Title

Assessing insect herbivory on broadleaf canopy trees at 19 natural forest sites across Japan

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Abstract

We present the largest freely available herbivory dataset for Japan representing data collected from a network of 19 natural forest sites across the country. Sampled network sites were part of the Monitoring Sites 1000 Project organized by the Ministry of the Environment. Sites were located across a range of climate zones, from subarctic to subtropical, and broadleaf trees (both evergreen and deciduous) were targeted at each site. Litterfall traps were used to assess leaf damage caused by leaf-chewing insects in 2014 and 2015. Using a standardized protocol, we assessed herbivory on 117,918 leaves of 39 dominant tree species. Preliminary analyses suggest that insect herbivory increases with increasing latitude for deciduous broadleaf species. In particular, oak (*Quercus crispula*) and beech (*Fagus crenata*) were subject to increased insect herbivory with increasing latitude. In contrast, insect herbivory decreased with increasing latitude in evergreen broadleaf species. The latitudinal gradient of herbivory differed according to leaf type (i.e., evergreen or deciduous). This dataset offers excellent opportunities for meta-analysis and comparative studies of herbivory among various forest types.

Keywords

evergreen species, deciduous species, insect-plant interactions, the Monitoring sites 1000 Project, latitudinal gradient

Metadata

1. Introduction

Herbivory, the act of eating plants, plays a fundamental role in carbon and nutrient cycling (Metcalfe et al., 2013) and may affect diversity and structure in forest communities by altering biomass (Cyr & Pace, 1993) and tree fitness (Coley & Barone, 1996). Exploring changes in herbivory that may reflect global climate change has become increasingly popular in recent decades (Kozlov & Zvereva, 2015). However, debate remains as to the mechanisms by which biotic and abiotic factors regulate herbivory (e.g., Coley, Bryant, & Chapin, 1985; Endara & Coley, 2011; Moles, Bonser, Poore, Wallis, & Foley, 2011).

It is believed that biotic interactions become stronger as latitude decreases (Dobzhansky, 1950; Janzen 1970; Schemske et al. 2009). For insect–plant interactions, ecologists have long examined how insect herbivory intensity varies with latitude (e.g., MacArthur, 1972; Pennings & Siliman, 2005; Schemske, Mittelbach, Cornell, Sobel, & Roy, 2009; Hiura & Nakamura, 2013). In two seminal review papers published in the 1990s, Coley and colleagues found that tropical forests experienced significantly higher herbivory than did temperate forests (Coley & Aide, 1991; Coley & Barone, 1996). These studies served as the foundation for the latitudinal herbivory–defense hypothesis (LHDH), which predicts that herbivory will be higher in warmer and more stable climates (i.e., at low latitude or low elevation), which then leads to selective pressure for the evolution of more effective plant defenses (Dobzhansky, 1950; MacArthur, 1972; Coley & Aide, 1991). Latitudinal gradients in insect herbivore abundance and species richness are likely responsible for stronger herbivore pressure on plants at low latitudes (Salazar & Marquis, 2012). It is widely accepted that forests in warmer climates suffer greater herbivory than those in cooler climates (Kozlov, 2008; Kozlov, van Nieukerken, Zverev, & Zvereva, 2013; Lim, Fine, & Mittelbach, 2015; Wang et al., 2016; Zhang, Zhang, & Ma, 2016; Moreira et al., 2018). Additionally, variation in the production cost of defense compounds as predicted by optimal defense theory is an important determinant of geographic patterns in plant defense (Kooyers et al. 2017). However, some studies have shown that no latitudinal gradient in herbivory exists (e.g., Andrew & Hughes, 2005), that the trend is counter to what would generally be expected by the LHDH (e.g., Moles et al., 2011), or that the trend is nonlinear (e.g., Kozlov, Lanta, Zverev, & Zvereva, 2015). Therefore, despite widespread interest in this pattern, the empirical evidence comprises controversial results regarding latitudinal gradients in herbivory. The wide range of latitudes (20–46 degrees) and mountainous terrain in Japan, which include a wide range of subarctic and subtropical forest types themselves, gives rise to suitable conditions for addressing this question.

This study reports insect herbivory data collected across a network of 19 natural forest sites; this is the largest published herbivory dataset available for Japan with sites spanning a wide latitudinal gradient (26.74–44.37°N). This study focuses on the latitudinal gradient in insect herbivory in temperate regions of East Asia. The forest site network is part of the Forest and Grassland Survey of the Monitoring Sites 1000 Project established by the Ministry of the Environment (Ishihara, Toyota, & Nakamura, 2007; Ishihara et al., 2010). Some Monitoring Sites 1000 locations are also part of the Japan Long-Term Ecological Research Network (JaLTER), which further contributes to the International Long-Term Ecological Research Network (ILTER). These herbivory data, which were collected in 2014 and 2015, offer an opportunity for meta-analysis and comparative studies among forest types and for testing community ecology and ecosystem function hypotheses at broad spatial scales (e.g., testing for a latitudinal gradient in insect–plant interactions and elucidating the relative importance of insect herbivory in forest ecosystem function).

2. IDENTIFER

xxxx(Ecologial Research Data Paper Archives ID, describe after accepted)

3. CONTRIBUTER

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B. Dataset Creator

Hino Takafumi, Network Center of the Forest and Grassland Survey of the Monitoring Sites 1000 Project, Japan Wildlife Research Center

Masahiro Nakamura, Wakayama Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Wakayama, Japan

4. GEOGRAPHIC COVERAGE

A. Geographic Description

Japan

B. Geographical Position

Longitude: 128º 23´ E - 142º 28´ E

latitude: 26º 74´ N - 44º 37´ N

5. TEMPORAL COVERAGE

A. Begin:

2014

B. End:

2015

6. TAXONOMIC COVERAGE

The data include 20 families, 27 genus and 39 species of broadleaf trees (see SpList.csv for details). *Castanopsis* spp. in Tano site includes *Castanopsis sieboldii* and *Castanopsis cuspidate*.

7. METHODS

A. Study sites and data acquisition

Herbivory data were obtained at 19 natural forest sites as part of the Monitoring Sites 1000 Project, with one to five permanent plots located within each site. These sites covered the major climate zones and biogeographic regions in Japan (Ministry of the Environment 2001, http://www.env.go.jp/press/press.php?serial=2908, last accessed on

October 6, 2020) (Fig. 1, Table 1; see also Ishihara et al., 2011) as well as the four major forest types. Plots were classified to four forest types based on the dominant tree species; evergreen conifer forest (EC), broadleaf and conifer mixed forest (BC), deciduous broadleaf forest (DB), and evergreen broadleaf forest (EB) (Ishihara et al., 2011). The majority of the surveyed forest were old-growth or older secondary forests, but some were secondary forests aged <100 years. We classified forests stands to three age categories: old growth (OG), old secondary (OS), and secondary (S) (Ishihara et al., 2011; see Appendix 1 for details).

The mean annual temperature and precipitation and mean maximum snow depth during 1981–2010 were extracted from the Mesh Climate Data 2010 database distributed by the Japan Meteorological Agency (2012). The database provides climate variables estimated at 1-km spatial resolution. Mean annual temperature was corrected to account for altitudinal difference between a given plot and the 1-km cell mean using a lapse rate of 0.55°C per 100 m. Database estimates for snow depth may contain inaccuracies (i.e., over- or underestimation) given that snow depth is highly spatially heterogeneous. Therefore, we provide snow depths reported in other publications and personal observations in Appendix 1 and Table S1.

Additional ecological data collected at the 19 study sites were available from publications, including seasonal patterns and inter-annual dynamics of litterfall (Suzuki et al., 2012), forest stand structure, composition, and dynamics (Ishihara et al., 2010), as well as ground-dwelling beetle community and understory variables (Niwa et al., 2016). At the Shiiba site (SI), only tree census data (Ishihara et al., 2010) were available. Additional ecological information including understory vegetation, disturbance history, and soil parameters collected from study sites are provided in Appendix 1 and partially summarized in Table S1.

B. Sampling design, field methodology, and preliminary analyses

B-1. Sampling design

One permanent plot at each of the 19 sites was selected for litter collection. Plots ranged in size from 0.64 to 1.2 ha and were usually approximately 1 ha in size (see Appendix 1, SiteList.csv). Plots were placed or their shapes were adjusted to avoid forest roads and urban edges. Plots were typically divided into 10 x 10-m grid cells. Typically, 25 conical litter traps, each with a circular collection area of 0.5 m^2, were installed within each plot (see Suzuki et al., 2012 for details of the litter traps). Traps were placed approximately 1 m above the ground at grid cell corners and were spaced 20 m apart. Litterfall that collected within the traps was collected monthly. Traps were either removed or placed on the ground during winter at sites that received snow.

B-2. Field methodology

Litterfall from these traps was then used for a visual assessment of leaf damage by leaf-chewing insects. Herbivory has been assessed visually in other publications (e.g., review by Kozlov et al., 2015). Although few studies have used litter traps for the visual assessment of herbivory (but see Hiura & Nakamura, 2013), litter traps are useful for collecting litterfall, especially for the assessment of multiple tree species over long periods. One technician visually assessed leaf damage blindly with respect to site. The protocol was standardized across all sites, enabling comparisons among forest types. At broadleaf forest sites, the 5 traps with the largest amount of litter were selected from all 25 traps. At BC sites, 5 traps located near broadleaf trees were selected. During the 4-month period when litterfall was highest (Table 2), we visually categorized the extent of herbivory on fallen leaves to six classes: no damage; 1–10% of leaf area lost; 11–25% loss; 26–50% loss; 51–75% loss; and >76% loss (Nakamura, Asanuma, & Hiura, 2010; Nakamura, Nakaji, Muller, & Hiura, 2014). This herbivory assessment was applied to all broadleaf tree species that were considered dominant at each site (up to 50% dominance, Table 3). In addition, oak (*Quercus crispula*, 8 sites in 2014, 8 sites in 2015) and beech (*Fagus crenata*, 8 sites in 2014, 9 sites in 2015) leaves were also assessed regardless of their dominance at sites.

B-3. Preliminary analyses

We preliminarily analyzed the latitudinal gradient in insect herbivory as observed in deciduous species, evergreen species, *Q. crispula*, and *F. crenata* in 2014 and 2015 using linear mixed models (LMM) in the R library lme4 package. In the models, the median herbivory rate of each leaf (i.e., 0%, 5.5%, 18%, 38%, 63%, and 88%, respectively) was treated as a response variable; latitude, year sampled, and their interaction were treated as fixed effect variables. The year sampled was treated as a factor. Plot ID was treated as a random effect variable. The likelihood-ratio chi-square test was used to determine whether the herbivory rate was significantly related to latitude. The preliminary analyses indicated that insect herbivory on deciduous species significantly increased toward higher latitudes ($\chi^2 = 35.03$, $P < 0.001$; Fig. 2a, Table 4), whereas that on evergreen species significantly decreased ($\chi^2 = 4.82$, $P < 0.05$; Fig. 2b, Table 4). These results were congruent with the latitudinal pattern in defense strategy in deciduous and evergreen species reported by Saihanna et al. (2018), who showed that deciduous species used physical defenses at lower latitudes, whereas evergreen species exhibited the opposite latitudinal defense patterns. In particular, insect herbivory on *Q. crispula* significantly increased with increasing latitude ($\chi^2 = 8.99$, $P < 0.05$; Fig. 3a, Table 4), and herbivory on *F. crenata* tended to increase with latitude, although the trend was not significant (Fig. 3b, Table 4). These results were congruent with the latitudinal pattern in beech herbivory reported by Hiura & Nakamura (2013).

Our findings suggested that the latitudinal gradient of insect herbivory differed depending on leaf type (i.e., evergreen or deciduous). Leaf type is an important predictor of resource use; evergreen species typically show a more conservative resource-use strategy and slower growth rates (Givinish, 2002), whereas deciduous species show an exploitative resource-use strategy and higher growth rates (Reich, Ellsworth, & Walters, 1998). Our preliminary results suggest that the resource-use strategy may be an important determinant of the directionality of latitudinal gradients in insect herbivory.

C. Data verification procedures

We note that our data collection at two sites, Kamigamo (2014) and Wakayama (2015), was limited to a single year. The selected litter traps at some sites did not capture fallen leaves of some target tree species. Specifically, we did not capture leaves from *Acer* *ukurunduense* at Otanomosutaira in 2015, *Castanea crenata* at Ogawa in 2015, *Illicium anisatum* at Shiiba in 2014, *Quercus acuta* at Aya in 2014, and *Ilex macropoda* at Kamigamo in 2015. Thus, herbivory was not assessed for those species in those years.

8. DATA STATUS

A. Latest update

January 15 2020

B. Metadata status

Metadata are complete for this period and stored with the data.

9. ACCESSIBILITY

A. License and usage right

B. Contact

Data Set Contact

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10. DATA STRUCTURE

A. Data tables

Data file name	Description
SiteList.csv	Site-wise information table. Sites are listed by latitude from north to south.
SpList.csv	Species-wise information table.

Herbivory.csv	Herbivory data of each species in each site in 2014 and 2015. The herbivory of each leaf was classified into the six herbivory class, and a total number of the leaves of each the class is calculated (see method 7. B).

B. Format type

The data files are comma delimited (csv) in UTF-8 encoding.

C. Header information

Headers corresponding to variables names (see 10. D.) are included as the first row in the data files.

D. Variable definitions

The variables are listed in the order they appear in each data file. Variable names are headers included as the first row in the data files. All variables of SiteList.csv are compliant with the data papers (Ishihara et al., 2010; Suzuki et al., 2012; Niwa et al., 2016), although variables of Temp30yr, Rain30yr, and Snow30yr (1971-2000) are updated to 1981-2010 due to updating the database Mesh Climate Data by the Japan Meteorological Agency.

Data file name	Variable name	Variable definition
SiteList.csv	Code	Plot code. The third and fourth digits are unique to each site, and the fifth and sixth digits are plot numbers.
	PlotID	Alphanumeric plot code.
		An alphanumeric code as [abbreviated site name]-[forest type code][plot number]. For example, TM-DB1 represents the first plot of deciduous broadleaf forest (DB) in the

		site, Tomakomai (TM).
	SiteName	Site name.
	Type	Alphabetical code for forest type:
		BC = Broadleaf conifer mixed forest.
		DB = Deciduous broadleaf forest.
		EB = Evergreen broadleaf forest.
		EC = Evergreen coniferous forest.
	Status	Forest age classifications (See 7. A and Appendix 1.pdf).
		S: Secondary.
		OS: Old secondary.
		OG: Old growth.
	Latitude	WGS84 latitudinal coordinates in decimal degrees (°) to 2 decimal places.
	Longitude	WGS84 longitudinal coordinates in decimal degrees (°) to 2 decimal places.
	Altitude	Elevation above mean sea level (m).
		The precision is 5 m.
	Area	Plot area (ha).
		The precision is 0.01 ha.
	Shape	Shape of plot.
	Temp30yr	Mean of mean annual temperature during the period from 1981 to 2010 (°C).
		The precision is 0.1 °C.
	Rain30yr	Mean of annual precipitation during the period from 1981 to 2010 (mm).
		The precision is 0.1 mm.
	Snow30yr	Mean of annual maximum snow depth during the period from 1981 to 2010 (cm).

		The precision is 1 cm.
SpList.csv	SpJapan	Japanese common name of species, which was romanized following the Kunrei-siki romanization system (ISO3602).
	Family	Botanical family to which the species.
	Genus	Genus name.
	SpecificName	Specific name.
	Subspecies	“subsp.” represents subspecies.
	SubspeciesName	Subspecies name.
	NameAuth	The scientific name of species with authority name. Under-bars are used in place of spaces.
	Synonym	Numeric code for a synonym in Japanese common name.
		1 = accepted name.
		0 = synonym.
	Deciduous_Evergreen	Functional type of the species.
		Deciduous_broadleaf or Evergreen_broadleaf.
Herbivory.csv	SiteName	Site name.
	Year	Leaves sampled year. The leaf collection period at Aichi-akazu, Kamigamo, and Shiiba were two calendar years because the peak month of litter fall occurred during these calendar years (See Table 2).
	Genus	Genus name.
	SpecificName	Specific name.
	Subspecies	“subsp.” represents subspecies.
	SubspeciesName	Subspecies name.

	herbivory_0	A total number of leaves as classified herbivory class 0 (no damage).
	herbivory_1	A total number of leaves as classified herbivory class 1 (1-10% loss).
	herbivory_2	A total number of leaves as classified herbivory class 2 (11-25% loss).
	herbivory_3	A total number of leaves as classified herbivory class 3 (26-50% loss).
	herbivory_4	A total number of leaves as classified herbivory class 4 (51-75% loss).
	herbivory_5	A total number of leaves as classified herbivory class 5 (> 76% loss).
	Latitude	WGS84 latitudinal and longitudinal coordinates in decimal degrees (°) to 2 decimal places.
	Longitude	Elevation above mean sea level (m).

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13. FIGURE LEGEND

Figure 1 Location of the 19 natural forest sites across Japan.

Figure 2 Latitudinal gradient of insect herbivory in (a) deciduous and (b) evergreen broadleaf tree species in 2014 and 2015. Symbols represent the mean herbivory rate of each site. Lines indicate fitted lines from the prediction from the linear mixed models.

Figure 3 Latitudinal gradient of insect herbivory in (a) *Quercus crispula* and (b) *Fagus crenata* in 2014 and 2015. Symbols represent the mean herbivory rate of each site. Lines indicate fitted lines from the prediction from linear mixed models.

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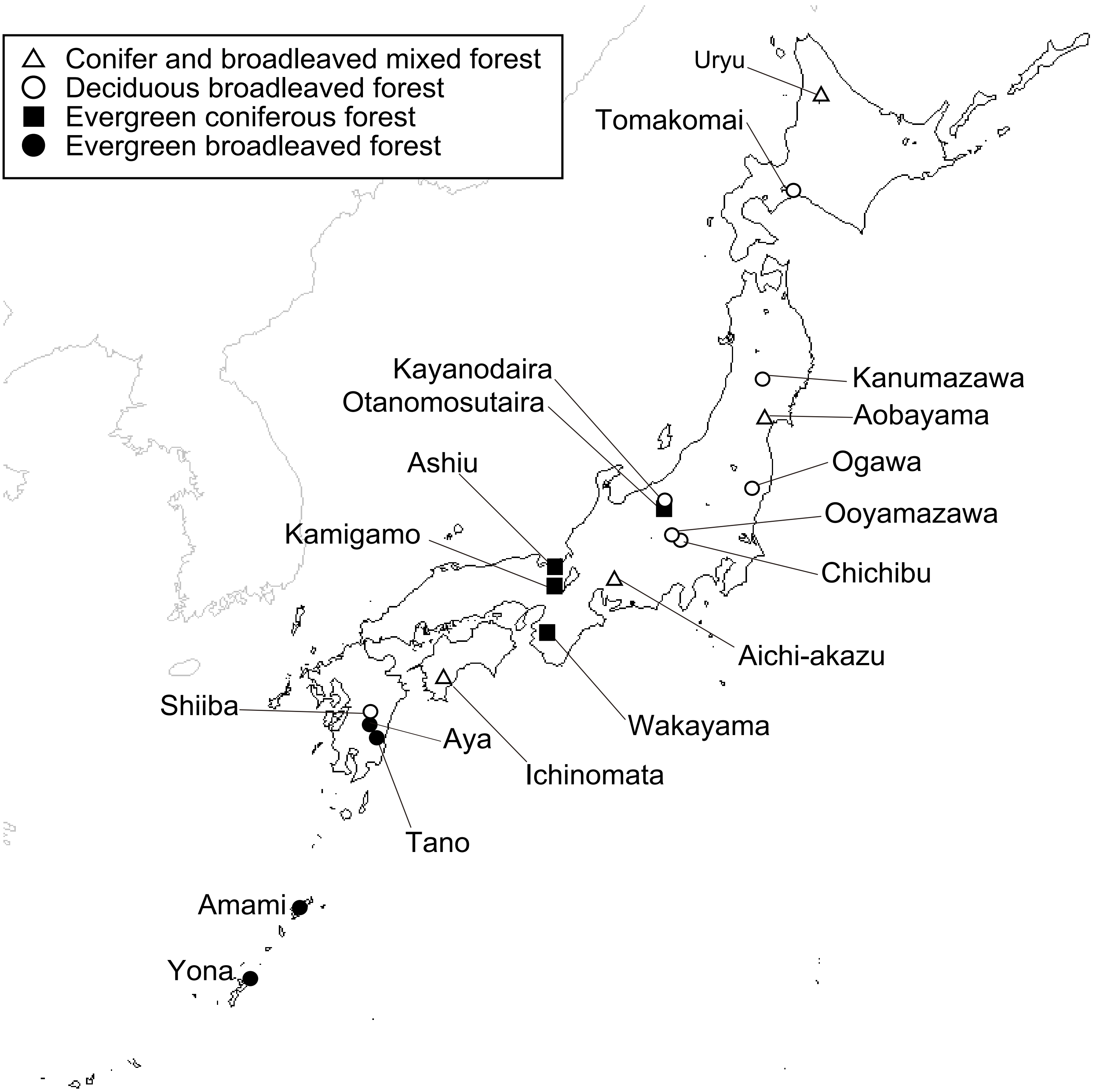
Figure 1. Takafumi *et al.*



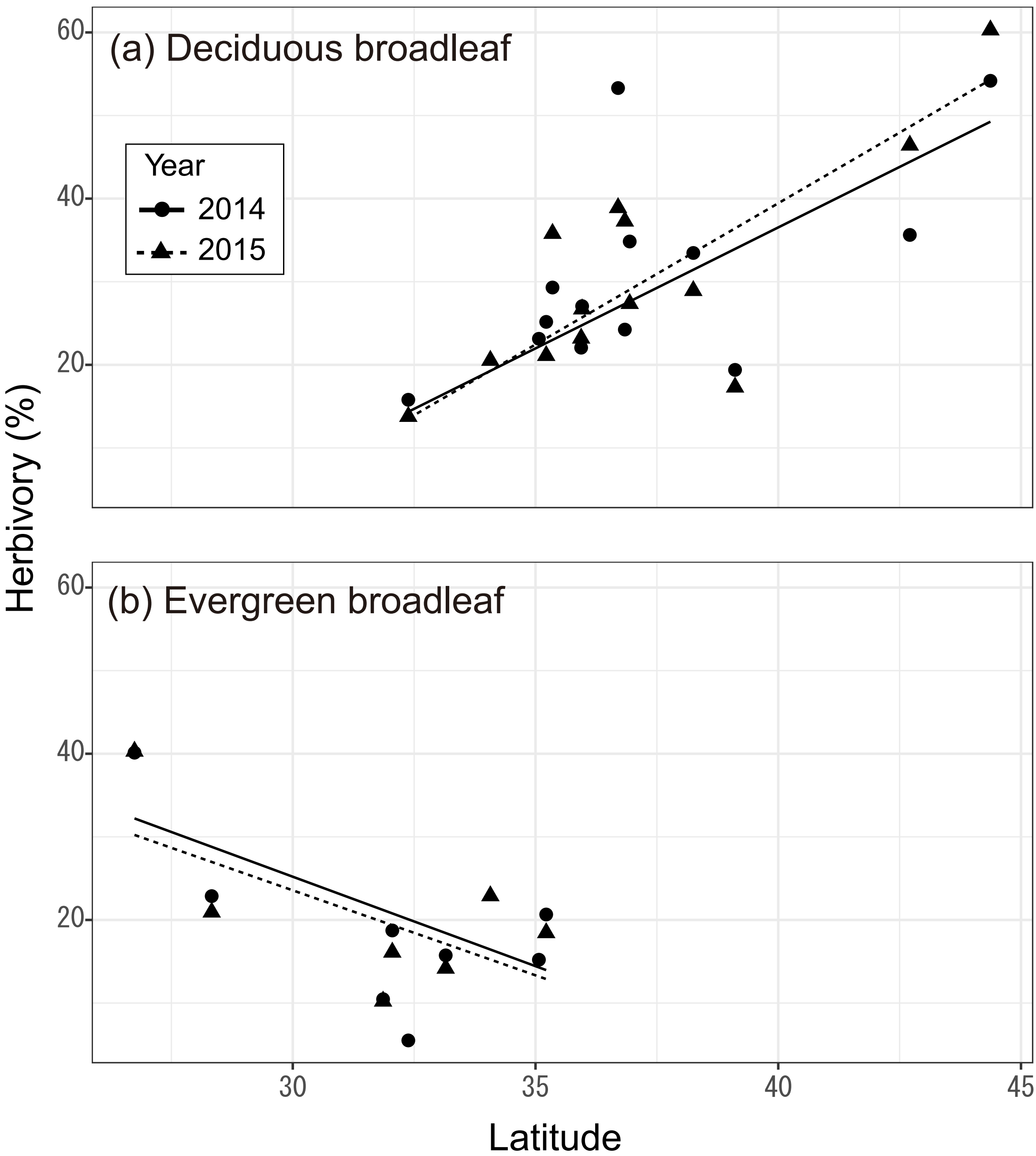

(a) Deciduous broadleaf
Year
2014
2015
(b) Evergreen broadleaf
Herbivory (%)
60
40
20
30
35
40
45
Latitude

Figure 3 Takafumi et al.

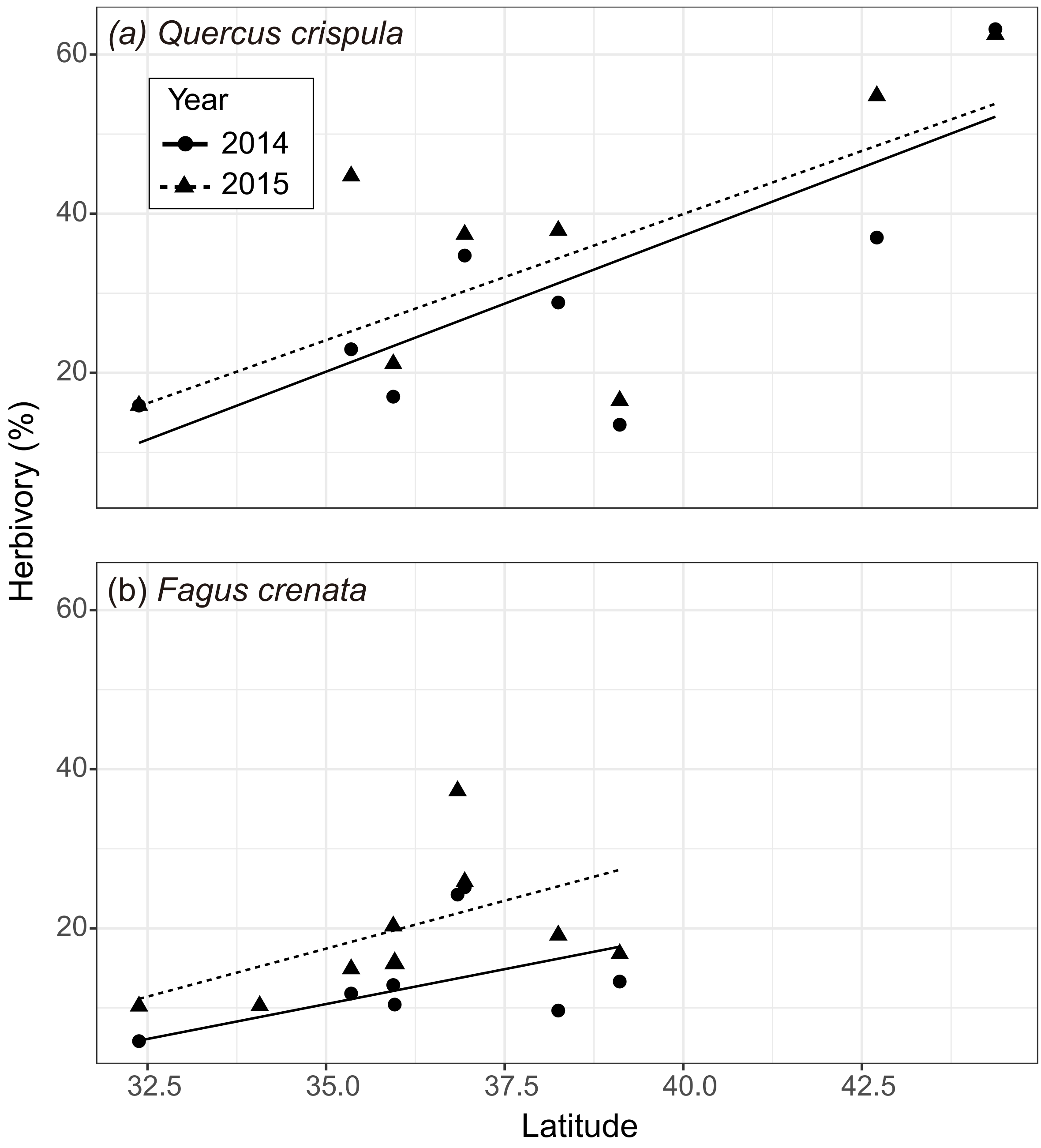


Table 1. Major climatic zones and biogeographic regions of the 19 sites. The blank cells incidate our study sites is not located on these climatic zones and biogeographic regions, although these distribute in Japan. "Rare" and "Not distributed" in the cell means that the combination of climatic zones and biogeographic regions is rarely or not distributed in Japan.

Biogeographic region	Climatic zone			
	Subalpine or subarctic	Cool temperate	Warm temperate	Subtropical
Eastern Hokkaido Island		Uryu (UR)	*Not distributed*	*Not distributed*
Western Hokkaido Island		Tomakomai (TM)	*Not distributed*	*Not distributed*
The Pacific Ocean side of the Northern Honshu Island		Aobayama (AO)[1] Ogawa (OG) Chichibu (CC) Ooyamazawa (OY)		*Not distributed*
The Sea of Japan side of the Northern Honshu Island	Otanomosutaira (OT)	Kanumazawa (KM) Kayanodaira (KY)	*Rare*	*Not distributed*
Hokuriku and Sanin region		Ashiu (AU)	Kamigamo (KG)	*Not distributed*
The Pacific Ocean side of the Chubu region			Aichi-akazu (AI)	*Not distributed*
The Inland Sea	*Not distributed*	*Rare*		*Not distributed*
The Kii Peninsula, Shikoku and Kyushu Islands	*Rare*	Shiiba (SI)	Wakayama (WK) Ichinomata (IC) Aya (AY) Tano (TN)	*Not distributed*
The Amami and Ryukyu Islands	*Not distributed*	*Not distributed*	*Rare*	Amami (AM) Yona (YN)
The Bonin Islands	*Not distributed*	*Not distributed*	*Not distributed*	

[1] Sites located between the cool and warm temperate zones.

Table 2. The four months when these traps caught the largest amount of fallen leaves in each site. The visual measurement of leaf damage by leaf-chewing insects was applied to these leaves.

Site name	Abbreviated site name	Leaf collection period
Uryu	UR	August–November
Tomakomai	TM	August–November
Kanumazawa	KM	August–November
Aobayama	AO	September–December
Ogawa	OG	September–December
Kayanodaira	KY	August–November
Otanomousutaira	OT	July–November
Ooyamazawa	OY	August–November
Chichibu	CC	September–December
Ashiu	AU	August–November
Aichi-akazu	AI	October–January
Kamigamo	KG	October–January
Wakayama	WK	September–December
Ichinomata	IC	April–July
Shiiba	SI	September–January in 2014 (sampled year), September–December in 2015 (sampled year)
Aya	AY	April–July
Tano	TN	April–July
Amami	AM	March–June
Yona	YN	February–May

Table 3. The measured species in this study. Broadleaf tree species with a dominant ranking of five or species with a total of up to 50% of dominance and broad distributed species *Quercus crispula* and *Fagus crenata* were measured.

SiteName	Broadleaf tree species									
Uryu	*Betula ermanii*	*Quercus crispula*	*Acer mono*							
Tomakomai	*Cercidiphyllum japonicum*	*Ostrya japonica*	*Quercus crispula*	*Tilia japonica*	*Acer mono*					
Kanumazawa	*Cercidiphyllum japonicum*	*Fagus crenata*	*Quercus crispula*	*Pterocarya rhoifolia*	*Aesculus turbinata*					
Aobayama	*Fagus crenata*	*Quercus crispula*	*Quercus serrata*	*Idesia polycarpa*	*Prunus verecunda*					
Ogawa	*Castanea crenata*	*Fagus crenata*	*Fagus japonica*	*Quercus crispula*	*Quercus serrata*	*Acer mono*				
Kayanodaira	*Fagus crenata*									
Otanomosutaira	*Betula ermanii*	*Acer ukurunduense*								
Ooyamazawa	*Cercidiphyllum japonicum*	*Fagus crenata*	*Fraxinus platypoda*							
Chichibu	*Carpinus cordata*	*Fagus crenata*	*Fagus japonica*	*Quercus crispula*						
Ashiu	*Magnolia obvata*	*Betula grossa*	*Fagus crenata*	*Quercus crispula*	*Acer sieboldianum*					
Aichi-akazu	*Quercus serrata*	*Acer sieboldianum*	*Cleyera japonica*							
Kamigamo	*Castanopsis cuspidata*	*Clethra barbinervis*	*Ilex macropoda*	*Ilex pedunculosa*						
Wakayama	*Fagus crenata*	*Quercus acuta*	*Stewartia monadelpha*							
Ichinomata	*Quercus salicina*	*Cleyera japonica*								
Shiiba	*Illicium anisatum*	*Betula grossa*	*Carpinus laxiflora*	*Carpinus tschonoskii*	*Fagus crenata*	*Quercus crispula*	*Acer sieboldianum*	*Swida controversa*	*Kalopanax pictus*	*Acer rufinerve*
Aya	*Machilus thunbergii*	*Distylium racemosum*	*Quercus acuta*	*Quercus salicina*						
Tano	*Machilus thunbergii*	*Distylium racemosum*	*Castanopsis* spp.[1]	*Quercus salicina*						
Amami	*Castanopsis sieboldii subsp. lutchuensis*									
Yona	*Castanopsis sieboldii subsp. lutchuensis*	*Schima wallichii*								

[1] *Castanopsis sieboldii* and *Castanopsis cuspidata* were included.

Table 4. Results of generalized linear mixed-effect models for estimating the latitudinal gradient of insect herbivory of deciduous broadleaf species, evergreen broadleaf species, *Q. crispula*, and *F. crenata* in 2014 and 2015. Estimates of parameters, Chi-square value, and statistical significance (*P*-value) are given. The likelihood ratio test was used for the statistical significance.

Functional type/Species	Parameter	Estimate	Chi-square	*P*-value
Deciduous broadleaf	Latitude	2.91	35.03	$P < 0.001$
	Year	-16.66	76.29	$P < 0.001$
	Latitude*Year	0.49	69.22	$P < 0.001$
Evergreen broadleaf	Latitude	-2.15	4.82	$P < 0.05$
	Year	-4.84	25.98	$P < 0.001$
	Latitude*Year	0.11	0.58	0.45
Quercus crispula	Latitude	3.42	8.99	$P < 0.01$
	Year	12.69	5.92	$P < 0.05$
	Latitude*Year	-0.25	1.01	0.32
Fagus crenata	Latitude	1.75	2.91	0.09
	Year	-16.01	641.48	$P < 0.001$
	Latitude*Year	0.66	18.11	$P < 0.001$

Table S1. Detailed ecological information of each plot collected from study sites. Soil parameters, snow depth, and maximum canopy height collected from study sites. This information was described in Appendix of Ishihara et al. (2011), Suzuki et al. (2012), and Niwa et al. (2016). Plot ID indicates an alphanumeric code of each plot (see SiteList.csv and Ishihara et al. (2011)). Soil types based on the soil classification system of the Food and Agriculture Organization of the United Nations (FAO) (Dudal 1968), were extracted from the 1:200,000 scale soil map of the Land Classification Survey conducted by the Ministry of Land, Infrastructure, Transport and Tourism, Japan (http://nrb-www.mlit.go.jp/kokjo/inspect/landclassification/download/index.html, last accessed on March 13, 2020). In addition, soil types based on the Classification of Forest Soil in Japan (Forest Soil Division 1976) were also shown, which are according to related literatures and personal observations of researchers.'NA' means data not available. See appendix 1 for details and references, and other ecological information.

Site name	PlotID	Soil type			Soil pH		Bedrock		Snow depth		Maximum canopy height	
		FAO	Forest Soil Divisior	Reference	Value	Reference	Type	Reference	Value (m)	Reference	Value (m)	Reference
Uryu	UR-BC1	Humic Cambisols	Brown forest soil	Shibata *et al.* 2002	3.9–4.5	Shibata *et al* . 2002	Andesite tuff-breccia	Shibata *et al* . 2002	2	Shibata *et al.* 2002	28	Yoshida T. unpublished data
Tomakomai	TM-DB1	(Andic) Rhegosols	Shallow top soil	Hiura *et al.* 1998	5.3–6.2	Shibata *et al.* 1998	Volcanic ejecta of 1–2 m depth	Igarashi 1987	0.5	Shibata *et al.* 1998	26.5	Ishihara M. personal observatior
Kanumazawa	KM-DB1	Residual Regosols	Gravel (large and sandy), brown forest soi[1]	Masaki *et al.* 1999	5.2	-	Igneous rock (green tuff and others)	-	1.8	Suzuki *et al.* 2002	30	Suzuki *et al.* 2002
Aobayama	AO-BC1	Humic Cambisols	Brown forest soil[2]	-	NA		Aobayama formation on tuff[3]	-	0.1	-	20	Kobayashi K. personal observation
Ogawa	OG-DB1	Ochric Cambisols	Brown forest soil partly black or gley soi	Masaki *et al.* 1999	4.7–6.2	Yoshinaga *et al.* 2002	Metamorphic rock, volcanic ejecta	Yoshinaga *et al.* 2002	0.5	Masaki *et al.* 1999	About 35	Nakashizuka 2002
Kayanodaira	KY-DB1	Humic Cambisols	Brown forest soil	Ida H. personal observatior	NA		Plateau originated from lava flow	Ida 2013	3–4	Ida 2013	25	Watanabe 1994
Otanomousutaira	OT-EC1	Humo-Ferric (Gleyic) Podzols	Wet humus podzolic partly dry podzolic or moderately moist brown forest soil	Takai *et al.* 1976	3.8–4.5	Takai *et al.* 1976	Deposition of andesite and volcanic mudflow	Takai *et al.* 1976	2	Ida H. personal observation	22	Kuroiwa and Watanabe 1997
Ooyamazawa	OY-DB1	Humo-Ferric Podzols	Sand, gravel, rock	Sakio 1997	NA		Greywacke, sandstone	Sakio 1997	0.3	Sakio 1997	35	Sakio H. unpublished data
Chichibu	CC-DB1	Humic Cambisols	Moderately moist brown forest soi	University Forest in Chichibu 200	NA		Sedimentary rock	University Forest in Chichibu 200	0.2–0.3	Sawada *et al.* 2005	29	University Forest in Chichibu unpublished dat
Ashiu	AU-EC1	Humic Cambisols	Brown forest soil	Ueda *et al.* 1993	4.5	Ueda *et al.* 1993	Sandstone, slate, mudstone, shale, cher	Ueda *et al.* 1993; Yamanaka *et al.* 1993	2–3	Yamanaka *et al.* 1993	25	Kawanabe et al. 1994; Sakimoto M. personal observatio
Aichi-akazu	AI-BC1	Humic Cambisols	Moderately moist brown forest soil	Moroto *et al.* 1987	4.5–5.1	Moroto *et al.* 1987	Deeply weathered granite	Moroto *et al.* 1987	0.101[4]	University Forest in Aichi, the University of Tokyo unpublished data	20	Ariyakanon *et al.* 2000
Kamigamo	KG-EC1	Gleysols	Dry brown forest soil	Tokuchi *et al.* 2002	NA		Bedded chert with siliceous shale	Kimura *et al.* 1998	Few[5]	-	20	Sakimoto M. personal observation
Wakayama	WK-EC1	Humic Cambisols	Moderately moist brown forest soil	Ueda *et al.* 1994	4.8–4.9	Ueda *et al.* 1994	Sandstone, shale	Toda *et al.* 2000	0.3[6]	-	25–30	Sakimoto M. personal observation
Ichinomata	IC-BC1	Humic Cambisols	Moderately moist to weakly dried brown forest soil, dry podzolic soil	Hirai *et al.* 2007	3.6–5.1	Hirai *et al.* 2007	Sandstone, mudstone	Sakai *et al.* 2006	0.15	Sakai T. personal observation	41	Sakai *et al.* 2006
Shiiba	SI-DB1	NA	Brown forest soil	Enoki T. personal observatior	4.97-5.29	Shibata H. unpublished data	Granite	Hatsushima 1970	0.2	Enoki T. unpublished data	27	Enoki T. unpublished data
Aya	AY-EB1	Humic Cambisols	Dry, moderately moist, or moderately moist drier subtype brown forest soil	Sato *et al.* 1999	NA		Shale, sandstone, partly covered by pumice stone from volcanic eruption	Ohnuki *et al.* 1998; Sato *et al.* 1999	0	Masaki *et al.* 1999	30	Saito and Sato 2007
Tano	TN-EB1	Andosols	Moderately moist brown soi	Takagi M. unpublished data	5.7	Takagi M. unpublished data	Shale	Endo 1958	0	Takagi M. personal observatior	25	Takagi M. unpublished data
Amami	AM-EB1	Humic Cambisols	Weakly dried to moderately moist yellow soil at the valley	Ishida K. personal observation	NA		Shale partly sandstone	Ishida K. personal observation	0	Ishida K. personal observation	25	Kumamoto Forest Office and Japan Forest Technology Association 1997
Yona	YN-EB1	Helvic Acrisols	Weakly dried to moderately moist yellow soi	Yamamori *et al.* 1986	4.1–4.3	Yamamori *et al.* 1986	Sandstone and slate	Enoki 2003	0	-	20	Shinzato *et al.* 1986

[1] Cambic Red-Yellow soils (based on Japan Soil Inventory https://soil-inventory.dc.affrc.go.jp), with boulders and gravels.

[2] Scale 1:50,000 Fundamental Land Classification Survey in Miyagi, Sendai, 1976.

[3] http://www.biology.tohoku.ac.jp/garden/geology.htm

[4] Average between 1966 and 1999.

[5] Few cm (Kamigamo Experimental Station, Kyoto University http://fserc.kyoto-u.ac.jp/kami/).

[6] Wakayama Forest Research Station, Kyoto University (http://fserc.kyoto-u.ac.jp/waka/).

[7] 27 m for *Abies firma* and 24 m for *Fagus crenata*.

Appendix 1 Detailed information of each plot.

This material gives detailed information of each plot: forest age, disturbance history, soil type, soil pH, bedrock, snow depth, dwarf bamboo as understory vegetation, maximum canopy height, layout of the plot and subplots, remarks (optional), and acknowledgements (optional). This material includes information which was described in Appendix of Ishihara et al., (2011), Suzuki et al., (2012), and Niwa et al., (2016). Plot ID indicates an alphanumeric code of each plot (see SiteList.csv and Ishihara et al., (2011)). For definition of forest age classifications, see 7. A and Ishihara et al., (2011). Forest age or maximum tree age is the age in 2010 unless specified. Soil types based on the soil classification system of the Food and Agriculture Organization of the United Nations (FAO) (Dudal, 1968), were extracted from the 1:200,000 scale soil map of the Land Classification Survey conducted by the Ministry of Land, Infrastructure, Transport and Tourism, Japan (http://nrb-www.mlit.go.jp/kokjo/inspect/landclassification/download/index.html, last accessed on March 13, 2020). In addition, soil types based on the Classification of Forest Soil in Japan (Forest Soil Division, 1976) were also shown, which are according to related literatures and personal observations of researchers. 'NA' means data not available. References with * are those conducted in the plot.

Site name: Uryu

Plot ID: UR-BC1

Forest age: OG.

Disturbance: No record of human disturbance (Yoshida T. personal communication).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Brown forest soil (Shibata et al., 2002).

Soil pH: 3.9–4.5 (Ozawa, Shibata, Satoh, & Sasa 2001).

Bedrock: Andesite tuff-breccia (Shibata et al., 2002).

Snow depth: 2 m (Shibata et al., 2002).

Dwarf bamboo as understory vegetation: Understory is covered by dwarf bamboo (Yoshida T. personal observation).

Maximum canopy height: 28 m (Yoshida T. unpublished data).

Plot & Subplots: The shape of plot is 70×150 m. The direction of Y-axis is 71° west from true north.

Remarks: Croplands are 600 m northwest and 300 m southwest of the plot.

Acknowledgements: We thank the staff of Uryu Experimental Forests of Hokkaido University for the field work.

Site name: Tomakomai

Plot ID: TM-DB1

Forest age: OG. About 270–340 years old (Igarashi, 1987).

Disturbance: The forest regenerated after the volcanic eruption of Mt. Tarumae in 1669 and 1739 (Igarashi, 1987). The forest was disturbed by strong typhoons in 1954 (Mishima, Taniguchi, Taniguchi, & Hishinuma, 1958) and 2004.

Soil type FAO: (Andic) Rhegosols.

Soil type Forest Soil Division: Shallow top soil (Hiura et al., 1998*).

Soil pH: 5.3–6.2 (Shibata, Kirikae, Tanaka, Sakuma, & Hatano, 1998).

Bedrock: Volcanic ejecta of 1–2 m depth (Igarashi, 1987).

Snow depth: 0.5 m (Hiura et al., 1998*).

Dwarf bamboo as understory vegetation: Understory vegetation is partly dominated by *Sasamorpha borealis* (Hiura et al., 1998*).

Maximum canopy height: 26.5 m (Ishihara M. personal observation).

Plot & Subplots: The 1-ha plot is a part of a 9-ha permanent plot. The direction of Y-axis is 31° west from true north.

Acknowledgements: We thank the staff of Tomakomai Experimental Forests of Hokkaido University for the field work.

Site name: Kanumazawa

Plot ID: KM-DB1

Forest age: OG. Maximum tree age is about 1000 years old according to Suzuki, Osumi, Masaki, Takahashi, Daimaru, & Hoshizaki (2002*).

Disturbance: Canopy gaps and more infrequent, debris flows. No sign of human disturbance although selective cuttings were conducted at surrounding forests until 20–30 years ago (Masaki, Tanaka, Tanouchi, Sakai, & Nakashizuka, 1999*; Suzuki et al., 2002*).

Soil type FAO: Residual Regosols.

Soil type Forest Soil Division: Cambic Red-Yellow soils (based on Japan Soil Inventory https://soil-inventory.dc.affrc.go.jp), with boulders and gravels; brown forest soil (Masaki et al., 1999*).

Soil pH: 5.2.

Bedrock: Igneous rock (green tuff and others).

Snow depth: 1.8 m (Suzuki et al., 2002*).

Dwarf bamboo as understory vegetation: *S. kurilensis* and *S. palmata* are distributed widely but dominant only patchily. Instead, evergreen shrub (*Camellia japonica* var. *decumbens*), tall herbs (e.g. genera *Laportea, Elatostema and Petasites*) and ferns (genera *Polystichum*, *Dyropteris* and *Arachniodes*) dominate the understory layer (Hoshizaki, Suzuki, & Sasaki, 1997*).

Maximum canopy height: 30 m (Suzuki et al., 2002*).

Plot & Subplots: The 1-ha plot is a part of a 4.71-ha permanent plot. The direction of Y-axis is 11° east from true north.

Remarks: A stream flows in the plot. A road is 50 m east and 100 m northwest of the plot. Rivers are 250 m southeast and 400 m southwest of the plot.

Acknowledgements: We thank Wajirou Suzuki, Katsuhiro Osumi and Kazunori Takahashi for early setup of the plot; Ohta Kazuhide for soil descriptions.

Site name: Aobayama

Plot ID: AO-BC1

Forest age: OG.

Disturbance: Human usage of the forest has been restricted for the past 400 years (Suzuki Mitsuo personal communication).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Brown forest soil (Scale 1:50,000 Fundamental Land Classification Survey in Miyagi, Sendai, 1976).

Soil pH: NA.

Bedrock: Aobayama formation on tuff (http://www.biology.tohoku.ac.jp/garden/geology.htm).

Snow depth: 0.1 m.

Dwarf bamboo as understory vegetation: Patchy distribution of *Sasa borealis* (Kobayashi K. personal observation).

Maximum canopy height: 20 m (Kobayashi K. personal observation).

Plot & Subplots: The direction of Y-axis is 18° west from true north.

Remarks: Grasslands and urban areas are 150 m north and southeast of the plot.

Acknowledgements: We thank Kadzutaka Kobayashi, Motonari Oyama for the field work.

Site name: Ogawa

Plot ID: OG-DB1

Forest age: OG.

Disturbance: Although the forest is an old-growth forest, human disturbances such as fire, grazing, and selective cutting took place until 1930s at surrounding forests. Remains of charcoal making were found around the plot (Masaki et al., 1999*; Suzuki, 2002*).

Soil type FAO: Ochric Cambisols.

Soil type Forest Soil Division: Brown forest soil partly black or gley soil (Masaki et al., 1999*).

Soil pH: 4.7−6.2 (Yoshinaga, Takahashi, & Aizawa, 2002*).

Bedrock: Metamorphic rock, volcanic ejacta (Yoshinaga et al., 2002*).

Snow depth: 0.5 m (Masaki et al., 1999*).

Dwarf bamboo as understory vegetation: Patchy distribution of *Sasamorpha borealis* and *Sasa nipponica* (Suzuki, 2002*).

Maximum canopy height: About 35 m (Nakashizuka, 2002*).

Plot & Subplots: The 1.2-ha (100×120 m) plot is a part of a 6-ha permanent plot (see Nakashizuka & Matsumoto, 2002). The direction of Y-axis is 100° west from true north.

Remarks: Grasslands and croplands are 400 m north and 500 m southwest of the plot.

Acknowledgements: Grants in support came from the Ministry of Agriculture, Forestry and Fishery, and the Ministry of Education, Science, Sports and Culture.

Site name: Kayanodaira

Plot ID: KY-DB1

Forest age: OG.

Disturbance: A light selective cutting probably occurred because remains of charcoal making were found around the plot (Watanabe, 1993; Ida, 2013).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Brown forest soil (Ida H. personal observation).

Soil pH: NA.

Bedrock: Plateau originated from lava flow (Ida, 2013).

Snow depth: 3−4 m (Ida, 2013).

Dwarf bamboo as understory vegetation: Understory is dominated by 1.5 m high *Sasa kurilensis* and *Sasa senanensis* (Peters, Nakashizuka, & Ohkubo, 1992; Ida, 2013).

Maximum canopy height: 25 m (Watanabe, 1994).

Plot & Subplots: The direction of Y-axis is 97° west from true north. Subplots were slightly moved after the census in 2006.

Remarks: Grasslands and pastures are 100 m west and 350 m south of the plot.

Site name: Otanomosutaira

Plot ID: OT-EC1

Forest age: OG.

Disturbance: No record of human disturbance (Ida H. personal observation).

Soil type FAO: Humo-Ferric (Gleyic) Podzols.

Soil type Forest Soil Division: Wet humus podzolic partly dry podzolic or moderately moist brown forest soil (Takai, Kanazawa, Asami, Takeshima, & Kawashima, 1976).

Soil pH: 3.8–4.5 (Takai et al., 1976).

Bedrock: Deposition of andesite and volcanic mudflow (Takai et al., 1976).

Snow depth: 2 m (Ida H. personal observation).

Dwarf bamboo as understory vegetation: Understory is dominated by 1 m high *Sasa kurilensis* (Kuroiwa & Watanabe, 1997*).

Maximum canopy height: 22 m (Kuroiwa & Watanabe, 1997*).

Plot & Subplots: The direction of Y-axis is 3° west from true north.

Remarks: Grasslands, wetlands, ski slopes and a road are 600 m west to southwest of the plot.

Site name: Ooyamazawa

Plot ID: OY-DB1

Forest age: OG. 254-year-old tree was recorded in 1988 (Sakio, 1997*).

Disturbance: *Fraxinus platypoda* established after a land slide caused by an earthquake in 1770 to 1790 (Sakio, 1997*). No record of logging (Kubo, Sakio, Shimano, & Ohno, 2005*).

Soil type FAO: Humo-Ferric Podzols.

Soil type Forest Soil Division: Sand, gravel, rock (Sakio, 1997*).

Soil pH: NA.

Bedrock: Greywacke, sandstone (Sakio, 1997*).

Snow depth: 0.3 m (Sakio, 1997*).

Dwarf bamboo as understory vegetation: 2 m height *Sasamorpha borealis* dominates at slope (Sakio H. personal observation).

Maximum canopy height: 35 m (Sakio H. unpublished data).

Plot & Subplots: The direction of Y-axis is 116° west from true north.

Remarks: The plot includes a stream and was established in a riparian forest dominated by *Fraxinus platypoda*, *Pterocarya rhoifolia*, and *Cercidiphyllum japonicum* (Sakio, Kubo, Shimano, & Ohno 2002*).

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Site name: Chichibu

Plot ID: CC-DB1

Forest age: OG.

Disturbance: No record of logging since the University forest was established in 1916.

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Moderately moist brown forest soil (University Forest in Chichibu, 2000).

Soil pH: NA.

Bedrock: Sedimentary rock (University Forest in Chichibu, 2000).
Snow depth: 0.2−0.3 m (Sawada, Ohkubo, Kaji, & Oomura, 2005*).
Dwarf bamboo as understory vegetation: None.
Maximum canopy height: 29 m (University Forest in Chichibu unpublished data).
Plot & Subplots: The direction of Y-axis is true north.
Remarks: A river flows 350 m southwest of the plot.
Acknowledgements: We thank the staff of the University of Tokyo Chichibu Forest for the field work.

Site name: Ashiu
Plot ID: AU-EC1
Forest age: OG. 230-year-old tree was recorded in 1980 (Tamai & Tempo, 1990).
Disturbance: Since the establishment of Ashiu Experimental Forest in 1924, no human disturbance occurred (Yamanaka, Matumoto, Oshima, & Kawanabe, 1993). Mass mortality of Fagaceae trees by Japanese oak wilt has occurred since 2002.
Soil type FAO: Humic Cambisols.
Soil type Forest Soil Division: Brown forest soil (Ueda, Ando, & Kanzaki, 1993).
Soil pH: 4.5 (Ueda et al., 1993).
Bedrock: Sandstone, slate, mudstone, shale, chert (Ueda et al., 1993; Yamanaka, Matumoto, Oshima, & Kawanabe, 1993).
Snow depth: 2–3 m (Yamanaka et al., 1993).
Dwarf bamboo as understory vegetation: None since before sever herbivory by Sika deer occurred (Sakimoto M. personal observation).
Maximum canopy height: 25 m (Kawanabe, Ando, Sakai, & Wada, 1994; Sakimoto M. personal observation).
Plot & Subplots: The direction of Y-axis is 69° west from true north.
Acknowledgements: We thank the technical staff of Aisu Forest Station, Kyoto University for their work.

Site name: Aichi-akazu
Plot ID: AI-BC1
Forest age: S. Less than 100 years old (Shibano, 2000*).
Disturbance: The forest established on the previously bare land due to fuel wood consumption (Shibano, 2000*). *Chamaecyparis obtusa* trees were planted in 1917−1918 to prevent soil erosion. At present, the forest is composed of pine tree and broadleaf tree species that have naturally established. Mass mortality of pine trees by Pine wilt disease occurred in 1980s and late 2000s. In

2010 and 2011, many oak trees were attacked by ambrosia beetle *Platypus quercivorus*, which transport the pathogenic fungi *Raffaelea quercivora* causing Japanese oak wilt.

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Moderately moist brown forest soil (Moroto, Mashimo, & Haruta, 1987).

Soil pH: 4.5−5.1 (Moroto et al., 1987).

Bedrock: Deeply weathered granite (Moroto et al., 1987).

Snow depth: 0.101 m on average between 1966 and 1999 (University Forest in Aichi, the University of Tokyo unpublished data).

Dwarf bamboo as understory vegetation: None.

Maximum canopy height: 20 m (Ariyakanon, Numamoto, & Suzuki, 2000).

Plot & Subplots: The direction of Y-axis is true north. All subplots were relocated from outside to inside the plot after the census in 2004. Subplot 1, 3, 4 and 5 were moved several meters after the census in 2009.

Remarks: Roads are 100 m south and 200 m north of the plot. Open lands and some buildings are 200 m west of the plot.

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Site name: Kamigamo

Plot ID: KG-EC1

Forest age: S. About 90 years old (Sakimoto, Morishita, & Sakanoue, 2009b*).

Disturbance: After mass mortality of dominant pine trees by Pine wilt disease in 1970s, *Chamaecyparis obtusa* that formed the middle and lower layers have become dominant (Sakimoto M. unpublished data).

Soil type FAO: Gleysols.

Soil type Forest Soil Division: Dry brown forest soil (Tokuchi, Fujimaki, & Terai, 2002*).

Soil pH: NA.

Bedrock: Bedded chert with siliceous shale (Kimura et al., 1998).

Snow depth: Few cm (Kamigamo Experimental Station, Kyoto University http://fserc.kyoto-u.ac.jp/kami/).

Dwarf bamboo as understory vegetation: None (Sakimoto M. personal observation).

Maximum canopy height: 20 m (Sakimoto M. personal observation).

Plot & Subplots: The shape of plot is 80×80 m. The direction of Y-axis is 180° east from true north.

Remarks: A grassland and a golf course are 50 m south and 500 m southwest of the plot, respectively.

Urban areas are 150 m north, east and south of the plot.

Site name: Wakayama

Plot ID: WK-EC1

Forest age: OS. About 100 years old (Sakimoto et al., 2009a*).

Disturbance: Cut stumps created in 1920–1922 were found and the forest was used until the establishment of the University Forest in 1926 (Furuno, Uenishi, & Uenishi, 1986).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Moderately moist brown forest soil (Ueda., Ando, & Takeuchi, 1994).

Soil pH: 4.8–4.9 (Ueda et al., 1994).

Bedrock: Sandstone, shale (Toda et al., 2000).

Snow depth: 0.3 m (Wakayama Forest Research Station, Kyoto University http://fserc.kyoto-u.ac.jp/waka/).

Dwarf bamboo as understory vegetation: None (Sakimoto M. personal observation).

Maximum canopy height: 25–30 m (Sakimoto M. personal observation).

Plot & Subplots: The directionof Y-axis is 30° east from true north.

Site name: Ichinomata

Plot ID: IC-BC1

Forest age: OG. Maximum tree age is about 300 years old (Sakai T. unpublished data).

Disturbance: *Chamaecyparis obtusa* trees were cut selectively in 1985–1986 at the ridge (Sakai, Sakai, Kuramoto, & Sato, 2006*; Sakai T. personal communication).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Moderately moist to weakly dried brown forest soil, dry podzolic soil (Hirai , Kaneko, & Takahashi, 2007*).

Soil pH: 3.6–5.1 (Hirai et al., 2007*).

Bedrock: Sandstone, mudstone (Sakai et al., 2006*).

Snow depth: 0.15 m (Sakai T. personal observation).

Dwarf bamboo as understory vegetation: None (Sakai T. personal observation).

Maximum canopy height: 41 m (Sakai et al., 2006*).

Plot & Subplots: The direction of Y-axis is 142° west from true north.

Remarks: A road is 450 m east of the plot.

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Site name: Shiiba

Plot ID: SI-DB1

Forest age: OS.

Disturbance: No record of logging since the establishment of University Forest at about 70 years ago. No cut stump can be found although large trees are scarce (Enoki T. personal observation).

Soil type: Brown forest soil (Enoki T. personal observation).

Soil pH: 4.97−5.29 (Shibata H. unpublished data).

Bedrock: Granite (Hatsushima, 1970).

Snow depth: 0.2 m (Enoki T. unpublished data).

Dwarf bamboo as understory vegetation: *Sasamorpha borealis* dominates (Murata et al., 2009; Saruki, Inoue, Shiba, Nagasawa, Osaki, & Kubota, 2004).

Maximum canopy height: 27 m for *Abies firma* and 24 m for *Fagus crenata* (Enoki T. unpublished data).

Plot & Subplots: The shape of plot is 100×100 m.

Acknowledgements: We thank technical staff of the Shiiba Research Forest for the field work.

Site name: Aya

Plot ID: AY-EB1

Forest age: OG.

Disturbance: No record of human disturbance (Tanouchi and Yamamoto, 1995*). The forest experienced typhoon disturbance in 1993, 2004 and 2005 (Saito and Sato, 2007*).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Dry, moderately moist, or moderately moist drier subtype brown forest soil (Sato et al., 1999*).

Soil pH: NA.

Bedrock: Shale, sandstone, partly covered by pumice stone from volcanic eruption (Ohnuki, Sato, Fujimoto, & Inagaki 1998*; Sato et al., 1999*).

Snow depth: 0 m (Masaki et al., 1999*).

Dwarf bamboo as understory vegetation: None (Saito S. personal observation).

Maximum canopy height: 30 m (Saito and Sato, 2007*).

Plot & Subplots: The 1-ha plot is a part of a 4-ha permanent plot. The direction of Y-axis is 166° west from true north.

Remarks: A road and a river are 450 m northeast of the plot.

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Site name: Tano

Plot ID: TN-EB1

Forest age: S. 87 years old (Kubota and Takagi, 2007*).

Disturbance: The forest regenerated in 1924 (Kubota and Takagi, 2007*).

Soil type FAO: Andosols.

Soil type Forest Soil Division: Moderately moist brown soil (Takagi M. unpublished data).

Soil pH: 5.7 (Takagi M. unpublished data).

Bedrock: Shale (Endo, 1958).

Snow depth: 0 m (Takagi M. personal observation).

Dwarf bamboo as understory vegetation: None (Takagi M. personal observation).

Maximum canopy height: 25 m (Takagi M. unpublished data).

Plot & Subplots: The direction of Y-axis is 6° east from true north.

Acknowledgements: We thank the staff of University of Miyazaki Tano Forest Science Station for the field work. We also thank Machiko Kuroki for processing litter trap samples.

Site name: Amami

Plot ID: AM-EB1

Forest age: OS. About 140 years old.

Disturbance: Remains of charcoal making were found in the plot. Protected from human disturbance for 100 years as a reserve (Ishida, Kawaguchi, Torikai, Takashi, & Kawaguchi, 2008).

Soil type FAO: Humic Cambisols.

Soil type Forest Soil Division: Weakly dried to moderately moist yellow soil at the valley (Ishida K. personal observation).

Soil pH: NA.

Bedrock: Shale partly sandstone (Ishida K. personal observation).

Snow depth: None (Ishida K. personal observation).

Dwarf bamboo as understory vegetation: None (Ishida K. personal observation).

Maximum canopy height: 20 m (Kumamoto Forest Office and Japan Forest Technology Association, 1997).

Plot & Subplots: The direction of Y-axis is 175° east from true north. Subplots were slightly moved after the first pitfall trapping in 2005.

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Site name: Yona

Plot ID: YN-EB1

Forest age: OS.

Disturbance: Human disturbance such as selective cutting occurred until 1950s (Enoki, 2003*; Saito, 2011).

Soil type FAO: Helvic Acrisols.

Soil type Forest Soil Division: Weakly dried to moderately moist yellow soil (Yamamori, Hirata, Aramoto, Sunakawa, & Asato 1986).

Soil pH: 4.1–4.3 (Yamamori et al., 1986).

Bedrock: Sandstone and slate (Enoki, 2003*).

Snow depth: 0 m.

Dwarf bamboo as understory vegetation: *Pleioblastus linearis* distributed at ridges (Takashima A. personal observation).

Maximum canopy height: 20 m (Shinzato, Taba, Hirata, & Yamamori, 1986).

Plot & Subplots: The direction of Y-axis is 40° west from true north.

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