American-Eurasian J. Agric. & Environ. Sci., 5 (4): 526-532, 2009
ISSN 1818-6769

The Influence of Single - Tree Selection Cutting on Silvicultural Properties of a Northern Hardwood Forest in Iran

[1]*Mohammad Reza Pourmajidian and* [2]*Ali Rahmani,*

[1]Department of Forestry, Faculty of Natural Resources,
Sari Agricultural Sciences and Natural Resources University, Sari, Iran
[2]M.Sc. Graduate Students, Department of Forestry,
Faculty of Natural Resources, Mazandaran University, Sari, Iran

Abstract: In this study the effect of single-tree selection cutting on stand structure and regeneration density was investigated by comparing the silvicultural properties of stands at two time treatments 1994 and 2006 in Alandan Forest, Mazandaran province, Iran. 63 circular plots with a size of 500 m^2 and 63 circular micro plots with a size of 200 m^2 were considered for measuring the vegetative parameters and regeneration density, respectively. Results indicated that there were no significant effects from the slope classes and slope aspects on vegetative parameters before and after single-tree selection cutting in 1994 and 2006 ($P>0.05$). In single-tree selection cutting, the total species volume per hectare in different diameter classes in 1994 (before cutting) was approximately similar to 2006 (after cutting) ($P>0.05$). The total species density and basal area per hectare in 2006 were more than 1994 ($P<0.05$). These results were also observed for *Fagus orientalis* Lipsky, whereas there wasn't significant difference between the *Carpinus betulus* L. and other species density, basal area and volume per hectare among two time treatment 1994 and 2006 ($P>0.05$). The mixture percentage of *Fagus orientalis* Lipsky in 2006 was increased by 2% compared with the 1994, whereas the mixture percentage of *Carpinus betulus* L. and *Parrotia persica C.A.M*. was reduced from 8.4% to 8% and 14% to 13.8%, respectively. The regeneration of *Ulmus glabra huds* was removed completely and then was replaced by *Acer velutinum* Bioss and *Alnus subcordata* C.A.M. So, according to mixture percentage of beech, it seems that our selection forest goes to the pure stand of beech which it is not main goal of single-tree selection system.

Key words: Selection cutting · Stand structure · Forest regeneration · Vegetative parameters

INTRODUCTION

Iran is low forest cover country (LFCC) with the forest cover of 7.4%. Hyrcanian Forest has a total area of 1.85 million hectares comprising 15% of the total Iranian forest and 1.1% of the country's area [1]. In Iran, shelterwood cutting in northern hardwood forest has given rise to public concern in recent years, mainly because of its negative impacts on silvicultural properties, biological and aesthetical values.

Recently, shelterwood cutting have been replaced by low-impact forest management systems such as single-tree selection cutting as alternatives to logging in northern hardwood stands, because this system differs in size, intensity, frequencyand in the pattern of disturbance, local habitat structures and spatio-temporal habitat distribution in the landscape should be quite different [2,3,4,5].

Selection cutting is the silvicultural practice of harvesting a proportion of the trees in a stand. Selection cutting is the practice of removing mature timber or thinning to improve the timber stand. This system may be used to manage even or uneven-aged stands. Management objectives can include the protection of forest soils, maintenance or improvement of wildlife habitat, the increase of individual stem productivity and species diversity. Selection cutting may include opening up areas to allow tree species that require greater light intensity to grow but that are not large enough to meet the legal definition of a clear cut [6,7,8]. The main goal of

Corresponding Author: Mohammad Reza Pourmajidian, Department of Forestry, Faculty of Natural Resources, Mazandaran University, Sari, Mazandaran province, IR-Iran, P.O. Box. No.737

selection cutting is provide the mixed and uneven aged stand. The diagram of trees reduction based on diameter in a selection forest is a secondary mid-hyperbolic diagram which its formula is $Logy = \log k - ax \log e$. Where, y is the trees number, a and K are the fixed values (a is the reduction coefficient of tree number per diameter class and K is the relative coefficient of stand density), e is the base of natural logarithm (2.71828) and x is the tree diameter [9].

Marina *et al*. [10] studied the changes of stand structure and regeneration in three permanent plots in the Shiretoko National Forest, where selection cutting had been carried out in 1987. In 2002, the *Abies sachalinensis* and *Quercus mangolica var. grosseserrata* densities (over 2m height) in 2002 were from 1992 stems/ha to 1288 stems/ha. The growing stocks and the total basal areas in 2002 were from 319 m^3 ha^{-1} to 477 m^3 ha^{-1}, from 54.25 m^2 ha^{-1} to 74.17 m^2 ha^{-1}, respectively. The number seedlings that had two meters in height during the period from 1997 to 2002 was different between the plots: 12 stem ha^{-1} in the closed stand and 296 stem ha^{-1} in the stand with canopy gaps caused by cutting.

The short-term effects of selection cutting with different intensities on the forest structure and species diversity of evergreen broad-leaved forest in northern Fujian Province of china were investigated by Ren-hui *et al*. [11]. The results showed that selection cutting of low and medium intensities caused little variation in the forest structure. After cutting, the dominant species retained their leading status in the community. However, the community structure changed significantly following selection cutting of high and extra-high intensities; the status of the dominant species of the community declined dramatically.

The effects of group selection cutting on white pine (*Pinus strobus* L.), red oak (Quercus rubra L.), yellow birch (*Betula alleghaniensis* Britton) and paper birch (*Betula papyrifera* Marsh.) regeneration was compared to the single-tree selection cutting in Canada. The experimental design comprised three cover reduction treatments (circular gap, 25% and 35% single-tree selection cutting), two scarification treatments (scarified and non-scarified) and two seeding treatments for white pine (seeded and non-seeded). After three years, scarification had a positive effect on white pine, yellow birch and paper birch regeneration but also on aspen (*Populus* spp.) and pin cherry (*Prunus pensylvanica* L.f.) in the three cover reduction treatments. Red oak regeneration was negatively affected by scarification. Shade-tolerant species (sugar maple and American beech) tended to be less present in the regeneration gaps than in the single-tree selection cutting [12].

In many northern hardwood stands in New Hampshire and New England, partial cutting or single-tree selection results in understories with a high proportion of beech and other species with low timber values. Patch cutting, using small openings of about 1/4-ac in size or larger coupled with sufficient logging disturbance, has proved to be an effective way to replace understories of beech and other less valuable species with a new stand containing a high proportion of yellow and paper birch in mixture with other deciduous species. Unless present as well-developed advanced regeneration, sugar maple is seldom common in the new stands produced by small patch cutting. However, when these early successional stands reach 40-50 years of age, understories dominated by sugar maple and with lesser proportions of beech frequently develop, possibly due to the rich leaf-fall, lower proportions of beech litterand/or changed light conditions. Although small patch cutting may not immediately regenerate abundant sugar maple, it appears as though this technique may help over time to maintain sugar maple as a significant component of northern hardwood forests [13].

This study assessed the effect of single-tree selection cutting on stand structure (trees diameter and basal area at breast height, crown form, canopy cover, herbaceous cover, stories structure, trees height, volume, quality and density) by comparing the silvicultural properties of stands at two time treatments 1994 and 2006. In addition, the impact of selection cutting on regeneration density and quality was investigated in present study.

MATERIALS AND METHODS

Site Description: This study was conducted in the Alandan Forest, south east of sari city, Mazandaran province, Iran (53°24'00" to 53°27'26" E, 36°10'57" to 36°13'56"N). The elevation of the site ranges from 1000 to 1783 m and slopes are in the range of 0 to 30%. The mean annual temperature is 10.5°C and annual precipitation is 858 mm. The total amount of annual evaporation is 760 mm and average relative humidity is 75.2%. General texture type of soil in research area is loam. The bedrock is typically marl, marl lime and limestone. Vegetation period maintains for 7 months in average (Fig. 1).

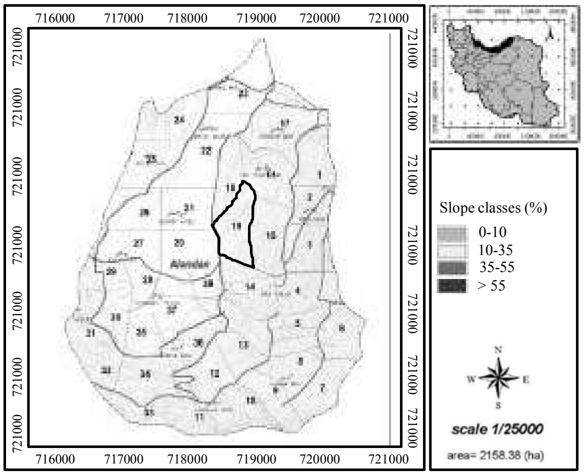

Fig. 1: Geographical position of the study site in compartment 19 of Alandan Forest

Data Collection: Data were collected in 2006 from compartment 19 of Alandan forest harvested in 1994 with single tree-selection cutting. In order to inventory and recognizing the study area a topographical map with scale of 1:10000 was prepared. The map was placed on a network with dimensions of 75 × 100m in the nature based on systematic randomize sampling method. 63 circular sample plots with a size of 500 m^2 (with radius of 12.62 m) were considered and their central points were determined on the map. Diameter at breast height of all trees in each of 500 m^2 plots was measured by caliper.

In addition, diameter at breast height and height of two trees (one tree was nearest to the plot center and another was largest in diameter) were recorded. Other parameters such as trees diameter and basal area at breast height, crown form, canopy cover, herbaceous cover, stories structure, trees height, volume, quality and density were calculated. In each macro plot a circular micro plot with the size of 200 m^2 (with radius of 7.98 m) was established for measuring regeneration density and quality. Regeneration less than 1.3 m in height and diameter at breast height (1.3 m above the ground) 0-2.4 cm, 2.5-7.4 cm and 7.5-12.4 cm was recorded in each micro plots.

Statistical Analysis: All statistics were calculated with SPSS and SAS softwares. Linear regression and Analysis of variance (ANOVA) were used to determine the effects of terrain slope and geographical aspects of study area on vegetative parameters of selection forest in 1994 and 2006. The graphs drawing were done in EXCEL software.

RESULTS AND DISCUSSION

Results of this study showed that there were no significant effects from the slope classes and slope aspects on vegetative parameters before single-tree selection cutting in compartment 19 and in year of 1994 ($P>0.05$) (Table 1). Also, the results of analysis of variance revealed that the slope classes and slope aspects hadn't significant effect on vegetative parameters after 12 years single-tree selection cutting in compartment 19 ($P>0.05$) (Table 2).

Although traditional application of the selection system includes a focus on high-value trees that may reduce cavities and snags, few studies have quantified those habitat features in managed uneven-aged stands. Kenefic and Nyland [14] examined the effects of single-tree selection cutting on cavity trees and snags in a northern hardwood stand immediately prior to the second cutting. Results showed that more than 50% of sampled cavity trees were designated for removal in the second selection cut, reducing projected postcut density to 11.0 live cavity trees per hectare, a density similar to that found in other studies. The relatively high maximum diameter (61 cm dbh) and long cutting cycle (20 years) used to define the target stand structure may have contributed to the number of cavity trees observed, nevertheless, selection cutting as applied in this study will likely reduce cavity abundance unless retention of trees with decay is explicitly incorporated into the management strategy.

During the single-tree selection cutting from 1994 to 2006, the total number of regeneration was reduced. The mixture percentage of *Fagus orientalis* Lipsky in 2006 was increased by 2% compared with the 1994, whereas the mixture percentage of *Carpinus betulus* L. and *Parrotia persica C.A.M.* was reduced from 8.4% to 8% and 14% to 13.8% respectively (Table 3). The regeneration of *Ulmus glabra huds* was removed completely and then was replaced by *Acer velutinum* Bioss and *Alnus subcordata* C.A.M (Table 4). According to mixture percentage of beech, it seems that our selection forest goes to the pure stand of beech which it is not main goal of single-tree selection system. Number of stories in selection forest was increased after 12 years (Fig. 2).

In single-tree selection cutting, the total species volume per hectare in different diameter classes in 1994 (before cutting) was approximately similar to 2006 (after cutting) ($P>0.05$). The total species density and basal area per hectare in different diameter classes in 2006

Fig. 2: Comparison of stories classification in percentage (%) before (1994) and after single-tree selection cutting (2006) in compartment 19 of Alandan forest

were more than 1994 (P<0.05). These results were also observed for *Fagus orientalis* Lipsky, whereas there wasn't significant difference between the *Carpinus betulus* L. and other species density, basal area and volume per hectare among two time treatment 1994 and 2006 (P>0.05). The allowable cutting volume for 12 years period was 1800 silve per compartment (Fig. 3).

In the Missouri Ozarks, there is considerable concern about the effectiveness of the uneven-aged methods of single-tree selection and group selection for oak (*Quercus* L.) and shortleaf pine (*Pinus echinata* Mill.) regeneration.Jensen and Kabrick [15] compared the changes in reproduction density of oaks and pine following harvesting by single-tree selection, group selectionand clearcutting during a 10-year period in the

Table 1: Effects of terrain slope and aspect on vegetative parameters before single-tree selection cutting in compartment 19 (1994)

Variables	Sources	Df	MS	F	CV	R^2
Canopy cover (%)	Aspect	3	92.849	0.49 ns	0.238	18.996
	Slope	2	39.613	0.21 ns		
Number of stories	Aspect	3	0.189	0.68 ns	0.314	36.440
	Slope	2	0.315	1.14 ns		
Trees quality	Aspect	3	0.023	0.39 ns	0.294	23.323
	Slope	2	0.031	0.51 ns		
Crown form	Aspect	3	0.175	0.70 ns	0.309	30.065
	Slope	2	0.219	0.87 ns		
Herbaceous cover (%)	Aspect	3	15.905	0.12 ns	0.208	116.088
	Slope	2	132.642	0.96 ns		
Regeneration cover (%)	Aspect	3	221.140	0.28 ns	0.276	79.649
	Slope	2	85.650	0.11 ns		
Regeneration quality	Aspect	3	0.377	1.36 ns	0.404	29.608
	Slope	2	0.505	1.82 ns		
Height of largest tree	Aspect	3	4.599	0.16 ns	0.434	15.445
	Slope	2	67.389	2.35 ns		

Table 2: Effects of terrain slope and aspect on vegetative parameters after 12 years single-tree selection cutting in compartment 19 (2006)

Variables	Sources	Df	MS	F	CV	R^2
Canopy cover (%)	Aspect	3	96.369	0.64 ns	26.954	0.545
	Slope	2	163.242	1.09 ns		
Number of stories	Aspect	3	0.260	2.13 ns	13.740	0.712
	Slope	2	0.018	0.15 ns		
Trees quality	Aspect	3	0.266	0.81 ns	32.578	0.372
	Slope	2	0.130	0.40 ns		
Crown form	Aspect	3	0.218	0.95 ns	29.614	0.495
	Slope	2	0.002	0.01 ns		
Herbaceous cover (%)	Aspect	3	65.248	0.62 ns	29.858	0.486
	Slope	2	35.997	0.34 ns		
Regeneration cover (%)	Aspect	3	54.393	0.34 ns	20.139	0.456
	Slope	2	153.356	0.97 ns		
Regeneration quality	Aspect	3	0.345	0.46 ns	35.034	0.482
	Slope	2	0.791	1.05 ns		
Height of largest tree	Aspect	3	3.548	0.74 ns	7.543	0.303
	Slope	2	0.355	0.07 ns		

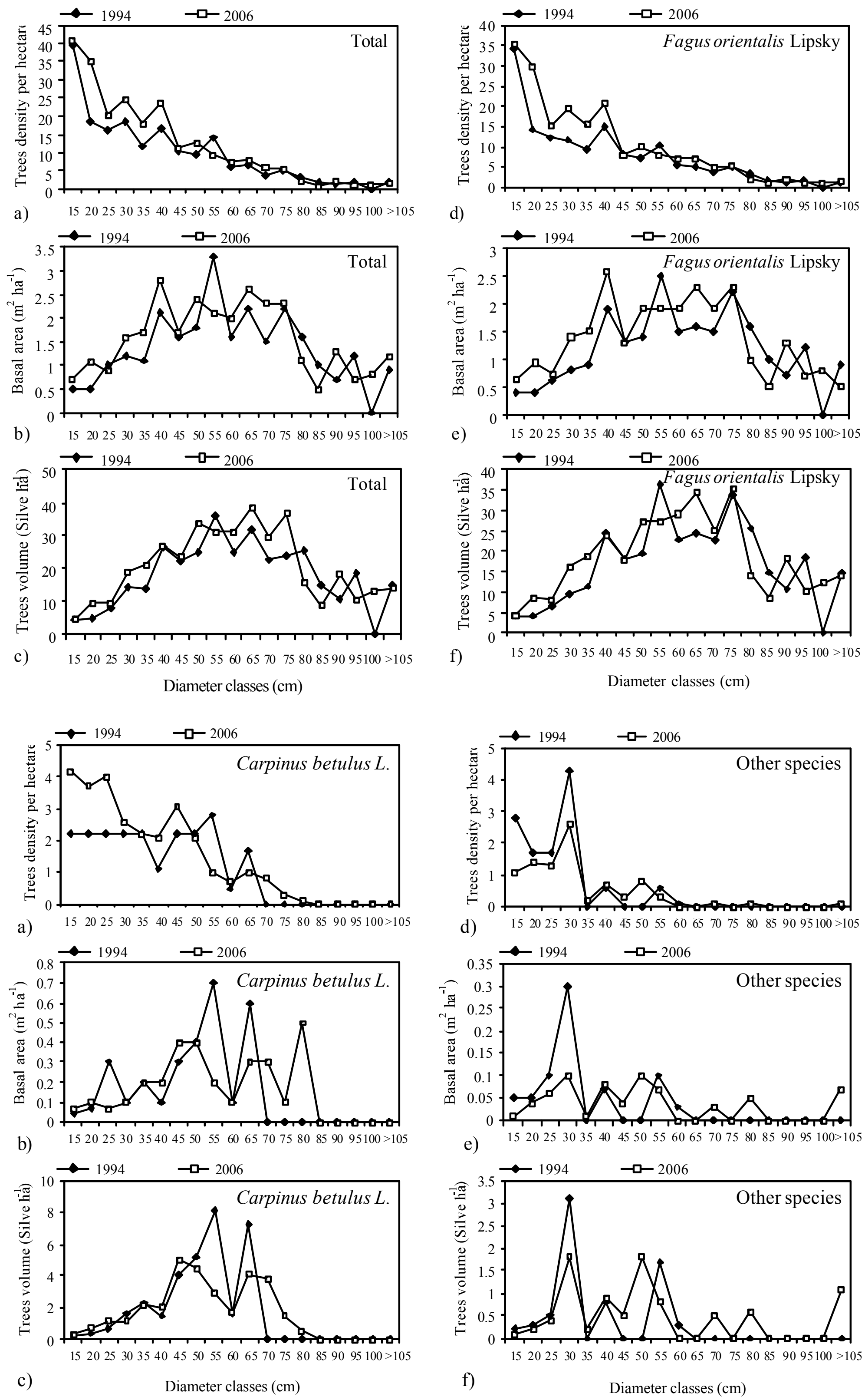

Fig. 3: Comparison of the trees density, basal area and volume per hectare among two time treatment 1994 and 2006 for total species, *Fagus orientalis*, *Carpinus betulus* L. and other species

Table 3: Regeneration density in percentage (%) before single-tree selection cutting in compartment 19 (1994)

	Diameter classes (cm)				
Species	0-2.4	2.5-7.4	7.5-12.4	Less than 1.3 meter in height	Total
Fagus orientalis Lipsky	24.20	5.50	2.20	45.10	77.00
Carpinus betulus L.	0.50	0.30	0.10	7.50	8.40
Ulmus glabra huds.	0.01	0.00	0.00	0.00	0.01
Parrotia persica C.A.M.	8.20	0.05	0.05	5.00	14.00

Table 4: Regeneration density in percentage (%) after 12 years single-tree selection cutting in compartment 19 (2006)

	Diameter classes (cm)				
Species	0-2.4	2.5-7.4	7.5-12.4	Less than 1.3 meter in height	Total
Fagus orientalis Lipsky	15.50	15.40	8.30	39.50	79.00
Carpinus betulus L.	0.20	1.00	1.00	3.00	5.00
Quercus castaneifolia C. A. Mey.	0.20	0.20	0.00	0.30	0.70
Parrotia persica C.A.M.	2.40	4.40	1.00	6.00	13.80
Acer velutinum Bioss.	0.00	0.00	0.00	0.10	0.10
Alnus subcordata C.A.M.	0.00	0.01	0.01	1.10	1.10

Missouri Ozarks. Inventories in permanent plots were completed preharvest (1995) and post-harvest (1998, 2002and 2006). Prior to harvesting, advance oak regeneration densities (trees < 4.5 inches diameter at breast height [d.b.h.]) ranged from 144 to 173 trees per acre. Ten years after harvesting, oak density in clearcut stands increased to 1,049 trees per acre and was about two times greater than in group openings (514 trees per acre) and more than four times greater than where single-tree selection (236 trees per acre) was used.

REFERENCES

1. Sagheb-Talebi, K.H., T. Sajedi and F. Yazdian, 2004. Forests of Iran. Research Institute of Forests and Rangelands. Technical Publication No. 339. pp: 28.
2. Doyon, F., D. Gagnon and J.F. Giroux, 2005. Effects of strip and single-tree selection cutting on birds and their habitat in a southwestern Quebec northern hardwood forest. For. Ecol. Manage., 209: 101-115.
3. Frelich, L.E. and C.G. Lorimer, 1991. Natural disturbance regimes in hardwood-hemlock forests of the upper Great Lakes region. Ecol. Monogr., 61: 145-164.
4. Runkle, J.R., 1990. Gap dynamics in an Ohio Acer-Fagus forest and speculations on the geography of disturbance. Can. J. For. Res., 20: 632-641.
5. Seymour, R.S., A.S. White and P.G. deMaynadier, 2002. Natural disturbance regimes in northeastern North America-evaluating silvicultural systems using natural scales and frequencies. For. Ecol. Manage., 155: 357-367.
6. Anderson, S.C., J.A. Kupfer, R.R. Wilson and R.J. Cooper, 2000. Estimating forest crown area removed by selection cutting: a linked regression-GIS approach based on stump diameters. For. Ecol. Manage., 137(1-3): 171-177.
7. Nyland, D., 1998. Selection system in northern hardwoods.J. Forestry., 96(7): 18-21.
8. Webster, C.R. and C.G. Lorimer, 2002. Single-tree versus group selection in hemlock-hardwood forests: are smaller openings less productive?. Can. J. For. Res., 32(4): 591-604.
9. Marvie-Mohadjer, M.R., 2005. Silviculture. University of Tehran press 2709. ISBN: 964-03-5098-2., pp: 387.
10. Marina, Y., M. Natsuko, K. Shunichi and Y. Takashi, 2003. Effects of selection cutting on forest dynamics in the Shiretoko national forest-stand structure and regeneration pattern, fifteen years after cutting. Research Bulletin of the Hokkaido University Forests., 60(2): 79-90.
11. Ren-hui, Q., C. Han and Z. Li-xin, 2006. Effects of selection cutting on the forest structure and species diversity of evergreen broad-leaved forest in northern Fujian, southern China. For. Stud. China., 8(1): 16-20.

12. Raymond, P., A.D. Munson, J. Ruel and P. Nolet, 2003. Group and single-tree selection cutting in mixed tolerant hardwood–white pine stands: Early establishment dynamics of white pine and associated species. The Forestry Chronicle., 79(6): 1093-1106.
13. Leak, W.B., 2005. Effects of small patch cutting on sugar maple regeneration in new hampshire northern hardwoods. Northern .J. Appl. For., 22(1): 68-70.
14. Kenefic, L.S. and R.D. Nyland, 2007. Cavity trees, snags and selection cutting: a northern hardwood case study. Northern .J. Appl. For., 24(3): 192-196.
15. Jensen, R.G. and J.M. Kabrick, 2008. Comparing single-tree selection, group selectionand clearcutting for regenerating oaks and pines in the Missouri Ozarks. Publication In: F. Jacobs, Douglass H. Michler, Charles (Eds). 2008. Proceedings, 16th Central Hardwood Forest Conference; 2008 April 8-9; West Lafayette, IN. Gen. Tech. Rep. NRS-P-24. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, pp: 38-49.