International Soil Congress (ISC) on
"Natural Resource Management for Sustainable Development"
June 7-10, 2004 Erzurum-Turkey

EFFECTS OF ASPECT AND SLOPE POSITION ON DECOMPOSITION OF *Picea orientalis* NEEDLE LITTER GROWN IN ARTVIN REGION

Temel SARIYILDIZ, Aydin TUFEKCIOGLU and Mehmet KUCUK

Kafkas Uni., Artvin Foresty Faculty, 08000, Artvin, Turkey

ABSTRACT

Effects of aspect and slope position on decomposition rates of spruce (*Picea orientalis*) needle litters was studied for two years. Litterbags (20 x 20 cm mesh bags with a mesh size of less than 1 mm^2) containing 2 g of needles were placed on a north, south, east and west facing sites and at three slope positions (top, middle and bottom) on each site. Three litterbags from each site were sampled at 6, 12, 18 and 24 months and decomposition rates were calculated. Decomposition rates of spruce needle litters from different slope positions were significantly different from each other for all sampling intervals. There were also significant differences in mass losses between aspects for the bottom and middle slope positions, but showed contrasting patterns. Mass losses at the bottom slope for the north- and east-facing sites were higher than for the south- and west-facing sites. However, in the middle slope final mass losses for the north- and east-facing sites were lower than for the south- and west-facing sites. The top slope position, however, didn't show significant differences. Differences in the decay rates of needle litters between aspects, and between the slope positions illustrate the important point that a number of physical climate variables (e.g. temperature and moisture) may define the potential rates of microbial decomposition and hence the nutrient cycling processes.

Key Words: Decomposition, Slope, Aspect, Climate, *Picea orientalis*

INTRODUCTION

Decomposition of plant litter plays a significant role in the structure and function of natural ecosystems by acting as an energy source for soil organisms and as a nutrient reservoir for the intra-system cycling processes (Heal *et al.* 1997; Sariyildiz and Anderson, 2003a,b). A large number of papers dealing directly with litter decomposition have been published using different plant species all over the world.

In these papers, it has been stated that decomposition rate and nutrient release patterns of plant litters are mainly influenced by environmental conditions, the nature of the micro-organisms and soil fauna active in the decomposition process and by substrate quality or litter quality. Climate (especially average annual temperature and actual evapotranspiration) governs decay rates on broad regional scales whereas initial litter quality variables (C:N ratio, N concentration, lignin concentration and lignin:N ratio) are of more importance in controlling decay rates at small scales, i.e. within site (Berg *et al.* 1995; Heal *et al.* 1997). However, a number of studies have shown that even at small scale topographical land forms (especially different aspects and slope positions) can create different environmental conditions which can hamper or accelerate litter decomposition through negative or positive effects on the activity of organisms (Mudric *et al.* 1994; Vitousek *et al.* 1994; Scowcroft *et al.* 2000).

The aspect of a slope is of great importance in the northern temperate zone, since south-facing slopes receive more intense sunlight than any other ones. At any given altitude then, the hottest and driest sites are those facing south with a slope orthogonal to the sun's declination at noon on summer days. Both steeper and more gradual slopes receive less insolation. The amount of insolation received on a site governs other related factors, including air and soil temperature, and soil water, all of which are important for establishment and growth of plants (McNab 1993). North slopes, on the other hand, receive less sunlight and are invariably cooler, moister and warm up more slowly in the northern hemisphere.

Ridge tops or upper convex slope surfaces are exposed to intense solar radiation, experience high wind speeds, and are subject to erosion and soil movement (McNab 1993). Therefore, they tend to be drier than is the average for the region. At the other extreme, lower slopes with concave surface tend to be sheltered from strong winds, subject to accumulation of organic matter and soil rather than to erosion and to cold-air drainage, and moister than average for the region. Mid-slopes are generally intermediate in their characteristics.

The effect of aspect and slope position on the decomposition rates of yellow poplar, red maple and chestnut oak litter was studied by Mudrick *et al.* (1994). They found that leaf litter decomposed faster on north-facing than on south-facing sites, and leaves placed at the middle slope position decomposed slower that those at either the upper or lower positions. They have stated that these differences in leaf litter mass loss can result from differences in energy fluxes, in litter chemistry and in biotic factors between these sites. Other researchers have attributed different litter mass losses between aspect and slope positions to site differences in microbial functions (Bauhus et al., 1998), interactions between litter quality and soil fertility (Prescot, 1996), moisture content (Mudric et al., 1994) and litter quality effects on fungal activities (Cox et al., 2001).

The 135959 ha area in Turkey is covered by spruce forests and it is widely distributed in Artvin region (the 39391 ha area) (Kucuk, 1989). However, there have been no available data to be so far published on the decomposition rates of this species in Artvin province. This region is a mountainous with steep slopes and high elevations. We therefore set up a study to provide data about decomposition rates of *Picea orientalis* needle litters over time and to investigate whether there is significant variation in mass losses of litter at different aspects and slope positions.

MATERIALS AND METHODS

Site description

This study was carried out in the Artvin province, north-east Turkey, (41° 51' N, 41° 06' E), a mountainous region with steep slopes (range from 30% to 65%) and high elevations (up to 3000m). In this province, *Picea orientalis* is dominant tree species followed by *Fagus orientalis*, *Abies nordmanniana* ssp. *nordmanniana*, *Pinus silvestris*, *Castenae sativa* and *Quercus* spp. The understory is generally occupied by grasses, ferns and broadleaf herbaceous plants during the growing season. During winter, the ground is often covered by snow, accumulating more heavily on the upper elevations, and reaching depths of up to 2 m.

The climate is generally characterized by cold winters and semi-arid summers. The mean annual precipitation (1948-2000) in lower elevations (Artvin meteorology station, at 597m) is 690 mm, with the highest amounts in January (99.7mm), and the lowest amount in August (27.1mm). Average monthly temperature ranges from 32 °C in August to -2.5 °C in January. However, the mean annual precipitation in higher elevations (Damar meteorology station in Borcka, at 1550 m) can reach over 1100 mm and the mean temperature can drop as low as -16.1 °C.

Sample preparation

Needle litter was sampled in September 2000 from five sites. In each site, three slope positions were selected at the top (1300m), middle (1000) and bottom (700m) on each aspect (30 sites in total). The north and east aspects had a slope of 50-55%, whereas the south and west aspects had a slope of 40-45 %. At all sites, the selected spruce trees were approximately 50-80 years old and 25-30 m high.

Freshly fallen needle litter was collected beneath five mature trees and bulked to form representative samples. Material showed no signs of discoloration or of obvious mycelial development at this stage. The samples were air-dried in the laboratory and then oven-dried at 40 °C for 48 h.

Field incubations

The five sampling sites had similar precipitation, aspect, hydrology and climate. Therefore, field decomposition experiment was only carried out at one site to determine rates of needle decomposition. The bags were 20 cm x 20 cm with a mesh size of 1.5 mm to allow for inclusion of mesofauna but exclusion of macrofaunal decomposers. About 3g of air-dried material was placed in each bag. Samples were also taken to determine a correction factor to calculate the initial oven dry mass of the material at 85 °C.

Litter-bags (three replicates, each) were numbered and fixed to the ground of the corresponding sites (north- *vs* south-facing, east- *vs* west-facing, three slope positions, each) with metal pegs. Three litter-bags were harvested from each site after 6, 12, 18 and 24 months of decomposition to follow the continuum of litter decay over time. Percentage loss of initial mass was calculated after drying samples at 85 °C. The Olson's equation ($\ln (X_t/X_o) = -kt$) was used to calculate the decay constant rate (k) of the given litter (Olson, 1963). Where X_o was the original mass of needle litter, X_t was the amount of needle litter remaining after time t, t was the time and k was the decay constant rate.

Statistical comparisons between sites were performed by analysis of variance (ANOVA) and one-way ANOVAs with Tukey's comparison of mean were used to determine significance in decay constant rates between aspects and between slope positions at $p<0,01$.

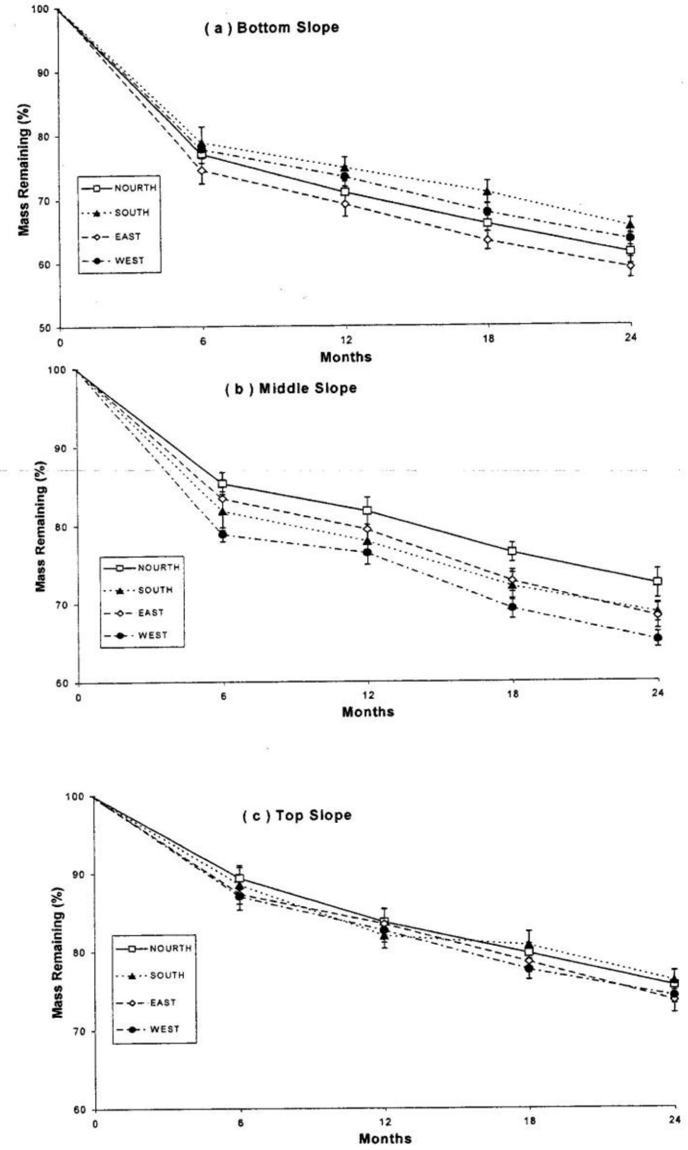

Fig.1: Mean mass remaining (± SE) of litter from the four aspect for the three slope positions

RESULTS

Decomposition on different aspect

The decay constant rates (k), obtained by an exponential decay function from Olson (1963) are given in Table 1. Mean mass losses at the bottom and middle slope positions showed significant differences between aspects, but showed contrasting pattern. For the bottom slopes, decomposition was higher on the north- and east-facing sites than on the south- and west-facing sites for all sampling intervals (Fig.1a). However, for the middle slopes, decomposition was slower on the north- and east-facing sites than on the south- and west-facing sites (Fig.1b). After 12 and 18 months, the differences between the four aspects were more marked than after 6 months (Fig.1). The top slope position, however, didn't show any significant differences in mass losses between aspects (Fig. 1c).

Decomposition at different slope positions on aspects

Mass losses on the three slope position for each aspect are shown in Fig. 2. Mass losses showed the same trends according to the slope position on each aspect. During the first decomposition period, litter mass losses were ranked in the slope position order bottom > middle >top on each aspect and were significantly different ($p<0.01$) between the slope positions. Decomposition was faster 23 % at the bottom slope than at the bottom (15%) and at the top slope (11%). The same trend in litter mass loss from bottom to top slope was also seen on the other three aspects, with higher mass losses at the bottom than at the middle and the top slope for all sampling intervals (Fig.2).

Table 1: and Results of analysis of variance (ANOVA) of decay constant rates (k) of *Picea orientalis* between slope positions and between aspects after 6, 12, 18 and 24 months of decay. All ANOVAs were significant at $p<0.01$. Tukey method of multiple pairwise comparisons at alpha=0.05 was used to determine significantly different means. Mean with the same letter are not significantly different by rows, (n=3).

		k			
Slope Position	Aspect	6	12	18	24
Top	North	$-0,049^{a}$	$-0,077^{a}$	$-0,099^{ab}$	$-0,122^{ab}$
	South	$-0,053^{a}$	$-0,087^{ab}$	$-0,093^{a}$	$-0,119^{a}$
	East	$-0,059^{a}$	$-0,079^{a}$	$-0,105^{ab}$	$-0,136^{ab}$
	West	$-0,061^{a}$	$-0,083^{a}$	$-0,110^{ab}$	$-0,130^{ab}$
Middle	North	$-0,066^{ab}$	$-0,088^{ab}$	$-0,117^{b}$	$-0,141^{b}$
	South	$-0,087^{cd}$	$-0,108^{cd}$	$-0,142^{c}$	$-0,163^{c}$
	East	$-0,079^{bc}$	$-0,100^{bc}$	$-0,138^{c}$	$-0,167^{cd}$
	West	$-0,103^{de}$	$-0,117^{de}$	$-0,160^{cd}$	$-0,186^{de}$
Bottom	North	$-0,114^{ef}$	$-0,149^{g}$	$-0,180^{ef}$	$-0,212^{fg}$
	South	$-0,103^{de}$	$-0,126^{ef}$	$-0,149^{cd}$	$-0,184^{de}$
	East	$-0,128^{f}$	$-0,160^{g}$	$-0,199^{f}$	$-0,229^{g}$
	West	$-0,109^{e}$	$-0,134^{f}$	$-0,169^{de}$	$-0,198^{ef}$

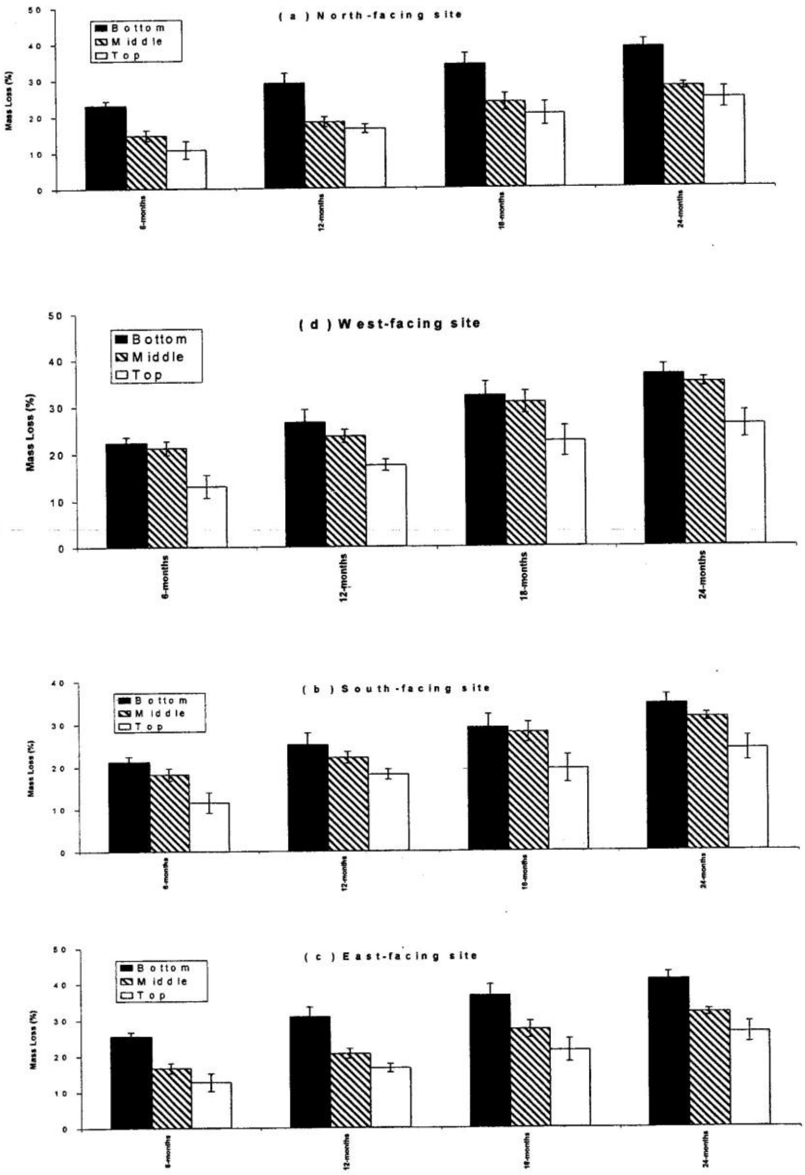

Fig.2: Mean percent weight losses of needle litter on the top, middle and bottom slope position for each aspect

DISCUSSION

The results in the present study provide evidence that slope positions and aspects significantly affect the decomposition rates of *Picea orientalis* needle litters. Differences in the decay rates of needle litters could be attributed to different physical climate (especially temperature and moisture), intra-specific variation in litter quality, decomposer communities and nutrient availability between aspects and slope positions. Climate sets the general limits of the litter decomposition process through physiological constraints on the activity of organisms while the chemical quality of the resource then defines the rates at which organisms can operate within these constraints (Couteaux et al., 1996). The interaction between climate and resource quality is therefore a key factor in regulating decomposition processes. Effect of these mechanisms on decay rates of needle litter has also been investigated but not completed yet, thus here we have just presented the evidence that there is significant variations in mass losses of *Picea orientalis* needles litters related to aspects and slope positions.

Spruce litter placed at the bottom slope position had higher mass loss than the same litters at the middle and top slope positions. The litters placed at the top slope position showed no significant variations in mass losses between aspects. However, at the bottom and middle slope position, the litters showed highly significant variations between aspects, but showed contrasting results.

Lower decomposition rate on the top slope positions in the present study seemed to be related to the higher elevation of the site (1800m). Winter rates of decomposition in temperate regions were often assumed to be negligible due to low temperature and loss of free water to ice (Schinner, 1983). From the beginning of this study to the last sampling the weather condition in the winter was quite harsh in Artvin. These cold weather conditions probably slowed down the microbial activity on the top slope and hence decay rates of the needle litters were the lowest compared to the middle and the bottom slopes. These results can also explain why the top slope position didn't show any significant differences in decay rates between aspects.

Mudrick et al., 1994 using three deciduous tree species showed that leaf litters placed at either bottom or top slope positions decomposed faster than the middle slope position. They related greater decomposition rates of the leaf litters to higher moisture content and stated that the middle slope positions was the driest site. Mudrick et al. (1994) found that decomposition was significantly more rapid on the north facing site than on the south facing site. The results from the bottom slope were similar to their results, with higher decomposition on north- and east-facing site than on the south- and west-facing site. However, the results from the middle slope showed the opposite trends, with higher decomposition on the south- and west-facing site than on the north- and east-facing site. The higher decomposition on the north- and east- facing site for the bottom slope could be explained by energy fluxes, generally the needle litter on the north and east-facing sites are moderately moisture, owing to the lower amounts of net radiation reaching the ground. This factor can facilitate the decomposition by providing a microclimate that encourages fungal and bacterial activity. However, for the middle slopes, the north and east-facing sites have more snow cover and less temperature than the south- and west-facing sites. These unfavourable conditions can negatively influence the microbial activity and numbers, and therefore results in low decomposition rates on the north- and east-facing sites compared to the south- and west-facing sites.

In conclusion, the results indicate that the slope position, slope aspect and its inclination can affect decay rates of litter. The main cause of different mass losses at different aspect and slope position will be more clear when we complete the remaining part of the study as the effects of slopes and aspects on variability in needle litter quality and environmental conditions.

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