Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 31, No. 1, pp. 7-13, February, 2015
http://dx.doi.org/10.7747/JFES.2015.31.1.7

JFES
Journal of Forest and Environmental Science

Composition and Structure of Himalayan Oak (*Quercus leucotrichophora* A. Camus) Forest under Various Degrees of Disturbance

Sunil Prasad[1]*, Pooja Uniyal[2] and D. S. Chauhan[2]
[1]*Centre for Ecology Development and Research (CEDAR), Dehradun, Uttarakhand*
[2]*Department of Forestry, H.N.B. Garhwal University Srinagar Garhwal, Uttarakhand.*

Abstract

Forest disturbance sometime considered as a tool of management as it believed that mid level disturbance constructs better micro-climatic conditions which ultimately boost up the plant diversity. The effect of different levels of disturbance on species composition and regeneration is very important. Present attempt was carried out in a temperate evergreen oak forest which was under various degree of disturbance. The study area is one of the large ranges of oak forest in Garhwal Himalaya and compensating various types of daily needs of local people. On the basis of IVI values *Quercus leucotrichophora* holds first position in all the disturbance zones whereas *Myrica esculenta* upgraded it's rank in highly disturbed zone and showed less impacted species by disturbance. *Berberis aristata* and *Eupatorium adenophorum* in shrub layer and *Anaphalis adnata* and *Bidens pilosa* in herb layer were found as disturbance friendly species because they attained higher rank in highly disturbed zone whereas *Caryopteris foetida* was found disturbance-sensitive in shrub layer. The banj oak regenerated well under mid disturbance as compared to no and high degree of disturbance and a sharp downfall in the species diversity was recorded with increasing magnitude of disturbance. Density-diameter curves showed a reverse trend of lower density in higher girth classes. The results of the study should be useful for the forest management strategies.

Key Words: disturbance, diversity, himalaya, *Quercus leucotrichophora*, temperate

Introduction

Biological diversity is essential for human survival and economic well-being (Sagar et al. 2003) and the loss of biological diversity is perhaps the most crucial concern for human survival as it influences all ecological services and livelihoods (Sapkota et al. 2010). Most of the tropical forests have enjoyed special attention due to high floral and faunal diversity, fragility of their structure and function as well as provision of forest products and ecosystem services (Menon and Bawa 1997). It resulted into little attention to the temperate ecosystem as a whole. The recurrent interventions into the forest communities for large-scale collection of fuel wood and minor forest products and the practices of grazing and trampling may alter the habitat of many species (Westman 1990) therefore, many time the structure of plant and animal communities in many natural ecosystems is largely determined by the disturbances, which occur quite frequently (White 1979; Vogl 1980; Armeston and Pickett 1985). Himalayan region facing chronic form of

Received: October 30, 2013. Revised: May 11, 2014. Accepted: February 4, 2015.

Corresponding author: Sunil Prasad
Centre for Ecology Development and Research (CEDAR), Dehradun, Uttarakhand
Tel: 91-8958646078, Fax: 91-8958646078, E-mail: bhatt.sunil.for@gmail.com

disturbance in which people remove only a small fraction of forest biomass in the form of grazing, lopping, surface burning and litter removal at a given time and plants or ecosystems often do not get time to recover adequately because the human onslaught never stops (Singh1998). Although such chronic form of disturbance has negative impacts on plant communities but sometime it acts as a positive force that might increase species diversity in the community by minimizing competition among species. Therefore, a better understanding of interactions between spatial pattern and disturbance is needed (Robert and Gilliam 1995).

Quercus is a broad-leaved genus of family Fagaceae and has many superior characteristics for its wide acceptance as fuel, timber and nutritious fodder across the Himalaya (Osmoston 1927). These broad-leaved forests of *Quercus* are considered to provide the most effective water and soil conservation (Saxena and Singh 1982). Owing to multifarious nature of this genus, most of the species are over-exploited for various purposes. Among these species, *Quercus leucotrichophora* is worst affected one (Pandey and Shukla 2001; Saxena and Singh 1982). In Garhwal Himalaya major portion of oak forests is owned by the local inhabitants of hilly areas; therefore, nature and frequency of disturbance are under explored. Under this study, we used several disturbance indicators to quantify the intensity of disturbance e.g. tree density, canopy cover, light interception, number of cut stumps has also been used by earlier workers viz. Mishra et al. 2004; Pandey and Shukla 1999; Rao et al. 1990 etc. Keeping in view the vulnerability and significance of oak species, present study aims to investigate how the community composition, species diversity and tree population structure behave under different degree of disturbance.

Materials and Methods

Study area

The present study was conducted in Diwalikhal oak forest, district Chamoli, Uttarakhand-India. It is located between 30^{o} 06' 22.8"N to 30^{o} 08' 17.1"N latitude and 79^{o} 14' 30.4"E to 79^{o} 16' 48.4"E longitude. The whole forest area represents north-facing aspect, steep or partially steep and stretches between 1,500 to 2,100 m masl elevation ranges. Climate of the area very largely depend on altitude. The winter season is from about mid November to March. As most of the region is situated on the southern slopes of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the monsoon from June to September. The highest temperature was 34 degree Celsius and lowest 0 degree Celsius. January is the coldest month after which the temperature begins to rise till June or July. The tract of Chamoli district consists of outward succession of ridges viz; Greater Himalaya and Lesser Himalaya of decreasing height. These hills posses very little level land and he soils have developed from rocks like granite, schist, gneiss, phyllites, shales, slate etc. under cool and moist climate.

Disturbance classification

Disturbance has been measured in terms of percent of canopy cover, lopping (%), tree density, and number of cut stumps. Canopy cover was measured directly by spherical Densitometer. Lopping percentage was calculated as Lopping %=Total number of lopped trees in sample plot/ Density x100. Counting of cut stumps was carried out by direct count from forest floor. By using maximum and minimum values of above said indicators we considered undisturbed forest zone as >1,200 trees ha^{-1}, >70% canopy cover, <10% lopping and <20 cut stumps ha^{-1}, highly disturbed as <500 trees ha^{-1}, <30% canopy cover, >40% lopping, >75 cut stumps ha^{-1}. The moderately disturbed zone occupied the intermediate position with respect to these parameters. By using these values, the whole study area was divided into three disturbance zones i.e. undisturbed, moderately disturbed and highly disturbed.

Field sampling

To analyze the plant diversity, baseline vegetation survey was conducted by using transect sampling method. Two vertical transects of 100 m width were used under this survey. These transects were spatially distributed to minimize the autocorrelation among the vegetation. In each transect, twenty sample plots/quadrats of (10x10 m=100 m^2) at 100 m intervals were laid down randomly for recording occurrence of different species. Number and circumference at breast height (1.37 m) of the tree species individuals were measured individually and species-wise. Two Sample plots or quadrates (2x5 m=10 m^2) which were

nested within 100 m^2 plot were used for shrubs & saplings and five 1 m^2 (1x1 m=1 m^2) sample plots which were also nested within 100 m^2 were used to enumerate herbs and seedlings.

Analysis of data

Individuals having >31.5 cm circumference at breast height (1.37 m) considered as tree and <10.5 cm circumference at breast height were considered as seedling whereas intermediate position between tree and seedling with respect to these circumferences was considered as sapling (Knight 1963). Tree individuals were classified into four diameter classes viz. 31～50, 51～70, 71～90 and >90 cm to understand the population structure. Density, frequency, abundance and basal cover of all the species determined as per Mishra (1968). The Important Value Index (IVI) for

Table 1. Density and importance value index (IVI) of different species under different levels of disturbance

Species	Undisturbed		Moderately disturbed		Highly disturbed	
	Density	IVI*	Density	IVI*	Density	IVI*
Tree (Density: trees/ha)						
Quercus leucotrichophora	980.0	167.1	750.0	175.2	580.0	186.2
Benthamedia capitata	26.7	8.8	-	-	-	-
Lindera pulcherrima	6.7	2.3	60.0	20.8	10.0	6.2
Lyonia ovalifolia	153.3	36.9	130.0	33.0	50.0	24.3
Myrica esculenta	106.7	26.0	60.0	18.3	50.0	27.5
Neolitsea pallens	6.7	2.3	30.0	7.8		
Pinus roburghii	-	-	-	-	10.0	6.2
Pyrus pashia	33.3	11.3	-	-	30.0	16.9
Quercus floribunda	-	-	20.0	7.2	-	-
Rhododendron arboreum	160.0	45.3	70.0	21.9	60.0	32.8
Sorbus aucuparia	-	-	60.0	15.8	-	-
Total	1,473.4		1,180.0		790.0	
Shrub (Density: Plants/ha)						
Artemisia roxburghiana	-	-	-	-	167	4.1
Asparegus racemosus	167	3.5				
Asparegus spp	111	2.8	-	-	-	-
Berberis aristata	1,444	35.5	667	26.2	1,250	29.9
Boenninghausenia albiflora	-	-	167	5.2	333	10.3
Caryopteris foetida	1,944	41.3	250	9.1	1,000	18.5
Colebrookia oppositifolia	-	-	-	-	917	23.7
Daphne papyracea	667	15.5	167	7.9	750	19.6
Daphne spp	56	2.2				
Eupatorium adenophorum	333	8.5	2,333	44.4	1,333	24.7
Indigofera atropurpurea	56	2.2	333	10.3	83	3.1
Inula cuspidate	278	6.3	-	-	-	-
Leptodermis lanceolata	889	16.6	333	10.3	167	6.2
Myrisine Africana	833	20.6	1,583	47.6	917	21.6
Pyracantha crenulata	444	11.4	333	10.3		
Rhus parviflora	56	2.2	-	-	167	6.2
Rosa macrophylla	-	-	250	11.9	417	13.4
Rubus ellipticus	444	11.4	250	6.3	167	6.2
Rubus foliolosus	278	6.3	333	10.3	250	7.2
Sinarundinaria falcate	333	8.5	-	-	250	5.1
Viburnum erubescens	167	5	-	-	-	-
Total	8,500		6,999		8,168	

different species was calculated as sum of relative frequency, relative density and relative basal cover of each species. The dominance (C) for each community was calculated by Simpson's index, $C=\sum pi^2$, (Simpson 1949) and diversity by Shannon's index, $H=-\sum$ pi ln pi (Shannon and Wiener 1963). Here pi represents the proportional abundance of i^{th} species in any given stand. Species diversity indices were calculated using the Biodiversity-Professional version II-1997 software.

Results

Floristic composition of all three disturbance zones is given in Table 1. *Benthamedia capitata*, *Crotolaria albida*, *Asparegus spp*, *Viburnum erubescens*, and *Valeriana jatamansii* were found only in undisturbed zone whereas species like *Pinus roxburghii*, *Artemisia roxburghiana*, and *Colebrookia oppositifolia*, were recorded only in highly disturbed zone. The top canopy layer (tree) was mainly composed of *Quercus leucotrichophora*, *Rhododendron arboreum*, *Lyonia ovalifolia* and *Myrica esculenta*. It was interesting to see that all the top canopy species lost their density with increasing the intensity of disturbance except *Lindera pulcherria* and *Neolitsa pallens*. Sub-canopy (shrub layer) was dominated by *Caryopteris foetida*, *Berbaris aristata* and *Myrisine africana* in the undisturbed stand, whereas the dominant species recorded in moderately disturbed stand were *Myricine africana* and *Berbaris aristata*. *Caryopteris foetida* was found dominant in the highly disturbed stand. *Q. leucotrichophora* was found first in species ranking in all disturbance categories whereas *Myrica esculenta* found in better position in highly disturbed zone (Table 2). *Caryopteris foetida* lost their top rank in disturbed zones while *Berbaris aristata* got better rank (Ist) in highly disturbed zone (Table 2).

As far as the seedling and sapling density was concerned, *Q. leocotrichophora* was the dominant species in both seedling and sapling stages in all disturbance zones. *Rhododendron arboreum*, *Lyonia ovalifolia* in seedling stage and *Rhododendron*

Table 1. Continued

Species	Undisturbed		Moderately disturbed		Highly disturbed	
	Density	IVI*	Density	IVI*	Density	IVI*
Herb (Density: Plants/ha)						
Achyranthes aspera	75.6	7	53.3	5.7	63.3	6.5
Ainsliaea latifolia	88.9	8	70	8.6	33.3	4
Anaphalis adnata	104.4	10.1	106.7	13.5	123.3	19.5
Andropogon munroi	388.9	37.6	336.7	26.8	200	24.2
Aster peduncularis	-	-	46.7	5	-	-
Bidens pilosa	75.6	6.6	103.3	14.4	90	8.7
Carex caricina	17.8	2.1	50	5.2	46.7	6.1
Chrysopogon gryllus	-	-	133.3	9.9	-	-
Crotolaria albida	15.6	1.6	-	-	-	-
Cynadon dactylon	448.9	40.4	340	26.9	586.7	42.9
Cyprus niveus	24.4	2.4	46.7	3.7	36.7	4.2
Fragaria nubicola	120	13.4	123.3	15	86.7	9.5
Galium asperifolium	82.2	6.5	66.7	10.2	76.7	7.6
Herteropogon contortus	426.7	39	416.7	29.9	433.3	35.5
Micromaria biflora	-	-	-	-	123.3	12.7
Potentilla gerardiana	111.1	12.5	66.7	11.2	-	-
Reinwardtia indica	51.1	5	-	-	113.3	13.2
Senecio nudicaulis	57.8	4.9	33.3	2.7	50	5.3
Valeriana jatamansii	26.7	3	-	-	-	-
Total	2,115.7		1,993.4		2,063.3	

*In case of shrubs and herbs, IVI is calculated by summing Relative Density and Relative Frequency.

arboreum and *Myrica esculenta* in sapling stage were found in good numbers in undisturbed zone along with *Q. leucotrichophora*. The seedlings of *Lyonia ovalifolia* and *Rhus punjabensis* and saplings of *Myrica esculanta* and *Sorbus aucuparia* were highest in moderately disturbed zone, while seedlings of *R. arboreum* and *Lyonia ovalifolia* and saplings of *R. arboreum* were found highest in highly disturbed zone (Table 3).

Table 2. Change in top five species ranking (on the basis of IVI values) of dominant species under different levels of disturbance

Species	Undisturbed	Moderately disturbed	Highly disturbed
Tree			
Quercus leucotrichophora	1	1	1
Rhododendron arboreum	2	3	2
Lyonia ovalifolia	3	2	4
Myrica esculenta	4	5	3
Pyrus phasia	5	-	5
Lindera pulcherrima	-	4	-
Shrub			
Berberis aristata	2	3	1
Daphne papyracea	5	-	5
Myrisine Africana	3	1	4
Caryopteris foetida	1	-	-
Leptodermis lanceolata	4	-	-
Eupatorium adenophorum	-	2	2
Rubus foliolosus	-	5	-
Rosa macrophylla	-	4	-
Colebrookia oppositifolia	-	-	3
Herb			
Andropogon munroi	3	3	3
Herteropogon contortus	2	1	2
Cynadon dactylon	1	2	1
Anaphalis adnata	-	-	4
Fragaria nubicola	4	4	-
Potentilla gerardiana	5	-	-
Reinwardtia indica	-	-	5
Bidens pilosa	-	5	-

Diversity

Shannon Diversity Index decreased with the increasing magnitude of disturbance in tree species. It was recorded 0.633 for undisturbed, 0.593 for moderately disturbed and 0.517 for highly disturbed zones. Similar trend was recorded in shrubs and herbs species for this index. On the other hand, Simpson Dominance Index was recorded increasing with increasing level of disturbance in all three layers of vegetation and ranged between 0.400 to 0.549, 0.238 to 0.101 and 0.124 to 0.163 for trees, shrubs and herbs respectively (Table 4).

Density-diameter distribution

The density-diameter distribution is directly correlated with age-structure of the stand. Density of higher diameter classes was found low in all the three disturbance zones (Fig. 1). Moderately disturbed zone showed a slight increment in last diameter class (>90 cm) than previous diameter class (71～90 cm). The density of first diameter class (31 to 50) deceased with increasing intensity of disturbance and slight downfall in density was found in the second diameter class (51 to 70) from undisturbed to moderately disturbed but it was found more or less similar in moder-

Table 3. Density of seedling and sapling (ha) under different levels of disturbance

Species	Undisturbed		Moderately disturbed		Highly disturbed	
	Seedling	Sapling	Seedling	Sapling	Seedling	Sapling
Quercus leucotrichophora	666.71	152.39	1,000	185.71	304.86	96.43
Rhododendron arboreum	476.14	66.67	142.86	28.57	283.86	64.71
Lyonia ovalifolia	347.86	38.1	285.71	28.57	93.86	49.29
Myrica esculenta	334.71	76.19	142.86	71.43	93.43	34.71
Sorbus aucuparia	285.71	19.04		57.14	81	
Lindera pulcherrima	95.29		142.86	28.57	80.57	
Banthmidia capitata	381		285.71	42.86	65.57	
Pyrus phasia	190.43	66.67	142.86	28.57	63.43	26.71
Rhus punjabenansis			285.71			
Total	2,777.86	419.06	2,428.57	471.43	1,066.57	271.86

ately and highly disturbed zones. Third diameter class (71 to 90) exhibited similar density in undisturbed and highly disturbed stands while moderately disturbed stand showed highest density for this class. As far as the fourth diameter class (>90) is concerned, the highest density was recorded in moderately disturbed zone followed by undisturbed and highly disturbed zones (Fig. 1).

Discussion

In the present study, we found decrease in total number of species along the disturbance in case of tree and herb may reflect high exploitation pressure (Sagar et al. 2003). Presence of *Asparegus spp*, *Viburnum erubescens*, and *Valeriana jatamansii* only in undisturbed zone showed the vulnerability of these species towards disturbance. The pressure on these species in study area might be due to their medicinal properties. *Pinus roxburghii* was only recorded in the highly disturbed zone which advocated that disturbance promotes the invasion of pine in oak zone. The biotic stress exerted by hill population in relation to oak species has encouraged the expansion of *Pinus roxburghii* (chir pine) in various ways (Saxena et al. 1984).

Quercus leucotrichophora showed it's supreme importance in all the disturbance zones which reflects its strong ecological strength in it's pure stand. Species like *Myrica esculenta* gained its rank in highly disturbed zone which showed a minimum disturbance pressure on it. The reason of this low pressure is the protection of the plant as it is an economically potential wild fruit's plant. Many shrub species like *Myricine africana*, *Berbaris aristata* and *Caryopteris foetida* performed better in disturbed zone which might be the result of better microclimatic condition created by the disturbance on forest floor which suited to shrub flora. Regeneration status (seedling and sapling density) of *Quercus leucotrichophora* was found highest in moderately disturbed zone which indicating that the regeneration is triggering by mild disturbance. Thadani and Ashton (1995) also concluded that moderate disturbance appears to benefit regeneration. The density of higher dbh (diameter at breast height) classes was found low in all three disturbance zones showed uneven aged forest stand (Schmelz and Lindsey 1965). It also indicates the selective felling of individuals of higher girth classes in the study area where

Table 4. Species diversity and dominance under different levels of disturbance

	Undisturbed	Moderately disturbed	Highly disturbed
Tree			
Shannon index	1.633	1.593	1.517
Simpson index	0.400	0.423	0.549
Shrub			
Shannon index	1.894	1.858	1.794
Simpson index	0.238	0.102	0.101
Herb			
Shannon index	1.879	1.860	1.849
Simpson index	0.124	0.113	0.163

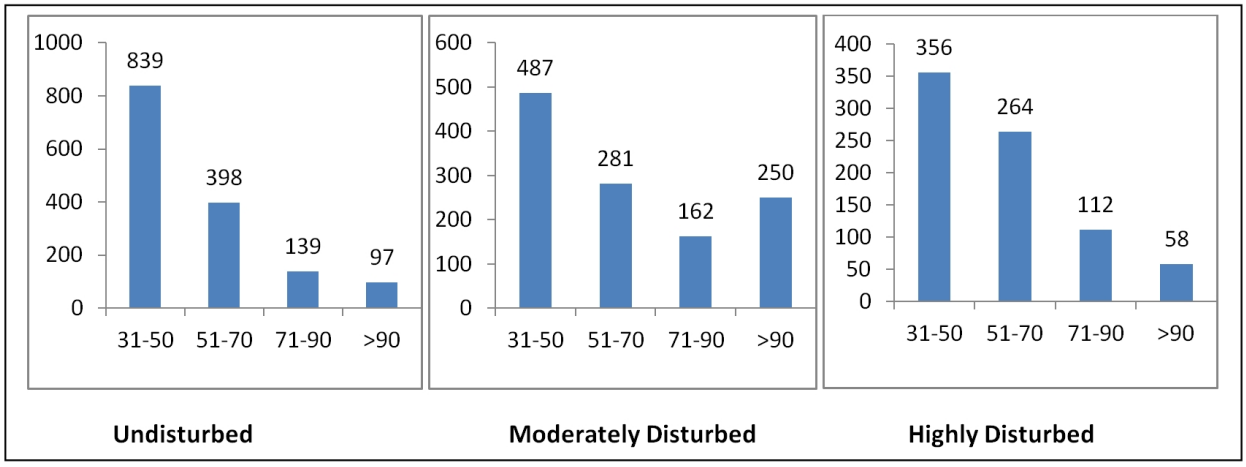

Fig. 1. Density-Diameter distribution under different degree of disturbance (Density=individuals/ha, Diameter= Cm).

people often cut mature trees for fuel-wood during various ceremonies. Moreover, over aged tree exhibited less resistant against diseases. The study also illustrated that Shannon Diversity of tree, shrub and herb decline while dominance increases along disturbance which is already confirmed by Sapkota et al. (2010).

The study revealed a clear relationship between disturbance and plant community with negative and positive collisions. Thus, there is an urgent need to evaluate the level of disturbance at which we can permit the removal of forest resources without losing ecosystem health.

Acknowledgement

Authors greatly acknowledge the financial assistance received from Ministry of Environment and Forests, Government of India, New Delhi.

References

Knight DH. 1963. A distance method for constructing forest profile diagrams and obtaining structural data. Tropical Ecology 4: 89-94.

Menon S, Bawa KS. 1997. Applications of Geographic Information Systems (GIS), remote-sensing, and a landscape ecology approach to biodiversity conservation in the Western Ghats. Current Science 73: 134-145.

Mishra BP, Tripathi OP, Tripathi RS, Pandey HN. 2004. Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. Biodiversity and Conservation 13: 421-436.

Mishra R. 1968. Ecology work book. Oxford and IBM publishing Co. Calcutta, pp 244.

Osmaston AE. 1927. A forest flora of Kumaun. Govt Press Allahabad, United Province, pp 605.

Pandey SK, Shukla RP. 2001. Regeneration strategy and plant diversity status in degraded sal forests. Current Science 81: 95-102.

Pimm SL, Russell GJ, Gittleman JL, Brooks TM. 1995. The future of biodiversity. Science 269: 347-350.

Rao P, Barik SK, Pandey HN, Tripathi RS. 1990. Community composition and population structure in a sub-tropical broad leaved forest along a disturbance gradient. Vegetatio 88: 151-162.

Roberts MR, Gilliam FS. 1995. Disturbance effects on herbaceous layer vegetation and soil nutrients in Populus forests of northern lower Michigan. Journal of Vegetation Science 6: 903-912.

Sagar R, Rughuvanshi AS, Singh JS. 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.

Sapkota IP, Tigabu M, Oden PC. 2010. Changes in tree diversity and dominance across a disturbance gradient in Nepalese Sal forests. Journal of Forestry Research 21: 25-32.

Saxena AK, Singh JS. 1982. A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. Vegetatio 50: 3-22.

Saxena AK, Singh SP, Singh JS. 1984. Population structure of forests of Kumaon Himalaya: implications for management. Journal of Environmental Management 19: 307-324.

Schmelz DV, Lindsey AA. 1965. Size-class structure of old-growth forests in Indiana. Forest Science 11: 258-264.

Shannon CE, Wiener W. 1963. The mathematical theory of communication. University of Illinois Press, Urbana.

Simpson EH. 1949. Measurement of diversity. Nature (London) 163: 688.

Singh SP. 1998. Chronic disturbances, a principal cause of environmental degradation in developing countries. Environmental Conservation 25: 1-2.

Thadani R, Ashton PMS. 1995. Regeneration of banj oak (Quercus leucotricophora A. Camus) in the central Himalaya. Forest Ecology and Management 78: 217-224.

Vogl RJ. 1980. The ecological factors that produce perturbation dependent ecosystems. In: The Recovery process in damaged ecosystems (Cairns J, ed). Ann Arbor Science publishers, Ann Arbor, Michigan, USA, pp 63-94.

Westman WA. 1990. Managing for biodiversity. Bioscience 40: 26-33.

White PS. 1979. Pattern, processes and natural disturbance. Botanical Review 45: 229-299.