Mosello, R., B. Petriccione and A. Marchetto (Guest Editors)
Long-term ecological research in Italian forest ecosystems
J. Limnol., 61 (Suppl. 1): 19-24, 2002

Survey and assessment of vegetation in the CONECOFOR permanent plots

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ABSTRACT

*Phytosociological knowledge of plant communities and their synecological allocation are the reference basis of the CONECOFOR Programme. Vegetation surveys are performed in all the CONECOFOR plots (28), and have been performed in most of them for 6-7 years, following two fundamental approaches: (1) phytosociological (plant community level) and (2) dynamical (population level). According to a syntaxonomical analysis, 17 plant communities are represented in the CONECOFOR permanent plots, grouped in three classes (*Querco-Fagetea*,* Vaccinio-Piceetea *and* Quercetea ilicis*). Analysis of species richness at community level shows that the total number of vascular species varies between 14 and 81, the lowest values occurring in beech forests and the highest in Turkey oak forests; spruce forests are divided into two groups, the first comprising the secondary type (with high diversity values) and the second comprising the primary type (with relatively low diversity values). Analysis of the main dynamical tendencies show that fluctuation is the commonest ongoing process (occurring mostly in beech and primary spruce forests). Regeneration is also widespread, following the recent general decline of wood exploitation and coppicing, whereas regression and degeneration have been identified only in a few plots. The first vegetation changes seen during the first 6-7 years of investigation are slight and of very low significance. The temporal variation, however, is generally positive, with a fair increase in the number of species. Further assessment is required to evaluate the ongoing trends.*

Key-words: vegetation, plant communities, permanent plots, syntaxonomy, species richness, dynamical tendencies

1. INTRODUCTION

Phytosociological knowledge of plant communities and their synecological allocation are the reference basis of the CONECOFOR Programme in its initial phase. The main objective of ground vegetation monitoring in the CONECOFOR permanent plots is to record changes due to natural dynamics and macro-disturbance factors (air pollution, climate change, etc.). The vegetation survey is performed in all the CONECOFOR plots (Tab. 1): 20 of them have been monitored since 1996/7, when the network was first established; 8 plots were added in 1999 or 2000, when the network was enlarged.

2. MATERIAL AND METHODS

Preliminary field surveys at community level were performed by the author, as part of the activities of the CONECOFOR National Focal Centre (Ministry for Agriculture and Forestry Policy - National Forest Service - CONECOFOR Service), as well as syntaxonomical and synecological allocation of plant communities in all plots. The author also takes part annually in intercalibration exercises and in the subsequent repetition of measurements in certain plots. The Department of Botany and Ecology of the University of Camerino coordinates all the stages of the research, in particular the measurements performed by specialised personnel on all the plots; the Department supervises the harmonisation of the methods, the training and intercalibration of survey teams and local experts, applying quality control checks and implementing procedures to acquire, validate and store data, with a view also to making them available for subsequent integrated elaboration.

All plots are assessed every three years, and 11 plots annually, following two fundamental approaches (Canullo *et al*. 2001), according to EU Regulations no. 1091/1994 and no. 1545/1999 and the ICP Forests Manual (UN/ECE 1998): (1) phytosociological (plant community level) and (2) dynamical (population level). In the first approach the Braun-Blanquet data collection method (coverage scale for each species per layer) is applied to the analysis area and the large surrounding area, the former divided into 25 sample units of 100 m^2. The second approach is based on 100 smaller sample units (0.25 m^2), placed at random in the analysis area, where species coverage is studied more closely (functional individuals per species). A detailed map of plant populations (synusies) and functional individuals occurring in the analysis area will be drawn up every six years, to assess micro-changes in the plant coverage of each species (the first map, at 1:250 scale, was drawn in 1998).

According to the first approach, 25 sample units (12, in the routine survey) are marked out systematically in the inner grid of the fenced analysis area. Comparable replicates (12) are designated outside the fenced area within the buffer zone. A survey of forest systems with well-defined seasonality is performed in spring (14 plots). Measurements are made of the higher plants, ferns, bryophytes and epigean lichens. For the species nomenclature, see "Flora d'Italia" (Pignatti 1982),

Paper prepared within the CONECOFOR programme, by the contract with the Ministry for Agriculture and Forestry Policy – National Forest Service, Italy. CONECOFOR is part of the Pan-European Level II Intensive Monitoring of Forest Ecosystem and is co-sponsored by the European Commission.

Tab. 1. Permanent plot list: ICP Forests, ICP Integrated Monitoring and National code, official name, altitude, mean annual temperature, mean annual precipitation, mean tree age (years), predominant tree species, survey years.

ICPFor.	ICP IM	Nat.	Official name	Altitude (m a.s.l.)	Mean temp. (°C)	Annual precipit. (mm)	Mean tree age (y)	Dominant tree species	Survey years
01	IT05	ABR1	Selva Piana	1500	10,0	1300	110	*Fagus sylvatica*	1996/7-2002
02	-----	BAS1	Monte Grosso	1125	13,0	750	110	*Quercus cerris*	1996/7-1999
03	IT06	CAL1	Piano Limina	1100	10,0	1500	110	*Fagus sylvatica*	1996/7-2002
04	-----	CAM1	Serra Nuda	1175	10,0	1250	90	*Fagus sylvatica*	1996/7-2002
05	IT07	EMI1	Carrega	200	12,0	1200	30	*Quercus petraea*	1996/7-2002
06	IT08	EMI2	Brasimone	975	10,0	1800	50	*Fagus sylvatica*	1996/7-1999
07	-----	FRI1	Bosco Boscat	6	14,0	1500	30	*Carpinus betulus, Q. robur*	1996/7-2002
08	-----	FRI2	Tarvisio	820	6,0	1500	70	*Picea abies*	1996/7-1999
09	IT09	LAZ1	Monte Rufeno	690	12,0	1000	30	*Quercus cerris*	1996/7-2002
10	IT10	LOM1	Val Masino	1190	8,0	1300	50	*Picea abies*	1996/7-2002
11	IT11	MAR1	Roti	775	10,0	1250	50	*Quercus cerris*	1996/7-2002
12	-----	PIE1	Val Sessera	1150	8,0	1500	70	*Fagus sylvatica*	1996/7-1999
13	-----	PUG1	Foresta Umbra	800	12,0	800	50	*Fagus sylvatica*	1996/7-1999
14	-----	SAR1	Marganai	700	14,0	900	110	*Quercus ilex*	1996/7-1999
15	-----	SIC1	Ficuzza	940	13,0	800	30	*Quercus cerris*	1996/7
16	IT12	TOS1	Colognole	150	15,0	900	30	*Quercus ilex*	1996/7-2002
17	IT03	TRE1	Passo Lavazè	1775	5,0	800	110	*Picea abies*	1996/7-1999
18	-----	UMB1	Pietralunga	725	11,0	1250	50	*Quercus cerris*	1996/7-1999
19	IT13	VAL1	La Thuile	1740	5,0	1000	70	*Picea abies*	1996/7-2002
20	-----	VEN1	Pian di Cansiglio	1100	5,0	1900	110	*Fagus sylvatica*	1996/7-2002
21	-----	ABR2	Rosello	960	8,5	1000	130	*Abies alba, Q. cerris*	2002
22	-----	LAZ2	Monte Circeo	190	15,5	900	30	*Quercus ilex*	2002
23	-----	LOM2	Giovetto	1260	8,0	1350	70	*Picea abies*	2002
24	-----	LOM3	Valsassina	1250	8,0	1500	50	*Fagus sylvatica*	2002
25	-----	TOS2	Cala Violina	30	15,0	650	40	*Quercus ilex*	1999
26	-----	TOS3	Vallombrosa	1170	10,0	1300	130	*Fagus sylvatica*	1999
27	IT01	BOL1	Renon	1740	4,0	970	110	*Picea abies*	2002
28	-----	LIG1	Monte Zatta	1290	10,0	1800	110	*Fagus sylvatica*	2002

"Mosses of Europe and Azores" (Corley *et al*. 1981, 1991), and for the lichens, local florae. Codified lists of European reference are also being prepared, based on Flora Europaea (Tutin *et al*. 1964-1980) and "Moos- und Farnpflanzen Europas" (Frey *et al*. 1995). Measurements are performed following the phytosociological method of Braun-Blanquet (1932, 1964), based on the visual estimate of cover by percentage intervals, with indexes assigned to each species (r = rare; + = <1%; 1 = 1-5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-100%). The vertical layers considered are: trees, shrubs, herbs and mosses. Syntaxonomical nomenclature is according to Pignatti (1998) and follows the International Association for Vegetation Science Code (Barkman *et al*. 1986; Weber *et al*. 2000).

The second approach involves systematically marking out 100 sampling units inside an ideal grid in the fenced analysis plot, comprising the vegetation layer below 1.3 m. The cover of each species is estimated in cm^2, mean height is measured, the individuals present are counted according to various typologies and any damage recorded; in ligneous species these elements are measured individually.

A detailed mapping (scale 1:250) of the dominant species and synusies in the same layer over the whole fenced study area (50×50 m^2) is also envisaged.

To standardise the methods used by the survey teams, especially during the phase of data measurement in the field, a handbook has been written (Manuale Nazionale di Riferimento, Canullo *et al*. 1999), defining procedural and technical standards; in addition, annual intercalibration and training exercises are organised for survey personnel. Controls to assess the quality of the measurements are also performed annually by the Department of Botany and Ecology of the University of Camerino.

Dynamical tendencies in the vegetation (fluctuation, regeneration, degeneration and regression, according to Falinski 1986, 1989) have been identified on the basis of species composition and, secondarily, vertical structure. A check-list of indicator species of dynamical processes has been used (Petriccione & Claroni 1996), as well as the few papers describing forest vegetation in Italy (among them, Pedrotti & Falinski 1990, 1991; Canullo & Pedrotti 1993).

3. RESULTS

The plant communities represented in the CONECOFOR permanent plots are described systematically and syntaxonomically. The 28 areas considered include 17 different vegetal associations, grouped in three classes (Tabs 2, 3).

The best represented class, with a total of 17 areas, is that of deciduous broadleaf European forests (*Querco-Fagetea*), divided into two different orders.

1) Thermophilous oak forests (*Quercetalia pubescentis*): these include all *Quercus cerris* forests, divided

Tab. 2. Systematical and syntaxonomical outline of plant communities represented in the CONECOFOR permanent plots (National codes on side).

QUERCETEA ILICIS Br.-Bl. 1936	
QUERCETALIA ILICIS Br.-Bl. 1936	
ERICO-QUERCION ILICIS Brullo, Di Martino & Marcenò 1977	
◆*Quercetum gussonei* Brullo & Marcenò '84	SIC1
QUERCION ILICIS Br.-Bl. 1936	
◆*Viburno-Quercetum ilicis* Br.-Bl. 1936	SAR1, TOS2
◆*Orno-Quercetum ilicis* Horvatic 1956, 1958	TOS1, LAZ2
QUERCO-FAGETEA Br.-Bl. et Vlieger 1937	
QUERCETALIA PUBESCENTIS Br.-Bl. 1931, 1932	
QUERCION PUBESCENTIS Knapp 1942	
◆*Rubio-Quercetum cerridis* Pignatti E. & S. 1968, Bas Pedroli *et al*. 1988	LAZ1
◆*Aceri obtusati-Quercetum cerridis* Ubaldi & Speranza 1982	MAR1, UMB1
QUERCION FRAINETTO Horvat 1954	
◆*Physospermo verticillati-Quercetum cerridis* Aita *et al*. 1977	BAS1
FAGETALIA SYLVATICAE Pawl. 1928	
CARPINION Issl. 1931, Oberd. 1953	
◆*Ornithogalo pyrenaici-Carpinetum* Marincek *et al*. 1982	FRI1
◆*Physospermo cornubiensi-Quercetum petraeae* Oberdorfer & Hofmann 1967	EMI1
FAGION SYLVATICAE Luquet 1926, Pawl. 1928	
◆*Polysticho-Fagetum* Feoli & Lagonegro '82	ABRI
◆*Aquifolio-Fagetum* Gentile 1969	CAL1, CAM1, PUG1
◆*Trochiscantho-Fagetum* Gentile 1974	EMI2, LIG1
◆*Luzulo pedemontanae-Fagetum* Oberdorfer & Hofmann 1967	PIE1, TOS3
◆*Luzulo albidae-Fagetum* Meusel 1937	VEN1
◆*Cardamini pentaphyllae-Fagetum* Mayer & Hofmann 1969	LOM3
◆*Aceri lobelii-Fagetum abietetosum albae* Aita, Corbetta & Orsino 1984	ABR2
VACCINIO-PICEETEA Br.-Bl. 1939	
PICEETALIA ABIETIS Pawl. 1928	
PICEION ABIETIS Pawl. 1928	
◆*Homogyno-Piceetum* Zukrigl 1973	BOL1, TRE1, VAL1
ABIETI-PICEION Br.-Bl. 1939	
◆*Veronico urticifoliae-Piceetum* Ellenberg & Klotzli 1972	FRI2, LOM1, LOM2

into three associations (note that the areas MAR1 and UMB1 belong to the same entity, while the Turkey oak forest of BAS1 is quite distinct from the other areas of Central Italy, being located in an autonomous alliance).

2) Mesophilous oak and beech forests (*Fagetalia sylvaticae*): these include *Quercus robur* and *Q. petraea* acidophilous forests (of the *Carpinion* alliance) and beech forests (of the *Fagion sylvaticae* alliance); the last of these present a great variety, as they are divided into 7 associations, according to latitude, climate and type of substrate. All the areas in southern Italy (CAL1, CAM1 and PUG1) belong to the same entity, the most thermophilous of all the entities. Those of the northern Apennines (EMI2, LIG1 and TOS3) are divided into two associations, one neutrophilous and the other acidophilous. The Alpine beech forests (LOM3, PIE1 and VEN1) are divided into three different associations with differences in their ecological and biogeographical significance; the beech forest situated at the highest altitude is that of area ABR1, in the internal Central Apennines, ascribed to a particularly microthermal autonomous association. In the same geographical area, but in a more southerly position and on the eastern Adriatic slope, is area ABR2, which is a case apart, in so far as it is a forest in which beech is completely absent, with marked co-dominance of *Abies alba*, *Quercus cerris*, *Carpinus betulus*, *Acer lobelii* and *Acer campestre*, in direct contact with

Tab. 3. Permanent plot list: ICP Forests, ICP Integrated Monitoring and National code, syntaxon, total number of vascular species (first survey year), number of species occurring in tree layer (first survey year), main dynamical tendency.

ICP For	IM	Nat.	Syntaxon	Vascular species N°	Tree layer species N°	Main dynamical tendency
15	-----	SIC1	*Quercetum gussonei*	81	1	regression
14	-----	SAR1	*Viburno-Quercetum ilicis*	38	5	regression
25	-----	TOS2	"	20	5	fluctuation
16	IT12	TOS1	*Orno-Quercetum ilicis*	44	15	regression
22	-----	LAZ2	"	29	6	regeneration
09	IT09	LAZ1	*Rubio-Quercetum cerridis*	53	1	degeneration
11	IT11	MAR1	*Aceri obtusati-Quercetum cerridis*	69	4	regeneration
18	-----	UMB1	"	55	4	regression
02	-----	BAS1	*Physospermo-Quercetum cerridis*	72	2	degeneration
07	-----	FRI1	*Ornithogalo pyrenaici-Carpinetum*	43	6	regeneration
05	IT07	EMI1	*Physospermo-Quercetum petraeae*	30	6	regeneration (fluctuation)
01	IT05	ABR1	*Polysticho-Fagetum*	22	1	regeneration
03	IT06	CAL1	*Aquifolio-Fagetum*	34	3	fluctuation (regeneration)
04	-----	CAM1	"	31	2	fluctuation
13	-----	PUG1	"	29	7	fluctuation (regeneration)
06	IT08	EMI2	*Trochiscantho-Fagetum*	26	3	regeneration
28	-----	LIG1	"	24	2	fluctuation
12	-----	PIE1	*Luzulo pedemontanae-Fagetum*	17	2	flictuation
26	-----	TOS3	"	14	1	fluctuation
20	-----	VEN1	*Luzulo albidae-Fagetum*	42	1	fluctuation
24	-----	LOM3	*Cardamini pentaphyllae-Fagetum*	28	3	fluctuation
21	-----	ABR2	*Aceri lobelii-Fagetum abietetosum*	66	12	fluctuation
17	IT03	TRE1	*Homogyno-Piceetum*	14	2	fluctuation
19	IT13	VAL1	"	39	4	fluctuation
27	IT01	BOL1	"	54	5	regression
08	-----	FRI2	*Veronico uticifoliae-Piceetum*	59	5	regeneration
10	IT10	LOM1	"	56	14	regeneration (fluctuation)
23	-----	LOM2	"	34	3	regeneration

communities dominated by *Fagus sylvatica* and *Abies alba*, the composition and structure of which are linked to optimal local edaphic and climatic conditions.

The second most represented class (6 areas) includes the boreal coniferous forests (*Vaccinio-Piceetea*), divided into only two associations (both of the order *Piceetalia abietis* and each belonging to a different alliance), according to the altitude: the mountain spruce forests, replacing the original beech forests, are represented in areas FRI2, LOM1 and LOM2, while the subalpine spruce forests are found in the network's areas of maximum altitude (BOL1, TRE1 and VAL1).

The last class (5 areas) includes the evergreen Mediterranean forests (*Quercetea ilicis*), divided into two alliances (of the same *Quercetea ilicis* order): the endemic alliance *Erico-Quercion ilicis* includes an endemic association of Sicily, represented in area SIC1 by a *Quercus cerris* forest (deciduous) in a very distinctive morphological and ecological form, which some authors have elevated to the rank of subspecies or even to that of an autonomous species, *Quercus gussonei* (Borzì) Brullo; the other alliance (*Quercion ilicis*) includes the other two associations, one more thermophilous (areas SAR1 and TOS2) and the other more mesophilous (LAZ2 and TOS1).

The detailed maps produced in 1998 (Canullo *et al*. 2001) were a useful contribution towards defining the initial state of the system. Digitalisation and the fact that data can be processed using GIS techniques, together with the referenciation of the measurement grid at phytocenosis and population level, offer an excellent chance that in future we will be able to visualise medium scale changes in the study areas.

A preliminary analysis of species richness at community level, on the basis of the first survey year (the only one with fully comparable data), reveals some interesting points (Tab. 3; data refer to all vascular plants on 25 sample units, on a total relevé surface of 2500 m^2).

1) The total number of vascular species varies between 14 and 81, with the lowest values in plots with *Fagus sylvatica*-dominated forests and the highest in *Quercus cerris*-dominated plots (plot ABR2 is in a very high diversity situation, due to its peculiar status, explained above).
2) *Picea abies*-dominated plots are divided into two groups, the first including secondary spruce forests (FRI2 and LOM1), with high diversity values, and the second including primary spruce forests (TRE1, VAL1), with relatively low diversity values (plot BOL1 is in a situation of high diversity, due to a major ongoing regression process).
3) *Quercus ilex*-dominated plots show a wide range of degrees of diversity, with low values in forests in which fluctuation and regeneration are dominant

processes, and medium values where regression is the main tendency (SAR1, TOS1).

4) The number of species occurring in the tree layer varies between 1 and 15, with the lowest value in *Fagus sylvatica*-dominated plots and the highest in the plots characterised by marked ecological transitions (Central-European *vs* Subatlantic belt: ABR2; Subatlantic *vs* Boreal belt: LOM1; Mediterranean vs. Central-European belt: TOS1).

According to a preliminary analysis of the main dynamical tendencies, the plots are divided into four groups (Tab. 3).

1) Fluctuation is the predominant ongoing process in *Fagus sylvatica* and primary *Picea abies*-dominated forests (12 plots, including the special case of ABR2 and the *Quercus ilex*-dominated forest of TOS2).
2) Regeneration is the predominant ongoing process, following the recent decline of wood exploitation and coppice management, in secondary *Picea abies*, *Quercus cerris* and some *Fagus sylvatica*-dominated forests (9 plots, including the *Quercus ilex*-dominated forest of LAZ2).
3) Regression is the predominant ongoing process in some *Quercus cerris*- and *Quercus ilex*-dominated forests (5 plots); the main indicator species are *Rubus ulmifolius*, *Urtica dioica*, *Pteridium aquilinum* and *Cytisus villosus*.
4) Degeneration is the predominant ongoing process in some *Quercus cerris*-dominated forests (2 plots); the main indicator species are *Geranium robertianum*, *Geum urbanum*, *Galium aparine*, *Cruciata glabra* and *Cirsium arvense*.

Fluctuation occurs in plots with a low number of species (<30, except for the special case of ABR2), whereas regression and degeneration processes occur in plots with high diversity (total no. of species >40 in the first case and between 50 and 70 *ca* in the second one).

The first changes in vegetation observed in the initial phase of the survey, from 1996/7 to 1999 (19 plots) and from 1996/7 to 2002 (11 plots), were slight and of very low significance. During the first 2-3 years of the survey (Campetella & Canullo 1999), the total number of species, in some plots, showed a fairly marked variation, largely because bryophytes and lichens were also included in the assessment in the last year, but also due, albeit to a lesser degree, to an improvement in the identification of the collected taxa. The temporal variation, however, is generally positive. The results for 11 plots (6-7 years) show a similar increase in the total number of species in all except LOM1 and TOS1, where there was a slight decrease. Only in the case of *Quercus cerris*-dominated plots (BAS1, MAR1, LAZ1 and UMB1) does the increase reach significant values (*ca* 10-20 species).

However, in no case did we observe the permanent disappearance of species previously recorded. To evaluate the kind of trends in progress it would be essential to be in possession of longer time series, of at least 10-20 years; significant changes (including the disappearance of many species) have been recorded, e.g. in Swiss beech and oak forests, on the basis of 30-50 years of observations (Walther 1997; Walther & Grundmann 2001). It will in any case be necessary to analyse the qualitative variations in the species composition, highlighting any temporal changes in the presence, frequency and cover of certain key species chosen as indicators of ongoing processes (e.g. nitrophilous, thermophilous, etc. species).

4. CONCLUSIONS

A systematic and syntaxonomical profile of plant communities represented in the CONECOFOR permanent plots shows that the 28 studied plots include 17 plant communities, grouped in three classes. The best represented class includes the Central-European broadleaved deciduous forests (*Querco-Fagetea*); the second includes the Boreal coniferous forests (*Vaccinio-Piceetea*), with the least represented including the Mediterranean evergreen forests (*Quercetea ilicis*).

A preliminary analysis of species richness at community level reveals that the lowest values occur in beech forests and the highest in Turkey oak forests, whereas spruce forests are divided into two groups, the first including the secondary type (with high diversity values) and the second including the primary type (with relatively low diversity values).

According to a preliminary analysis of the main dynamical tendencies, fluctuation is the commonest ongoing process (occurring mostly in beech and primary spruce forests). Regeneration is also widespread, following the recent general abandonment of wood exploitation and coppice management (occurring mostly in Turkey oak and secondary spruce forests). Regression is recorded in a few plots, becoming predominant in some *Quercus cerris*- and *Quercus ilex*-dominated forests, whereas degeneration is predominant only in two *Quercus cerris*-dominated plots.

The first vegetation changes identified during the initial 6-7 years of investigation are slight and of very low significance. The temporal variation, however, is generally positive, with a fair increase in the number of species. Further assessment is required to evaluate ongoing trends: significant changes (including the disappearance of many species) have been recorded, e.g. in Switzerland, on the basis of 30-50 years of observations (Walther 1997; Walther & Grundmann 2001).

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