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The influence of microtopography on forest patches behavior in mixed hardwood forests

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ABSTRACT

In temperate forests, small-scale disturbances resulting in single or multiple tree fall patches play an important role in driving stand dynamics. Many factors contribute to patch regime heterogeneity within and among forest stands, including wind and storms fire, site erosion and landslide, stand age, and stand composition. While there is evidence suggesting that topography can also affect patch formation, most studies have examined patches in steep terrain rather than in relatively level terrain such as temperate forests. This study examined the treefall patch regime among three microtopographical classes: ridge, slope, and bowl in a mixed hardwood forest in the Mazandaran of north Iran. The first hypothesis that the patch regime does not vary among microtopographical positions was tested. Using point sampling, microtopographic variation was estimated throughout the site. Line intersect sampling was used to select patches for measurement of patch frequency, area, fraction (percent cover) and abundance (density) within the study area. Patch area, frequency, fraction and abundance differed significantly among topoclasses. Ridges contained the highest patch area, frequency, fraction and highest abundance compared to slopes and bowls. Based on these findings, the first hypothesis was rejected and we concluded that microtopography affects at least some aspects of the patch regime in this mixed hardwood forest.

Keywords: Abundance, Disturbance, Fraction, Frequency, Line intersect.

INTRODUCTION

Usually inception of grand vicissitude in ecosystems with resumption disturbance. But whatever pragmatism, in forest ecosystems resumption disturbances is rare and more seem in small scale [32]. Forest dynamics are driven by rare but significant disturbance events such as wind and storms, fire, drought, flooding, land-slide and disease [4, 12, and 33].

Mixed hardwood forests in northern of Iran relict are into tertiary vertigo and reach climax avoid age glacial that is partial of temperate forests. Disturbances in temperate forests have been reviewed by Everham and Brokaw (1996) and Webb (1999), but few data are included from Iranian forests [10, and 31]. Disturbance takes a variety of forms and occurs at varying temporal and spatial scales. Basic element of disturbance in these forests similar another temperate forest is wind and storm [3] that causer hack into infrastructure patches and renowned micropatch regime [2]. Since the 1980s, these canopy patches have therefore been a major focus of forest ecologists, whose aim was to understand the functioning of forest ecosystems and to provide information useful for forest management. They studied not only herb layer response [6], environmental conditions [7, and 11] and effects on tree regeneration [28, and 35], but also disturbance patterns [19, and 22]. Falling of individual or group trees create patches in area that determined future composition of forest stand with adjustment microclimate position and accessible resource for recruitment.

Light availability is primarily affected by disturbances. Where large-scale disturbances are rare, the primary type of disturbance is the patch [20]. Patches are defined as any opening in the forest canopy. Patches can range in size from a few square meters to several hectares; however, patch researchers generally study areas of 10–1000 m^2 created by the death of a large limb or canopy (dominant) tree [21, and 34].

Small canopy openings often alter under story microclimate, leading to changes in forest structure and composition. It is generally accepted that physical changes in the under story (i.e., microclimatic) due to canopy removal drive changes in basic forest processes. Patches promote recruitment and growth of under story vegetation that may eventually become dominant trees by altering the availability of resources, including light levels, soil moisture, and nutrients [11]. The availability of these resources, and consequently species survival and vegetative growth, is a function of patch characteristics, including area, orientation, and shape [18]. Environmental variables vary significantly among individual patches, even among those in the same forest stand, contributing to diversity in canopy replacement species. The general features of patches in a forest, including shape, orientation, spatial relations among patches, patch area, patch fraction (percent of forest under patches), patch closure rate, and patch abundance (number of patches per unit area) describe the overall patch regime. Understanding the patch regime is a crucial step in outlining the importance of patches in a forest [15, and 27] and helps to determine the composition of the future canopy.

The patch regime is affected by weather patterns, topography, disease, pests, and physiological characteristics of common tree species [30]. These variables can either directly or indirectly affect patch formation. For example, topography affects wind patterns and stability of the soil all of which are direct patch-causing agents. Indirectly, topography changes local resource availability and hence the local species composition. Different species grow to different sizes and mature at different rates, thus affecting the patch regime. Several researchers have examined the effects of topography on a patch regime [5, 13, 15, and 17]; however, patch formation has not been examined relative to a micro topographical scale. This study investigated relationships between micro topography and several patch regime characteristics, including fraction, abundance, area, and frequency, in Iranian Mixed hardwood forest.

MATERIALS AND METHODS

Study Area

The study site is located in, approximately 80 km of Chaloos, Iran northern that Virgin forest namely Lalis (36° 29′ and 36° 32′ Latitudinal- 51° 23′ and 51° 28′ Alitudinal). It is a 60 ha Fagus mixed forest stand (old growth) in intermediate elevation within hard wood Forest, that do not any cutting sometime. The climate at mixed hardwood forest is humid subtropical, with average temperatures ranging from 32.2 °C to 0 °C, and rainfall totaling 800-1000 mm annually. Common tree species include beech (*Fagus orientalis*), maple (*Acer velutinum*, and *Acer cappadocicum*), alder (*Alnus subcordata*), elm (*Ulmus glabra*), hornbeam (*Carpinus betulus*), ash (*Fraxinus excelsior*), and iron wood (*Parrotia persica*).

Research Method

The line intersect method was used to sample treefall patches at Mixed hardwood forest [24]. With this technique, random transects with no width are laid throughout a site and any patches intersected by transects are sampled. For this study, four parallel, randomly placed transects were established through the research stand. These transect varied in length from 1050 to 1060 m. Transects were spaced at least 50 m apart to prevent sampling the same patch with separate transects [25].

Patches were defined as any opening caused by the death of approximately 1/2–10 canopy trees. In general, patches can be delineated in two ways: canopy patches and expanded patches [21]. Canopy patches include only the ground area where there is no canopy leaf cover, while the expanded patch area is measured to the tree boles that surround the patch (a portion is under the canopy). Patches that had canopy openings smaller than 25 m^2 were not included in this study for two reasons: (1) small patches generally close from lateral expansion of surrounding tree branches, and (2) small patches are difficult to detect and are only ambiguously included in most patch definitions [5]. A canopy patch was considered closed when trees within the patch reached two-thirds the height of surrounding trees. In addition, only canopy patches in the dominant canopy were sampled; those with just mid-story openings were not considered. The definition of a canopy patch was important for determining if an open area would be sampled. Once we concluded that an area was a patch, we identified the surrounding perimeter tree boles to determine the boundaries of the expanded patch. To be included as part of the expanded patch boundary, all perimeter trees had to be dominant; no mid-story trees (especially ironwood) were identified as perimeter trees. Additionally, the patch perimeter had to be contiguous, with the ‘‘canopy connection’’ distance between perimeter tree crowns not greater than 3 m. The patch was sampled if any of the four transects crossed within the area of the expanded patch.

The expanded patch was used for all patch characterizations, including area, fraction, frequency, and abundance measurements. The expanded patch covers a larger area than the canopy patch, but more closely resembles the patch where under story vegetation is released from suppression, especially in middle and high latitudes where solar angles allow light penetration beyond the canopy patch area [1, and 29].

The length of each transect was determined using a cloth tape. From these values the ratio of each topoclass within each transect and the sum of all transect lengths were calculated. If 30 elevation points were sampled along a transect, that transect’s length is 600 m (20m×30 points). If 10 of the points were classified as ‘‘bowl’’, then 33% of the transect length, or 200 m, was assumed to lie in bowls.

Each patch was classified as ridge, slope, or bowl and based upon the class of the nearest transect elevation point to the mathematical center of the patch. Two characteristics of the patch regime, fraction and abundance, were calculated from the line intersect sampling. Patch fraction is the sum of all forest area under patches at any one time, expressed as a percent of the total area. The patch fraction for each transect was calculated using:

$$F = \frac{1}{L}\sum_{j=1}^{n}\frac{Aj}{dj} \qquad (1)$$

Where F is the patch fraction, L the total length of one transect, n the number of patches intersected by a transect, Aj the area of the jth patch, and dj the effective diameter of the jth patch [15, and 24]. The effective diameter is included to eliminate the bias caused by the higher probability of a transect intersecting a large patch versus a small patch. It is calculated using [15]:

$$d = \frac{convex\ perimeter}{\pi} \qquad (2)$$

The convex perimeter is the smallest convex cover of the patch polygon (Fig. 2). By substituting the length of the transect (L) with the length of the transect within a specific topo-class, and the number of patches on the transect (n) with the number of patches in a respective class on the transect, the patch fraction for any topoclass can be calculated.

The second characteristic calculated from line intersect sampling is patch abundance, which indicates the number of patches per unit area of forest. It was calculated using:

$$AB = \frac{1}{L}\sum_{j=1}^{n}\frac{1}{dj} \qquad (3)$$

Where AB is the patch abundance, L the length of a single transect, n the number of patches intersected, and dj the effective diameter of the jth patch (DeVries, 1986; Battles et al., 1996). The patch abundance for each transect in ridges, slopes, and bowls was determined by letting L equal the length of the transect within the respective topo-class and n equal the number of patches found in that class along the transect.

After the patch fraction and abundance were determined for each topo-class on each transect, the overall fraction and abundance for the entire site was estimated. Because transect lengths varied, a weighted mean was calculated using [24]:

$$Xw = \frac{\sum_{j=1}^{n} LjXj}{\sum_{j=1}^{n} Lj} \qquad (4)$$

Where Xw is the weighted mean for patch fraction or patch abundance, n the number of transects (which always equals 9 for this study), Lj the length of the jth transect, and Xj the patch fraction or abundance for a topo-class on the jth transect. The variance of the weighted mean is calculated using [24]:

$$V = \frac{\sum_{j=1}^{n} Lj\left(Xj - Xw\right)^2}{\left(n-1\right)\sum_{j=1}^{n} Lj} \qquad (5)$$

Where V is the variance of the weighted mean, n the number of transects, Lj the length of the jth transect, and Xj the fraction or abundance of patches located on the jth transect.

RESULTS

In all, there were 4.11 km of transects established at Mixed hardwood forest. The difference between the highest and lowest elevations, based on 59 samples, was 95 m. Using the method illustrated in Fig. 3, the length of each transects on ridges, slopes, or bowls was determined. A total of 26.07% of the length of all transects occurred on ridges; 59.39% occurred on slopes; and 14.5% occurred in bowls (Table 1).

Table 1. Length of transects at Mixed hardwood forest and percent of each transect on ridges, slopes, and bowls

Transect No.	Length (m)	% on ridges	% on slopes	% in bowls
1	1000	33.7	52.2	13.9
2	1050	24.4	51.4	24.1
3	1060	26.4	66.1	7.5
4	1000	19.7	67.7	12.5
Total for site*	4110	26	59.4	14.5

**For ridges, slopes, and bowls, the sum of transect lengths in a topo-class divided by the total length of all transects.*

Fifty-nine expanded patches were sampled along the four transects at Forest mixed forest. Expanded patch areas ranged from 78 to 1600 m2, and the total of all expanded patches in the study area was approximately 2.61 ha. Mean patch area differ significantly among topo-classes (Table 2), the frequency of patches significantly vary among topo-classes and high frequency pertain to ridge.

Table 2. Summary statistics for patch frequency and patch area at Mixed hardwood forest [a]

Topo-class	Patch frequency (chi-square test)[b]		Patch area (GLM)	
	Expected No. of patches [c]	Actual No. of patches	Mean area (m^2)	Std Error of Mean (m^2)
Ridge	15.34	25	694.9	74.75
Slope	35.05	20	261.12	48.82
Bowl	8.55	14	200.78	28.76
Entire site	59	59	385.60	72.14

[a] Differences among patch frequencies were tested using the chi-square test, which compares the actual number of patches to the proportionally expected number of patches. Patch areas were tested using GLM.
[b] P< 0.005
[c] Based on the proportion of transects length in each topo-class.

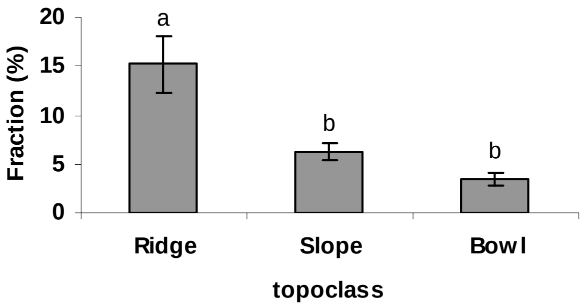
Table 3. Analysis Variance for patch properties in several topoclasses

Variable		Sum of Squares	df	Mean of squares	F-Statistic	Sig.
Fraction	Transect	28	3	9.33	0.65 ns	0.613
	Topo-class	302.17	2	151.08	10.48 *	0.011
	Error	86.5	6	14.42	-	-
Abundance	Transect	3.04	3	1.01	1.52 ns	0.302
	Topo-class	8.47	2	4.23	6.35 *	0.033
	Error	4.002	6	0.67	-	-

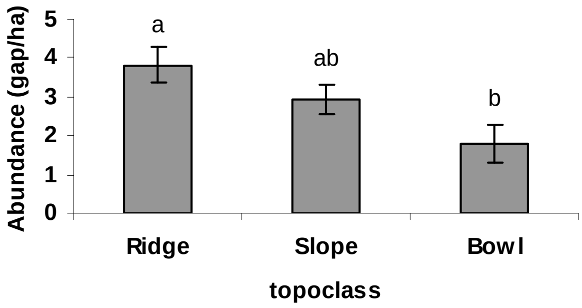
*Ns: No Significant; *: in 0.05 Significant*

We found that the weighted mean patch fraction for the four transects at mixed hardwood forest was 25% (using Eq. (4)). The weighted mean fraction for ridges, slopes and bowls was 15.25, 6.25, and 3.5%, respectively (Table 3, Figure 1). The weighted mean patch abundance for the four transects at Mixed hardwood forest was 7.5 patches/ha. Patches were most abundant on ridges, where the density was 3.8 patches/ha. Patch abundance was 2.9 patches/ha on slopes and

1.7 patches/ha in bowls. Hence, the mean value of frequency, fraction and abundance was significantly outranked in ridge topoclass (Table 3, Figure 1).



(a)



(b)

Figure 1. Fraction (a) and Abundance (b) in topoclass

DISCUSSION

Due to few large-scale disturbances, the treefall patch is the primary mode for regeneration and canopy replacement in forests where large-scale disturbances are infrequent [20]. Patch characteristic values at our site compare well with values in other forests where small-scale disturbances are dominant [26]. This indicates that patches potentially play an important role in disturbance and succession at mixed hardwood forest.

Many researchers have examined the effects of topography on disturbance patterns, including Battles et al. (1995), Bergeron and Brisson (1990), Hunter and Parker (1993), and Worrall and Harrington (1988) [13, 16, 17, and 37]. They found that disturbances often varied significantly with topography, especially in areas with steep elevation gradients. Temperate forest, like most mixed hardwood forest, has only small-scale topographic variation. However, it is widely recognized that the microtopography in Temperate forests affects many features of the stand, including windstorm, hydrology, soil properties, and species composition [9, 14, and 23].

This study presents some evidence refuting the first hypothesis that patch regime characteristics do not change along a microtopographical gradient in a mixed hardwood forest. Two variables patch area and patch frequency, did not significantly vary among topo-classes at mixed hardwood forest. However, patch fraction and patch abundance, which are meaningful characteristics because they incorporate the length of each sampling transect, varied significantly with microtopography. Patch fraction is higher on ridges and bowls than on slopes, and patch abundance is greater on ridges than on slopes or in bowls. These results are reasonable considering the effects that microtopography has on mixed hardwood forest dynamics, and evidence from other research that topography in general can alter disturbance patterns.

Microtopography could potentially affect the patch regime in several ways. Hunter and Parker (1993) suggest that topographic features related to the patch regime both directly and indirectly [13]. For example, steep terrain directly causes slope failures that create patches; indirectly, topography influences air movement that could make some sites more susceptible to high wind and blowdowns. With attention to landform differences values of wind storm. The study site on location in high elevation always is open in local and state windstorm. The ridge topoclass more than other topoclasses open direct windstorm. The windthrow is biggest factor for creation of patch in temperate ecosystem [3], especially in northern forest, Iran. Hence, that is importance, transcend of area, frequency, fraction and abundance in ridge topoclass. Edaphic qualification among factor that impressionable by topographic factors. Transmission Process of nutrient and water elements do in ridge and slope topoclass rather into flat and bowl surface. The soil of ridge by erosion process launder and sediment delivery in low surface. This reflex causer decrease of soil depth in ridge that can conjugate with peer of mother stone. Occurrence of this process decreases vigor of trees for environmental position similar windstorm and snow.

There are two additional possible explanations for observed differences: shallow root systems caused by a high water table, and growth pattern variability that reflects the different tree communities found on each topographical position. The first explanation, shallow root systems, would be indicated by higher patch frequency, fraction, and abundance values in bowls than on slopes and ridges. This was not the case at the mixed hardwood forest stand; thus, shallow roots were probably not the primary cause for variation in the patch regime.

The second reason, growth pattern variability, is likely the primary factor of patch regime differences at mixed hardwood forest. While almost all of the trees in the stand were roughly the unaged, dissimilarity in life-spans, root stability, disease susceptibility, and tolerance to windstorm may cause differences in patch patterning among species. This study did not attempt to determine the species of patch maker or species composition adjacent to patches. It was observed that tree species composition varied among ridges, slopes, and bowls at our study site, which agrees with the well-established relationship between microtopography and mixed hardwood forest tree composition [8, and 36]. However, further research is needed at temperate Forest to determine if species composition is a factor in patch characteristic variability. If it is a factor, then patch pattern differences would become apparent among microtopographical classes as species composition changed.

While the cause of patch regime variability is not yet known, this study showed that Mixed hardwood forest have diverse patch characteristics among microtopographical features. This abundance, seedlings growing in low sites will have more difficulty reaching the canopy than those on ridges. Availability caused by smaller patch fraction and this has implications for Mixed hardwood forests relationships between light and water, and is an important step toward further understanding seedling recruitment and regeneration.

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