of interventions (management) and the intentions of the human community (forest policy) are its parameter.

The definitions presented at the „F.A.O. World Symposium on Man-made forest and their industrial importance” (Canberra, Australia, 1967) and the recommendations made by the „Working Group on Afforestation and Reforestation” of the European Forestry Commission O.C.D.E. are the object of a critical analyses.

1. Existing terms and classifications

Human impact on the forest has always been important and the part of the earth actually covered by absolutely untouched natural forests is far less considerable as was accepted some years ago.

On the other hand it is not suitable to use the term artificial regeneration, as a specific characteristic for the man-made forest, as could erroneously be concluded from the British Commonwealth Forest Terminology defining it as „a forest crop raised artificially, either by sowing or by planting.”

The term „forest crop” already implies a restriction in the use of the forest, in that it does not consider the many exclusive functions a forest, created by sowing or planting, is able to fulfil.

Besides the term „artificial regeneration” is not always understood in the same sense.

To Bonnemann („Waldbauliche Terminologie” Bd. 40, Schriftenreihe der Forstl. Fak. der Univ. Göttingen) artificial regeneration means „Begründung eines Bestandes durch Saat oder Pflanzung” (Creation of a stand by sowing or planting).

The „Working Group on Afforestation and Reforestation” (European Forestry Commission O.C.D.E.) holds a different opinion, defining artificial regeneration as „Restoration of forest cover by planting or sowing in the natural course of management”. It is not so obvious what is to be understood by „the natural course of management”, but the O.C.D.E. definition implies that artificial regeneration has to do with the renewal of a pre-existing forest by a logical sequence of preconceived actions, which are part of a plan to establish a certain order in time and space.

The idea of a remake of the forest stand is also to be found in the French terms « régénération » or « rajeunissement ».

From the point of view of silvicultural technique it is not advisable to consider the act of planting or sowing as a distinguishing characteristic for the man-made forest in its traditional concept.

1° Different regeneration types (artificial vs. natural regeneration) can be at the origin of stands, that, in due course, will develop highly similar structural characteristics.

2° In the same stand, artificial and natural regeneration are often used in the course of the same renewal process, but in different combinations.

- underplanting (or sowing) in naturally regenerated stands;
- advance planting (or sowing) on a site to be regenerated subsequently;
- planting (or sowing) to complete an insufficient natural regeneration;
- planned mixing of the two types of regeneration to introduce non-present species.

3° Silvicultural interventions to obtain natural regeneration (man-induced natural regeneration) can lead to a stand, which

is highly different from the one resulting from spontaneous regeneration on the same site.

4° Some forms of renewal of trees and stands (stool shoot, layer, sucker regeneration, die-back) occur spontaneously, but can also be systematically induced by man or indirectly provoked (forest fire, transport damage). In an attempt to make a distinction between "forests made by man" and "forests re-made by man", the terms "afforestation" and "reforestation" were introduced as differentiating characteristics.

The O.C.D.E. Working Group defined "reforestation" as "reforestation of forest cover by planting or sowing, when it is not possible to effect this restoration in the normal course of management" as opposed to the preceding definition of "artificial regeneration" (sowing or planting in the normal course of management).

The term "normal course of management" is not clearly defined, as management objectives can change in the course of stand development or are influenced by unpredictable events and cutting practices.

It therefore seems suitable to understand the O.C.D.E. definition of artificial regeneration as the restoration of forest cover by sowing or planting shortly or immediately after cutting the previous stand. Subsequently, "reforestation" would then imply the acceptance of a considerable period of interruption, although of undefined length, extending from the disappearance of the previous stand to the act of planting or sowing to create a new one.

There remains however some doubt about the value of these terms as a sound basis for forest classification.

The same observation applies to the F.A.O. classification, worked out at the Canberra-Symposium along the following lines :

1. Forest created by afforestation
Creation of a forest on sites that were not covered by forest during the last 50 years.
2. Forests arising from reforestation
Creation of a forest on sites that were not devoid of a forest cover during all of the last 50 years.
Commenting upon this definition, it was said that a fundamental difference exists between the new stand and the preceding forest :
 - a) other species are used;
 - b) the same species are used but with a different and superior genotype.
3. Forests brought forth by artificial regeneration
Forest cover present during the entire or part of the preceding period of 50 years.

The same tree species are used.

Also called "Forests re-made by man".

4. Forests originating from natural regeneration and after silvicultural intervention.

Also called "Natural man-assisted forests."

5. Forests originating from natural regeneration and without any silvicultural intervention.

The weaker points of the classification are obvious.

"Artificial regeneration" is used as a forest management term, although in fact it stands for, or represents a set of silvicultural actions and interventions to create a stand by artificial means, not making use of the spontaneous colonisation of the site.

The term is more or less used in opposition to "afforestation" and "reforestation", which are silvicultural management terms.

In practice the same techniques and artificial interventions are applied to afforestation and reforestation as well as to the quick renewal of a preceding forest immediately or shortly after its planned or accidental destruction. It therefore stands to reason that classes 1, 2 and 3 have in common the methods and techniques for their creation and are fundamentally differentiated from each other only by the length of the period of time extending from the disappearance of the preceding forest to the creation of the new one :

artificial regeneration : less than 5 years

reforestation : not more than 50 years

afforestation : more than 50 years

Such a distinction is equivocal and arbitrary, as well as the implication that for reforestation new species should be used or the same species, though of a better genotype, as in the previous forest. This in fact can be done at every occasion : within the limit of less than 5 years after the disappearance of the preceding forest, or at any other moment by way of underplanting, in group regeneration, etc.

Nor is it advisable to restrict the qualification "man-made forest" to afforestations and reforestations as was proposed.

In this case two consecutive forest generations could be absolutely identical (tree species, spacing, planting technique, soil preparation, growth rate etc.) and nevertheless be put into different classes.

A forest classification for practical use must start from easily discernable and lasting characteristics corresponding to variations in composition, structure, growth, form etc. Management characteristics, not reflected in the physiognomy of the forest, are not

useful. Nearly identical forests should be classed together in any classification system.

2. Revision of terms and basic options

In working out a proposal for a new forest classification, a clear position should be taken with regard to matters and problems, directly or indirectly related to the object of classification.

It therefore was thought suitable to express opinion on terms and definitions, used as a basis for classification.

Regeneration (R)

Basic definition :

The replacement of one generation of trees building up a forest stand or being part of it by another generation of younger trees out of which a new forest stand or renewal of a part of the old stand arises.

The term "regeneration" is a biological concept expressing the idea of "rejuvenation". It clearly implies the existence of a previous stand irrespective of the period of time, separating the two forest generations.

This is logical, since the length of this period has no fundamental importance; forests are only in exceptional cases to be made on sites where they never occurred before.

The term can be applied to all types of the F.A.O. classification and covers afforestations, reforestations, man-made forests and others as well.

The regeneration of the forest follows one of three fundamental time patterns :

— continuous regeneration over a period of undefined length without any significant interruption. This is the case in some forests not yet touched by man or in the classical selection forest (Plenterwald) of Central-European concept.

— Regeneration over a fairly long period covering an important part of the age of exploitability of the trees, the rotation accepted for a given forest stand or the age for the average tree to attain its maturity (Verjüngungsperiode = Regeneration period)

— Regeneration over an extremely short period, standing for one seed year or the time needed for immediate sowing or planting by man.

Natural regeneration (NR)

Basis definition :

The appearance, in important numbers, of young rooted plants arising from seed germinating on the spot, but not intentionally deposited there to that purpose by man, including those produced, without any silvicultural intervention, from suckers, stool shoots and layers.

Seed bearing trees in the immediate neighbourhood are mostly at the origin of natural regeneration, but also biotical and abiotical agents (birds, insects, mammals, wind, water) can carry seeds over a long distance.

Natural regeneration leads mostly to the fixation of autochthonous tree species, local races and ecotypes. It can also result in the proliferation of exotic species and even their naturalisation (after repeated regeneration).

Silvicultural intervention can be essential in deciding where and when regeneration will take place, and which species will build up the new stand.

This case is defined as "man-assisted natural regeneration" (MANR) to distinguish it from "spontaneous natural regeneration" (SR), arising without any help nor preceded by planned silvicultural action, directly aiming at the establishment of regeneration.

Artificial regeneration (AR)

Basic definition :

The installation of a new forest stand by sowing or planting for which all kinds of material (seed, rooted plants, suckers, layers, cuttings) can be used, transported by man, often over a great distance from the place where it was collected or cultivated to the planting or sowing site.

The "artificial" character of this type of regeneration appears from the fact that a well-organized order in time and space is

imposed by man, who decides about the rooting place and growing space allowed to each young tree.

Other types of regeneration

Quite often natural and artificial regeneration occur at about the same time and place.

If the natural seedlings are not to be used in the building up of a new stand or are considered non-existent or inconvenient, the regeneration is considered "artificial".

If, on the other hand, a wilful combination of the two forms of regeneration is made with the intention to give all elements a function in the building up of the new stand, it is advisable to use the term "fusionated regeneration".

It is quite unimportant which type of regeneration arises first or serves as a protection or a complement to the other. It is evident that material, provided by either form of regeneration, can afterwards fulfil a cultural function or become a basic element of economic production.

When transplants are used, collected from over-dense natural regenerations and planted out at a greater distance from each other or in a place where natural regeneration is failing, incomplete or unsatisfactory, the result of this action is to be considered a special type of artificial regeneration. The artificial character of the regeneration is determined by the transport of the material from the place of origin to the place of use, as well as by the technical interventions by which the plants were put into the soil following a pattern, worked out in advance. It stands to reason that the term "mixed regeneration" applies to the mixture of species independent from the fact whether natural, artificial or fusionated regeneration is used.

Forest

It is taken for granted that "forest" implies a certain form or space (F.A.O. note: "Forest" implies width as well as length) and a certain density of the cover it provides, that may not sink permanently below a fixed level.

It was suggested (Canberra-Symposium) that in younger stands the number of stems present (N) or a survival index (I) could be used as a temporary characteristic :

Completely covered	N > 1.000 ha	1	>	75
Partially covered	1.000 > N > 300/ha	75 %	>	1 > 25 %
Badly covered	N < 300/ha	1	<	25 %

These indications express in any case that a forest is supposed to be a more or less closed community, that loses its specific character the moment the contact between its components is permanently loosened up. But there is more to it. Considering that the principal distinguishing mark of the forest is its biocoenotical presence and its ecological impact on the environment-qualities it possesses even before human intervention and use start- it seems preferable to define the forest as

— a dynamic community of trees,

— growing in close social contact with each other in a relation of mutual protection and concurrence, the degree of which is determined by the rate of growth, the density of the canopy and the horizontal and vertical distribution of the trees,

— forming with the site, on which it grows, a relatively independent ecological entity with a specific microclimatical character,

— and showing a distinguishable biocoenotical structure, imposed by the relationship between the growing stock and the site and by the accompanying flora and fauna, living and developing in a characteristic, qualitative and quantitative combination of species.

The standing timber becomes of economic value only as soon as human use of the forest starts. In a relatively short time the latter can develop into the principal objective of forest management and silvicultural treatment, but it never is the essential characteristic of the forest. Economic use of the forest need not necessarily provoke a disrapture of the ecological equilibrium, nor lead to the neglect of all other functions of the forest.

The one-sided promotion of timber production, aiming at the highest financial gain in the shortest period possible, usually has the replacement of natural regeneration by artificial regeneration, extensive treatment and the application of clearcutting practices as a consequence.

It ultimately leads to the disappearance of the "forest" and its replacement by the "timber plantation".

The obvious total neglect of the direct economic aspects of timber production and a one-sided interest in the social, bio-ecological and protective function of the forest eventually leads to the creation of the "forest park" or "park forest", the "forest reserve" or the "protection forest".

Forest stand

The forest stand is a part or a sub-division of the forest, big enough to be the object of an independent silvicultural treatment.

It is supposed to be a separate ecological unity with its own microclimatical character.

3. The basic units of the proposed classification

The following forest types are used as basic units for classification :

1. The natural forest
2. The semi-natural forest
3. The intermediary forest
4. The artificial forest
5. The naturalized forest
6. The marginal forest forms

1. *The natural forest* (1)

Primary autochthonous forest

La forêt naturelle

Der Naturwald

Het natuurlijk bos

The main characteristics of the natural forest are the apparent absence of direct human intervention in past and present time, the exclusive occurrence of autochthonous tree species and the continuous renewal of the forest by spontaneous natural regeneration without any outward assistance.

As a consequence this kind of forest shows a high degree of ecological stability and little variation as far as standing volume and yearly increment are concerned.

The structural complexity and the high number of species growing together in a typical combination are not to be considered as essential features. They are only typical for the climax stadium of natural forests on good sites where several tree species can grow and multiply.

The natural forest does not necessarily present these characteristics on poor sites, in the struggle zone of the forest (alpine and northern forest border line) or in the very first stages of its development (recent colonisation of a new site).

It is not always possible to conclude with absolute certitude whether or not the evolution of the forest was influenced by human intervention at a certain moment or during a rather short period. A slight or accidental interference does not necessarily modify the normal evolution or change the combination of species.

It is therefore proposed to use the term "*virgin forest*" (1.1) (Urwald, forêt vierge, oerbos) if no trace of human intervention is detectable and to speak of a "*pseudo virgin forest*" (1.2) (Pseudo-Urwald, forêt pseudo vierge, pseudo oerbos) if the influence of human intervention is apparent. Such an intervention must be accidental and may not have reduced the number of species. The upper limit can be fixed at a maximal reduction of 10 % of the growing stock by a single intervention or at 25 % over a period corresponding with the age of the average dominant tree. (A).

2. *The semi-natural forest* (2)

Der Semi-Naturwald
La forêt semi-naturelle
Het semi-natuurlijk bos

A semi-natural forest is exclusively composed of naturally regenerated autochthonous tree species. Proof of non-accidental human intervention is evident, leading to a reduction of the standing volume with 10 to 25 % at a given moment and with at least 25 % of this volume by repeated interventions over a period corresponding with the average age of the dominant trees. (A).

In most cases this type of forest still shows the ecological stability, the intricate pattern of mixture and structure, the constant covering of the soil typical for the corresponding natural forest type.

Human interference can have various consequences :

— Natural regeneration remains the rule, but it varies between spontaneous and man-assisted or even man-directed natural regeneration.

— Most often the number of tree species is reduced and the pattern of mixture modified, even to such a degree that structural changes with a direct impact on stand evolution occur.

— The standing volume may be reduced, mostly by accidental or unorganized interventions, to such a degree that complete recuperation becomes impossible.

The reduction of stand volume may however also occur as a consequence of organized management or have a temporary character.

It is not impossible, on the other hand, that an increase of volume can be obtained and is aimed at by wilfully modifying the structure and the composition of the stand.

The unmanaged semi-natural forest (2.1)

Forêt semi-naturelle non aménagée
Semi-Naturwald ohne Hiebsregulierung
Het onbeheerd semi-natuurlijk bos

The term applies if human interference is unevenly spaced and not really organized, no management plan exists or even no cutting scheme is made: Human intervention is accidental or not regularly repeated. The absence of silvicultural treatment is evident.

If the changes in stand volume are limited and no far-reaching modifications in stand structure have taken place so that all or most original tree species are still present in their typical combination, the term "*undegraded (and unmanaged) semi-natural forest*" (2.1.1) can be used [(Forêt semi-naturelle non-dégradée (et non-aménagée); undegraierter Semi-naturwald (ohne Hiebsregulierung) ongedegradeerd (en onbeheerd) semi-natuurlijk bos)]. By prolonged absence of further cuttings this type can come close to the pseudo-virgin forest; after one or more tree generations it may even completely take the aspect of the original virgin forest. It is not excluded that some of the actual virgin forests or some considered as such, at one time or other, belonged to this type.

By the elaboration of a sound management plan, the undegraded and unmanaged semi-natural forest can easily become an economic forest (EF) without having to change its basic structural characteristics in many cases.

In the opposite case, where an important and lasting decrease of the standing volume with at least 40 % at one time is evident and when profound structural changes cause the modification of the pattern of mixture and the reduction of the number of tree species, the forest is considered as a "*degraded (and unmanaged) semi-natural forest*" (2.1.2.) [(Forêt semi-naturelle dégradée (et non-aménagée); Degradierter Semi-Naturwald (ohne Hiebsregulierung), gedegradeerd (en onbeheerd) semi-natuurlijk bos).]

If stand degradation has arrived at a level, where it becomes quite impossible to reconstruct, by whatever means, the original or an equivalent situation, characterized by a high degree of bio-ecological stability and the presence of a maximal number of autochthonous tree species, the degradation is called irreversible and the corresponding type "*(unmanaged) semi-natural forest with*

irreversible degradation" (2.1.2.1.) [(Forêt semi-naturelle (non aménagée) à dégradation irréversible; irreversibel degradiertes Semi-Naturwald (ohne Hiebsregulierung), (onbeheerd) semi-natuurlijk bos met irreversibele degradatie).]

If no care is taken of the forest at this stage, it very often breaks down completely, eventually provoking soil degradation and erosion.

Under good ecological conditions and on the less exposed sites, a new forest type often appears, due to spontaneous recolonisation of the uncovered area by non-tolerant species with easy seed dispersion. Such a secondary formation can be interesting from an economic point of view. It can even arrive at a fair degree of stability, although, due to an eventual decrease of soil fertility following destruction of the primary forest, the composition of the stand is poorer and its structure less intricate.

If put under management the semi-natural forest with irreversible degradation is due for direct transformation, using artificial regeneration.

In the "*unmanaged semi-natural forest with reversible degradation*" (2.1.2.2.) [(Forêt semi-naturelle (non aménagée et) à dégradation réversible; reversibel degradiertes semi-Naturwald (ohne Hiebsregulierung) (onbeheerd) semi-natuurlijk bos met reversibele degradatie)] the equilibrium between forest stand and site was never completely broken so that growing conditions and the possibilities for regeneration were not fundamentally changed.

If spontaneous regeneration is abundant (number of seedlings, number of species) shortly after partial destruction of the stand, the chances for complete reversal of the situation can be real, so that the original or an equivalent type may arise after a fairly short period.

Silvicultural interventions to promote a desirable evolution may be needed or at least helpful.

The semi-natural forest under management (2.2)

La forêt semi-naturelle aménagée
Semi-Naturwald mit Hiebsregulierung
Het beheerd semi-natuurlijk bos.

The moment a natural forest is brought under control and put to regular use by some kind of management plan, it becomes a semi-natural forest.

The semi-natural forest, whatever its origin may be, often possesses a high potential for economic use, especially for timber production.

A sound management of the semi-natural forest requires the unequivocal definition of the aims of silvicultural treatment regarding composition and structure of the stands, and elaborate choice of the methods and techniques to be used as well as a fair estimate of the optimal level of stand volume to be obtained. The reconstitution of ecological and economic stand stability will undoubtedly become the direct objective of the treatment.

The treatment and the management of the semi-natural forest result unavoidably into its modification and amendment to a variable degree, depending on the basic ecological and floristic characteristics of the forest, the technological possibilities and the economic desirability.

The semi-natural forest under management becomes in this way an economic forest, the renewal of which is not only assisted by man, but in most cases even induced. (MIR = man-induced natural regeneration).

In exceptional cases it is possible to aim at the fixation of a given stage of evolution of a semi-natural forest and to create a "stabilized semi-natural forest" (2.2.1) (*Forêt semi-naturelle fixée. Fixierter Semi-Naturwald. Gefixeed semi-natuurlijk bos*).

Fixating a given evolution stage, it is of the utmost importance not to change the rhythm of stand growth and regeneration. Exploitation and renewal cuttings must be blended in a perfect way with the dynamic evolution of the forest and human interventions must tend to become a copy of the natural phenomena, although they have to occur with a slightly shortened periodicity.

Technical problems can arise by an insufficient concentration in space of the cuttings and by the necessity to accept an abstract structural model of the natural forest. It is in fact rather doubtful whether it is feasible to put an untouched natural forest under management without any modification.

A more frequent case is the reconstruction and, consequently, the fixation at a superior level of evolution of a natural forest suffering from reversible degradation. It is in fact quite exceptional to wilfully give a permanent character to a degradation stage as it does not correspond with the productive capacity of the site and thus cannot be the ultimate objective of a normal management activity.

To reconstruct a degraded semi-natural forest, use is made of natural regeneration of autochtoneous species, whether spontaneous or man-induced but, in any case, man-assisted.

This activity implies continual care in the early stages of reconstruction and planned silvicultural treatment as well.

This type of forest is to be called "*reconstructed semi-natural forest*" (2.2.2.) (Forêt semi-naturelle reconstruite; rekonstruierter Semi-Naturwald; gereconstitueerd semi-natuurlijk bos).

The superior level of evolution to be attained can be different depending on the degree of degradation, the quality of the site and the intensity of the treatment. It may be possible to arrive at a stabilized type of forest, corresponding with a stage of the former evolutionary sequence (sub-climax) on the site. Under exceptional conditions it may even be possible to recreate a situation, more or less comparable to the natural climax. In most cases, however, autochthonous tree species appear that could not emerge as long as a dense cover existed. These may belong to earlier stages of natural evolution, but never grew together with the remaining species that belonged to later stages. If they are interesting enough from an economic, technological or cultural point of view, they may well be conserved and a new stabilized combination of tree species can be created and maintained by silvicultural treatment (para-climax).

In case planting and sowing are used to reconstruct the forest, it is no longer to be considered semi-natural.

As management and treatment must start with a thorough investigation into the qualities of the species found in the natural forest, it may be judged opportune to favour some species more than others or to change their position in the stand fundamentally. Without eliminating a great number of species or none at all, a new pattern and a new degree of mixture can be obtained, reflected in modifications of stand structure (horizontal and vertical dispersal of the trees).

The result of such treatment is called the "*modified semi-natural forest*" (2.2.3.) (Forêt semi-naturelle remaniée; modifizierter Semi-Naturwald; geremanieerd semi-natuurlijk bos).

As is quite often the case, especially on sites with a high number of tree species (tropical regions), silvicultural treatment and management directly start to favour a restricted number of the interesting ones and destructing the others systematically. When natural regeneration is the rule and no exotic species are introduced, the ensuing type is to be considered a "*reduced semi-natural forest*" (2.2.4.) (Forêt semi-naturelle réduite, Vereinfachter Semi-Naturwald; gereduceerd semi-natuurlijk bos).

In Europe, many so-called natural forests under management or forests treated on a natural or ecological basis belong to this type. (Beech forest, oak forest, larch forest, spruce forest, pine forest).

3. *The intermediary forest* (3)

La forêt intermédiaire
Der Intermediärwald
Het intermediaire bos

Exclusive natural regeneration is one of the essential characteristics of the natural and the semi-natural forest.

As soon as artificial regeneration comes into use, whether or not combined with natural regeneration, spontaneous or man-assisted, the forest is reverted to an intermediary position between the natural forest and the artificial or purely man-made forest.

It will be considered an "*intermediary forest*" (3) as long as no more than 50 % of the growing stock is made up of artificial regeneration, even if autochthonous tree species are used to this end, and no more than 25 % of the growing stock in case non-autochthonous or exotic species are introduced.

The use of artificial regeneration changes in fact profoundly the dynamics of stand evolution, creates a different stand structure and calls for an intensive silvicultural intervention and treatment, with a direct impact on bio-ecological conditions and thus on growth.

A recent trend in the regeneration of mixed stand, especially in those parts of Europe where a severe labour shortage is felt and the possibilities for mechanisation are limited, calls for the use of both artificial and natural regeneration, either simultaneously or consecutively, but within the limits of a normal regeneration period.

The essential characteristic is that they occur on the same spot (stand, group, partial clear-cutting) and are intimately mixed or fusionated with each other. They give birth to a type to be indicated as an "*intermediary forest with fusionated regeneration*" (3.1) (Forêt intermédiaire à régénération fusionnée. Intermediärwald mit gemischter Verjüngung; Intermediair bos met gefusioneerde verjonging) that needs a rather complicated silvicultural treatment.

As a rule, no preference is given as a matter of principle to one type of regeneration or the other: they complete each other, irrespective of the fact which of the two types was induced first. In the same line of thought the functional equivalence of both regeneration types is accepted: they can eventually produce elements for economic production or trees with a predominantly cultural function as well.

As soon as artificial regeneration is favoured unilaterally, so as to contribute to more than 50 % of all regeneration or if the part of introduced exotics exceeds 25 %, the forest is no longer to be considered as belonging to the intermediary type. It becomes a man-made forest in which natural regeneration is not completely neglected, but silvicultural management nevertheless gets the character of a real stand transformation or conversion.

An intermediary transitional situation is also created when, outside a normal regeneration period and not using or neglecting spontaneous natural regeneration, new elements are introduced by sowing or planting. The main objective of this measure is to obtain a stand with a bigger volume and a higher potential for economic production. Either autochthonous or exotic tree species can be introduced this way, but with the same restriction as applied to the former type (the introduced species will ultimately make out less than 50 % of the growing stock, less than 25 % for exotic species).

Because the principal aim of the intervention is to enrich the forest, the corresponding type is called "*enriched intermediary forest*" (3.2) (Forêt enrichie intermédiaire; angereicherter Intermediärwald; aangerijkt intermediair bos).

It must be stressed, that the enrichment has nothing to do with the reversal of a degradation, but only with the partial replacement of elements of a well-equilibrated forest with a fairly low level of production by quicker growing or more valuable ones. The original elements are to be treated carefully with regard to their important bio-ecological function.

A not so clearly distinguishable type is the "*revalorized forest*" (3.3) (Forêt révalorisée; revalorisierter Wald; gerevaloriseerd bos) which arises from the rebuilding of a distinctly degraded forest by planting or sowing.

Artificial regeneration is used because of lacking or insufficient natural regeneration. For revalorisation quick growing species are preferable.

The remnants of the original forest must be conserved as well as possible, otherwise the artificial regeneration would have the character of a real transformation.

Therefore any trace of natural regeneration is intensively cared for and cutting in the old stand are reduced to the minimum required for giving the younger plants the growing space they need. When the stand arrives at the stage of economic production the

remnants of the old stand should cover more than 50 % of the stand volume, otherwise the forest is to be considered artificial or man-made.

4. *The artificial forest* (4)

La forêt artificielle
Der Kunstwald
Het kunstmatig bos

The artificial forest is a real man-made forest, as it possesses the following characteristics :

1° It is created exclusively by artificial regeneration by all kind of techniques and materials (sowing, planting, cuttings etc.)

2° Creation of the new forest follows the wilful (clearcutting) or accidental (biotic or abiotic catastrophes) destruction of the preceding forest generation.

The length of time between destruction and regeneration is immaterial : it can be a very long time, but in exceptional cases destruction and regeneration practically occur at the same time (stand transformation; highly mechanized replanting immediately after forest destruction).

For regeneration all kind of species can be used (autochtonous and exotic). The number of species is restricted and in most cases reduced to a single one, so that the artificial forest is predominantly homogeneous, at least at the moment of its creation.

The trees are regularly and widely spaced so that complete covering of the soil is only obtained after some years. As the initial number of stems is remarkably low compared to natural regeneration, genetic selection in the nursery takes the place of genotypic selection by silvicultural treatment, which must be less intensive than in mixed forests.

In the man-made forest the use of conifers with a direct industrial value is prevailing.

The most marginal form of artificial forest is the "*transformation*" (4.1) (La transformation. Die Umwandlung. De omvorming). It supposes the act of artificial regeneration immediately after partial clearcutting (group cutting) or even before complete cutting of the old stand.

In the first case it is called "*direct transformation*" (4.1.1.) (Transformation directe; direkte Umwandlung; direkte omvor-

ming) and in the second case "*indirect transformation*" (4.1.2.) (Transformation indirecte; indirekte Umwandlung; indirekte omvorming). In both cases eventual regeneration, provided by the older seed trees, is never abundant nor taken much into consideration; it is simply used as a complement or to maintain a good soil covering. The transformation is essentially undertaken to replace one stand by an other. Out of a transformation a permanently or temporarily mixed stand may arise.

The direct transformation leads to a horizontal pattern of mixture (group mixture), that is more apt to become permanent.

By indirect transformation a vertical pattern of mixture (individual mixture) is created, that tends to be more temporary, due to the necessity to remove gradually the old forest cover in favour of the underplantings, requiring more light once they are well-established.

The main advantage of indirect transformation is that it can be done without loss of increment; the two intertwined stands compensate each other and the rate of growth is clearly related to the varying density of the cover.

The mixture is many times only temporary: Progressive removal of elements of the old stand leads to the replacement of one stand by an other.

In the direct transformation, mixture becomes permanent (group mixture).

If immediately after the removal of the old stand (clearcutting) an artificial regeneration is undertaken within a period of 5 years, the term "*renewal*" (4.2) (Renouveau: Erneuerung; Bosvernieuwing) is to be used.

It is quite unimportant whether the same or other species, autochthonous or exotic, are used, whether they are of a better genetic quality or not and which techniques or methods are chosen to arrive at a desirable result.

It stands to reason that stand renewal, as well as reforestation or afforestation is very suitable to introduce better material and to rationalize treatment or management.

Artificial regeneration of a stand at least 5 years and not more than 50 years after clearcutting or destruction of the previous stand is called a "*reforestation*" (4.3.) (Reboisement; Wiederaufforstung; Herbebossing).

If the period between cutting and planting outlasts 50 years the term "*afforestation*" (4.4) (Boisement; Aufforstung) is preferable.

Stand renewal, reforestation and afforestation have most characteristics in common. They are only differentiated by the conventional length of the period between destruction of the preceding forest stand and regeneration.

5. *The naturalized forest* (5)

La forêt naturalisée
Der naturalisierte Wald
Het genaturaliseerd bos

The introduction of exotic tree species, already some centuries ago in different parts of Europe, has lead to an equivocal situation with regard to their appreciation as basic elements.

Some of them do not regenerate spontaneously or do not respond in a satisfactory way to regeneration cutting. Others regenerate quite easily, get intermixed with autochthonous species and seem to adapt so well to the site, that they are nearly not distinguishable, from a silvicultural point of view, from indigenous species as far as their growth and position in the stand are concerned. To a third group belong the species which are to be labelled only after some hesitation as exotics because they were taken in adjoining natural areas of dispersion or were supposedly present on the site at one time or another. It is acceptable to consider species naturally regenerating easily in consecutive generations as naturalized.

In the same line of thought, special consideration should be given to man-made forest types of autochthonous tree species that are regenerated naturally at the end of the first artificial generation.

A man-made forest, meaning a forest created by artificial regeneration, that is subsequently regenerated naturally is called a "*naturalized forest*" (5) (Forêt naturalisée; Naturalisierter Wald; Genaturaliseerd bos).

In the case of exotic tree species it could be prudent to wait for a second natural regeneration before considering the species sufficiently naturalized to speak of a "*naturalized forest with introduced tree species*" (5.1) (Forêt naturalisée à essences introduites; naturalisierter Wald mit eingeführten Baumarten; Genaturaliseerd bos met vreemde boomsoorten).

In artificially created stands with autochthonous tree species a first natural regeneration is sufficient to use the denomination of "*naturalized forest with autochthonous tree species*" (5.2.) (Forêt naturalisée à essences autochtones; Naturalisierter Wald mit einheimischen

Baumarten; Genaturaliseerd bos met autochtone boomsoorten). This type may well develop, in due time, into a semi-natural forest.

6. *Marginal forest types and growing forms* (6)

A certain number of growing forms, natural or man-created, are dominated by the presence of trees, that can eventually have a direct or indirect economic value. For the sake of completing this classification they are summed up, without further comment.

Their number is in fact not limited.

The modification of this type of forest is not undertaken in most cases. Their conservation is the main objective of eventual management for many reasons.

6.1. The forest with permanent incomplete cover

Typical for the forest in the struggle-zone (alpine forest limit, northern forest, dune forest, mangrove etc.)

The presence of high growing trees is not excluded. Natural regeneration, however widely spaced, is mostly manifest.

Due to the permanent action of extreme ecological factors with a destructive effect, the forest cover never becomes complete.

6.2. The bush forest

Forest with low growing tree species or bushes, representing a natural climax under critical ecological conditions or as a result of severe and irreversible degradation, due to the action of man.

Spontaneous vegetative regeneration may be found next to natural regeneration by seed. No measurable timber volume is present.

6.3. The forest with vegetative regeneration

6.3.1. *The plantation*

Creation of a timber production unit by the exclusive use of vegetatively produced material (cuttings directly or indirectly planted out on the site). In most cases (poplar plantation) severely selected and highly superior genetic material, sometimes absolutely identical from a genetical point of view (clones) is used.

Index	Forest Type	Regeneration	Characteristics	Evolution
3.2.	Enriched intermediary forest		AR + NR outside of normal regeneration period	
3.3.	Revalorized intermediary forest		Rebuilding after degradation by AR; NR used	
4.	Artificial forest	AR	EF made exclusively by AR following destruction preceding forest	→ CC and new AF → Naturalized forest
4.1.	Transformation		AR immediately after partial CC or before complete CC of whole stand	
4.1.1.	Direct transformation		AR immediately after partial CC → horizontal pattern of mixture	→ disappearance of mixture
4.1.2.	Indirect transformation		AR before complete CC of whole stand → vertical pattern of mixture	
4.2.	Renewal		AR within 5 years after CC	
4.3.	Reforestation		AR between 5 and 50 years after CC	
4.4.	Afforestation		AR more than 50 years after CC or stand destruction	
5.	Naturalized forest	MINR	NR of artificial forest (EF)	
5.1.	Naturalized forest with introduced species		Second NR of exotics	
5.2.	Naturalized forest with autochthonous species		First NR of autochthonous species	→ semi-natural forest → intermediary forest
6.	Marginal types			
6.1.	Forest with permanently incomplete cover		Forest in struggle zone	→ stabilization
6.2.	Bush forest		Low growing species under critical growing conditions	→ transformation → intermediary forest
6.3.	Forest with vegetative regeneration	VR	Mostly EF	
6.3.1.	Plantation		High growing trees planted at regular space intervals. Plant material originating from cuttings	CC
6.3.2.	Coppice	VR	Low growing bushes	
6.3.3.	Coppice and standards	VR+AR+NR	Combination of regeneration types. Mixture of high growing trees with low growing bushes	→ semi-natural forest
6.4.	Multiple-use forest		Different forms of use of forest Timber production secondary	
6.5.	Rows		Single or multiple rows without ecological independence Several objectives possible	

Abbreviations

A	average age of mature dominant trees	NR	natural regeneration
AR	artificial regeneration	SF	secondary forest
CC	clearcutting	SR	spontaneous regeneration
EF	economic forest (timber production)	V	stand volume in age of economic or maximal production
MAR	man-assisted natural regeneration	VR	vegetative regeneration
MIR	man-induced natural regeneration		

Index	Forest Type	Regeneration	Characteristics	Evolution
1.	Natural forest	NR SR	No treatment and no management Autochthonous species	Stabilized
1.1.	Virgin forest		No trace of human intervention	
1.2.	Pseudo virgin forest		Accidental human intervention Maximal reduction with 10 % by single intervention; 25 % over period corresponding with A	
2.	Semi-natural forest	NR	Autochthonous species Reduction of: 10 to 25 % by single intervention; more than 25 % over period corresponding with A	
2.1.	Unmanaged semi-natural	SR	No management, no organized use, no treatment	
2.1.1.	Undegraded semi-natural		Most species still present	→ pseudo-virgin forest → EF (put under management)
2.1.2.	Degraded semi-natural forest		V reduced with at least 40 % Modification of structure and pattern of mixture	
2.1.2.1.	Semi-natural forest with irreversible degradation		Impossible to reconstruct original or equivalent situation Loss of bio-ecological stability	→ complete breakdown → secondary forest with less tolerant species (SR) → EF → transformation (AR)-EF
2.1.2.2.	Semi-natural forest with reversible degradation		Equilibrium not completely broken Reversal of situation possible if abundant SR	→ pseudo-virgin forest → semi-natural forest under management
2.2.	Semi-natural forest under management	SR MANR	Management and regular use → EF	
2.2.1.	Stabilized semi-natural forest		Permanent character given to attained evolution stage	→ SF
2.2.2.	Reconstructed semi-natural forest		Reversal of degradation toward higher level of evolution (sub-climax, climax or para-climax)	→ intermediary forest (by AR)
2.2.3.	Modified semi-natural forest		New pattern and degree of mixture without elimination of species	
2.2.4.	Reduced semi-natural forest		Reduction number of species	
3.	Intermediary forest	AR + NR (SR or MANR)	EF with less than 50 % of V composed by AR autochthonous species or by 25 % AR exotics	→ mixed stands
3.1.	Intermediary forest with fusionated regeneration		AR + NR at same spot either simultaneously or consecutively but during same regeneration period	

High production, absence of silvicultural treatment, wide spacing, short rotation, clearcutting and rationalized management belong to the principal characteristics of the plantation.

6.3.2. *The coppice forest*

Low-growing forest, comparable to the bush forest as regards its physiomy, originated by vegetative reproduction on stools.

The original material was planted or arose from natural regeneration. Treatment can be very intensive if a good market for timber of low dimensions exists.

The coppice forest can be highly productive and by its conversion into a forest with high growing trees, the ensuing evolution may permit to obtain an intermediary forest or even a semi-natural forest.

6.3.3. *The forest with coppice and standards*

Forest composed out of coppice elements and high growing trees, in different combinations, but always intimately intermixed.

Vegetative regeneration is the rule for the coppice elements, but the standards arise from artificial or natural (generative) regeneration and from letting grow up coppice elements as well.

The forest with coppice and standards can be highly productive and the object of intensive silvicultural treatment.

Under favourable conditions it may even evolve toward a semi-natural forest or to an intermediary forest by way of transformation.

6.4. The multiple-use forest

Forests put to different kinds of uses (recreation, grazing, collection of secondary products, etc.) in which timber production is secondary, neglectable or not even considered.

The direct and indirect economic value of such a forest can be important. Its social function is considered essential.

6.5. Hedge rows

Single or multiple rows of trees (road side planting, shelterbelts etc.), that do not build up a stabilized and independent ecological entity.

Their physical presence is of great importance and meets a particular need. The timber they produce can be valuable and of a certain importance in less forested countries.

4. Conclusions

The proposed classification of forests tries to establish a systematic order, based partly on morphological aspects of the forest stand, but principally on the degree and the characteristics of human interference as expressed by use, treatment and the aims of management. Its application belongs essentially to the domain of forest policy. The number of types it covers is not to be considered limitative: practical use of the classification will give the opportunity to find out its weaker points and eventually lead to necessary modifications.

It can be used simultaneously with other classifications based on floristic, ecological, phytosociological and phytogeographical characteristics. Neither is it intended as a substitute for usual stand description, needed for planning management and silvicultural treatment, because it does not take into consideration the particularities of the local situation.

ZUSAMMENFASSUNG

Eine Waldklassifikation auf Basis von Betriebsführung und Behandlung

Eine Waldklassifikation wird vorgeschlagen, die von 6 Grundtypen ausgeht:

1. Der Naturwald
2. Der Semi-Naturwald
3. Der Intermediärwald (Zwischenwald)
4. Der Kunstwald
5. Der naturalisierte Wald
6. Die marginalen Waldformen

In der vorgeschlagenen Klassifikation wird versucht eine systematische Ordnung auszuarbeiten, teilweise ausgehend von morphologischen Bestandesmerkmalen, aber vor Allem von Art und Grad der menschlichen Beeinflussung wie diese durch Benutzung, Behandlung und Betriebsführung zum Ausdruck gelangt. Sie gehört daher wesentlich zum Gebiet der Forstpolitik.

Die Anzahl der aufgeführten Waldtypen ist nicht als endgültig zu betrachten: Die praktische Anwendung der vorliegenden Klassifikation wird möglicherweise zu notwendigen Modifikationen führen.

Sie kann ausserdem gleichzeitig mit andern Klassifikationen die von floristischen, oekologischen, pflanzensoziologischen oder pflanzengeographischen Merkmalen ausgehen, verwendet werden. Sie ist auch nicht zu betrachten als einen Ersatz für die übliche Wald- und Bestandesbeschreibung, wie diese zwecks waldbaulicher Planung und Forsteinrichtung gemacht wird, indem sie den örtlichen Spezialeigenschaften des Waldbestandes keine Rechnung trägt.

RÉSUMÉ

Classification des forêts basée sur l'aménagement et le traitement

Une classification des forêts est élaborée acceptant 6 types principaux :

1. La forêt naturelle
2. La forêt semi-naturelle
3. La forêt intermédiaire
4. La forêt artificielle
5. La forêt naturalisée
6. Les formes marginales

Elle se propose d'établir un ordre systématique se basant partiellement sur l'aspect morphologique du peuplement forestier, mais surtout sur le caractère et le degré de l'interférence humaine telle que celle-ci se manifeste par l'emploi, le traitement et l'aménagement de la forêt. Son application réside donc essentiellement dans le domaine de la politique forestière.

Le nombre de types qu'elle conçoit n'est pas limitatif; L'application et la critique raisonnée de la classification entraîneront les modifications nécessaires.

Elle se prête d'ailleurs à l'emploi simultané avec d'autres classifications, basées sur des caractéristiques floristiques, écologiques, phytosociologiques ou phytogéographiques des peuplements forestiers.

Elle n'est pas destinée à remplacer la description usuelle des peuplements, telle qu'elle est conçue comme point de départ du traitement sylvicole et de l'aménagement des forêts, puisqu'elle ne tient pas compte des particularités locales des peuplements.

SAMENVATTING

Bosklassifikatie gebaseerd op bedrijfsvoering en behandeling

Een bosklassifikatie werd uitgewerkt, waarbij 6 basistypen worden aangenomen :

1. Het natuurlijk bos
2. Het semi-natuurlijk bos
3. Het intermediair bos (overgangsbos)
4. Het kunstmatig bos
5. Het genaturaliseerd bos
6. De marginale bosvormen

Deze klassifikatie stelt zich tot doel een systematische orde tot stand te brengen, die uitgaat van de bestandsmorphologie, maar vooral van aard en graad van menselijke beïnvloeding, zoals deze tot uiting komen door bosgebruik, bosbehandeling en bosbedrijfsvoering. Haar toepassing behoort derhalve in de eerste plaats tot het gebied van de bospolitiek.

Het aantal opgenomen bosstypes is niet als een beperking te beschouwen. De toepassing van de klassifikatie en een beredeneerde kritiek van de moeilijkheden, die zij kan opleveren, kunnen het uitgangspunt worden van latere aanpassingen.

Uiteraard kan deze klassifikatie tegelijkertijd toegepast worden met andere klassifikatiesystemen, die uitgaan van de floristische, ecologische, phytosociologische of phytogeografische kenmerken van de bosbestanden.

Zij is ook niet ontworpen tot vervanging van de gebruikelijke bestandsbeschrijving, die wordt aangewend als uitgangspunt voor bosbehandeling en bosbedrijfsvoering, omdat zij geen rekening houdt met de specifieke kenmerken van een gegeven lokale toestand.