富士山研究第４巻（2010）
９～12頁

富士山精進登山道の冷温帯老齢林における林分動態

長池卓男[1]・松崎誠司[2]

Stand dynamics of a cool-temperate old-growth forest in the foothills of Mt. Fuji, central Japan

Takuo NAGAIKE[1], Seiji MATSUZAKI[2]

Abstract

We examined the stand dynamics of an old-growth forest and the effects of bark stripping by Sika deer (*Cervus nippon*) on these dynamics. Two study plots (plots 1 and 2) were established in a cool-temperate old-growth forest along the Shoji trail in the foothills of Mt. Fuji, and trees were censused in 2002 and 2008. In this interval, total basal area of trees in both plots increased, especially in plot 1, and total stem density, which was lower in plot 1 than in plot 2, increased in plot 1 and decreased in plot 2. Thus, parameters of stand structure and dynamics differed between plots, reflecting different phases of forest development. The effects of bark stripping on stand dynamics appeared to be weak in this census period; however, it is important to carefully monitor the effects of Sika deer population growth on forest ecosystems in the region.

要　旨

富士山精進登山道の冷温帯老齢林における林分動態とニホンジカによる剥皮がそれに及ぼす影響を調査した。2002年に２ヶ所の調査区を設定し、2008年に再測を行った。両調査区の胸高断面積合計は増加しており、特にplot 1で増加していた。立木密度はplot 1よりもplot 2で少なかったが、plot 1では増加し、plot 2では減少していた。このように林分構造と動態に関するパラメータは、調査区間で異なり、林分の発達段階の違いを示している。ニホンジカの剥皮の影響は現時点では小さいものの、この地域での個体数が増加していることから、注意深くモニターしていく必要がある。

Introduction

Human activity on the Pacific side of Japan, which experiences low snow cover in winter, has been intense compared to that on the Japan Sea side (Nakashizuka and Iida 1995). In the foothills of Mt. Fuji, as well as in other regions on the Pacific side of the country, primary or old-growth forests remain only as fragments (Nakano et al. 2008) because of human activity (e.g., logging). Thus, such fragments are important to forest management as model systems for matching natural disturbances and as reserves for conserving biological diversity in the region. The dynamics of such forests can be studied in the context of ecological forestry (e.g., Franklin et al. 2002).

Recently, the population of Sika deer (*Cervus nippon*) has sharply increased in the region, and the effects of bark stripping on plantation trees have been serious (Jiang et al. 2005). Because bark stripping by the deer can strongly affect forest stand dynamics and species composition (Akashi and Nakashizuka 1999), it is important to carefully monitor these effects in natural forests. In this study, we examined the dynamics of an old-growth forest and the effects of bark stripping by Sika deer on these dynamics.

Methods

Study sites and data collection

Two study plots (plots 1 and 2) were established in a cool-temperate old-growth forest along the Shoji trail in the foothills of Mt. Fuji in 2002. The elevations of plots 1 and 2 were 1500 and 1560 m, respectively. Each plot was 50 × 50 m. Because the forest was included in a Special Protection Zone of Fuji-Hakone-Izu National Park, human intervention such as forest management has been limited. In each plot, all living trees greater than 3 cm in diameter at breast height (DBH) were identified, and girth at breast height was measured. We re-surveyed the same plots in 2008. In both censuses, we monitored the trees for signs of bark stripping by Sika deer.

Analysis

We estimated mortality and recruitment rates in

１．山梨県森林総合研究所
２．富士森林施業技術研究所

Corresponding author：Takuo Nagaike
E-mail：nagaike-zty@pref.yamanashi.lg.jp

each plot for this census period (i.e., 6 years) using a logarithmic model (Condit et al. 1999 ; Miura et al. 2001):

Mortality rate (% / year) = ln (Nb / Ns) / 6 × 100 , where Nb and Ns are the numbers of stems alive at the beginning of the study and surviving to the end of the census period, respectively.

Recruitment rate (% / year) = ln (Ne / Ns) / 6 × 100 , where Ne is the total number of stems alive at the end of the study.

Population changes were calculated from the population growth rate, λ , (Condit et al. 1999) for basal area (BA) and the numbers of stems (s) of a species using data from 2002 and 2008 :

λ BA (% / year) = (BA 2008 - BA 2002) / BA 2002 / 6 × 100 ,

and

λ s (% / year) = ln (N 2008 / N 2002) / 6 × 100 , where N and BA are the numbers of stems and the BA of a species in census, respectively.

Results and discussion

The recruitment rate in plot 1 exceeded that of mortality, and the opposite was true in plot 2 (Fig. 1).

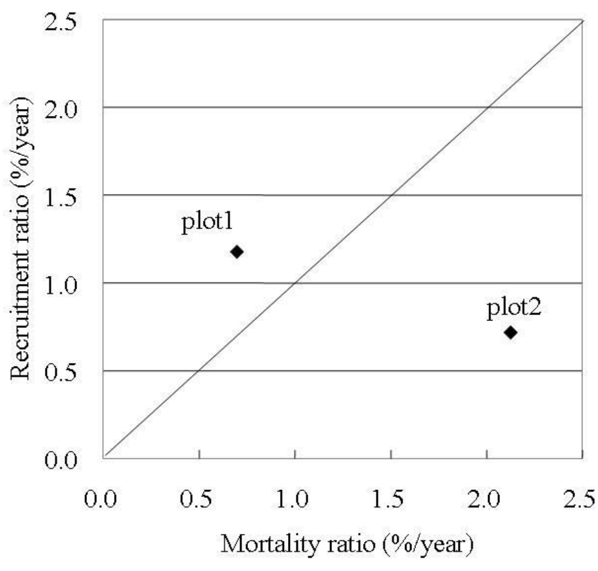

Figure 1 . Relationship between mortality and recruitment ratios in the study plots.

In plot 1 , the dominant species by BA and stem density were *Quercus crispula* and *Fagus crenata*, and *Abies homolepis* and *F. crenata*, respectively (Table 1). In plot 2 , the dominant species by BA and stem density were *F. crenata* and *A. homolepis*, and *Acer shirasawanum* and *Tilia japonica*, respectively. Although *A. shirasawanum* and *T. japonica* dominated by stem density in plot 2 , their stem size was small and the canopy was dominated by large individuals of *F. crenata*. Total BA was similar in both plots, but stem density was greater in plot 2 . Total BA increased in both plots during the interval between censuses, particularly in plot 1 (Table 1). The BA of all of the species in plot 1 , except for *Prunus maximowiczii*, increased, whereas the BA of 7 of 27 species in plot 2 decreased. Total stem density, which was lower in plot 1 than in plot 2 , increased in plot 1 and decreased in plot 2 . Thus, stand structure and dynamics differed between the two plots, reflecting different phases of forest development.

Stem density of *F. crenata* was greater in plot 1 , whereas its DBH was greater in plot 2 . Given that BA was similar in both plots, plot 2 contained larger and fewer canopy trees, whereas trees in plot 1 were smaller and more numerous.

The density of bark-stripped trees was lower in plot 1 than in plot 2 in both census years (Table 2). However, both the numbers of bark-stripped trees and trees killed by bark-stripping increased during this census period in plot 2 . These numbers increased in particular for *A. shirasawanum* and *Sorbus commixta*, supporting the idea that Sika deer preferentially bark-strip trees of certain species (Nagaike and Hayashi 2003 ; Ando and Shibata 2006). Such preferred species may disappear if bark-stripping continues (Akashi and Nakashizuka 1999). Although the effects of bark-stripping on stand dynamics seemed to be weak in this study, it is important to carefully monitor the effects of population growth of Sika deer on forest ecosystems in the region.

Acknowledgments

We would like to thank Nana Ishiguro, Nobumasa Arai, Yumi Terada, Eriko Yamanaka, Ayumi Inoue, and Keisuke Mizuta for their help in field data collection. This study was performed with permission from the Environmental Ministry of Japan.

References

Akashi N, Nakashizuka T (1999) Effects of bark-stripping by Sika deer (*Cervus nippon*) on population dynamics of a mixed forest in Japan For Ecol Manage 113 : 75 - 82

Ando M, Shibata E (2006) Why do Cervids strip the tree bark? J Jpn For Soc 88 : 131 - 136 (In Japanese with English summary)

Condit R, Ashton PS, Manokaran N, LaFrankie JV, Hubbell SP, Foster RB (1999) Dynamics of the forest communities at Pasoh and Barro Colorado: comparing two 50 -ha plots. Phil Trans Royal Soc London Biol Sci 354 : 1739 - 1748

Franklin JF, Spies TA, Van Pelta R, Carey AB, Thornburgh DA, Berge DR, Lindenmayer DB, Harmon ME, Keeton

Table 1 . Basal area, stem density, population growth rates, and mean diameter at breast height (DBH) of tree species in the study plots.

Species	Basal area (m^2/ha)						Stem density (No./ha)						Mean DBH (cm)			
	plot1			plot2			plot1			plot2			plot1		plot2	
	2002	2008	λ BA (%/year)	2002	2008	λ BA (%/year)	2002	2008	λ s (%/year)	2002	2008	λ s (%/year)	2002	2008	2002	2008
Abies homolepsis	8.14	8.56	0.87	13.08	13.97	1.13	116	116	0.00	120	112	-1.15	26.4	27.2	29.1	31.0
Acanthopanax sciadophylloides	0.07	0.09	5.89	0.05	0.05	0.75	20	24	3.04	4	4	0.00	5.9	6.1	12.8	13.1
Acer japonicum	0.72	0.72	0.07				4	4	0.00				47.8	47.9		
Acer micranthum	0.04	0.04	2.49		0.00		8	8	0.00		4		7.5	8.1		3.3
Acer mono subsp. *marmoratum*	0.65	0.69	0.92	0.01	0.02	3.48	36	40	1.76	4	4	0.00	9.4	9.1	6.7	7.4
Acer palmatum	0.01	0.01	0.83				8	8	0.00				4.0	4.1		
Acer palmatum subsp. *amoenum*	0.18	0.20	0.98				4	4	0.00				24.3	25.0		
Acer rufinerve	0.23	0.24	1.25	0.63	0.70	1.74	68	56	-3.24	8	8	0.00	6.3	7.2	25.3	27.0
Acer shirasawanum	1.90	1.97	0.66	2.20	2.52	2.38	56	60	1.15	468	476	0.28	17.5	17.1	6.3	6.7
Acer sieboldianum	0.12	0.13	0.86				4	4	0.00				19.9	20.4		
Aralia elata				0.07		-16.67				4		-			15.2	
Betula ermanii	0.15	0.18	2.48	3.32	3.49	0.87	12	8	-6.76	16	16	0.00	12.4	16.7	49.3	50.7
Betula grossa	0.03	0.04	4.77	0.03	0.03	2.34	4	4	0.00	4	4	0.00	10.4	11.8	9.4	10.0
Carpinus cordata	0.07	0.07	0.00				4	4	0.00				15.4	15.4		
Cercidiphyllum japonicum				0.04	0.07	10.80				4	4	0.00			11.3	14.5
Cornus controversa	0.05	0.06	3.62	0.22	0.29	4.61	8	8	0.00	8	8	0.00	8.5	9.4	18.8	21.3
Enkianthus campanulatus				0.01	0.01	-1.06				8	8	0.00			3.7	3.6
Euonymus planipes				0.05	0.02	-10.11				12	4	-18.31			7.0	7.7
Fagus crenata	16.85	17.13	0.28	19.13	17.73	-1.22	104	100	-0.65	36	32	-1.96	36.4	37.3	74.8	80.1
Fraxinus langinosa	0.02	0.03	5.67	0.33	0.33	0.22	24	32	4.79	72	56	-4.19	3.4	3.4	6.0	6.9
Kalopanax pictus	0.25	0.27	1.31	1.57	1.64	0.66	4	4	0.00	16	16	0.00	28.1	29.2	32.1	33.2
Ligustrum tschonoskii				0.00		-16.67				4		-			3.1	
Magnolia obovata	0.04	0.07	9.29				4	4	0.00				11.9	14.9		
Phellodendron amurense	0.39	0.43	1.53				4	4	0.00				35.4	37.0		
Picea jezoensis var. *hondoensis*				8.84	9.44	1.14				24	24	0.00			65.8	68.2
Prunus maximowiczii	0.01	0.00	-9.77	0.18	0.26	7.73	8	4	-11.55	20	24	3.04	3.6	3.3	10.1	10.8
Pyrus ussuriensis var. *hondoensis*	0.00	0.00	-0.80				4	4	0.00				3.9	3.9		
Quercus crispula	23.15	24.15	0.72	5.23	5.54	0.99	84	84	0.00	20	20	0.00	57.3	58.5	50.9	52.5
Sambucus racemosa				0.05		-16.67				12		-			6.8	
Sorbus alnifolia	0.97	1.00	0.42	0.00	0.00	-0.29	28	28	0.00	4	4	0.00	19.3	19.6	3.7	3.7
Sorbus commixta				0.68	0.59	-2.22				60	44	-5.17			10.7	11.6
Sorbus japonica				0.05	0.05	0.61				4	4	0.00			12.4	12.6
Tilia japonica	0.15	0.20	4.92	1.72	1.95	2.22	68	88	4.30	180	156	-2.39	5.0	5.0	9.3	10.7
Tsuga diversifolia				1.15	1.25	1.49				4	8	11.55			60.5	38.1
Viburnum furcatum				0.02	0.00	-13.42				16	4	-23.10			4.0	3.6
Viburnum wrightii		0.00						4						3.2		
Viburnum wrightii var. *stipellatum*				0.01		-16.67				4		-			4.1	
Total	54.22	56.30	0.64	58.68	59.96	0.36	684	704	0.48	1136	1044	-1.41	22.8	22.7	15.1	16.4

Table 2 . Densities of stems bark stripped by Sika deer in the study plots (No. stems / 2500 m^2).

Species	plot1						plot2					
	2002			2008			2002			2008		
	Bark stripping (a)	Death by bark stripping (b)	b/a*100 (%)	Bark stripping (a)	Death by bark stripping (b)	b/a*100 (%)	Bark stripping (a)	Death by bark stripping (b)	b/a*100 (%)	Bark stripping (a)	Death by bark stripping (b)	b/a*100 (%)
Acer micranthum										1	0	0.0
Acer shirasawanum										12	0	0.0
Euonymus planipes	2	2	100.0				5	2	40.0	3	2	66.7
Fraxinus langinosa							1	0	0.0			
Sambucus racemosa										1	1	100.0
Sorbus alnifolia							1	0	0.0	1	0	0.0
Sorbus commixta							2	0	0.0	10	3	30.0
Tilia japonica										1	0	0.0
Viburnum furcatum							2	1	50.0	2	1	50.0
Viburnum wrightii var. *stipellatum*							1	0	0.0			
Total	2	2	100.0	0	0	0.0	12	3	25.0	31	7	22.6

WS, Shaw DC, Bible K, Chen J (2002) Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. For Ecol Manage 155 : 399 - 423

Jiang Z, Ueda H, Kitahara M, Imaki H (2005) Bark stripping by sika deer on veitch fir related to stand age, bark nutrition, and season in northern Mount Fuji district, central Japan. J For Res 10 : 359 - 365

Miura M, Manabe T, Nishimura N, Yamamoto S (2001) Forest canopy and community dynamics in a temperate old-growth evergreen broad-leaved forest, south-western Japan: a 7 -year study of a 4 -ha plot. J Ecol 89 : 841 - 849

Nagaike T, Hayashi A (2003) Bark-stripping by Sika deer (*Cervus nippon*) in *Larix kaempferi* plantations in central Japan. For Ecol Manage 175 : 563 - 572

Nakano T, Yasuda T, Huruya H, Ishihara S, Watanabe S (2008) Distributional pattern of large trees in a deciduous-broad leave forest in northern slope of Mt. Omuro, a parasitic volcano of Mt. Fuji. Mount Fuji Research 2 : 25 - 31 (in Japanese)

Nakashizuka T, Iida S (1995) Composition, dynamics and disturbance regime of temperate deciduous forests in Monsoon Asia. Plant Ecol 121 : 23 - 30