ECOLOGIA BALKANICA

2013, Vol. 5, Issue 2 December 2013 pp. 41-50

Plants Species Diversity in Hyrcanian Hardwood Forests, Northern Iran (Case Study: Mazandaran Province)

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Abstract. In order to better understand and manage forest ecosystems, it is important to study the relationship between environmental factors and plants in these ecosystems. We investigated plant species diversity of three hardwood forest stands in the Hyrcanian forests, Sari, northern Iran. Our aim was to determine the effect of forest stand type on the diversity of plant species. One plot 150 × 150 m established at the center of each forest stand and in each plot, nine subplots 50 × 50 m were selected. Diversity values (Richness, diversity and evenness indices) were measured in five sample areas 0.01 ha per 50 × 50 m quadrates by estimating cover percentage of each species. The results showed that Geophytes (43.33%) had the highest life form spectrum among species. JACCARD'S similarity index revealed that the highest values exist between *Parrotia-Carpinus* and *Carpinus* stands. All herb layer species diversity indices varied significantly among different forest stands. Cover percentage significantly positively correlated with diversity indices in *Parrotia-Carpinus* stand. Diversity and richness indices of herb-layers plants were significantly negatively correlated with cover percentage in *Fagus* stand. Correlation analysis between all diversity measures and cover percentage in *Carpinus* stand wasn't significant. The result of the present study revealed that species diversity in temperate broad-leaved deciduous forest was significantly influenced by forest stand type.

Key words: biodiversity, broad-leaved trees, herb-layer species, Hyrcanian forests.

Introduction

Forest ecosystems give unequal share to the world's biodiversity (BATTLE *et al.*, 2000) and biodiversity maintenance is one of the major goals defined to attain forest sustainability (OSORIO *et al.,* 2009). In addition to economical importance, forests are significant as natural ecosystems and their biodiversity conservation, accordingly, is one of the main objects of forest management (PITKANEN, 2000). In most temperate forest ecosystems, herbaceous species play an important role in the overall plant species diversity (VON OHEIMB & HARDTLE, 2009). Forest ecosystems undergo several natural and human disturbances and due to major differences in terms of life form and regeneration, the way the herbaceous plants usually react to such disturbances is different from the way trees do (GILLIAM, 2007). In general, understory plants appears to be the largest element of temperate forest diversity and may be an important sign of site quality, upperstory regeneration patterns and preservation position (GRACIA *et al.*, 2007). The herbaceous layer is a significant and dynamic forest layer that contributes only to a small part of the total biomass of an ecosystem (GILLIAM & TRULLI, 1993). The species diversity dispersal is dependent on environmental factors and biological influence (WANG, 2006). Conservation of species diversity is an important object in sustainable forest management (LINDERMAYER *et al.,* 2000; POTTS *et al.,* 2005; ITO *et al.*, 2006). Forest operations that change site conditions to develop tree regeneration may result in changes in biodiversity patterns (ELLIOTT & HEWITI, 1997), consequently; the nature and distribution of biodiversity resources of the managed region is determined through biodiversity measures before forest management operations starts (SAGER *et al.,* 2003). According to AUBERT *et al.* (2003), the assessment of biodiversity in managed forest has become an important issue for studying ecosystems and their conservation. The herb-layer plants play important roles in the broadleaved forests for example in the competition among herbaceous species and seedling of upper-story dominant trees (GILLIAM, 2002). A major concern of forest managers in timber resources development is the maintenance of understory plant diversity (ELLUM *et al.,* 2010). Hyrcanian (Caspian) forests are positioned at green strip streching over the northern slopes of Alborz range and southern coasts of the Caspian Sea (HAGHDOOST *et al.,* 2011) and the vegetation is consisted typically of deciduous forests (AKHANI *et al.,* 2010). These forests were formed at the end of the third geological era (HOSSEINI, 2010). In Hyrcanian forest similar other temperate broadleaved forests, herb –layer species play an important role in the ecosystem. Plant species diversity in Hyrcanian forest have been addressed in some recent studies (ABRARI VAJARI *et al.*, 2012; POORBABAEI & RANJAVAR 2008; POORBABAEI & ROOSTAMI, 2006; SHABANI *et al.*, 2011; SOHRABI & HABASHI, 2011; ABEDI & POORBABAEI, 2010). The objectives of this study were to (1) characterize the effect of forest stand type on herb-layer species diversity indices and (2) determine the correlation between diversity indices and herb-layer species cover in each stand. This study is helpful to evaluate the plant species diversity in a given forest to design forest management plans.

Material and Methods

Study site. The study was conducted at three districts in forestry plan of Tajan watershed, located in Sari, northern Iran. In each district, one compartment was selected to study plant species diversity (Table 1, Fig 1). The region has a humid temperate climate, and dominant type of soil is forest brown soil.

Data collection. This experiment was conducted during the growing season of 2010. One plot 150 × 150 m established at the center of each forest stand (BAIDER *et al.,* 2001) and in each plot, nine subplots of 50 × 50 m (COX & ALLEN, 2008) were selected (Fig 2). Sampling plant species was carried out within five sample areas 0.01 ha per 50 × 50 m quadrate by estimating cover percentage of each species. For determining herb-layer diversity, herb-layer SR (species richness), Shannon-Wiener diversity index H' and evenness E [H'= – (Pi) (LnPi), where Pi = percentaged cover value; E=H'/ H' max; H' max: Ln(n), where n=herb-layer SR] were calculated. JACCARD'S similarity index was applied to evaluate ß diversity similarity among forest stands based on presence/absence of the species as follows: JI=a/(a+b+c); a: number of common species in samples, b: species that exist just in first sample, c: number of species exist just in second sample.

Data analysis. One-way ANOVA and S.N.K test post hoc were applied to distinguish herb-layer species diversity indices among different forest stand. The correlation calculated between herb-layer species diversity indices and its cover percentage with Pearson correlation coefficient. Differences obtained at a level of ≤ 0.01 were considered significant.

Table1. Characteristics of forest stand types in the study site.

Characteristic	Stand type		
	Parrotia-Carpinus	***Carpinus***	***Fagus***
Altitude(m a.s.l)	240-300	820-700	1335-1550
Area(ha)	44	59.57	39
Position	NW	NW	NW
Annual mean rainfall(mm)	808	900	858
Annual mean temperature(°c)	16-14	14-16	15
Slope(%)	30-0	50-80	70-0
Coordination	36° 26′N, 53° 07′E	36° 22′N, 53° 04′E	36° 13′N, 53° 27′E

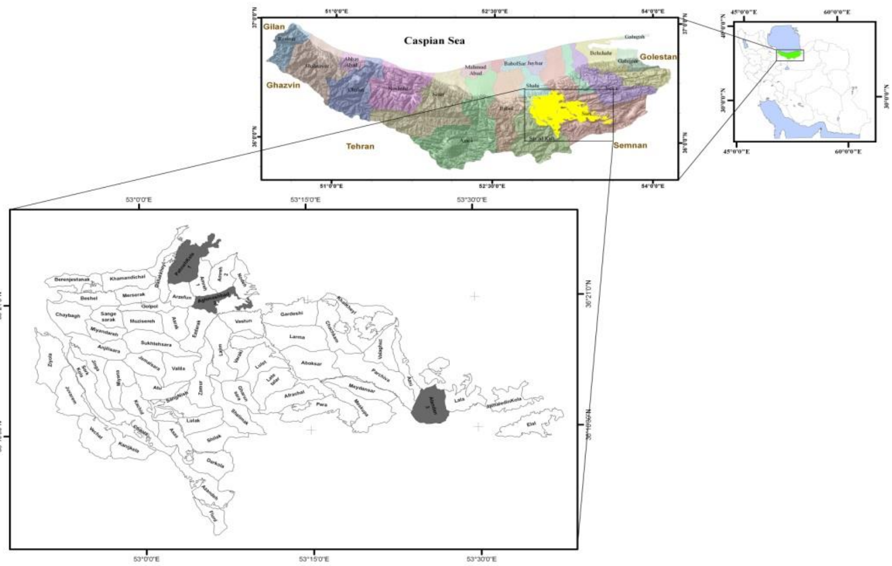

Fig.1. Location of study site in northern Iran, Mazandaran

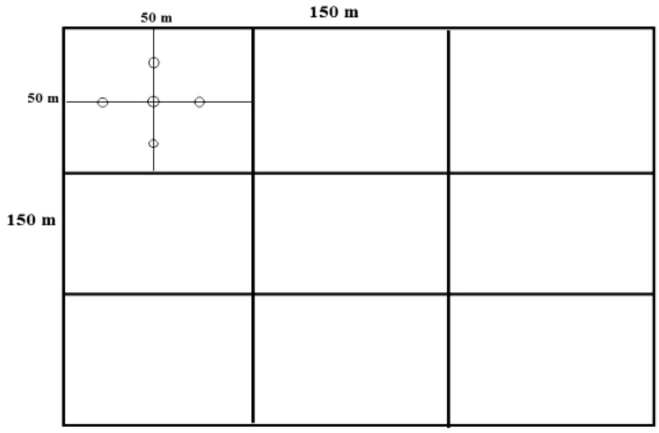

Fig 2. Location of sampling points of plant species in plots

Results

A total of 30 species representing 26 botanical families were identified within three forest stands in the study area (Table 2). The life form of these species is shown in Table 3, as the highest life form belongs to *Geophytes* (43.33%). JACCARD'S similarity index (Table 4) revealed that there are the highest values between *Parrotia-Carpinus* and *Carpinus* stands (0.625). All herb layer species diversity indices (Table 5, 6) varied significantly among forest stand types (p≤0. 01). Correlation analysis (Table 7) showed that diversity and richness indices of herbaceous plants and cover percentage significantly positively correlated in *Parrotia-Carpinus* stand (p≤0.01). Diversity and richness indices of herb-layer plants were significantly negatively correlated with cover percentage in *Fagus* stand (p≤0.01). Correlation analysis between all diversity measures and cover percentage in *Carpinus* stand wasn't significant (p≥0.01).

Table 2. List of plant species in field

Species	Family	Life form
Carex sylvatica Huds.	Cyperaceae	He
Euphorbia helioscopia L.	Euphorbiaceae	Ge
Fragaria vesca L.	Rosaceae	He
Phylitis scolopendrium (L.) Newn.	Aspleniaceae	He
Hedera pastuchovii Woronow	Araliaceae	Ph
Urtica dioica L.	Urticaceae	He
Hypericum androsaemum L.	Hypericaceae	Ge
Viola alba Bess.	Violaceae	He
Lappa major Gaertn.	Compositae	He
Mentha sp.	Labiatae	Ge
Sambucus ebulus L.	Caprifoliaceae	Cha
Pteris cretica L.	Pteridaceae	Ge
Primula heterochroma Stapf.	Primulaceae	He
Rubus hyrcanus Juz.	Rosaceae	Ph
Smilax excelsa L.	Smilacaceae	Ge
Oplismenus undulatifolius (Ard.) L. P.	Graminae	Th
Trifolium repens L.	Leguminosae	Ge
Graminae sp.	Graminae	Ge
Pteridium aquilinum (L.) Kuhn	Dennstaedtiae	Ge
Sanicula europaea L.	Umbelliferae	He
Solanum dulcamara L.	Solanaceae	Ph
Polygonatum orientale Desf	Polygonaceae	Ge
Galium odoratum (L.) (Scope.)	Rubiaceae	He
Festuca rubra L.	Graminae	Ge
Allium sativum L.	Liliaceae	Ge
Poa nemoralis L.	Graminae	Ge
Polygonatum orientale Desf.	Liliaceae	Ge
Arum sp.	Araceae	Ge
Ruscus hyrcanus Woron.	Liliaceae	Ph
Cardamine impatiens L.	Cruciferae	He

He:Hemicryptopyte; Ph:Phanerophye; Ge:Geophyte; Th:Therophyte

Table 3. Frequency (%) of life forms for herb -layer species in site

Life form	Frequency(%)
Phanerophyte	13.33
Geophyte	43.33
Chamaephyte	3.33
Hemcryptophyte	30
Therophyte	3.33

Table 4. Jaccard 's similarity index of heb-layer species in research site

Stand	Index
Parrotia-Carpinus,Carpinus	0.625
Parrotia-Carpinus,Fagus	0.290
Fagus,Carpinus	0.435

Table 5. Analysis of variance of herbaceous plant diversity indices in different forest stands

Variables	MS	DF	F value
Richness	188.49	3	36.23**
Diversity	9.79	3	13.64**
Evenness	0.08	3	6.42**

**, Significant at *p≤ 0.01*.

Table 6. Means (± SE) for plant species diversity indices in different stand

stand	Richness	Diversity	Evenness
Parrotia-Carpinus	5.15±0.38[b]	1.55±0.75[b]	0.88±0.02[a]
Carpinus	8.66±0.35[a]	2.54±0.88[a]	0.81±0.02[b]
Fagus	8.73±0.24[a]	2.5±0.06[a]	0.80±0.01[b]

Letter superscripts (a , b) in each column represent statistical differences using S.N.K test , SE: standard error of means.

Table 7. Pearson's correlation between herb-layer cover percentage and diversity indices in different stands

	Forest stand type					
	Parrotia-Carpinus		*Carpinus*		*Fagus*	
index	*R*	*P*	*R*	*P*	*R*	*P*
richness	0.754	0.000**	0.242	0.110 ns	-0.063	0.679 ns
diversity	0.620	0.000**	0.103	ns 0.499	-0.443	0.000**
evenness	0.003	0.984 ns	-0.064 ns	ns0.676	-0.642	0.000**

**, Significant at *p≤ 0.01*; ns: no significant.

Discussion

Difference among diverse stand types can be determined regarding to species richness, vegetation cover, diversity indices and the distribution of plant functional groups (MOELDER & SCHMIDT 2006). Biodiversity measures have been broadly used as indicator of ecosystem status, and take part in a vital task in studies dealing with the measurement of human effect on ecological systems (LEITNER & TURNER 2001). Results from different life forms within three forest stands included in this research showed that geophytes had the highest rate among various life forms whose overwintering buds are below the soil surface including *Euphorbia helioscopia* L., *Hypericum androsaemum* L., *Pteris cretica* L., *Allium sativum* L., *Polygonatum orientale* Desf. Ground vegetation differ in terms of their capability to penetrate into litter (SYDES & GRIME, 1981). SCHMIDT (2005) claimed that understorey flora and vegetation are suitable indicators for site conditions, human impact and forest dynamics. For example, *Galium odoratum* is indicators of suitable moisture, mild temperature, and high N, and *Sanicula europaea* show high relative humidity in beech stands (ABRARI VAJARI & AZIZI 2002). A comparison between the different functional groups showed that higher proportion belongs to forbs, while graminoids didn't respond to forest stand type. This may be caused by plant functional groups having diverse resource necessities (VOCKENHUBER *et al.*, 2011). The incidence of a particular plant life form could reveal the characteristic of the climatic condition in a specified region to which the species have adapted (BEENAKUMARI DEVI & SINGH 2011). In general, species richness (SR) was higher in the beech stand than in other forest stands. Plant species diversity in pure stands of beech and hornbeam was higher than mixed stand of Ironwood–Hornbeam and this in not consistent with BEATTY (2003) claimed that higher tree layer diversity might enhance herb layer diversity. Tree species can effect on the herbaceous layer by altering resource accessibility and environmental conditions in lower forest layers (BARBIER *et al.*, 2008). Soil conditions have a intense consequence on the herbaceous layer under maturing closed stands, Tree species composition can also be a factor in herbaceous diversity because of the different impacts on light regime and soil features of multi-species stands (KELEMEN *et al.*, 2012). Soil pH, nutrient status, and light conditions strongly affect on the species composition of the herbaceous layer in beech forests (BRUNET *et al.*, 2010). SCHMIDT (2005) declared that species richness of beech forests increases with increasing base-richness. Due to the lower Transmission of photosynthetically active radiation in beech canopies rather than canopies of other deciduous tree species, the establishment and development of shade-intolerant herb-layer and tree species are held back (SCHMIDT, 2005). An admixture of other tree species has a favorable influence on humus quality and herb species richness (GODEFROID *et al.*, 2005). Species richness significantly increased with pH when hornbeam and beech were combined but also the two species separately (KOOIJMAN & CAMMERAAT, 2009). According to TINYA *et al.* (2009) optimal light conditions are obviously different for the understory species. HARDTLE *et al.* (2003) showed that the impacts of light on the species richness of the understory depend on the type of the forest. Variations in understory diversity or composition in parallel with tree species composition are often seen as being a result of disparities in topsoil (BARBIER *et al.*, 2008). The multi-layered canopy produced much more heterogeneous light conditions in beech and hornbeam stands than Ironwood–Hornbeam stand. This resulted in the high diversity of herb-layer species. Due to the dominant position of trees in forests and their influence on different ecological gradients, the identity and composition of tree species can be expected to affect plant species diversity (BARBIER *et al.*, 2008). Understory composition usually varies noticeably among diverse forest types (LU *et al.*, 2011). Many factors influence the variations in species diversity and the proportion of forest related species groups, including site history, management practice, time since cessation of management and the existing site conditions (SCHMIDT, 2005). Jaccard's similarity value is higher in *Parrotia-Carpinus, Carpinus* stands than other forest stands (Table 4) and this higher value show greater similarity between two stands, hence low ß diversity. According to MAGURAN (2004) a value close to 1 indicates greater similarity between stands and hence low ß diversity. In each of stands, these plots were located close to each other; it is thus reasonable that alike seed distribution mechanism were operational and that there may have been similar soil seed bank, regard to (OMORO *et al.,* 2010). The reason is that the two forest stands in good quality environmental conditions have high similarity. It explains these high values by the sampling method used: selection of stands developed on the similar soil, with the similar management and located in one forest may decrease factors of variability in plant communities (AUBERT *et al.*, 2003). Higher Beta diversity between *Pattrotia-Carpinus* and *Carpinus* stands and the lower Beta diversity between *Parrotia-Carpinus* and *Fagus* stands may be attributed to the magnitude of differences in species-individual ratio found there regarding to SAPKOTA *et al.* (2010). Beta diversity is used in biogeographic studies to generate results that better clarify the choice and plan of protected natural áreas (HERNANDEZ-SALINAS & RAMAREZ–BAUTISTA, 2012). Changing land use in forest systems certainly produces changes in biodiversity (LANGE *et al.*, 2011) this study indicates that the impacts of management may depend on the history of the particular forest system. The herbaceous layer is significant to the structure and function of forest ecosystems (GILLIAM, 2007) and understanding species diversity and distribution patterns is important for helping managers evaluate the complexity and resources of these forests. Variation in understory plants may be a useful indicator of overall response of biodiversity to forest stand type.

Conclusion

The understory vegetation diversity within different forest stands examined in this study demonstrated the significant difference among them. The present study indicates that beech stand has higher species richness and diversity values which may be due to biotic and abiotic factors. The high percentage of geophytes reveals high adaption capability of them to ecological parameters in these forest stands. In general, we can say that different herb species dynamics were related to different community types, reflecting differences in habitats in region. Many unharvested stands in Hyrcanian forests may be too dense for allowing the establishment of a variety of species in the stand. It can be recommending implementation of a seasonal monitoring of plant diversity in the three selected sites.

References

ABEDI R., H. POORBABAEI. 2010. Plant diversity in natural forest of Guilan Rural Heritage Museum in Iran. - *Biodiversitas*, 11(4): 182-186.

ABRARI VAJARI K., P. AZIZI. 2002. Recognition of plant association in *Fagetum* of Khoshkab zone (Siyakal-Deylaman). - *Journal of Agricultural Sciences and Natural Resources,* 9(2): 3-14.

ABRARI VAJARI K., H. JALILVAND. M. R. POURMAJIDIAN. K. ESPAHBODI. A. MOSHKI. 2012. Effect of canopy gap size and ecological factors on species diversity and beech seedlings in managed beech stands in Hyrcanian forests. - *Journal of Forestry Research,* 23(2): 217-222.

AKHANI H., M. DJAMALI. A. GHORBANALIZADEH, E. RAMZANI. 2010. Plant biodiversity of hyrcanian relict forests, Northern Iran: An overview of the flora, vegetation palaeoecology and conservation. - *Pakistan Journal of Botany*, 42: 231-258.

AUBERT M., D. ALARD. F BUREAU. 2003. Diversity of plant assemblages in managed temperate forests; a case study in Normandy (France). - *Forest Ecology and Management,* 172: 322-327.

BAIDER C., M. TABARELLI. W. MANTOVANI. 2001. The soil seed bank during atlantic forest regerneration in southeast brazil. - *Revista Brasileria de Biology,* (61)1: 35-44.

BARBIER S., F. GOSSELIN. P. BALANDIER. 2008. Influence of tree species on understory vegetation diversity and Mechanisms involved: A critical review for Temperate and boreal forests. - *Forest Ecology and Management,* 254: 1-15.

BATTLES J.J., A.J. SHLINSKY. R.H. BARRETT. R.C. HEALD. B.H. ALLEN-DIAZ. 2001. The effects of forest management on plant species diversity in a Sierran conifer forest. - *Forest Ecology and Management,* 146: 211–222.

BEATTY S.W. 2003. Habitat heterogeneity and maintenance of species in understory communities. In: Gilliam, F.S., Roberts, M.R. (Eds.), *The Herbaceous Layer In Forests of Eastern North America.* Oxford University Press, New York, pp. 177-197.

BEENAKUMARI DEVI N., N.S. SINGH. 2011. Ecological Assessment of the Plant Communities inside Kangla Fort Manipur. - *Journal of Experimental Sciences,* 2(9): 27-30.

BRUNET J., O. FRITZ. G. RICHNAU. 2010. Biodiversity in European beech forests – a review with recommendations for sustainable forest management. - *Ecological Bulletins,* 53: 77–94.

COX R.B., E.B. ALLEN. 2008. Composition of soil seed bank in southern California coastal sage scrub and adjacent exotic grassland. - *Plant Ecology*, 198: 341-346.

ELLIOTT K.J., D. HEWITI. 1997. Forest Species Diversity in Upper Elevation Hardwood Forests in the Southern Appalachian Mountains. - *Castanea,* 62(1): 32-42.

ELLUM D.S., M.S. ASHTON. T.G. SICCAMA. 2010. Spatial pattern in herb diversity and abundance of second growth mixed deciduous-evergreen forest of southern New England, USA. - *Forest Ecology and Management,* 259: 1416-1426.

GILLIAM F.S., N.L. TRULII. 1993. Herbaceous layer cover and biomass in a young versus a mature stand of a central Appalachian hardwood forest. - *Bulletin of the Torrey Botanical Club,* 120(4): 445-450.

GILLIAM F.S. 2002. Effects of harvesting on herbaceous layer of a central Appalchian hardwood forest in West Virginia, UAS. - *Forest Ecology and Management,* 155: 33-43.

GILLIAM F.S. 2007. The ecological significance of the herbaceous layer in forest ecosystems. - *BioScience,* 57: 845-858.

GODEFROID S., W. MASSANT, N. KOEDAM. 2005. Variation in the herb species response and the humus quality across a 200-year chronosequence of beech and oak plantations in Belgium. - *Ecography,* 28: 223-235.

GRACIA M., F. MONTANE. J. PIQUE. J. RETANA. 2007. Overstory structure and topographic gradients determining diversity and abundance of understory shrub species in temperate forests in central Pyrenees (NESpain). - *Forest Ecology and Management,* 242: 391–397.

HARDTLE W., G. VON OHEIMB. C. WESTPHAL. 2003. The effects of light and soil conditions on the species richness of the ground vegetation of deciduous forests in northern Germany (Schleswig-Holstein). - *Forest Ecology and Management,* 182: 327-338.

HERNANDEZ-SALINAS U., A. RAMAREZ-BAUTISTA. 2012. Diversity of Amphibian Communities in Four Vegetation Types of Hidalgo State. Mexico. - *Open Consevation Biology Journal,* 6: 1-11.

HOSSEINI S.M. 2010. Forest operations management and timber products in the Hyrcanian forests of Iran. – In: *Forest Engineering: Meeting the Needs of the Society and the Environment,* July 11 - 14, 2010, Padova, Italy.

ITO S., S. ISHIGAMI, N. MIZOUE, G.P. BUCKLEY. 2006. Maintaining plant species composition and diversity of understory vegetation under strip clear cutting forestry in conifer plantations in Kyushu, southern Japan. - *Forest Ecology and Management,* 231: 234-241.

KELEMEN K., B. MIHK. L. GALHIDY. T. STANDOVAR. 2012 .Dynamic Response of Herbaceous Vegetation to Gap Opening in a Central European Beech Stand. - *Silva Fennica,* 46(1): 53-65.

KLENNER W., A. ARSENAULT, E.G. BROCKERHOF, A. VYSE. 2009. Biodiversity in forest ecosystems and landscapes: A conference to discuss future Directions in biodiversity management for sustainable forestry. - *Forest Ecology and Management,* 258: S1-S4.

KOOIJMAN A.M., E. CAMMERAAT. 2009. Biological control of beech and hornbeam affects Species richness via changes in the organic layer, pH and soil moisture characteristics. - *Functional Ecology,* 24(2): 469-477.

LANGE M., W.W. WEISSER, M.M. GOSSNER, E. KOWALSKI, M. TURKE, F.S. JONER, C. ROBERTO FONSECA. 2011. The impact of forest management on litter-dwelling invertebrates: A subtropical–temperate contrast. - *Biodiversity and Conservation,* 20: 2133-2147.

LEITNER W., W .R. TURNER. 2001. Measurement and analysis of biodiversity. - In: Levin S.A. (Ed.) *Ecyclopedia of biodiversity,* Vol. 4. Academic Press, Princeton, pp. 123-144.

LINDERMAYER D.V., C.R. MARGULES, D.B. BOTKIN. 2000. Indicators of biodiversity for ecologically sustainable forest management. - *Conservation Biology*, 14(40): 941-950.

LU X.T., J.X. YIN, J.W. TANG. 2011. Diversity and composition of understoryvegetation in the tropical seasonal rain forest of Xishuangbanna, SW China. - *Revista de Biologia Tropical,* 59(1): 455-463.

MAGURAN A.E. 2004. *Measuring biological diversity,* Oxford and Victoria: Blackwell publishing, Malden, 256 p.

OMORO M.A.L., P.K.E. PELLIKKA, P.C. ROGERS. 2010. Tree species diversity, richness, and similarity between exotic and indigenous forests in the cloud forests of Eastern Arc Mountains, Taita Hills, Kenya. - *Journal of Forestry Research,* 21(3): 255-264.

MOELDER A., M. BERNHARDT-ROMERMANN, W. SCHMIDT. 2006. Forest ecosystem research in Hainich National Park (Thuringia): first results on flora and vegetation in stands with contrasting tree species diversity. - *Waldokologie-Online,* (3): 83-99.

OSORIO L .F., F. BRAVO, P. ZALDIVAR, V. PANDO. 2009. Forest structure and plant diversity in aritime pine *Pinus pinaster* (Ait) stands in central Spain. Investigación Agraria. - *Sistemas Recursos Forestales,* 18(3): 314-321.

PITKANEN S. 2000. Classification of vegetational diversity in managed borealforests in eastern Finland. - *Plant Ecology,* 146: 11–28.

POORBABAEI H., S.T. ROOSTAMI. 2006. Floristic composition and plant species diversity in altitudinal classes of the managaed forests, Asalem región Talesh, north of Iran. - *Ecology, Environment and Conservation,* (12)4: 589-598.

POORBABAEI H., A. RANJAVAR. 2008. The effect of shelterwood silvicultural method on plant species diversity in beech (*Fagus orientalis* Lipsky.) forests in Shafaroud, Guilan province. - *Iranian Journal of Forest and Poplar Research,* 16: 61-73.

POTTS M.D., A. KASSIM, M.N. NURSUPARDI, S. TAN, W.H. BOSSERT. 2005. Sampling tree diversity in Malaysian tropical forests: An evaluation of a pre-felling inventory. - *Forest Ecology and Management,* 205: 385-395.

SAPKOTA I.P., M. TIGABU, P.C. ODEN. 2010. Changes in tree species diversity and dominance across a disturbance gradient in Nepalese Sal (*Shorea robusta* Gaertn. f.) forests. - *Journal of Forestry Research,* (21)1: 25-32.

SAGAR R., A.S. RAGHUBANSH, J.S. SINGH. 2003. Tree species composition, dispersion and diversity along a Disturbance gradient in a dry tropical forest region of India. - *Forest Ecology and Management,* 186: 61-71.

SCHMIDT W. 2005. Herb layer species as indicators of biodiversity of managed and unmanaged beech forests. - *Forest Snow and Landscape Research,* 79(1/2): 111-125.

SHABANI S., M. AKBARINIA, G.A. JALALI. 2011. Assessment of relation between soil characteristics and wood species biodiversity in several size gaps. - *Annals of Biological Research,* 2(5): 75-82.

SYDES C., J.P. GRIME. 1981 .Effects of tree leaf litter on herbaceous vegetation in deciduous woodland. I. Field investigations. - *Journal of Ecology,* 69: 237–248.

TINYA F., S. MARIALIGEI, I. KIRALY, B. NEMETH, P. ODOR. 2009. The effect of light conditions on herbs, bryophytes and seedlings of temperate mixed forests in Orseg Western Hungary. - *Plant Ecology,* 204: 69-81.

VOCKENHUBER E.A., C. SCHERBER, C. LANGENBRUCH, M. MEIBßNER, D. SEIDEL, T. TSCHARNTKE. 2011. Tree diversity and environmental context predict herb species richness and cover in Germany's largest connected deciduous forest. - *Perspectives in Plant Ecology, Evolution Systematics,* 21(3): 111-119.

VON OHEIMB G., W. HARDTLE. 2009. Selection harvest in temperate deciduous forests: impact on herb layer richness and composition. - *Biodiversity and Conservation,* 18:271–287.

WAND Q.G., Y.J. XING, X.F. ZHOU, S.J. HAN. 2006. Relationship between diversity of forest plant species and environmental gradient in eastern mountainous area of Heilongjiang Province, China. - *Journal of Forestry Research*, 17(3): 252–254.

Received: 23.07.2013
Accepted: 02.11.2013