Provisional chapter

Decreased Epiphytic Bryophyte Diversity on Mt. Odaigahara, Japan: Causes and Implications

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Additional information is available at the end of the chapter

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1. Introduction

When wildlife populations grow excessively, they affect other flora and fauna within their ecosystems (Fuller & Gill, 2001; Pellerin et al., 2006; Rooney, 2001; Schütz et al., 2003; Stewart & Burrows, 1989; Stockton et al., 2005; Takatsuki, 2009; Webster et al., 2005). For example, the recent increase in the sika deer population in Japan has led to the degradation of ecosystems in many areas. From 1979 to 2002, the range of this species expanded by as much as 70% (Nakajima, 2007). Although stripping of bark, grazing on grass, and browsing on tree understories are normal foraging behaviors in deer, these activities in excess can cause severe damage. Excessive bark stripping causes wood decay, leading to a decline in the forest cover (Akashi & Nakashizuka, 1999; Miquelle & van Ballenberghe, 1989; Yokoyama et al., 2001), and excessive browsing and/or grazing may alter the structure and composition of vegetation on the forest floor (Kumar et al., 2006; Rooney & Waller, 2003; Schütz et al., 2003; Stockton et al., 2005; Webster et al., 2005). These environmental changes indirectly affect other organisms in the forest ecosystem (Allombert et al., 2005; Feber et al., 2001; Flowerdew & Ellwood, 2001; Rooney, 2001).

To protect forest vegetation from further damage by the increased sika deer population, protective management, for example, wrapping tree trunks in wire mesh, have been implemented in addition to deer population control via culling and the erection of deer-proof fences (Ministry of the Environment-Kinki Regional Environment Office, 2009; Takatsuki, 2009). However, although these measures are effective for the protection of vegetation, they sometimes negatively affect other organisms.

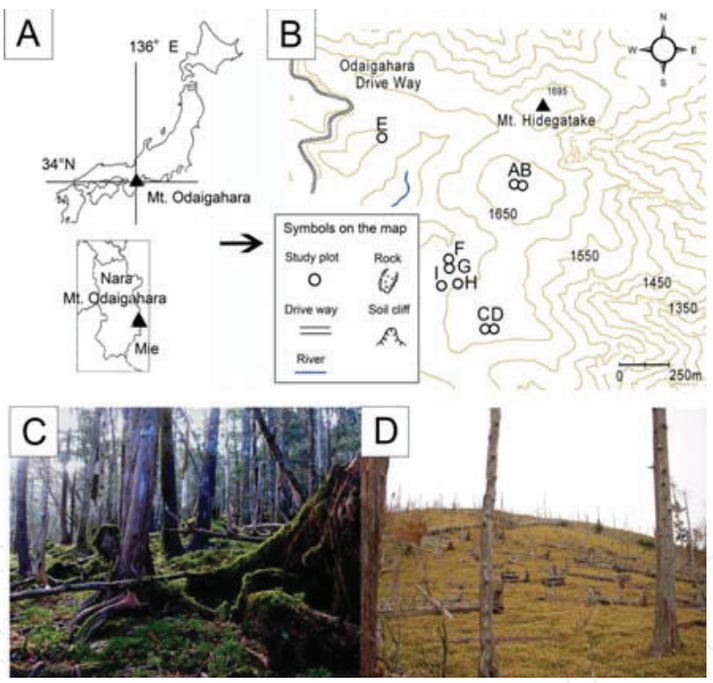
This chapter describes the effects of protective management activities on epiphytic diversity at Mt. Odaigahara in central Japan, which is a hotspot for bryophyte diversity. It discusses

the best practices for biodiversity conservation in this scenario on the basis of a previously published article (Oishi, 2011).

2. Study site

2.1. Location and characteristics of the study site

Mt. Odaigahara (34°N, 136°E; altitude, ca. 1,500 m) is located in Yoshino Kumano National Park, which is in the southeastern part of the Nara Prefecture in Japan (Fig. 1). The climate in this region is relatively mild (annual mean temperature, 5.7 °C), with high levels of precipitation (annual mean precipitation, 4,500 mm; Nara Local Meteorological Observatory 1997). The vegetation on Mt. Odaigahara is classified into 2 main types: (1) the dominant tree species on the eastern part of the mountain is *Picea jezoensis* (Sieb. et Zucc.) Carriere var. *hondoensis* (Mayr) Rehder, and (2) those on the western part are *Fagus crenata* Blume and *Abies homolepis* Sieb. et Zucc (Ide & Kameyama, 1972).



A; Location of Mt. Odaigahara in Japan. B: Location of study plots. C and D: Views of forests in Mt. Odaigahara. Photo C shows a forest of *P. jezoensis* var. *hondoensis* trees, whereas D shows a heavily declined forest.

Figure 1. Mt. Odaigahara and study plots, adapted from Oishi (2011)

2.2. Deer population

The population density of sika deer in Mt. Odaigahara has increased from the 1960s (Ando & Goda, 2009). To be specific, it has increased from approximately 12.0–22.2 individuals per square kilometer in the 1980s to 17.5–39.5 individuals per square kilometer in the 1990s (Ando & Goda,

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The photo on the left shows *Sasa nipponica* Makino et Shibata. browsed by sika deer. In this photo, the upper parts of the plants were browsed by sika deer. The right photo shows a deer fence and the effects of protection from browsing by sika deer: the height of the plants within the deer fence (back) is greater than that of the plants outside the fence.

Figure 2. Deer fence and the influence of browsing by deer on vegetation

2009). This increase led to serious damage to the forest vegetation in this mountain region (Ministry of the Environment, Kinki Regional Environment Office, 2009); for example, extensive bark stripping by the deer resulted in the dieback of damaged trees, and excessive browsing/grazing led to the loss of vegetation on the forest floor (Fig. 2). The Ministry of the Environment initiated a forest protection program in 1986 to conserve the forest ecosystem in this region (Ministry of the Environment, Kinki Regional Environment Office, 2009). This program was executed in a part (ca. 703 hectare) of Mt. Odaigahara (Ministry of the Environment, Kinki Regional Environment Office, 2009). To prevent bark stripping by the deer, the trunks of around 32,500 trees were wrapped with wire mesh composed of zinc-coated galvanized iron (Ministry of the Environment, Kinki Regional Environment Office, 2009) (Fig. 3).

The middle part of the tree trunk that does not have wire mesh protection has been debarked by deer.

Figure 3. Examples of tree trunks without (left) and with (right) wire mesh protection (Oishi, 2011)

2.3. Bryophyte diversity

In addition to the rapidly increasing population of sika deer on Mt. Odaigahara, this region is recognized for its bryophyte diversity. In fact, Mt. Odaigahara is home to approximately 30% (> 620 species) of the bryophytes in Japan (Doei, 1988), including several nationally endangered species that are listed in the Red Data Book of Japan (Ministry of the Environment, 2000). The rich diversity of epiphytic bryophytes in this region is attributed to the high humidity of this region (Doei, 1988) (Fig. 4). The major species on Mt. Odaigahara include *Pogonatum japonicum* Sull. & Lesq., *Dicranum japonicum* Mitt., *Hylocomium splendens* (Hedw.) Schimp., and *Pleurozium schreberi* (Brid.) Mitt., which grow on the forest floor; *Heterophyllium affine* (Hook.) M. Fleisch, *Bazzania yoshinagana* (Steph.) S. Hatt., *Mylia verrucosa* Lindb., and *Scapania ampliata* Steph., which grow at the base of trees; and *Pterobryon arbuscula* Mitt., *Hypnum tristo-viride* (Broth.) Paris, and *Bazzania denudata* (Torr. ex Lindenb.) Trevis., which grow on tree trunks (Fig. 5). Bryophytes contribute to species diversity as well as the ecological integrity of Mt. Odaigahara because they function as microhabitats for the seedbeds of vascular plants and are involved in rainfall interception and nutrient cycling (Coxson, 1991; Nadkarni, 1984; Nakamura, 1992; Pypker et al., 2006) (Fig. 6).

2.4. Changes in bryophyte diversity and the deer population since the 1960s

In the 1980s, epiphytic bryophyte flora in *P. jezoensis* var. *hondoensis* were surveyed in 2 parts of Mt. Odaigahara—Masakitoge and Masakigahara Masakigahara (Doei & Nakanishi, 1984) by using 20 × 20 m quadrants (plots A, B, C, and D in Fig. 1), and we examined the changes in these areas that had occurred over in the last 30 years. These areas were dense forests in the 1960s, but by 2008, they had become open forests because the changes in the environmental conditions after a severe typhoon in 1959 gradually resulted in dieback (Ando, 2009). Because many trees were blown down by the typhoon, the light conditions in the forests improved, and *S. nipponica* grew vigorously on the forest floor (Ando, 2009). This expansion resulted in an increase in the population of sika deer, which in turn resulted in dieback due to debarking (Yokoyama & Shibata, 1998).

The lower parts of many tree trunks (left) and fallen logs (right) are extensively covered with epiphytic bryophytes because of the high humidity.

Figure 4. Epiphytic bryophytes in Mt. Odaigahara

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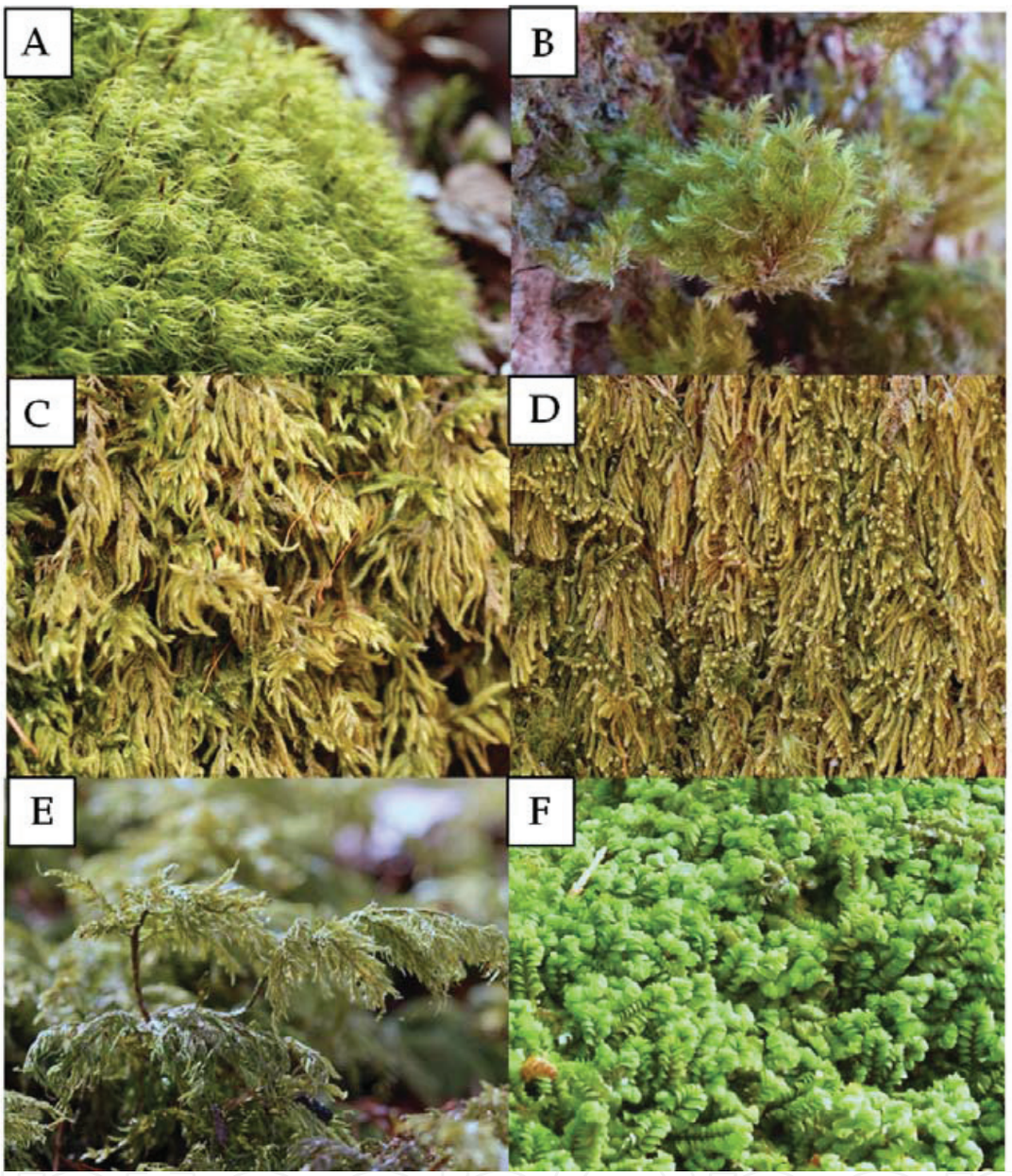

These species frequently occurred in the study plots: A, *D. japonicum*; B, *P. arbuscula*; C, *H. affine;* D, *H. tristo-viride*; E, *H. splendens;* F, *M. verrucosa*

Figure 5. Major species in the study plots

In 2008, we surveyed the epiphytic bryophyte flora in almost the same places as those examined in a previous study (Doei & Nakanishi, 1984) by using 20 × 20 m quadrants (plots A, B, C, and D in Fig. 1), and we examined the changes in these areas that had occurred over in the last 30 years. Table 1 summarizes the environmental conditions in these plots.

The species richness of individual *P. jezoensis* var. *hondoensis* trees decreased over 30 years from 18.0 ± 3.5 to 5.7 ± 3.4 in Masakitoge and from 18.0 to 7.5 ± 5.3 in Masakigahara (mean or mean ± SD) [[Table 1 and Fig. 7 are based on Doei & Nakanishi (1984) and Oishi (2011)]].

Thus, in direct contrast to the increasing deer population, epiphytic bryophyte diversity significantly declined over time.

Possible reasons for the decrease in bryophyte diversity are that (1) the decline in the forest cover indirectly affected bryophyte diversity because of the changes in the environmental conditions (e.g., air humidity), and (2) the protection of trees using wire mesh directly affected bryophyte diversity because of metal pollution.

To determine the reasons for the decline in bryophyte diversity, we examined the correlation between the diversity of epiphytic bryophytes and environmental variables, including wire mesh protection.

Figure 6. Bryophyte function in the ecosystem

Bryophytes provide safe microhabitats for the seedbeds of vascular plants (left). B: Bryophytes absorb water from rain drops and mist and therefore function in water storage in forests (right).

Plot	Year	No. of *Picea jezoensis* var. *hondoensis* trees surveyed		DBH (mean ± S.D.)
		Total	With wire mesh	
Masakitoge	1980s	2	0	23.7
	2008	10	8	23.8 ± 4.2
Masakigahara	1980s	13	0	34.4 ± 7.6
	2008	10	9	25.0 ± 11.2

Table 1. Summary of the characteristics of the study plots sampled for comparing the changes in the species richness from the 1980s to 2008

The bars represent the mean value of species richness and epiphyte cover on a single tree, and the error bars represent the corresponding standard deviations.

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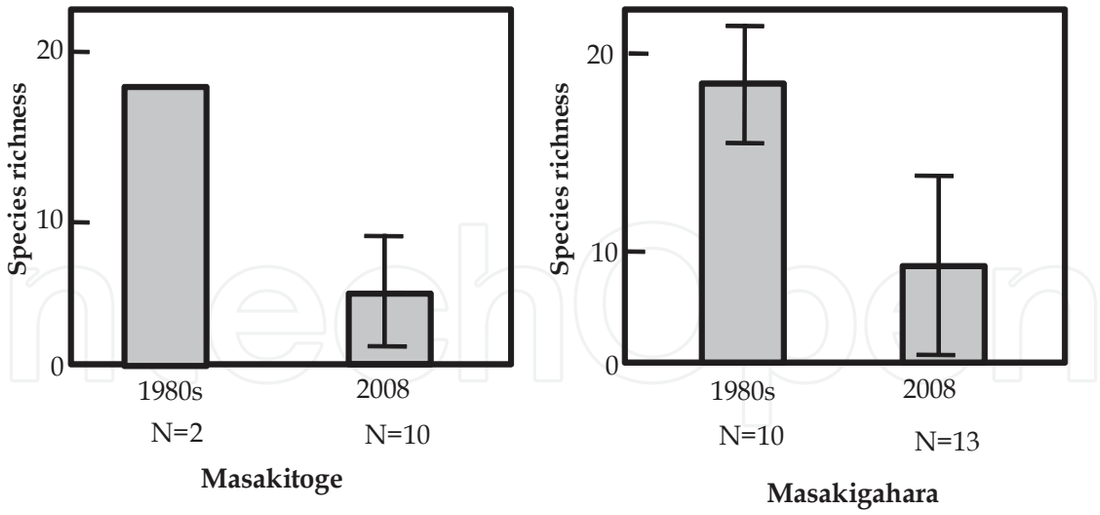


Figure 7. Species richness of epiphytic bryophytes on a single *P. jezoensis* var. *hondoensis* tree in the 1980s and 2008

3. Bryophyte diversity and environmental variables

3.1. Major environmental factors influencing bryophyte diversity

3.1.1. Site selection

A preliminary survey was conducted to identify plots of forest that were dominated by *P. jezoensis* var. *hondoensis* trees, including those with and without a protective wire mesh. In total, 9 plots (each 20 × 20 m in size) were selected (Fig. 1 A–I; Table 2) to examine the influence of wire mesh protection on epiphytic bryophyte diversity The names of plots were changed from those used in previous reports (Oishi, 2011) to adjust to the context of the present study. Plots A–D were identical to those mentioned in section 2.4. We observed that the tree trunks were completely wrapped with wire mesh, from the ground up to a height of 150–180 cm. The mesh was composed of zinc-coated galvanized iron, a commonly used material for wire meshes (Japan Society of Corrosion Engineering, 2000). In each plot, the tree density (m^2/plot) was measured on the basis of the total basal area of the trunks. Further, the fraction of the trunk area of the *P. jezoensis* var. *hondoensis* trees that had been debarked by sika deer was also recorded in each plot.

3.1.2. Bryophyte sampling

The epiphytic bryophyte flora on the trunks of *P. jezoensis* var. *hondoensis* trees in the study plots were surveyed from October to November 2008. The bryophyte species covering the tree trunks from ground level to a height of 1.5 m were examined.

Bryophyte nomenclature followed that reported by Iwatsuki (2001). The proportion of bryophyte cover, as a percentage of the total available bark area being investigated, was divided

into 6 levels: 1 (<1%), 2 (≥1% to <10%), 3 (≥10% to <25%), 4 (≥25% to <50%), 5 (≥50% to <75%), and 6 (≥75%).

3.1.3. Analysis of the correlation between bryophyte diversity and environmental variables

A simple generalized linear model (GLM) using R software for Windows 2.11.0 (R Development Core Team, 2010) was used to identify the correlations between species richness and the bryophyte cover with respect to environmental variables. To identify the most parsimonious model, we performed automated stepwise model selection using the Akaike information criterion (AIC) using the minimum AIC as the best-fit estimator. Bryophytes that had been identified only up to the genus level were not included in the calculation of species richness if any species of that genus was sampled. The environmental variables used in the GLMs were tree density, host tree diameter at breast height (DBH), percentage of debarked area, and percentage of tree trunks with wire mesh protection.

3.1.4. Results & discussion

Associated with the 110 tree trunks in the sampling plots, 68 species were identified in the bryophyte flora survey: 29 mosses and 39 liverworts (Appendix). Fig. 8 shows the species richness and cover in the study plots. The species richness on a single tree ranged from no species to 34 species (mean = 9.1, SD ± 9.0), while the bryophyte cover ranged from 0 to level 5 (mean = 2.0, SD ± 1.8).

The GLMs constructed using the environmental variables are presented in Table 3. These models showed that the species richness and bryophyte cover were significantly correlated with DBH (height, 1.5 m) and tree density ($p < 0.01$) but negatively correlated with the presence of wire mesh protection ($p < 0.01$). The GLMs for species richness and bryophyte cover explained 70.1% and 80.4% of the variance, respectively ($p < 0.01$ for both models).

High tree density and host tree DBH have been suggested to be beneficial for bryophyte diversity, as they provide better microclimates, e.g., humid conditions (Hazell et al., 1998; Ojala et al., 2000; Thomas et al., 2001). Further, the species richness and bryophyte cover may be positively correlated with high host tree DBH because DBH is correlated with bark features (e.g., bark thickness and bark roughness) (Boudreault et al., 2008; Ojala et al.,2000).

The results of this study raise the question of how wire mesh protection negatively affects bryophyte diversity. Considering that the galvanized iron, which is the primary component of the wire mesh, is coated with zinc, it is likely that the zinc affects the bryophytes. In the next section, we compare the zinc concentrations in bryophytes on trees with and without wire mesh protection.

3.2. Effect of wire mesh protection on bryophytes

3.2.1. Bryophyte samples

To examine the influence of wire mesh protection on the bryophytes, inductively coupled plasma-mass spectrometry (ICP-MS) was used to compare the concentration of zinc in bryophyte samples, since zinc coats the wire mesh surface. For this evaluation, 2 species of

bryophyte that are commonly found on the trunks of *P. jezoensis* var. *hondoensis* trees of this region, both with and without wire mesh, were sampled: *H.tristo-viride* and *S. ampliata*. For each species, 3 sets of samples each were collected from trees with and without wire mesh.

3.2.2. Analysis of zinc concentration

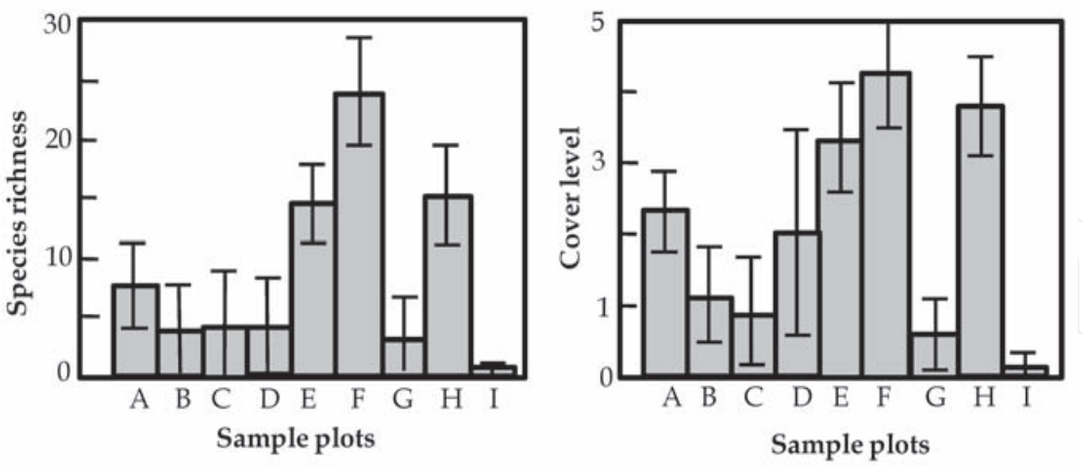
Dry samples (0.05–0.10 g) were placed in polytetrafluoroethylene vessels and weighed. Subsequently, 5 mL of nitric acid was added to the samples, and they were digested using a microwave system (MLS-1200 MEGA; Milestone General, Tokyo, Japan) before ICP-MS analysis. The samples were then analyzed using a 7500CX ICP-MS system (Agilent Technologies, Wilmington, DE, USA). Spectral interference was minimized or eliminated using the octopole reaction system, with helium as the reaction gas at a flow rate of 2.5 mL/min. The ICP-MS analysis was repeated twice for each sample, and the mean values were used in one-sided Student's t-test comparisons of the zinc concentration from bryophyte samples on tree trunks with and without wire mesh.

Plot	Altitude	Tree density	No. of *Picea jezoensis* var. *hondoensis* trees	
		(m^2/plot)	Total	With wire mesh
Plot A	1676	3.1	3	2
Plot B	1672	4.0	7	6
Plot C	1621	5.5	2	2
Plot D	1619	4.3	8	7
Plot E	1597	13.9	12	0
Plot F	1572	11.9	15	0
Plot G	1576	19.9	11	11
Plot H	1597	12.7	22	0
Plot I	1590	9.9	30	30

Table 2. Summary of the characteristics of the study plots sampled, including altitude, tree density, and number of trees surveyed, adapted from Oishi (2011)

	Species richness			Cover		
Variables	**coefficients**	***t*-value**	***p***	**coefficients**	***t*-value**	***p***
Intercept	7.30	3.81	< 0.01	2.26	7.30	< 0.01
Tree density	3.51×10^{-4}	3.10	< 0.01	6.30×10^{-5}	3.43	< 0.01
Host tree DBH	2.01×10^{-1}	3.12	< 0.01	2.29×10^{-2}	2.18	< 0.05
Wire mesh	-1.43×10^{-1}	−14.2	< 0.01	-3.19×10^{-2}	−19.5	< 0.01
Adjusted R squared	0.701			0.804		

Table 3. Generalized liner models showing the association of species richness and bryophyte cover with environmental variables (Oishi, 2011). The significance level of the coefficients and adjusted R^2 values are shown.



The bars represent the mean value of species richness and epiphyte cover on a single tree, and the error bars represent the corresponding standard deviations. Most tree trunks in plots A, B, C, D, G, and I had wire mesh protection.

Figure 8. Comparison of bryophyte species richness between trees with and without wire mesh protection, adapted from Oishi (2011)

3.2.3. Results & discussion

ICP-MS analysis showed a significant 3- to 6-fold higher concentration of zinc in bryophytes inhabiting the bark of trees with wire mesh protection than in those without wire mesh protection (Fig. 9). Previous studies have shown that a considerable amount of zinc is leached from the zinc coating of galvanized iron by rain and dew (Harris, 1946; Seaward, 1974). Research has also shown that zinc is highly toxic to bryophytes (Tyler, 1990). Consequently, from the decreased diversity and increased zinc concentration of bryophytes on trees with wire mesh protection, it is reasonable to conclude that the loss of bryophyte cover and species richness has primarily occurred because of the toxicity of the zinc in the wire mesh. Additionally, other heavy metals in the wire mesh (e.g., iron) may affect bryophytes, with different heavy metals exerting varying levels of toxicity for bryophytes (Tyler, 1990).

4. Implications for biodiversity conservation

The results show that epiphytic bryophyte diversity is positively influenced by tree density and host tree DBH but negatively influenced by wire mesh protection, because of zinc toxicity (Fig. 10). The decline in bryophyte abundance and diversity on the lower parts of the tree trunks may be a cause for concern for biodiversity conservation on Mt. Odaigahara. This is because bryophytes contribute significantly to the species richness and biomass of tree trunks (Fritz, 2009; Lyons et al., 2000), as well as for ecosystem functions.

Furthermore, in addition to bryophytes, tree bark also provides important habitats for lichens and vascular epiphytes (Williams & Sillett, 2007). However, as heavy metals are toxic

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to these plants (Tyler et al., 1989), wire mesh protection may also contribute towards decreasing their levels of diversity and ecosystem functions. Unfortunately, considering that wire mesh protection is generally used against mammalian pests due to its direct effectiveness (Salmon et al. 2006; Vercauteren et al. 2006), this negative impact on bryophyte diversity may be widespread.

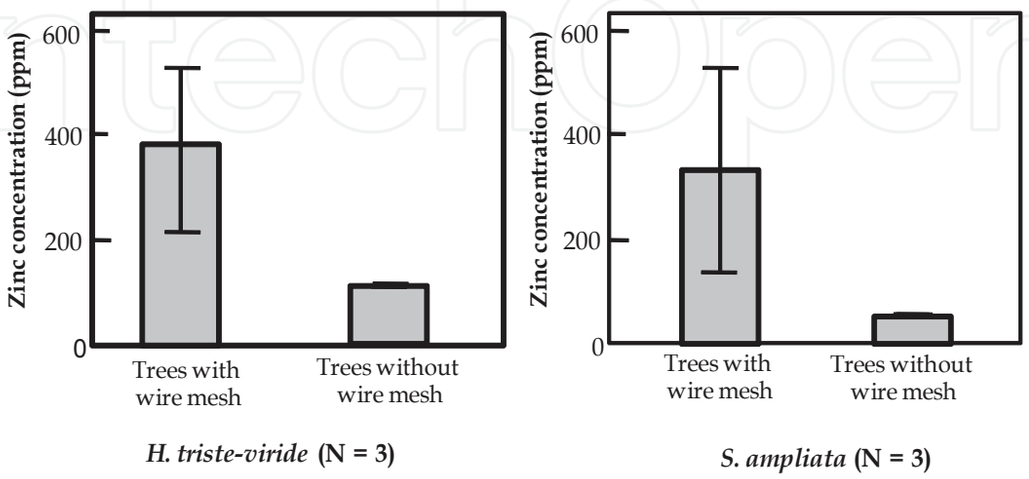

Figure 9. Zinc concentration (Oishi, 2011)

The zinc concentration was significantly higher in bryophytes on trees with wire mesh than in those without wire mesh ($p < 0.05$; *t*-test).

Therefore, to establish best practices for biodiversity conservation that includes bryophytes, we should not only protect trees against bark stripping by deer but also focus on the materials used for protection. Alternative techniques for plant protection include the use of tree shelters in which trees are enclosed in plastic tubes (Ward et al., 2000) and forest enclosures using plastic mesh fencing (Vercauteren et al., 2006). However, these alternatives may also affect biodiversity conservation. For example, tree shelters decrease light transmission (Ward et al., 2000), which might alter the composition of bryophyte species on tree trunks. Further, Shibata et al. (2008) reported that forest enclosures sometimes hamper tree regeneration within the fenced areas because of serious seed predation by increased mouse populations.

5. Conclusion

The difficulties faced in minimizing the effect of plant protection methods on ecosystems that have complex community interactions are shown in this chapter. To establish best practices for biodiversity conservation, adaptive management should be adopted. Within such frameworks, we should examine and revise protective management practices on the basis of scientific data assimilated from regular monitoring of such ecosystems, while also preferentially using metal-free plant protection materials.

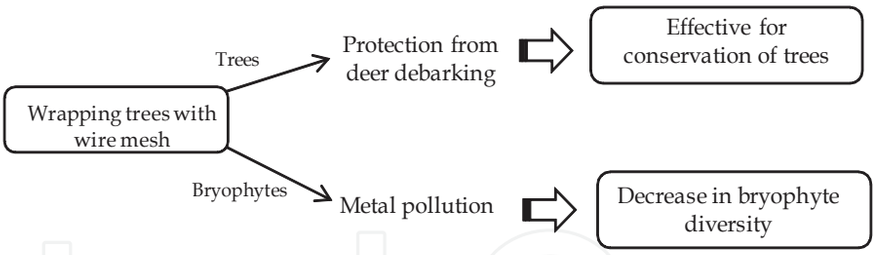

Figure 10. Positive and negative effects of wire mesh protection on the biodiversity

Appendix

This list shows the average cover of each species on a single *P. jezoensis* var. *hondoensis* tree. The cover levels are indicated for reference to the text. The bryophytes nomenclature follows that reported by Iwatsuki (2001).

Plots	A	B	C	D	E	F	G	H	I
Mosses									
Pogonatum alpinum (Hedw.) Röhl.	0	0	1.0	0	0.1	0.5	0	0	0.4
Pogonatum contortum (Brid.) Lesq.	0	0	0	0	0.1	0.1	0	0	0
Pogonatum japonicum Sull. & Lesq.	0	0	0	0	0.2	0	0	0	0
Dicranum japonicum Mitt.	0	0	0	0	0	0.3	0	0	0
Dicranum nipponense Besch.	0	0	0	0	0	0.2	0	0	0.2
Dicranum hamulosum Mitt.	0.3	0.1	0.5	0	1.2	0.7	0.1	0	0.6
Dicranum leiodontum Card.	1.0	0.6	1.0	0.3	0.8	0.6	0	0	0.6
Dicranum mayrii Broth.	0	0	0	0	0	0.1	0	0	0
Dicranum scoparium Hedw.	0	0.1	0	0	0.8	0.5	0	0	0.2
Dicranum viride (Sull. & Lesq.) Lindb. var. *hakkodense* (Card.) Takaki	1.0	0.4	1	0.5	0.9	0.9	0.4	0	0.4
Dicranodontium denudatum (Brid.) E. G. Britt. ex Williams	0	0.1	0.5	0	0.5	0.4	0	0	0.3
Dicranoloma cylindrothecium (Mitt.) Sakurai	0	0	0	0	0.3	1.2	0	0	0.8
Leucobryum bowringii Mitt.	0	0	0	0	0	0	0	0	0
Leucobryum juniperoideum (Brid.) Müll.Hal.	0	0	0	0	0.1	0.1	0	0	0
Trachycystis flagellaris (Sull. & Lesq.) Lindb.	0	0	0	0	0	0.3	0	0	0
Pterobryon arbuscula Mitt.	0	0	0	0	0	0.1	0	0	0
Neckera konoi Broth.	0	0	0	0	0	0	0	0	0
Fauriella tenuis (Mitt.) Card.	0	0	0	0	0.1	0.1	0	0	0
Thuidium tamariscinum (Hedw.) Shimp.	0	0	0	0	0	0	0	0	0
Plagiothecium euryphyllum (Card. & Thér.) Z.Iwats.	0	0	0.5	0	0	0.2	0	0	0
Heterophyllium affine (Hook.) M.Fleisch.	1.3	0.1	0.5	0	3.3	3.4	0.3	0	1.5
Brotherella fauriei (Card.) Broth.	0	0	0	0	0.1	0.3	0	0	0.2
Brotherella henonii (Duby) M.Fleisch.	0	0	0	0	0.1	0.2	0	0	0
Herzogiella turfacea (Lindb.) Z.Iwats.	0	0	0	0	0	0.1	0	0	0
Hypnum tristo-viride (Broth.) Paris	1.3	0.4	1.0	0.4	3.8	3.5	0.5	0	2.7
Hypnum fujiyamae (Broth.) Paris	0.3	0.1	0	0	0.5	0.5	0	0	0.5
Pseudotaxiphyllum pohliaecarpum (Sull. & Lesq.) Z.Iwats.	0	0	0	0	0.1	0.1	0	0	0
Hylocomium splendens (Hedw.) Schimp.	0	0	0	0	0	0.7	0	0	0.1
Pleurozium schreberi (Brid.) Mitt.	0	0	0	0	0	0.4	0	0	0.1

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Liverworts									
Herbertus aduncus (Dicks.) Gray	0.7	0.1	0.5	0	0.4	0.4	0	0	0.4
Trichocolea tomentella (Ehrh.) Dumort.	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum (L.) Dumort.	0	0	0	0	0.7	0.9	0	0	0.4
Lepidozia reptans (L.) Dumort.	0	0	0	0	0.1	0.5	0	0	0.4
Lepidozia subtransversa Steph.	0	0	0	0	0	0.1	0	0	0
Lepidozia vitrea Steph.	0.3	0	0	0	0.8	1.0	0.1	0	0.7
Bazzania bidentula (Steph.) Steph.	0	0	0	0	0	0.1	0	0	0.1
Bazzania denudata (Torr. ex Lindenb.) Trevis.	0.3	0.1	0.5	0.1	1.1	1.0	0.1	0	0.9
Bazzania yoshinagana (Steph.) S.Hatt.	0	0	0	0	0.3	1.2	0.1	0	0.8
Cephalozia leucantha Spruce	0	0	0	0	0.1	0.1	0	0	0
Cephalozia lunulifolia (Dumort.) Dumort.	0	0	0	0	0.1	0	0	0	0
Chephaloziella sp.	0	0	0	0.1	0	0.2	0	0	0
Nowellia curvifolia (Dicks.) Mitt.	0	0	0	0	0.1	0.2	0	0	0
Odontoschisma denudatum (Mart.) Dumort.	0	0.1	0.5	0.1	0.8	0.6	0.1	0	0.2
Odontoschisma grosseverrucosum Steph.	0	0	0	0	0	0.1	0	0	0
Jamesoniella autumnalis (DC.) Steph.	0	0	0	0	0.3	0	0	0	0
Jungermannia subulata A.Evans	0	0	0	0	0	0.1	0	0	0
Anastrophyllum michauxii (F.Weber) H. Buch	0	0	1.0	0	0.6	0.4	0.1	0	0.3
Lophozia longiflora (Nees) Schiffn.	0	0	0	0	0.3	0.6	0.1	0	0.2
Lophozia incisa (Schrad.) Dumort..	0	0	0	0	0	0.5	0.1	0	0.2
Mylia verrucosa Lindb.	0	0	0	0	0	0.3	0	0	0.4
Scapania ampliata Steph.	0.3	0.3	0	0	0.4	1.9	0.4	0	1.2
Scapania bolanderi Austin	0	0	0	0	0	0.1	0	0	0.1
Scapania ciliata Sande Lac.	0	0	0	0	0.1	0	0	0	0
Scapania hirosakiensis Steph. ex Müll. Frib.	0	0	0	0.1	0.3	0.3	0	0	0
Heteroscyphus planus (Mitt.) Schiffn.	0	0	0	0	0.1	0	0	0	0
Plagiochila gracilis Lindenb. & Gottsche	0	0.1	0.5	0.3	0.2	0.5	0.2	0	0.1
Plagiochila ovalifolia Mitt.	0	0	0	0	0	0.1	0	0	0
Plagiochila semidecurrens (Lehm. & Lindenb.) Lindenb.	0	0	0	0.1	0.4	0.9	0.2	0	0.1
Radula cavifolia Hampe ex Gottsche, Lindenb. & Nees	0	0	0	0	0	0.1	0	0	0
Radula brunnea Steph.	0	0	0	0	0	0.4	0	0	0
Ptilidium pulcherrimum (Weber) Vain.	0	0.1	0	0	0.1	0	0	0	0
Frullania tamarisci (L.) Dumort. subsp. *obscura* (Verd.) S.Hatt.	0	0	0	0	0.6	1.6	0.2	0	1
Cololejeunea macounii (Spruce ex Underw.) A.Evans	0	0	0	0	0	0.1	0	0	0
Drepanolejeunea angustifolia (Mitt.) Grolle	0	0	1	0.1	0	0.4	0	0	0.1
Drepanolejeunea ternatensis (Gottsche) Steph.	0	0	0	0	0.1	0	0	0	0
Drepanolejeunea teysmannii Steph.	0	0	0	0	0	0.2	0.1	0	0
Nipponolejeunea pilifera (Steph.) S.Hatt.	1.0	0.7	0	0.4	1.0	0.9	0.2	0	0.9
Nipponolejeunea subalpina (Horik.) S.Hatt.	0.3	0	0	0.1	0.1	0.1	0	0	0.1
Lejeunea ulicina (Taylor) Gottsche, Lindenb. & Nees	0.3	0	0.5	0.1	0	0.5	0.1	0	0

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