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Indicators for forest Biodiversity in Europe

DEVELOPING BIODIVERSITY ASSESSMENT ON A STAND FOREST TYPE MANAGEMENT LEVEL IN NORTH-EASTERN ITALY[1]

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Abstract. This paper discusses a simple operative proposal, elaborated by a team of advisers to the Forestry Service of the Veneto administrative region (north-eastern Italy), concerning the definition of stand-level forest type biodiversity indicators and biodiversity oriented management provisions. Such tools are conceived to transfer biodiversity conservation understanding in current forest stand management practices. The developed assessment system is targeted to: maintenance and increase of the variability of forest landscape mosaic; conservation of species variability; creation of resource reservoirs. The following criteria and indicators are taken into consideration: spatial pattern (widespreadness, connectedness, species contagion potential), forest structure (uneven aged stands: percent of trees in three broad diameter classes; even aged stands: number of development stages and surface of each development stage), herbs/shrubs species (average, minimum and maximum number of species; average number of short-lived herb/shrub species recorded in minimal anthropic disturbance conditions; dynamic trend in the number of herb/shrub species), bird species (average, minimum and maximum number of species); overall naturalistic quality (flora; vegetation; fauna). Such indicators are proposed as biodiversity reference standards for each forest type in the considered region: they provide practical baseline information with which forest stand management efficiency in achieving biodiversity targets can be compared.

[1] *The work, coordinated by prof. R. Del Favero, was carried out with equal contributions by the Authors.*

Introduction

In the last decades, biodiversity issues have been receiving increased attention in Europe (see Larsson, 1998). In particular with regard to forests, concerns are being expressed about habitat fragmentation and about the loss of species and ecotypes due to the cumulative impact of human activities. Forest management is directly involved in these problems, because of its effects on forest biodiversity at the landscape and stand scales. It is, consequently, necessary to set up an efficient way of collecting information on the type of biodiversity that is to be maintained, or enhanced, to implement forest biodiversity conservation measures in the framework of forest planning.

A viable solution may be to adopt a "habitat" approach, linking biodiversity assessment to forest types definition and description at a stand scale. The concept of stand-level forest typology (*sensu* Del Favero, 1992) embraces all those forest classification and nomenclature systems, that - on the basis of different disciplines- allow a hierarchical assessment of forest stands by a synoptic evaluation of either vegetation aspects (both floristic and phytosociological) and of ecological-silvicultural ones. The scale of the assessed units (i.e., the stand-level forest types) is relative to the scale of forest resources management. As a matter of fact, stand-level forest types have a straight operational meaning, each type being provided with distinctive silvicultural prescriptions. Such a kind of forest classification scheme benefits a more practical implementation, when compared with those based on a phytosociological approach or designed for land cover mapping.

A forest typology, by defining meaningful assemblages of structural and compositional diversity, can be assumed as the basis for delineating relevant biodiversity units among the forest landscape. Such an approach can help to effectively incorporate biodiversity conservation/enhancement issues within a practical forest planning and management context, the forest type scheme being suitable to join mapping and ground evaluation efficiency with forest planning/management/sylvicultural requirements and constraints. In Italy, valuable examples of forest typologies can be found in many administrative Regions (e.g. the Veneto, Friuli-Venezia Giulia, Toscana, Piemonte, Valle d'Aosta, Marche, Abruzzo).

In this perspective, the paper discusses basic issues for a biodiversity-oriented forest type management at a stand level. It concerns, distinctively, the definition of practical stand forest type biodiversity criteria and indicators and reference biodiversity standards for forest management. The set of criteria and indicators was conceived as an operative proposal elaborated by a team of advisers of the Regional Forestry Service of the Veneto region (north-eastern Italy); a list of stand forest types of the defined region, is documented in Table 1.

1. Operative framework

Three strategic management goals are taken as reference: maintenance and increase of the variability of forest landscape mosaic; conservation of species variability; creation of resource reservoirs.

Such a biodiversity management approach aims to operatively merge the concept of biodiversity conservation with that of natural resources sustainability (Schuetz, 1997). The definition of the kind of forest biodiversity has to be conserved and how to measure it is based mainly on those biodiversity aspects critical for the above-mentioned strategic objectives and directly influenced by the effects of forest management. The definition of the indicators is mainly based on structural and compositional key-factors (see also Hansson, 1998). Indicators based only on data currently available to the forest field managers, or adequately and promptly assessable by field expert judgement, are considered.

2. forest landscape Spatial pattern

It has become largely recognised that the structural diversity of the forest landscape has important effects on ecological functionality of a given geographical area. A variety of forest types provides a wide range of habitats for wildlife, plants and fungi. However, disturbance regimes (human and natural) acting on forest landscape and stand levels over a range of spatio-temporal domains, affect not only their own structure, but also their composition and related ecological processes. In order to implement a successful biodiversity conservation strategy, it is therefore necessary to work on a long term/landscape perspective, dealing with the protection of forest patches and fragments (source/sink areas), the preservation of their connectedness (hedgerows, woodlots, rivers) and the conservation/restoring of ecotones (Corona, 1993).

Monitoring forest landscape structure plays a fundamental role in evidencing the causal factors of biodiversity loss like forest fragmentation, degradation and elimination of habitats (Dunsworth and Northway, 1998). The underlying assumption is that landscape structure metrics can be thought of as predictor of the presence and potential of other components of forest biodiversity (e.g., macrofauna community). Metrics like density, size, shape and dispersion of forest patches can be used to calculate spatial indexes, useful to highlight critical points for biodiversity conservation strategies. Hereafter, two meaningful spatial indexes and an index of dynamical stability are proposed. Their use is to be intended in translating spatial patterns in terms of consequences for forest management at a landscape scale. Forest stand types have been assumed as the basis for distinguishing biodiversity relevant forest patches at this scale.

Table 1. List of forest types in the Veneto region (north-eastern Italy). Denominations of the forest types are expressed in Italian. Natura 2000 habitat classes refer to EU Habitat Directive 43/92. For details on European Information System on Nature, see PINBORG (1998).

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Arbusteto costiero	Fragments of Quercion ilicis Br.-Bl. (1931) 1936	9340	G2.1/P-45.31
Lecceta	Fragments of Quercion ilicis Br.-Bl. (1931) 1936	9340	G2.1/P-45.31
Bosco costiero dei suoli idrici	Fragments of different associations of Alnetalia glutinosae Tx. 1937 and Populetalia albae Br.-Bl. 1930	92A0	G1.5/P-44.6
Pseudomacchia	Cystus salvifolius stage of Quercus sp. woods with mediterranean elements.	-	F2.7/P-32.72 (?)
Querceto con elementi mediterranei	Quercus pubescens-Arbutus unedo prov. Phytocoenon	-	G1.8/P41.5
Querco-carpineto planiziale	Asparago-Quercetum roboris (Lausi 1966) Marincek 1994 (= Querceto-Carpinetum boreo-italicum Pignatti 1953 ex Lausi 1966)	p.p. 91F0	G1.4/P-44.4
Querco-carpineto collinare	p.p.Carici umbrosae-Quercetum petraeae (Poldini) ex Marincek 1994, Quercus robur var. of violetosum hirtae (Poldini 1982) ex Marincek 1994 subass.	9160	G1.8/P-41.2A
Carpineto tipico	Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 1983, subass. caricetosum pilosae Marincek, Poldini et Zupancic 1983	91G0	G1.8/P-41.2A
Carpineto con frassino	p.p. Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 1983, caricetosum pilosae subass., humid var. (e.g. Quercus robur var.) Marincek, Poldini et Zupancic 1983; p.p. Hacquetio epipactido-Fraxinetum excelsioris Marincek 1990 ex Poldini et Nardini 1993	91G0-9180	G1.8/P-41.2A
Carpineto con ostria	Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 1983, ostryetosum subass. Marincek, Poldini et Zupancic 1983	91G0	G1.H/P-41.81
Carpineto con cerro	p.p. Carici umbrosae-Quercetum petraeae (Poldini 1982) ex Marincek 1994, quercetosum cerris subass.	91G0	G1.8/P-41.2A
Rovereto tipico	Carici umbrosae-Quercetum petraeae (Poldini 1982) ex Marincek 1994	9170	G1.8/P-41.26
Rovereto dei substrati magmatici	-	9190	G1.8/P-41.5
Rovereto con tiglio	Carici umbrosae-Quercetum petraeae (Poldini 1982) ex Marincek 1994, tilietosum cordatae subass. Poldini prov. in sched.	9170	G1.8/P-41.26
Castagneto dei suoli xerici	p.p. Carici umbrosae-Quercetum petraeae (Poldini 1982) ex Marinek 1994, Quercetosum petraeae subass. (Poldini 1982) ex Marinek 1994; p.p. Buglossoido purpurocaeruleae-Ostryetum carpinifoliae Gerdol, Lausi, Piccoli et Poldini 1982	9260	G1.B/P-41.9
Castagneto dei suoli mesici	p.p. Ornithogalo pyrenaici-Carpinetum betuli Marinek, Poldini et Zupani 1983, Caricetosum pilosae subass.Marincek, Poldini et Zupani 1983	9260	G1.B/P-41.9

Table 1. Cont.

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Castagneto dei suoli acidi	Melampyro vulgati-Quercetum petraeae Puner et Zupani 1979, vaccinietosum myrtilli subass. Puner et Zupani 1979	9260-p.p. 9190	G1.B/P-41.9
Castagneto dei substrati magmatici	Melampyro vulgati-Quercetum petraeae Puncer et Zupancic 1979, vaccinietosum myrtilli subass.Puncer et Zupancic 1979	9260	G1.B/P-41.9
Castagneto con frassino	p.p. Hacquetio epipactido-Fraxinetum excelsioris Marincek 1990 ex Poldini et Nardini 1993 var. geogr. Anemone trifolia Poldini et Nardini 1993 (= Carpino betuli-Fraxinetum excelsioris Poldini 1982 non Duvigneaud 1969 cerastietosum sylvaticae Poldini 1982)	9260	G1.A/P-41.39
Orno-ostrieto primitivo di forra	Hemerocallido lilioasphodelo-Ostryetum carpinifoliae Poldini 1982	-	G1.H/P-41.81
Orno-ostrieto primitivo di rupe	Cytisantho radiatae-Ostryetum carpinifoliae Wraber 1960	-	G1.H/P-41.81
Orno-ostrieto primitivo di falda detritica	Seslerio albicantis-Ostryetum carpinifoliae Lausi et al. 1982 corr. Poldini et Vidali 1995 (= Seslerio variae-Ostryetum carpinifoliae Lausi et al. 1982, Art.43)	-	G1.H/P-41.81
Orno-ostrieto tipico	Seslerio albicantis-Ostryetum carpinifoliae Lausi et al. 1982 corr. Poldini et Vidali 1995 (= Seslerio variae-Ostryetum carpinifoliae Lausi et al. 1982, Art.43)	-	G1.H/P-41.81
Orno-ostrieto con carpino bianco	p.p. Seslerio albicantis-Ostryetum Lausi et al. 1982 corr. Poldini et Vidali 1995 (= Seslerio variae-Ostryetum carpinifoliae Lausi et al. 1982, Art.43), carpinetosum betuli subass. Poldini et Lasen 89 ex sched.; p.p. Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 1983, ostryetosum subass.Marincek, Poldini, Zupancic 1983	-	G1.H/P-41.81
Orno-ostrieto con tiglio	p.p. Seslerio variae-Ostryetum Lausi et al. 82 em. Poldini 88, tilietosum subass. prov. in sched.; p.p. Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 83, tilietosum subass. in sched.	-	G1.H/P-41.81
Orno-ostrieto con leccio	Seslerio albicantis-Ostryetum carpinifoliae Lausi et al. 1982 corr. Poldini et Vidali 1995 (= Seslerio variae-Ostryetum carpinifoliae Lausi et al. 1982, Art.43), quercetosum ilicis subass. Lasen et Poldini 1989 (= Quercetum ilicis H. Mayer 1969 non Br.-Bl. 1915), (= Celtidi australis-Quercetum ilicis Pedrotti 1992)	9340	G1.H/P-41.81
Ostrio-querceto tipico	Buglossoido purpurocaeruleae-Ostryetum carpinifoliae Gerdol, Lausi, Piccoli et Poldini 1982	91H0	G1.H/P-41.81
Ostrio-querceto a scotano	Buglossoido purpurocaerulae-Ostryetum carpinifoliae Gerdol et al. 1982, Cotynus coggygria subass., Lessini-Berici-Veronese race.	-	G1.H/P-41.81

Table 1. Cont.

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Aceri-tiglieto tipico	Ornithogalo pyrenaici-Carpinetum betuli Marincek, Poldini et Zupancic 1983, fraxinetosum excelsioris subass. Poldini in sched. var. Tilia	9180	G1.A/P-41.39
Aceri-tiglieto di versante	Ornithogalo pyrenaici-Carpinetum betuli Marinek, Poldini et Zupani 1983, Tilietosum platyphylli subass. prov. in sched.	9180	G1.A/P-41.39
Aceri-frassineto tipico	Hacquetio epipactido-Fraxinetum excelsioris Marinek 1990 ex Poldini et Nardini 1993 var. geogr. Anemone trifolia Poldini et Nardini 1993 (= Carpino betuli-Fraxinetum excelsioris Poldini 1982 non Duvigneaud	9180	G1.A/P-41.39
Aceri-frassineto con ostria	Hacquetio epipactido-Fraxinetum excelsioris Marinek 1990 ex Poldini et Nardini 1993 var. geogr. Anemone trifolia Poldini et Nardini 1993 (= Carpino betuli-Fraxinetum excelsioris Poldini 1982 non Duvigneaud	9180	G1.A/P-41.39
Aceri-frassineto con ontano bianco	p.p. Hacquetio epipactido-Fraxinetum excelsioris Marinek 1990 ex Poldini et Nardini 1993 var. geogr. Anemone trifolia Poldini et Nardini 1993 (= Carpino betuli-Fraxinetum excelsioris Poldini 1982 non Duvigneaud 1969 cerastietosum sylvaticae Poldini 1982)	9180	G1.A/P-41.39
Faggeta primitiva di rupe	Pinus mugo-Rhododendron hirsutum-Fagus phytocoenon Lasen et Poldini in sched.	-	G1.7/P-41.16
Faggeta primitiva di falda detritica	Pinus mugo-Rhododendron hirsutum-Fagus phytocoenon Lasen et Poldini in sched.	-	G1.7/P-41.16
Faggeta submontana dei suoli mesici	p.p. Hacquetio epipactido-Fagetum sylvaticae Kosir 1962, var. geogr. Anemone trifolia Kosir 1979, Luzula nivea subvar. geogr. Poldini et Nardini 1993	9150	G1.7/P-41.13
Faggeta submontana tipica	p.p. Hacquetio epipactido-Fagetum sylvaticae Kosir 1962, var. geogr. Anemone trifolia Kosir 1979, Luzula nivea subvar. geogr. Poldini et Nardini 1993	9150	G1.7/P-41.16
Faggeta submontana con ostria	Ostryo carpinifoliae-Fagetum sylvaticae Wraber 1966 ex Trinajstic 1972 var. geogr. Anemone trifolia Poldini 1982, Luzula nivea subvar. Dakskobler 1991	9150	G1.H/P-41.81
Faggeta submontana dei suoli acidi	Luzulo albidae-Fagetum sylvaticae Meus. 1937 var. geogr. Anemone trifolia Zukrigl 1989	9110	G1.7/P-41.11
Faggeta montana dei suoli xerici	Anemono trifoliae-Fagetum sylvaticae Tregubov 1962 var. geogr. Luzula nivea Marincek, Poldini et Zupancic 1989	9150	G1.7/P-41.16
Faggeta montana tipica esalpica	Dentario pentaphylli-Fagetum sylvaticae H. Mayer et Hofmann 1969, fagetosum subass. Poldini et Nardini 1993	9130	G1.7/P-41.13
Faggeta montana tipica esomesalpica	p.p. Dentario pentaphylli-Fagetum sylvaticae H. Mayer et Hofmann 1969	9130	G1.7/P-41.13
Faggeta montana tipica mesalpica	p.p. Dentario pentaphylli-Fagetum sylvaticae H. Mayer et Hofmann 1969	9130	G1.7/P-41.13

Table 1. Cont.

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Faggeta altimontana tipica	Dentario pentaphylli-Fagetum sylvaticae H. Mayer et Hofmann 1969, fagetosum subass.Poldini et Nardini 1993, altitudinal life form.	9130	G1.7/P-41.15
Faggeta altimontana dei suoli acidi carbonatici	Phytocoenon Rhododendron ferrugineum-Fagus prov.	9130	G1.7/P-41.15
Betuleto	-	-	-
Corileto	Phytocoenon Galanthus-Corylus Poldini 1989 (= Galantho-Coryletum Poldini 1980); Corylus e Daphne mezereum phytocoenon Poldini et Vidali 1995	-	-
Mugheta macroterma	Amelanchiero ovalis-Pinetum mughi Minghetti in Pedrotti 1994 (Orno-Pinetum mughi Martin-Bosse 1967 subass. pinetosum mughi Poldini 1982)	4060	F1.2/P-31.52
Mugheta mesoterma	Erico carneae-Pinetum prostratae Zöttl 1951 nom. Inv.	4060	F1.2/P-31.52
Mugheta microterma dei suoli basici	Rhodothamno-Rhododendretum hirsuti (Aich. 1933) Br.-Bl. et Siss. in Br.-Bl. et al. 1939	4070	F1.2/P-31.51
Mugheta microterma dei suoli acidi carbonatici	p.p. Rhododendro ferruginei-Pinetum prostratae Zöttl 1951 nom. inv.	4060	F1.2/P-31.51
Mugheta a sfagni	Pinetum rotundatae Kästner et Flößner 1933 corr. Mucina 1993	4060	F1.2/P-31.51
Pineta di pino silvestre primitiva di rupe	Erico carneae-Pinetum sylvestris Br.-Bl. in Br.-Bl. et al. 1939 nom. Inv. var. Arctostaphylos uva-ursi	-	G4.4
Pineta di pino silvestre primitiva di falda detritica	Erico carneae-Pinetum sylvestris Br.-Bl. in Br.-Bl. et al. 1939 nom. Inv. var. Arctostaphylos uva-ursi	-	-
Pineta di pino silvestre esalpica tipica	Fraxino orni-Pinetum nigrae Martin-Bosse 1967 pinetosum sylvestris subass. Lasen et Poldini 1989	9531	G3.6/P-42.61
Pineta di pino silvestre esalpica con pino nero	Fraxino orni-Pinetum nigrae Martin-Bosse 1967 pinetosum sylvestris subass. Lasen et Poldini 1989	9531	G3.6/P-42.61
Pineta di pino silvestre esalpica con faggio	p.p. Anemono trifoliae-Fagetum sylvaticae Tregubov 1962 var. geog. Anemone trifolia Marincek et al. 1989	9531	G3.6/P-42.61
Pineta di pino silvestre mesalpica tipica	Erico carneae-Pinetum sylvestris Br.-Bl. in Br.-Bl. et al. 1939 nom. inv.	-	G3.6/P-42.61
Pineta di pino silvestre mesalpica con abete rosso	p.p. Anemono trifoliae-Fagetum sylvaticae Tregubov 1962 var. geog. Luzula nivea Marincek et al. 1989	9422	G3.2/P-42.22
Pineta di pino silvestre endalpica	Erico carneae-Pinetum sylvestris Br.-Bl. in Br.-Bl. et al. 1939 nom. inv.	9422	G3.3/P-42.32
Piceo-faggeto dei suoli xerici	Anemono trifoliae-Fagetum sylvaticae Tregubov 1962 var. geog. Luzula nivea Marincek et al. 1989, caricetosum albae subass. Marincek et al. 1989	9150	G1.7/P-41.16
Piceo-faggeto dei suoli mesici	Anemono trifoliae-Fagetum Tregubov 1962 var. geog. Luzula nivea Marincek et al. 1989	9130	G1.7/P-41.13

Table 1. Cont.

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Abieteto esalpico submontano	p.p. Adenostylo glabrae-Abietetum albae H. Mayer et Hofmann 1969 em. Gafta 1994, subass. phyllitietosum H. Mayer et Hofmann 1969; p.p. Ulmo glabrae-Abietetum albae Poldini et Lasen ex schedis	-	-
Abieteto esalpico montano	Dentario pentaphylli-Fagetum sylvaticae H. Mayer et Hofmann 1969 var. with Abies alba	9130	G1.7/P-41.13
Abieteto dei substrati silicatici	Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (=Luzulo-Abietetum Oberd. 1957)	9411	G3.1/P-42.13
Abieteto dei suoli mesici tipico	Cardamino pentaphylli-Abietetum albae H. Mayer 1974 nom. mut. Em. Gafta 1994	9411	G3.1/P-42.13
Abieteto dei suoli mesici con faggio	Cardamino pentaphylli-Abietetum albae H. Mayer 1974 nom. mut. Em. Gafta 1994	9130	G3.1/P-42.13
Abieteto dei substrati carbonatici	Adenostylo glabrae-Abietetum albae H. Mayer et Hofmann 1969 em. Gafta 1994	9130	G3.1/P-42.12
Pecceta dei substrati carbonatici altimontana	Adenostylo glabrae-Piceetum abietetis M. Wraber 1966 ex Zukrigl 1973	9411	G3.2/P-42.21
Pecceta dei substrati carbonatici subalpina	Larici-Piceetum abietetis (Br.-Bl. et al. 1954) Ellenberg et Klötzli 1972 (= Homogyno-Piceetum Zukrigl 1973)	9411	G3.2/P-42.21
Pecceta dei substrati silicatici dei suoli mesici altimontana	Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (= p.p. Homogyno-Piceetum, Luzuletosum albidae subass. Zukrigl 1973).	9411	G3.2/P-42.21
Pecceta dei substrati silicatici dei suoli mesici subalpina	Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (= p.p. Homogyno-Piceetum, Luzuletosum albidae subass. Zukrigl 1973).	9411	G3.2/P-42.21
Pecceta dei substrati silicatici dei suoli mesici a megaforbie	Adenostylo alliariae-Abietetum albae Kuoch 1954 (= Adenostylo alliariae-Piceetum Hartm. 1942)	9411	G3.2/P-42.21
Pecceta dei substrati silicatici dei suoli xerici montana	p.p. Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (= p.p. Homogyno-Piceetum, subass. Luzuletosum albidae Zukrigl 1973).	9411-9412	G3.2/P-42.22
Pecceta dei substrati silicatici dei suoli xerici altimontana	p.p. Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (= p.p. Homogyno-Piceetum, subass. Luzuletosum albidae Zukrigl 1973).	9411-9412	G3.2/P-42.22
Pecceta dei substrati silicatici dei suoli xerici subalpina	p.p. Luzulo nemorosae-Piceetum abietetis (Schmid et Gaisberg 1936) Br.-Bl. et Siss. in Br.-Bl. et al. 1939 (= p.p. Homogyno-Piceetum, subass. Luzuletosum albidae Zukrigl 1973).	9411-9412	G3.2/P-42.22
Pecceta con frassino e/o acero	-	-	-
Pecceta secondaria montana	Carex alba-Picea phytocoenon	9412	G3.3/P-42.34
Pecceta secondaria altimontana	Aposeris foetida-Picea phytocoenon	9411	G3.3/P-42.34

Table 1. Cont.

Forest type	*(Reference phytosociological associations) Syntaxonomy**	*Reference Natura 2000 habitat*	*ReferenceEunis habitats (level 4/5) and Corine Palearctic equivalent*
Lariceto primitivo	Rhodothamno chamaecisti-Laricetum H. 1984 Mayer	-	G4.4
Lariceto tipico	Asplenio viridis-Laricetum H. Mayer 1984	9421-9422	G3.3/P-42.34
Lariceto in successione con pecceta	-	9411	G3.3/P-42.34
Larici-cembreto tipico	Calamagrostio villosae-Pinetum cembrae Filipello, Sartori et Vittadini 1981, Seslerietosum albicans subass., Filipello, Sartori et Vitadini 1981	9422	G3.3/P-42.32
Larici-cembreto con abete rosso	p.p. Calamagrostio villosae-Pinetum cembrae Filipello, Sartori et Vittadini 1981, Piceetosum subass. Filipello, Sartori et Vitadini 1981	9422	G3.3/P-42.32
Larici-cembreto con ontano verde	Calamagrostio villosae-Pinetum cembrae Filipello, Sartori et Vittadini 1981, alnetosum viridis subass. Filipello, Sartori et Vitadini 1981	9422-9421	G3.3/P-42.32
Alneta di ontano verde	Alnetum viridis Br.-Bl. 1918	-	-
Alneta extraripariale di ontano bianco	p.p. Aceri-Fraxinetum s.l.	9180	G1.1/P-44.21
Alneta extraripariale di ontano nero	p.p. Aceri-Fraxinetum s.l.	9180	G1.1/P-44.21
Robinieto puro	-	-	G1.J/P-83.324
Robinieto misto	-	-	G1.J/P-83.324

* abbreviations: subass. = subassociation; var. (geog.) = (geographic) variant; prov. = provenance

The first spatial index is a simple ordinal measure of the diffusion of the type over the landscape mosaic. At the defined regional scale, the *widespreadness* of a type is ranked into three categories: rare (overall area less than 100 ha); average diffusion (overall area between 100 and 1000 ha); high diffusion (overall area over 1000 ha). Such an information is useful, for instance, to readily assess the overall habitat area of a forest specialist, or for a regional report on the occurence of Natura 2000 habitats in and outside the pSIC (Proposed Sites of Communitaire Interest, according to the Habitat Directive, Dir. 43/92/EU).

The effects of forest landscape changes on forest species can be evidenced by fragmentation analysis. Fragmentation is a scale dependent process, meaning that a forest landscape can be classified as homogeneous at one scale and fragmented at another (see WIENS, 1994). Such a phenomenon implies important consequences for forest management because of the differently affected ecological processes (hydrological cycle, habitat dispersion, etc.). Moreover, the same landscape is perceived "fragmented" in different ways by different habitat dependency groups: the size of fragments to which most species of insects, mammals and birds are sensitive is 1, 10, 100 ha (FARINA, 1998). Table 2 shows a scheme to classify landscape fragmentation and to evidence its effects on species dynamics. A distinctive aspect one should investigate to tackle forest fragmentation problems is the degree to which forest types are aggregated or interconnected. *Connectedness* is the degree of physical connection between forest patches, which assures greater probability of survival to forest types dependant population; forest types connectedness can be therefore "measured" on available forest maps by easy GIS operations. It can be otherwise assessed by expert judgement using three ordinal classes: connected forest type, partially connected forest type, not connected forest type.

A suitable indicator of forest type stability can be derived from the ecological attitudes of its main tree species. Such a property, expressed by the concept of *tree species contagion potential* (Figure 1), can be evaluated on the basis of the synecological and autoecological characteristics of the main tree species of the forest type. Three broad ordinal classes can be assumed: high, average and low contagion potential, when, respectively, more than one, only one or none of the main tree species of the considered type tend(s) to actively spread into the neighbouring forest types.

Table 2. Effects of different fragmentation scales on habitat dispersion and organism involved (from LORD and NORTON, 1990)

PATCH FRAGMENTS	*FRAGMENTATION*	
	Geographical	Structural
Size (m^2)	Large>1000	Small<10
Isolation	Usually medium to large	Usually small
Boundary gradient	Steep	Shallow
Impact of exstrinsic disturbance	Confined to edge and up to a few hundred meters	Throughout
Vulnerability to functional disruption	Medium to small	Medium to large
Scale of organism affected	Large generalist to medium specialist	Medium specialist to small specialist
Advantages for conservation	Usually has intact interior	Usually greater total extent

3. FOREST STAND STRUCTURE

Sylviculture can significantly influence the structural and compositional features of forest biodiversity. The choice of a sylvicultural system implies always a trade-off between biodiversity conservation issues and economic objectives. This kind of conflict can be addressed by large scale forest management optimisation models (SOLBERG, 1998). Such models may, for instance, determine an "optimal" diameter distribution, which maximises some economic indicators (physical stocking, growth, economic quantity) and ensures a forest diversity, at least as great as a standard target condition (GOVE, 1998). The present proposal does not discuss a specific forest harvesting model; the aim is rather to point out some practical provisions of the forest management working plans, which focus on the building of certain structural diversity conditions. For this purpose, the diameter class/age diversity in/between forest stands is of primary interest. Yet such a factor is one of the many when considering forest structural diversity, other stand level diversity indicators (e.g., foliage height diversity) may be strictly dependent upon it. The question here addressed has a mostly management-oriented formulation: is it possible to define an optimal diameter class/age distribution for a particular forest type? At which spatial scale can such a structural equilibrium be feasibly realised? Some practical solutions have been delineated for the high stands.

3.1. Uneven-aged stands

Theoretically, when quantifying in a hectare the diameter distribution of an uneven-aged stand we expect diversity in the frequency of diameter class distribution. In reality, a multi-layered structure "tree by tree" is very rare: more frequently a diameter class tends to prevail at a stand level. Whatever the "assumed" optimal diameter distribution model is, it is necessary to seek its realisation in a fairly large area. Field experience suggests that, in the considered region, such an area may be roughly fixed at 10 ha.

When defining the optimal diameter class distribution for a specific forest type, many approaches can be used. One, already mentioned, is to consider the question structuring it as an optimisation problem. In Italy, and namely in north-eastern regions, the approach traditionally adopted by field forest managers is to use as target condition the so called "normal distribution"; this is represented by an overall hyperbolic distribution of trees in which the frequency decreases as diameter class increases. Such a distribution can be maintained by fine scale selective cuttings. The approach was originally intended to meet some economic benefits (i.e. steady and maximum wood production over time): it mimes natural selection to yield a dynamic equilibrium, yet sustained by continuous and fine sylvicultural interventions. Considering the concept of sustainable forestry, such an approach has been criticised for its artificialness and rigidity, in contrast with forest management on a true natural basis (CIANCIO *et al.*, 1999). In the present proposal, we suggest the use of a standard *percent distribution of the number of trees among four broad diameter classes* (dbh: <32.5 cm; 32.5-47.5 cm; 47.6-62.5, >62.5 cm) just as guideline, which actual forest type structural biodiversity can be compared with; such a solution allows for a possible compromise between the need of not forcing forest structure dynamics within hardly defined numerical partitions and the quest of broad target of structural equilibrium. Diameter distributions, assumed as standard biodiversity reference, were defined by relaxing the algorithms proposed by SUSMEL (1956, 1981) and adapting them to each forest type.

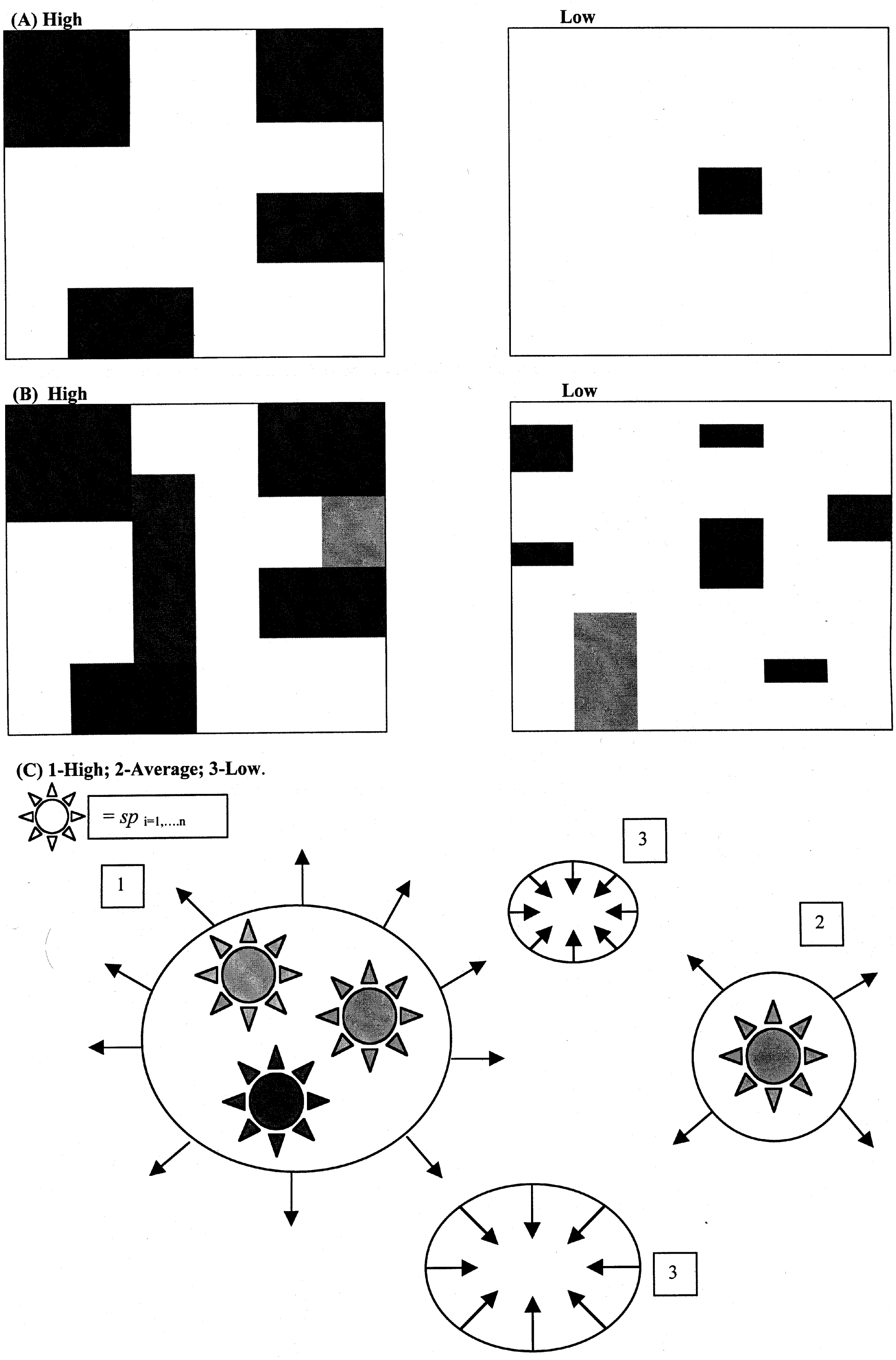

Figure 1. Schematic representation of the concepts of widespreadness (A), connectedness (B) and tree species contagion potential (C).

3.2. Even-aged high stands

In even-aged forests, vertical stand structure is likely to be considered the main key factor of structural diversity. In the evaluation of the habitat quality for birds communities, for instance, foliage height diversity measures are used (ERDELEN, 1984). Even the diversity of ground vegetation (shrub and herbs strata) can be directly related to the general patterns of crown strata. Thus, quite a logic provision is obtained: a well-balanced distribution of age class in a forest type chronosequence yields a dynamic equilibrium from many points of views (wood production, habitat supply, soil protection, etc.). Since it is often difficult to practically assess the age of spontaneous origin forest stands, structural classes are used to determine the distribution of age-classes.

Structural class features vary from forest type to forest type. They are related to forest developmental stages and can be summarised as follows: the clearing stage, characterised by typical post-harvesting flora (e.g. hazelnut, briar, etc.); the regeneration stage (on average, tree heights less than 3 m); the thicket stage (on average, tree heights between 3 and 10 m); the pole stage (on average, tree heights between 10 and 18 m); the high stand stage (on average, tree heights over l8 m); the technically mature high stand stage (evidence of forest regeneration). A fundamental question arises from a biodiversity management point of view: what should the spatial extent of a structure class be? Such a question involves many considerations. Current advances, based on the principles of "systemic sylviculture" (CIANCIO and NOCENTINI, 1996), tend to favour a fine scale management in small areas, in order to break the continuity of chronological classes. It is widely recognised indeed, that such a structural fragmentation has positive effects on the global stability of even-aged forest types, although homogeneous forest patches that are too small incur an economic sacrifice. In practice, such a general assumption should be adapted to local management conditions, with care of forest type structural tendencies and economic site constraints. A sustainability target, that is a chronological-structural equilibrium, should be sought on a forest compartment scale.

A "theoretical" structural classes equilibrium could be achieved by assigning to each structural class an area of *T/N* hectares, which is not necessarily unfragmented, where *T* is equal to the number of years of the forest type cycle and *N* is equal to the number of structural classes. In forest types where the productive function is prevalent, *T* is the rotation cycle period. In the other cases, *T* corresponds to the "permanence" time (permanence time is the biological lifetime of the main tree species of the forest type). In doing this, is followed the principle that the area of each structure class increases at the same rate as the permanence time does (WOLYNSKI, 1998). Thus, the synthetic expression of the chronological-structural equilibrium of each forest type patch can be provided by the *number of structure class/development stages* (which could be 6 or 7 if the clearing stage is present) and *corresponding surfaces* in hectares.

4. GROUND VEGETATION LAYER

The diversity of ground layer vegetation represents *per se* an important part of the compositional diversity of forest stands. Many herb-shrub species are sensitive to specific stand type conditions and their presence/abundance may be therefore used as ecological indicator. In spite of the evidence of such relationships, it is rather complex to assess the key factors of vegetation diversity. At a landscape scale, forest type compositional diversity is primarily conditioned by ecological factors and historical human influences, which have affected the physiognomy of type (number and relative abundance of native and alien forest and undestory species). But when focusing on a forest type scale, significant differences in ground layer vegetation diversity can be found, where changes in site heterogeneity, patch geometry (patch size, boundary gradient, isolation) and canopy structure (horizontal patchiness and vertical layers) occur. Whatever the scale, a general trend can be observed: species abundance raises where there is in evidence an increased availability of light is in relation to water availability and the lack of extreme soil conditions.

The light factor is generally time (and management) dependant at a stand scale. This is true particularly in even-aged types, where the amount of light reaching the ground is "filtered" by canopy cover for the most part of the silvicultural cycle. Consequently, due to light availability, the highest number of species may be found during the first phases of the forest regeneration process, or during the decadent phase. Such ground vegetation fluctuations are evident where vertical and horizontal homogeneity within stands (e.g., one close canopy layer in forest plantations) determines even shading conditions; in such cases, light availability strictly depends on developmental stages. Where the canopy cover is more open or clustered, the total number of herb/shrub species tends to be constant over time, due to a finer heterogeneity in ground layer light availability. This condition is also typical of types where the crown architecture of the main tree species determines an uneven canopy cover even in conditions of regular stem density (e.g., Scots pine stands). In other cases, as in larch or spruce types characterised by megaforbs and scarce canopy coverage, the number of herb/shrub species tends to decrease with forest ageing and particularly when close to the oldest specimens: these conditions set off the forest regeneration process.

Forest operations and other human influences (grazing, tourism pressure, etc.) may affect all these phenomena and the related dynamics of ground layer vegetation. It is therefore of primary interest to evaluate the responses of ground layer vegetation to the effects of man-induced changes in stand structure. The presence of near-natural stands of a specific forest type (where, for instance, a prolonged lack of management has allowed the development of complex forest structures) would be a fundamental reference to compare the diversity of managed stands with that of natural ones (CORONA and PIGNATTI, 1996). Unfortunately in north-eastern Italy, these conditions are seldom found. However, for a practical monitoring of the effects of forest management on forest type biodiversity it may be helpful to carry out flora relevés and to compare the results of different types of silvicultural alternatives. For such purposes, the following measures of ground layer vegetation biodiversity are proposed: *average number of herb/shrub species* recorded in all the relevés carried out in the considered forest type; *minimum and maximum value in the number of herb/shrub species* recorded in all the relevés carried out in the forest type; *average number of hemerophyta*[2] *herb/shrub species* recorded in the relevés carried out in the forest type; *dynamic trend in the number of herb/shrub species* in the forest type (variable over time; temporarily variable; constant).

5. ANIMAL SPECIES

Research on forest fauna in Italy still experiences a disparity between the concerns of biological conservation and those of forest habitats planning and management. To bridge such a gap practical forest evaluation tools (habitat quality indexes, habitat supply models) are needed to implement fauna conservation strategies within a wider planning/ management context. However, some indications about the relationships between forest diversity and its fauna may be obtained from research carried out in the field of applied ecology. Bird species diversity, for example, has been found primarily dependent on foliage height diversity and plant species diversity (MACARTHUR and MACARTHUR, 1961). Ornithofauna surveys carried out in different forest types in Italy have tested such proposition (FERRARI *et al.*, 1996), confirming that the more diverse the structural and compositional properties of the types (high stands of beech, chestnut or oaks) the higher bird community abundance (from 30 up to 40 species). In structurally similar types, bird species richness tends to increase with forest age and to decrease after forest harvesting.

Birds species diversity is just one key factor of the compositional diversity of forest fauna. But, considering bird sensitivity to forest diversity (and to its management) and the practical difficulties in monitoring other functional groups (large and small mammals, insects and other vertebrates), the diversity of bird community (*average, minimum and maximum number of bird species* recorded in all the observations carried out in the forest type) can be most easily evaluated in an operative framework.

6. OVERALL NATURALISTIC QUALITY

To complete the assessment, three forest naturalistic quality indicators are considered; they express a global evaluation of the importance of some compositional features of forest diversity (flora, vegetation, fauna) from a conservation perspective. The value of the *naturalistic quality for the flora* is represented by the sum of the number of protected species recorded in the floristic survey within a forest type, where protected species are those designated by EU Directives, national "red lists" and national/local laws; standard biodiversity reference is given by the average of such sums from all the flora relevés within a forest type. The value of the *naturalistic quality for the vegetation* is synthetically assessed by the biogeographical/syntaxonomical relevance of the forest type in terms of high, average, or low occurrence in the considered landscapes. The value of the *naturalistic quality for the fauna* is expressed by the sum of the number of protected species within a forest type, where protected species are those designated by EU Directives, national "red lists" and national/local laws; standard biodiversity reference is given by the average of such sums from all the records within a forest type.

RESULTS AND CONCLUDING REMARK

Biodiversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. It encompasses genetic diversity, species diversity, ecosystem diversity and scaling matters to deal with them. Biodiversity is a cause and effect of biocenosis natural tendency to homeostasis and is directly related to the complexity and the entropy of trophic-functional structures within a biocenosis. The concept should not be uncritically applied otherwise it may be unpractical and ambiguous field implementation.

A viable solution in the framework of current forest management is to refer to a "habitat" approach through forest types characterisation at a stand level. In such a perspective, simple indicators oriented to field definition and description of certain aspects of maintenance, conservation and increase of biological diversity in forest types have been presented. Table 3 shows the standard biodiversity reference of the proposed indicators as applied to three selected stand forest types in the Veneto region. The proposed indicators must not be intended as rating tools to compare biodiversity value among different forest types. They have been conceived as reference management standard for each forest type in the considered region. Such tools therefore, provide practical baseline information against which forest management efficiency in achieving biodiversity conservation/enhancement targets can be compared. The indicators can also be used to investigate both the internal relation-

[2] *Hemerophyta*: short-lived plant (from Greek: *hemero="day" -phyta "plants"*).

ships between different forest biodiversity aspects (for instance, forest crown diversity vs. ground layer vegetation diversity) and the related effects of human influence.

Table 3. Reference standard biodiversity indicators for three Veneto Region forest types.

Indicators	*Forest types* Faggeta montana tipica esalpica (beech mountain forest)*	Abieteto dei substrati silicatici (fir forest on siliceous rocks)**	Pecceta dei substrati silicatici dei suoli mesici altimontana (spruce high mountain forest)***
Spatial pattern			
Widespreadness	High	High	High
Connectedness	Connected	Connected	Connected
Tree species contagion potential	Low	Low	High
Forest structure			
Uneven aged stands: percent of trees in dbh classes (<32.5, 32.5-47.5, 47.6-62.5, >62.5 cm)	-	60; 25; 10; 5	-
Even aged stands: number of development stages and surface of each development stages (ha)	6 (22)	-	7 (19)
Ground vegetation layer			
Average number of herb/shrub species (min-max)	41 (18-62)	32 (25-41)	35 (16-49)
Average number of hemerophyta herb/shrub species	0.29	0.1	0.25
Dynamic trend in the number of herb/shrub species	Variable over time	Temporarily variable	Variable over time
Animal species			
Average number of bird species (min-max)	25 (23-27)	35 (33-37)	25 (23-27)
Overall naturalistic quality			
Flora	1	0	1
Vegetation	Average	Average	Average
Fauna	11	10	8

* Main tree species: *Fagus sylvatica;* secondary tree species: *Picea abies;* accessory tree species: *Abies alba, Laburnum alpinum, Acer pseudoplatanus, Sorbus aucuparia, Fraxinus excelsior, Ilex aquifolium, Populus tremula, Sorbus aria, Salix appendiculata, Prunus avium, Laburnum anagyroides.*
** Main tree species: *Picea abies, Abies alba;* accessory tree species: *Acer pseudoplatanus, Alnus viridis, Fagus sylvatica, Sorbus aucuparia, Larix decidua.*
*** Main tree species: *Picea abies;* secondary tree species: *Larix decidua*; accessory tree species: *Abies alba, Sorbus aucuparia, Sorbus chamaemespilus, Fagus sylvatica, Alnus viridis, Salix appendiculata.*

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