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Short communication

Ecological species group—Environmental factors relationships in unharvested beech forests in the north of Iran

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ABSTRACT

Beech forests are the richest forest community in Iran because they are both economically and environmentally valuable. The greatest forest volume occurs in Iran's beech forests. Forests dominated by oriental beech (*Fagus orientalis* Lipskey) cover about 565,000 ha and represent the total area of indigenous forests in Guilan Province. A system for classifying beech forests over such a large area is needed to aid its management. The aim of this study was to investigate the relationship between environmental factors with ecological species groups in unharvested beech forests in Guilan province in northern Iran using multivariate techniques of DCA and CCA. For this purpose, a random systematic 150 m × 200 m gird sampling plan was used to establish 60 1000 m^2 circular plots. In each plot, environmental factors (topographic and soil variables) and percent cover of each herbaceous species were recorded. The result of TWINSPAN analysis showed that six groups were distinct. Multivariate analysis was performed through CANOCO 4.5 to explore the relationship between the environmental factors and the plant community. The most important environmental factors associated with plant composition in beech communities were elevation, slope, slope aspect, N, P, K, pH, C, C/N ratio, organic matter, leaf litter, soil texture (clay, sand, silt) and EC. The use of natural vegetation as an indicator for site quality provides good results, due to the close relationship it has with abiotic site characteristics.

1. Introduction

Extant forests of northern Iran consist mostly of broadleaf deciduous species, but some areas are locally covered by a Mediterranean-type vegetation. Moreover, the distribution of forest types in northern Iran is heterogeneous, with forest productivity following a decreasing west-east gradient. Caspian forests appear to be very similar to broadleaf forests typical of central Europe, northern Turkey and the Caucasus (Marvie Mohadjer, 2006). Forests of the Guilan Province are located in the western part of the Hyrcanian forest region. The dominant species in the northern forests of Iran is beech (*Fagus orientalis* Lipsky), which covers about 565,000 ha and represents the total area of indigenous forests in Guilan Province. Beech forests are the richest, most productive forest communities in Iran because of their economical and environmental value. These forests represent a major carbon pool in the region and are important for their economic value, ability to protect soil, and provide recreation resources (Adel et al., 2012). The greatest forest volume occurs in Iran's beech forests (Adel et al., 2013).

The importance of the herb layer as containing indicator species has a long history in ecology to classify site type, natural community, or productivity class (Abella and Shelburne, 2004). Because they are responsive to changes in site conditions, certain understory plants act as phytometers that integrate many environmental factors that are difficult to measure directly (e.g., macroclimate, microclimate, physiography, soil and light conditions) (Barnes et al., 1998). Ecological species groups are comprised of plants that repeatedly occur together when certain combinations of site factors occur; they are species that are perceived to have similar ecological requirements or tolerances to environmental stresses and limitations (Host and Pregitzer, 1991). Ecological species groups are distinguished by their species composition and abundance patterns among sampling plots. Identifying ecological species groups involves recognizing species that share similar environmental affinities and typically occupy the same sites across the landscape in predictable relative proportions. They can be used to indicate environmental complexes of forest sites based on the presence

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and abundance of these different indicator species that form associations with fidelity to site (Goebel et al., 2001). The ecological species groups help to distinguish and map landscape ecosystems in the field by their presence or absence and by the relative coverage of plants in each group. They are never used alone, but always with attributes of physiography, soil, microclimate, and overstory tree composition and vigor (Barnes et al., 1998). Soil types with different structure and nutrients are important for plant growth and community development. Soil conditions are different in different forest areas and are also related to the restoration process (Zhang and Dong, 2010). The interactions of environmental factors are important in the restoration process and must be considered in the management of the areas (Gattie et al., 2003).

Well-defined species–environment relationships are important to understand vegetation patterns on forest landscapes (Hix & Pearcy, 1997). Ecological species groups act to integrate site attributes and can simplify the process of mapping ecological land units (Host and Pregitzer, 1991). Ecological species groups are often used for vegetation classification (Konollova & Chytry, 2004) and as a source of information on the spatial distribution of vegetation (Regato-Pajares and Elenna-Rosselo, 1995). Vegetation can function as a useful classifier of habitats because plants are a conspicuous and stationary habitat element, making them relatively easy to survey and track over time. Vegetation can also be highly sensitive to extrinsic biotic, environmental, or geomorphic factors, expressing localized changes through patterns in survival, growth and propagation (Bowers and Boutin, 2008). Therefore, phytosociology's major applications are in ecological assessment; vegetation mapping, monitoring environmental changes and nature conservation inventory (Dengler et al., 2008). Vegetation classification can be used for ecological studies and practical monitoring of vegetation cover (Woldewahid et al., 2007). Successful long-term monitoring of habitats is best achieved when using quantitative analysis for precise determination of change in vegetation over time (Benhouhou et al., 2003).

Species group research identifies environmental gradients correlated with species distributions, classifies species assemblages occupying similar environmental complexes, and relates species distributions to management-oriented variables such as tree growth. Once species groups are developed for an area, their distribution can be used for inferring soil properties and other variables relatively difficult to measure (Abella and Covington, 2006). As in many multivariate studies in plant ecology, species groups are hypotheses about species distributions and their relationships to environmental factors. These hypotheses have practical value for estimating site conditions, and are tractable for refinement through experimental research developing causal relationships about species distributions (Pabst and Spies, 1998). Determining of vegetation types has been the subject of numerous studies in a wide range of environments (Morgenthal et al., 2006). Mataji et al. (2009) observed that nitrogen, carbon, phosphorus, silt, moisture and acidity were factors in the occurrence of beech populations in northern Iran. Eshaghi Rad and Banj Shafiei (2010) identified aspect, clay, nitrogen, carbon, C/N, organic material and phosphorus as the main factors that affect the distribution of beech communities in northern Iran. Naqinezhad et al. (2008) found three major types of Acer glutinosa ssp. barbata habitats in Hyrcanian lowlands are distinguished mainly based on groundwater regime, soils factors and geomorphology. Naqinezhad et al. (2013) stated that the polythetic divisive classification method is an attractive preliminary tool for identifying associations between plant species and continuous and discrete environmental factors. Abella and Covington identified that fifteen ecological species group principles chiefly developed in temperate regions, and suggest that vegetation–environment research has great potential for enhancing our understanding of forests areas. Dvorsky et al. (2011) stated the most important environmental factors influencing the species composition were altitude, soil moisture and salinity in East Ladakh, India. The aim of this study was to investigate the relationship between environmental factors with ecological species groups in unharvested beech forests in Guilan province in northern Iran using multivariate techniques of DCA and CCA. Numerical classification has been reported as a powerful tool in detecting fine patterns of floristic variation and is confirmed in the present study.

2. Materials and methods

2.1. Study area

The study area is located in Zilaki, near Roudbar City, which is in the southern part of Guilan Province, northern Iran (36°54′30″–36°56′06″ N, 49°46′24″–49°51′17″ E) (Fig. 1). Elevation within the study area ranges from 1010 to 1560 m a.s.l., with 30–40% slopes that generally face northward. Common forest soils are deep and brown and have a heavy texture and weak acidic pH. Parent materials include lime silt, sandstone, siltstone and shill. The climate, based on the Emberger classification (Dagett, 1977), is very humid with mean annual precipitation of 1560 mm at the nearest meteorological station (Rasht City). The annual mean maximum temperature has been recorded in August (29.3 °C) and average minimum temperature in February (2.7 °C). The usual harvest method employed in the Hyrcanian forest is a single-tree selection system, but logging has never occurred in the study area. Consequently, the forest is uneven-aged and is composed of mixed deciduous broadleaf stands dominated by *Fagus orientalis*.

2.2. Data collection

This study included 170 ha of beech forests. We used a random systematic 150 m × 200 m grid sampling plan to establish 60 1000-m^2 circular plots in July, 2012. In each plot, we recorded slope percentage, geographical aspect, elevation, crown canopy percentage and percent cover of each herbaceous species. In addition, litter depth was measured at five locations within each plot. Because the 1000-m^2 plots were too large for detailed measurements of herbaceous species, we used a sub-sampling method according to the Whittaker nested plot sampling protocol and minimal areas method (Cain, 1938). Hence, sub-plots of 32 m^2 (center of each plot) were used for herbaceous species measurements, which consisted of percent cover of each species based on the Domin criterion. After leaf litter had been removed, soil samples were collected at these 60 sampling plots in the study area. At each sampling plot, soil samples were collected from 0 to 30 cm (Eshaghi Rad and Banj Shafiei, 2010) depth for physical and chemical properties. In each plot, we collected a composite sample, mixing five sub-samples, four in the corners of each plot and one in the center (Fig. 2). Soil samples were prepared for analysis by air-drying and sieving using a 2 mm screen. Sand, silt and clay percentages were determined by the hydrometric method (Bouyoucos, 1962). Soil pH and electrical conductivity (EC) were determined using appropriate meters. Total N was analyzed by the Kjeldahl method (Bremner, 1996). Available P was determined by colorimetry according to the Bray-II method (Bray and Kurtz, 1945). Organic carbon and organic matter were determined by the Walkley and Black (1934) method. C/N ratio and base saturation were calculated. Total K was analyzed by flame atomic absorption spectrophotometer (MAPA, 1994).