Diversity of wood-inhabiting polypores in temperate forests with different vegetation types in Japan

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Species composition and diversity of wood-inhabiting polypores were examined in beech, *Castanopsis*, secondary oak, secondary pine, Japanese cedar, and Hinoki cypress forests situated in a temperate area of Japan. Cluster analysis of the polypore communities revealed a correlation between forest vegetation types and the species composition of polypores occurring in the forests. Diversity of polypores is high in beech forests compared with secondary forests and conifer plantations. There are several specific species to beech, *Castanopsis*, and secondary pine forests, respectively. Secondary oak forests are expected to act as refuge and corridors for many of the species dwelling in hardwood forests.

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Key words: biodiversity, conservation, line transect, polypores, vegetation type.

Introduction

Polypores, basidiomycetes and *Xylariaceae* are important decomposers of woody materials in forest ecosystems (Lindsey and Gilbertson, 1978; Swift, 1982; Jung, 1987; Rayner and Boddy, 1988; Urairuj *et al*., 2003). Some of them also have practical importance for human beings as foods, medicines and resources for bioremediation (Gray, 1973; Gilbertson, 1980; Bi *et al*., 1993; Ralph and Catcheside, 2002). Additionally, many polypores are listed in red data books (Arnolds, 1989; Benkert *et al*., 1996; Bendiksen *et al*., 1997; Larsson, 1997) and are important targets for conservation.

Forest vegetation type is one of the factors that are related with the occurrence of macrofungal communities in the forests (Bujakiewicz, 1992; Kost, 1992; Perini *et al*., 1993). In North Europe, a number of polypores are reported to prefer certain tree species (Strid, 1975; Niemelä and Kotiranta, 1982; Niemelä and Kotiranta, 1983; Erkkilä and Niemelä, 1986; Niemelä and Kotiranta, 1986), and their distribution patterns reflect distributions of forest

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vegetation types (Strid, 1975; Väisuänen *et al*., 1992). However, little is known about host preferences of Asian wood-inhabiting polypores and its effects on their distribution patterns.

In central Japan, old growth forests are mainly composed of *Fagus* spp. and deciduous *Quercus* spp. in mountainous areas, and *Castanopsis* spp. and evergreen *Quercus* spp. in lowland areas (Yamanaka, 1979; Sasse, 1998). However, the area of primary forests is limited in central Japan because of logging activities and deforestation, and secondary forests and conifer plantations replace primary forests in large areas. Some wood-inhabiting basidiomycetes are specific to old growth forests in Europe (Bader *et al*., 1995; Parmasto, 2001) and many of them are red-listed (Arnolds, 1991). Similarly, some of the wood-inhabiting basidiomycetes specific to beech forests and *Castanopsis* forests may be endangered in central Japan.

Objectives of this research are (i) to list specific species and red-listed species in Environment Agency of Japan (2000) in each forest vegetation type, (ii) to compare the diversity of polypores in each vegetation type, and (iii) to evaluate the importance of each vegetation type for conservation of polypores.

Materials and methods

Study area

This study was conducted in Ibaraki Prefecture, situated in the central area of Japan. Three or four sites were selected for each of the following six forest vegetation types in this area: beech forest, *Castanopsis* forest, secondary oak forest, secondary pine forest, Japanese cedar plantation, and Hinoki cypress plantation (Table 1). Outlines of these forests in Ibaraki Prefecture are indicated below according to anonymous (1979), Suzuki (2002), and my observations. Logging profile and forest age of each site is after the Working Plan Maps of the National Forest established by the Japanese Forestry Agency. The altitude, latitude, and longitude of each plot are after 1:25,000 Topographic Maps by the Geographical Survey Institute, Japan.

Beech forests in this area are mainly composed of *Fagus crenata* Blume and *Quercus mongolica* Fischer ex Turcz. var. *grosseserrata* (Bl.) Rehder & Wilson in the tree layer. *Fagus japonica* Maxim. and *Q. serrata* Murray are also conspicuous in Ogawa Forest. This forest type is distributed in cool temperate areas that are mountainous i.e. usually higher than 500 m above sea level in this area. No logging has been occurred during the last 147 and 134 years in two sites examined in this study. Logging profile is unclear for one site, but it belongs to a Shinto Shrine and is highly reserved with huge trees in the tree layer.

Table 1. Stand profiles of the examined plots established in six forest vegetation types. Stand age of each site is mainly after the Working Plan Maps of the National Forest.

Plot name	Vegetation type	Locality	Stand age (yr.)	Altitude (m)	Latitude (N)	Longitude (E)
F1	Beech	Mt. Tsukuba, Tsukuba	147	850	36_13'23"	140_06'10"
F2	Beech	Ogawa, Kitaibaraki	134	650	36_56'06"	140_35'27"
F3	Beech	Mt. Wagakuni, Kasama	*	500	36_19'11"	140_12'13"
Ca1	*Castanopsis*	Sashiro, Kasama	117	50	36_22'42"	140_16'15"
Ca2	*Castanopsis*	Kataniwa, Kasama	*	200	36_23'50"	140_12'20"
Ca3	*Castanopsis*	Tomiya, Iwase	*	200	36_22'40"	140_06'17"
Q1	Secondary oak	Mt. Tsukuba, Tsukuba	<60	250	36_12'35"	140_05'40"
Q2	Secondary oak	Shishizuka, Tsuchiura	<60	50	36_04'15"	140_09'30"
Q3	Secondary oak	Oshoyama, Kitaibaraki	52	700	36_54'02"	140_35'48"
Q4	Secondary oak	Hatori, Makabe	<60	250	36_14'19"	140_06'00"
P1	Secondary pine	Mt. Tsukuba, Tsukuba	<60	250	36_12'38"	140_05'50"
P2	Secondary pine	Hatori, Makabe	<60	250	36_14'28"	140_05'50"
P3	Secondary pine	Sakurai, Makabe	<60	200	36_15'57"	140_07'30"
Cr1	Japanese cedar	Sashiro, Kasama	<60	50	36_23'06"	140_16'05"
Cr2	Japanese cedar	Shishizuka, Tsuchiura	<60	50	36_04'15"	140_09'20"
Cr3	Japanese cedar	Oshoyama, Kitaibaraki	52	700	36_54'10"	140_35'48"
Cr4	Japanese cedar	Hatori, Makabe	<60	300	36_14'10"	140_06'10"
Ch1	Hinoki cypress	Mt. Tsukuba, Tsukuba	44	750	36_13'27"	140_05'50"
Ch2	Hinoki cypress	Mt. Wagakuni, Kasama	33	450	36_19'00"	140_12'10"
Ch3	Hinoki cypress	Hatori, Makabe	40	300	36_14'03"	140_06'00"

*Plots whose stand ages are unclear, but supposed to be well reserved with huge trees in the tree layer.

In *Castanopsis* forests, *Castanopsis cuspidata* (Thunb.) Schottky var. *sieboldii* (Makino) Nakai and *Quercus myrisnaefolia* Bl. are important, but several other evergreen angiosperms including *Quercus glauca* Thunb. and *Persea thunbergii* (Siebl. & Zucc.) Kosterm. are mixed. This forest type is distributed in warm temperate areas that are mainly in lowlands in this area. No logging has been conducted during the last 117 years in one site. Logging profiles are unclear for the other two sites, but they belong to Buddhist temples and are supposed to be reserved with huge trees in the tree layer.

Secondary oak forests are mainly composed of *Q. serrata*, *Q. acutissima* Carr., *Castanea crenata* Sieb. & Zucc., and *Carpinus* spp. This forest type is widely distributed as regenerating stands from cool to warm temperate areas. Stand ages of those examined here are inferred to be less than 60 years because these forests were established after clear cuttings or intensive loggings after the World War II.

Secondary pine forests have mainly *Pinus densiflora* Sieb. & Zucc., but hardwood trees such as *Quercus* spp., *C. crenata*, *Carpinus* spp. are frequently mixed. These stands were also established after the World War II, therefore stand ages of those examined here are inferred to be less than 60 years.

Japanese cedar [*Cryptomeria japonica* (L. f.) D. Don] and Hinoki cypress [*Chamaecyparis obtusa* (Sieb. & Zucc.) Endlicher] plantations are widely distributed in warm and cool temperate areas. Few trees except for the planted species exist in the examined plots, but cut stamps of hardwood trees are scattered in some of them. Stand ages of those examined here are inferred to be less than 60 years because these plantations were established after the World War II in the examined area.

Species composition of polypores

Line transect sampling of wood-inhabiting polypores was conducted in each research site. Line transect was made by measuring a line by working at a constant speed (approximately 25 m/min) for 30 minutes in total toward a random direction. Occurrence of wood-inhabiting polypores was recorded by examining all the woody substrates more than 20mm in diam. within 1m on both sides of the measured line. Basidiocarps produced at heights of less than 1.8m above ground were recorded. Quantification of each species is made by the frequency of basidiocarps by counting the number of substrate unit bearing basidiocarps of the species. Multiple pieces apparently separated from a single substrate were counted as one substrate. Number of basidiocarps on each substrate unit and attached areas of basidiocarps to the substrate were neglected in quantification.

Most basidiocarps were determined *in situ*, but collected specimens were determined in the laboratory for those that field determination was difficult. 'Polypores' examined in this study are those belonging to the genera treated by Ryvarden (1991) including those with cruciate basidia. Scientific names used here mainly follow Núñez and Ryvarden (2000, 2001).

Data analyses

In addition to the number of polypore species and the total frequencies occurring in each plot, diversity of polypores in each plot was shown by Simpson's index of diversity (SID) defined by Simpson (1949) and Shannon-Weaver function (*H'*) calculated by the following equations:

$$SID = \sum(1/pi)^2, \; pi = ni/N$$
$$H' = - \sum pi \ln pi$$

where *ni* represents the frequency of the species *i* and *N* the total frequencies of all the species recorded in each plot. Analysis of variance (ANOVA) was used to test for the difference of diversity indices among different vegetation types.

Similarity of each polypore community was calculated by the following equation:

$$QS = 2c / a + b$$

where a and b represent the species numbers occurring in two different plots, and c the species number occurring in both plots (Sørensen, 1948). A dendrogram was established based on similarities between each two communities by the Group Average Strategies (Lance and Williams, 1967).

Results

A total of 82 species appeared in the 20 plots examined (Table 2). The similarity dendrogram of the polypore community in each plot is shown in Fig. 1. Polypore communities in hardwood forests and conifer forests are placed in different clusters, suggesting the low similarity of communities in hardwood forests and conifer forests. Three subclusters are detected under hardwood forest communities, i.e. beech, *Castanopsis*, and secondary oak forest communities. On the other hand, two subclusters are detected under conifer forests, i.e. secondary pine forests and Japanese cedar-Hinoki cypress plantations. This suggests that the species composition of polypores is related with the forest vegetation type.

Species number of polypores recorded in each plot is shown in Fig. 2. Thirteen to 26 species were recorded from beech forest plots and *Castanopsis* forest plots while less than 13 species were recorded from other plots. On the other hand, only 2 to 7 species were observed in Japanese cedar and Hinoki cypress plantation plots. Simpson's index of diversity (SID) and Shannon-Weaver function (*H'*) of polypore community recorded in each plot are shown in Table 3. Testing statistics (T) and differences of species richness, SID, and *H'* among different vegetation types are indicated in Tables 4-6. Species

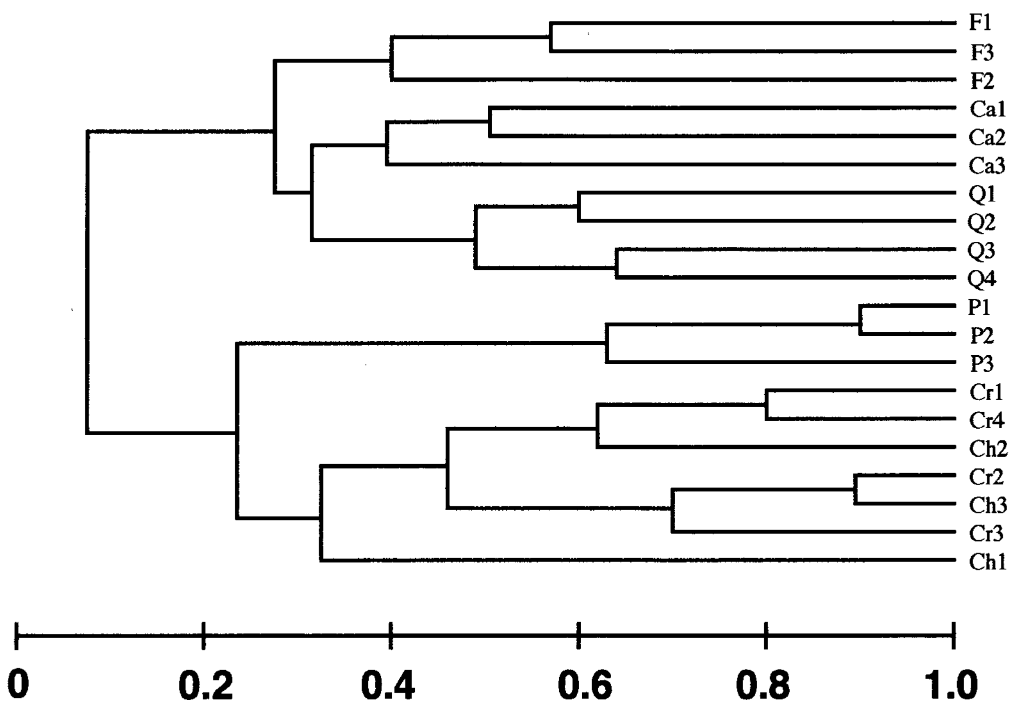

Fig. 1. A dendrogram showing the similarity of polypore communities recorded in the examined plots established by the Group Average Strategies. F1-3: beech forest plots. Ca1-3: *Castanopsis* forest plots. Q1-4: secondary oak forest plots. P1-3: secondary pine forest plots. Cr1-4: Japanese cedar plantation plots. Ch1-3: Hinoki cypress plantation plots.

richness and diversity indices were significantly higher in beech forest plots than in two secondary forests and two conifer plantations except for that *H'* for beech forest plots and secondary oak forest plots were not significantly different. Compared with conifer forest communities, species richness and diversity were significantly higher in hardwood communities except for *Castanopsis* forest communities that were not always significantly different from conifer forest communities.

Numbers of vegetation type specific species, hardwood or conifer specific species, and generalists are indicated in Fig. 2. 'Vegetation type specific species' are defined as those recorded only in one forest vegetation type, which will include real specialists restricted to the forest type and infrequent species possibly occurring in other forest types. 'Hardwood specific species' are those recorded only in beech, *Castanopsis* or secondary oak forest plots. 'Conifer specific species' are those recorded only in secondary pine forest, Japanese cedar, and Hinoki plantation plots. 'Generalists' are those that were discovered both in hardwood and conifer forest plots.

Table 2. Frequency of each species in the examined plots. Frequency of each species represents the number of substrate unit with basidiocarps of the species.

Species	Beech			*Castanopsis*			Secondary oak				Secondary pine			Japanese cedar				Hinoki		
	F1	F2	F3	Ca1	Ca2	Ca3	Q1	Q2	Q3	Q4	P1	P2	P3	Cr1	Cr2	Cr3	Cr4	Ch1	Ch2	Ch3
Abundisporus pubertatis							4	4	5	29								1		
Antrodia albida				1																
Antrodia heteromorpha	2									1										
Antrodiella albocinnamomea	1		1																	
Antrodiella aurantilaeta		1																		
Antrodiella fragrans			1																	
Antrodiella gypsea													1	22	4	3	9	8	42	25
Antrodiella hoehnelii	1																			
Antrodiella zonata	3			2	1	1				1										
Bjerkandera adusta		4	4		1				2											
Cerrena unicolor				2																
Cryptoporus volvatus												2	2							
Cyclomyces fusca				1																
Cystidiophorus castaneus											3	1	9							
Daedalea dickinsii	1	3		2																
Daedaleopsis styracina							2			3									1	
Daedaleopsis tricolor	4	3	1				1	2	4	4										
Datronia mollis				1														1		
Datronia stereoides								1											1	
Diplomitoporus lenis											11	8	4							
Fomes fomentarius	1	11	1																	
Fomitopsis pinicola				1							3	2								
Fomitopsis sp. *No. 1.*		1																		
Ganoderma applanatum			1																	
Ganoderma tsunodae	1		1																	
Gloeoporus dichrous													2							
Inonotus mikadoi						1														

Table 2 continued.

Species	Beech			*Castanopsis*			Secondary oak				Secondary pine			Japanese cedar				Hinoki		
	F1	F2	F3	Ca1	Ca2	Ca3	Q1	Q2	Q3	Q4	P1	P2	P3	Cr1	Cr2	Cr3	Cr4	Ch1	Ch2	Ch3
Irpex lacteus			2	1		1			1											
Hydnochaete tabacinoides		2																		
Junghuhnia nitida	1		1	5	2		12													
Laetiporus sulphureus						1														
Lenzites betulinus				1	4	2		1												
Megasporoporia sp. *No. 1.*	1																			
Microporus affinis				9	10	15														
Microporus vernicipes	1	9	11	2	4				6	8										
Oligoporus caesius s.l.					1		1	1			1	3	5	11	7	11	4		3	6
Oligoporus floriformis															1					
Oligoporus undosus																1				
Oligoporus sp. *No. 1.*																5				
Oxyporus corticola		1																		
Oxyporus cuneatus															3	4		1		2
Pachykytospora alabamae														1						
Perenniporia medulla-panis			2	1			1	1	3	1										
Perenniporia ochroleuca				1		1														
Perenniporia tephropora				2	1															
Phellinus gilvus		2	2	2	5	1		3	5	6										
Phellinus lonicerinus	2																			
Phellinus punctatus								1												
Phellinus sanfordii																		1		
Phellinus setifer						1	8	8												
Phellinus wahlbergii				3																
Phellinus xeranticus				1	2				3	3										
Physisporinus vitreus		1																		
Piptoporus soloniensis		1		1																
Polyporus alveolaris					1	1														

Table 2 continued.

Species	Beech			*Castanopsis*			Secondary oak				Secondary pine			Japanese cedar				Hinoki		
	F1	F2	F3	Ca1	Ca2	Ca3	Q1	Q2	Q3	Q4	P1	P2	P3	Cr1	Cr2	Cr3	Cr4	Ch1	Ch2	Ch3
Polyporus badius		1																		
Polyporus varius		1																		
Polyporus sp. *no. 1.*			1																	
Porodisculus pendulus			1																	
Protomerulius caryae	1		1																	
Pycnoporus cinnabarinus	1		1																	
Pycnoporus coccineus				1		1														
Pyrrhoderma sendaiense	1	1																		
Rigidoporus sp. *No. 1.*		1																		
Rigidoporus sp. *No. 2.*																1				
Rigidoporus sp. *No. 3.*			1																	
Schizopora cf. *paradoxa*	4	1	9	9	10	14	6	15	15	14			10							
Skeletocutis nivea	1			1					1											
Spongipellis delectans		1																		
Trametes cervina	2	1	1																	
Trametes gibbosa		2																		
Trametes hirsuta	2	3	1	1																
Trametes orientalis	1			2																
Trametes versicolor	7	7	5	5	4		6	13	6	2			1		1	1				4
Trametes villosa								1												
Trichaptum abietinum											20	17	38							
Trichaptum biforme		1							1											
Trichaptum fuscoviolaceum		3							1											
Trichaptum parvulum				1				2												
Tyromyces chioneus						1				2										
Wrightoporia sp. *No. 1.*							1													
Wrightoporia sp. *No. 2.*						1														

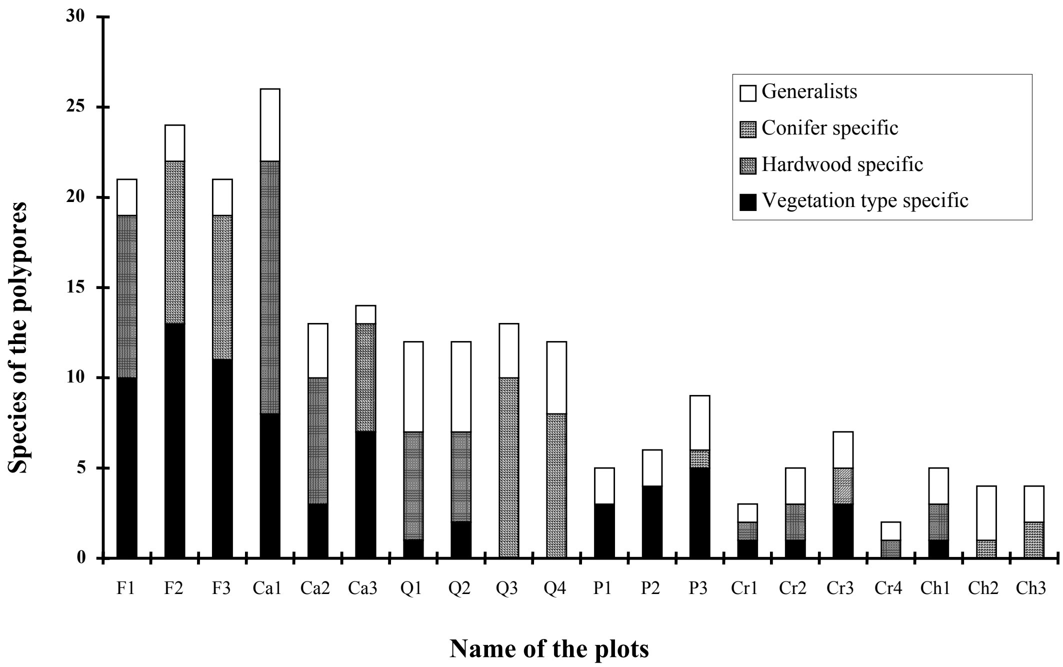

Fig. 2. Number of polypore species recorded in each plot showing generalists, conifer specific species, hardwood specific species, and vegetation type specific species. F1-3: beech forest plots. Ca1-3: *Castanopsis* forest plots. Q1-4: secondary oak forest plots. P1-3: secondary pine forest plots. Cr1-4: Japanese cedar plantation plots. Ch1-3: Hinoki cypress plantation plots.

In beech forest plots, 48 to 54% of the recorded species are vegetation type specific. *Fomes fomentarius* (L. : Fr.) Kickx. and *Trametes cervina* (Schwein.) Bres. were frequent in beech forest plots but were not seen in other forest types and suggested that they were indicative species for beech forests in this area. Additionally, the following species were also restricted to beech forest including the area outside the plots within the study sites: *Antrodiella hoehnelii* (Bres.) Niemelä, *Ganoderma tsunodae* (Lloyd) Trott., *Polyporus badius* (Pers.) Schwein., *Pyrrhoderma sendaiense* (Yasuda) Imazeki, and *Trametes gibbosa* (Pers.) Fr.

In *Castanopsis* forest plots, 23 to 50% of the recorded species were vegetation type specific. *Microporus affinis* (Blume & Nees. : Fr.) Kuntze was very frequent in all *Castanopsis* plots but was not seen in other plots. *Perenniporia ochroleuca* (Berk.) Ryvarden and *Phellinus wahlbergii* (Fr.) Reid were also common in *Castanopsis* forests but were not seen in other forest types including the area outside the plots.

On the other hand, only 0 to 17% of the recorded species were vegetation type specific in secondary oak plots. Most species recorded in these plots were also recorded in beech and/or *Castanopsis* forest plots. *Phellinus punctatus*

Table 3. Frequency of each species in the examined plots. Frequency of each species represents the number of substrate unit with basidiocarps of the species.

	Beech			***Castanopsis***			**Secondary oak**			
Diversity indices	**F1**	**F2**	**F3**	**Ca1**	**Ca2**	**Ca3**	**Q1**	**Q2**	**Q3**	**Q4**
Number of species	21	24	21	26	13	14	12	12	13	12
Total frequencies	39	62	49	59	46	42	45	51	53	74
SID*	12.78	11.7	9.93	13.24	7.4	4.05	6.55	5.28	7.22	4.63
H'#	0.92	0.9	0.85	0.89	0.87	0.7	0.85	0.80	0.9	0.8

	Secondary pine			**Japanese cedar**				**Hinoki**		
Diversity indices	**P1**	**P2**	**P3**	**Cr1**	**Cr2**	**Cr3**	**Cr4**	**Ch1**	**Ch2**	**Ch3**
Number of species	5	6	9	3	5	7	2	5	4	4
Total frequencies	38	33	72	35	16	26	13	12	47	37
SID*	2.67	2.93	3.09	2.01	3.37	3.89	1.74	2.11	1.25	2.01
H'#	0.74	0.8	0.7	0.68	0.3	0.7	0.7	0.85	0.82	0.89

*Simpson's Index of Diversity; #Shannon-Weaver function.

Table 4. Testing statistics (T) for comparing species richness of polypores in each two forest vegetation types and significance of the differences between the vegetation types.
$T = (x_k - x_l)/\sqrt{}((s_k^2/N_k + s_l^2/N_l)$
$s_k^2 = \Sigma (x_{ki} - x_k)^2/N_k - 1$, $s_l^2 = \Sigma (x_{li} - x_l)^2/N_l - 1$,
where x_k represents mean species number in vegetation type k, $x_k i$ species number in plot i, Nk number of plots in vegetation type k.

	Castanopsis	**Sec. Oak**	**Sec. Pine**	**Jap. Cedar**	**Hinoki**
Beech	1.009	9.459*	9.807**	11.899**	16.76**
Castanopsis		1.295	2.531	3.105	3.182
Secondary Oak			4.548*	7.039**	19.000**
Secondary Pine				1.478	1.871
Japanese Cedar					0.072

**Significantly different at $P<0.010$. * Significantly different at $P<0.050$.

Table 5. Testing statistics for comparing Simpson's index of diversity of polypores in each two forest vegetation types and significance of the difference between the vegetation types.

	Castanopsis	**Sec. Oak**	**Sec. Pine**	**Jap. Cedar**	**Hinoki**
Beech	1.153	5.451**	10.210**	11.889**	11.076**
Castanopsis		0.840	1.984	2.002	2.386
Secondary Oak			5.027*	4.030**	6.369**
Secondary Pine				0.270	3.716
Japanese Cedar					1.639

**Significantly different at $P<0.010$. * Significantly different at $P<0.050$.

Table 6. Testing statistics for comparing Shannon-Weaver function of polypores in each two forest vegetation types and significance of the difference between the vegetation types.

	Castanopsis	**Sec. Oak**	**Sec. Pine**	**Jap. Cedar**	**Hinoki**
Beech	1.050	2.173	11.181*	6.632**	8.811*
Castanopsis		0.344	3.061	3.258*	4.138*
Secondary Oak			3.854*	3.687*	4.914**
Secondary Pine				1.040	2.358
Japanese Cedar					0.876

**Significantly different at $P<0.010$. *Significantly different at $P<0.050$.

(Fr.) Pilát, *Trametes villosa* (Fr.) Kreisel, and *Wrightoporia* sp. No. 1. were recorded only from secondary oak plots. However, these species were found only once suggesting that these species are infrequent and were recorded only by chance. Frequencies of *Abundisporus pubertatis* (Lloyd) Parmasto and *Phellinus setifer* T. Hatt. were extremely high in secondary oak plots compared with other plots, but they were occasionally found in beech and *Castanopsis* stands out of the plots.

Species richness and both of the diversity indices were significantly low in secondary pine plots than in that of beech and secondary oak plots. However, there are several vegetation type specific species in this forest type such as *Cystidiophorus castaneus* (Lloyd) Imazeki, *Cryptoporus volvatus* (Peck) Shear, *Diplomitoporus lenis* (P. Karst.) Gilb. & Ryvarden, and *Trichaptum abietinum* (Dicks : Fr.) Ryvarden. *Fomitopsis pinicola* (Swartz : Fr.) P. Karst. was another frequent species in pine forests but also recorded on *Prunus* sp. in a *Castanopsis* plot.

Five species in total were vegetation type specific in Japanese cedar plantations. However, each of them was recorded only from one plot and it is unclear if they really are restricted to this vegetation type. *Phellinus sanfordii* (Lloyd) Ryvarden was recorded from a Hinoki plot, but the basidiocarps were found on a cut stump of a hardwood, and apparently not a species restricted to Hinoki plantation. *Antrodiella gypsea* (Yasuda) T. Hatt. & Ryvarden and *Oxyporus cuneatus* (Murrill) Aoshima were frequent both in Japanese cedar and Hinoki plantations, but were scarcely seen in other forest types.

There are several species commonly seen in three hardwood forest types but not seen in conifer forests and they were as follows: *Antrodiella zonata* (Berk.) Ryvarden, *Bjerkandera adusta* (Willd. : Fr.) P. Karst., *Junghuhnia nitida* (Fr.) Ryvarden, *Microporus vernicipes* (Berk.) Kuntze, *Perenniporia medulla-panis* (Jacq. : Fr.) Donk, and *Phellinus gilvus* (Schwein.) Pat. Among the generalists, following species were found on hardwood trees even in conifer plots therefore probably species restricted to hardwood trees: *Abundisporus pubertatis*, *Daedaleopsis styracina* (P. Henn. & Shirai) Imazeki, *Datronia mollis* (Sommerf. : Fr.) Donk, and *D. stereoides* (Fr.) Ryvarden. *Trametes versicolor* (L. : Fr.) Lloyd was very common in hardwood plots, but also was seen in some of conifer plots both on hardwood and conifer trees. *Schizopora* cf. *paradoxa* (Fr.) Donk was also common in hardwood plots, but also frequent on pine trees in a secondary pine plot. On the other hand, *Oligoporus caesius* (Schrad. : Fr.) Gilb. & Ryvarden *s.l.* was more frequent in conifer plots, but also was seen in some of hardwood plots.

Discussion

Many species of polypores were vegetation type specific in beech, *Castanopsis*, and pine forests. On the other hand, most species recorded in secondary oak forests were also seen in beech and/or *Castanopsis* forests. Occurrence of *Abundisporus pubertatis* and *Phellinus setifer* T. Hatt. are conspicuous in secondary oak forests because both of them are restricted to twigs or branches of deciduous oaks (Hattori and Zang, 1995; Hattori, 1999), but they also occur in beech and *Castanopsis* forests. Few species were also specific in Japanese cedar and Hinoki cypress plantations except for infrequent species recorded only from a single plot, and all the frequent species are common in the two vegetation types.

Among the species recorded only in beech forests, *Ganoderma tsunodae* (Yasuda) Trott. and *Pyrrhoderma sendaiense* (Yasuda) Imazeki are listed in the Japanese Red Data (Environment Agency of Japan, 2000). These two species are restricted to beech forests because they mainly occur on dead beech trees (Imazeki and Hongo, 1989). The following red-listed species, including non-polypores, have also been collected in the beech forests in this area: *Ascoclavulina sakaii* Otani, *Inonotus flavidus* (Berk.) Ryvarden, *Lampteromyces japonicus* (Kawamura) Singer, *Piptoporus quercinus* (Schrad.: Fr.) P. Karst., *Protodaedalea hispida* Imazeki, and *Polyporus tuberaster* Jacq.: Fr. Beech forests in this area are highly fragmented, and reduction of stand areas may induce loss of these species at the regional level. This suggests that these beech forests should be protected for conservation of rare fungi specific to this vegetation type. No other red-listed polypores were recorded in the other vegetation types in this area.

Species diversity of polypores is suggested to be lower in pine forests than in hardwood forests, but half of the species recorded in this vegetation type are not recorded from other vegetation types. Pine forests in this area have been seriously declined because of the damage by pine wilt nematodes, an introduced pathogen of *Pinus* spp. This suggests that some of the type specific species in pine forests may be reduced at the regional level if the damage will become more serious.

Many of the species seen in the beech and *Castanopsis* forests were also recorded in secondary oak forests. Therefore, these secondary forests may act as refugia for many hardwood specific species when primary hardwood forests are lost from the area. Secondary oak forests may also act as corridors for these species because distributions of beech and *Castanopsis* forests are highly fragmented in this area though oak forests are more widely distributed (Anonymous, 1979).

Most of the secondary oak forests and pine forests were established after deforestation of beech or *Castanopsis* forests in this area. The lower diversity in secondary forests compared with primary forests suggests that the diversity is reduced by deforestation of primary forests and are not recovered up to 60 years after the logging.

This work suggests that polypore flora reflects forest vegetation type. The diversity of polypores is high in primary beech forests followed by secondary forests, and low in conifer plantations in this area. Loss of primary forests is expected to reduce the diversity of polypores at the regional level. Secondary oak forests hold less species than primary forests, but are expected to act as refugia and corridors for polypores dwelling in hardwood forests. Several species are restricted to pine forests, and some others to Japanese cedar and/or Hinoki cypress plantations. These results suggest that the diversity of polypores is reduced in simplified landscape and maintained in various forest types at a regional level.

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