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Shuichi Noshiro[1] and Mitsuo Suzuki[2]: Utilization of forest resources in the early Jomon period at and around the Sannai-maruyama site in Aomori Prefecture, northern Japan

能城修一[1]・鈴木三男[2]：青森県三内丸山遺跡とその周辺における縄文時代前期の森林資源利用

Abstract Wooden artifacts and natural woods recovered from six localities around the Aomori plain were studied to clarify use of forest resources in the early Jomon period (5100 to 4600 yr BP) in northern Japan. The studied assemblages were wooden artifacts, natural woods, and charcoal fragments of the Sannai-maruyama site, wooden artifacts of the Iwatari-kotani no. 4 site, buried forest C at Ooyazawa, natural woods of the Mukaida no. 18 site, and wooden artifacts of the Sannai-maruyama no. 6 site. Natural woods showed that marsh forests of *Alnus* sect. *Gymnothyrsus* and *Fraxinus* prevailed in lowland with *Fagus, Acer, Quercus* sect. *Prinus*, *Carpinus* sect. *Distegocarpus*, and *Tilia* on surrounding upland. For wooden artifacts of the early Jomon period, *Castanea crenata* and *Thujopsis dolabrata*, especially at the Sannai-maruyama site, were strongly preferred, and the former was selected also in the middle to late Jomon periods. At the Sannai-maruyama site, these two species dominated also in natural woods and the former also in charcoal fragments. This composition and the occurrence of *Rhus verniciflua* and *Paulownia tomentosa* introduced from China seemed to indicate intensive management of the forest around the settlement by Jomon people.
Key words: Aomori plain, early Jomon period, forest resources, Japan, management

要　旨　青森平野の周辺には三内丸山遺跡をはじめとして縄文時代前期から中期に営まれた遺跡が存在し，木製品や加工木が多数出土している。また平野の南東部と陸奥湾南部では同時期の埋没林が確認されている。そのため，青森平野周辺の遺跡出土木製品と加工木の樹種組成を埋没林の樹種組成と対比することによって，縄文時代前期における森林資源利用の様相を出土木材から解明することが可能となった。本論で検討した出土木材は，三内丸山遺跡第6鉄塔地点の出土木製品・加工木と炭化材，同遺跡北の谷の柱状コラム採取の自然木と谷の中央から出土した木製品・加工木と自然木，岩渡小谷（4）遺跡出土の木製品・加工木，大矢沢の埋没林を構成する自然木，向田（18）遺跡出土の自然木，そして縄文時代中期～後期の三内丸山（6）遺跡出土の木製品・加工木である。その結果，低地にはハンノキ属ハンノキ節とトネリコ属を主体とする湿地林が成立し，台地よりにはブナ属，カエデ属，コナラ属コナラ節，クマシデ属クマシデ節，シナノキなどからなる林が存在していた。それに対し，三内丸山遺跡周辺では，縄文時代前期の木製品・加工木にクリとアスナロが多用され，クリは縄文時代中期～後期にも多用された。三内丸山遺跡では，クリとアスナロの自然木，およびクリの炭化材が多く，周辺の天然林にはまれなクリとアスナロの森林が遺跡周辺に成立し，中国起源とされるウルシとキリも植栽され，人間による森林の管理が行われていたことが想定された。
キーワード：青森平野，管理，縄文時代前期，森林資源，日本

Introduction

In Japan people have used timber for boards, stakes, or sticks since ca. 12,000 yr BP of the incipient Jomon period, but the use of wooden tools or containers is clearly known to be only since ca. 6000 yr BP of the early Jomon period (Yamada, 1993; Noshiro et al., 1996). At the Torihama Shell Midden in Fukui Prefecture, only three axe hafts and four bows or digging sticks were found among more than 200 stakes or other processed woods of the incipient to earliest Jomon periods (Amitani, 1996; Noshiro et al., 1996). In the early Jomon period, however, various wooden artifacts appeared and included ca. 200 axe hafts categorized into three types, ca. 200 bows or digging sticks of five types, ca. 60 owls of two types, and over 100 containers of six types including lacquered ones. Although known since 8000 yr BP of the earliest Jomon period (Minami-kayabe Town Archaeological Research

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Group, 2002), the manufacture of lacquer ware such as lacquered containers or pottery became common in the early Jomon period (Yamada, 2002). Lowland sites of the incipient to early Jomon periods with wooden artifacts are rare, and there is limited knowledge about the usage of forest resources and species selection for wooden artifacts in the those periods (Yamada, 1993).

Since the 1990s lowland sites of the early to middle Jomon periods with wooden artifacts have been discovered around the Aomori Plain in northern Japan. Of these sites, the Sannai-maruyama site represents 5100 to 3900 yr BP, corresponding to the middle phase of the early to the end of the middle Jomon periods. At this 38 ha area site, there was large-scale development and construction, including large six-pillared buildings using *Castanea* trees of ca. 1 m in diameter, over 500 pit-dwellings, long houses up to 30 m long, 10 m wide, extensive artificial mounds made of continuous dumping, refuse dumping sites on valley slopes, burial grounds, clay paved roads, and storage pits (Sannai-maruyama Site Preservation Office, 2004; Tsuji & Nakamura, 2001). At the Iwatari-kotani no. 4 site, which surrounds a valley and is 2 km southwest of the Sannai-maruyama site, a contemporaneous dam and a flume were made with stakes and boards and included several kinds of wooden artifacts such as lacquer ware and containers made of the lacquer tree, *Rhus verniciflua* Stokes (Noshiro & Ancient Forest Research, 2004; Noshiro & Suzuki, 2004). Besides such intensive large-scale development, contemporaneous buried forests or fossil wood assembles without clear traces of human usage have also been found at several places in or around the same plain, and allowed reconstruction of natural forests away from human settlements.

While these excavations were carried out in 1990s in and around the Aomori Plain, the technique of radiocarbon dating was improved by the usage of the accelerator mass spectrometry (AMS). Many fragmentary samples from several important archaeological sites throughout Japan were radiocarbon dated (Toizumi & Tsumura, 2000). Ninety samples from the Sannai-maruyama site allowed detailed reconstruction of the timing of the development of the settlement and precise dating of the typical pottery types around the Aomori Plain of the early to middle Jomon periods (Tsuji & Nakamura, 2001). Thus, the ages of the typical pottery types now are estimated: ca. 5100 to 4600 yr BP for the lower cylindrical pottery covering the middle to late phases of the early Jomon period, ca. 4600 to 4300 yr BP for the upper cylindrical pottery of the middle Jomon period, around 4100 yr BP for the Enoki-bayashi pottery of the final phase of the middle Jomon period, and around 3900 yr BP for the Saibana pottery of the final phase of the middle Jomon period to the initial phase of the late Jomon period. Settlement at the Sannai-maruyama site is now estimated to have continued from 5100 to 3900 yr BP, which is from 5900 to 4300 cal BP in calendar years.

To clarify usage of forest resources around the Aomori Plain in the early Jomon period, we investigated the species composition of wooden artifacts or natural woods at three sites (Sannai-maruyama, Iwatari-kotani no. 4, and Mukaida no. 18) and a buried forest at Ooyazawa. To compare species selection in later periods with that of the early Jomon period, we also studied wooden artifacts of the middle to late Jomon periods of the Sannai-maruyama no. 6 site. Except for the species composition of the buried forest at Ooyazawa (Noshiro et al., 2002b), most data on individual sites were preliminarily published in archaeological reports (Maeda & Suzuki, 1998; Noshiro & Suzuki, 1998; Noshiro et al, 2002a; Noshiro & Ancient Forest Research, 2004; Suzuki et al., 2004a). This paper compares these sites and discusses the species selection and usage of forest resources by Jomon people around the Aomori Plain.

Materials and methods

Except for one site, all the sites are located in the Aomori Plain at the northern tip of Honshu island of Japan (Fig. 1). Three archaeological sites, Sannai-maruyama, Iwatari-kotani no. 4, and Sannai-maruyama no. 6, are located on the western border of the present Aomori Plain within a radius of 3 km, and buried forests of Ooyazawa occur on the southeastern border ca. 7 km southeast of the Sannai-maruyama site. The Mukaida no. 18 site is located outside the Amori Plain at the foot of the Shimokita Peninsula ca. 45 km northeast of the Sannai-maruyama site. Below we describe the locality, stratigraphy, radiocarbon dates, and characteristics of the assemblages of the studied sites.

1. Sannai-maruyama site

The Sannai-maruyama site extended on a terrace on the southern bank of the Okidate River at ca. 15 m above sea level. An extensive settlement covering 38 ha area was maintained from 5100 to 3900 yr BP of the early to middle Jomon periods (Sannai-maruyama Site Preservation Office, 2004; Tsuji & Nakamura, 2001). During this period, people gradually developed this area, constructing six-pillared buildings, pit-dwellings, long houses, mounds, middens, burial grounds, roads, and storage pits.

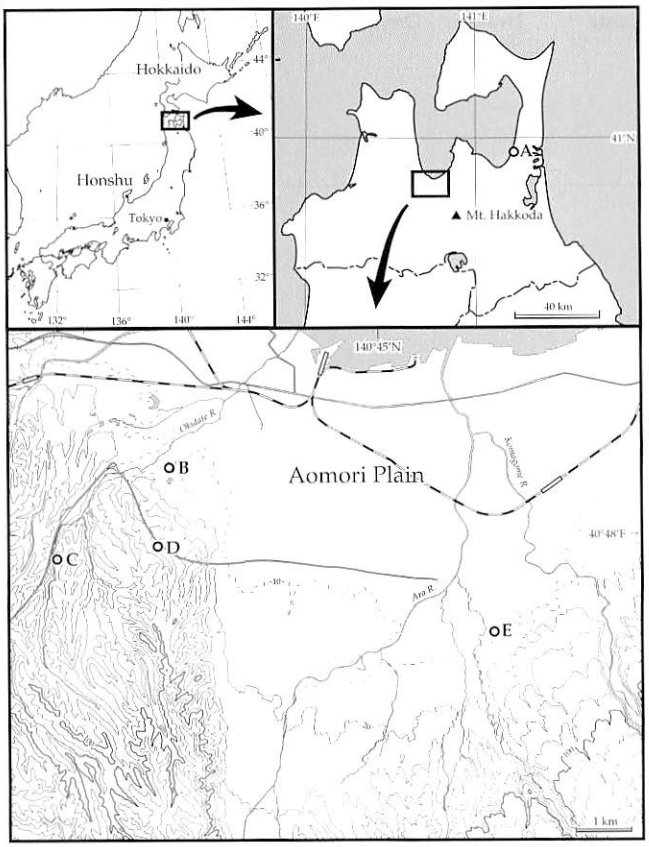

Fig. 1 Study sites in Aomori Prefecture. A: Mukaida no. 18 site, B: Sannai-maruyama site, C: Iwatari-kotani no. 4 site, D: Sannai-maruyama no. 6 site, E: Ooyazawa.

Four kinds of fossil wood assemblages were obtained here: wooden artifacts and natural woods (Noshiro & Suzuki, 1998) and charcoal fragments (Maeda & Suzuki, 1998) of the power line tower no. 6 block, natural woods in the lower end of the north valley, and wooden artifacts and natural woods of the middle part of the same valley.

The power line tower no. 6 block was a dumping site on the edge of the upland, and seeds of *Sambucus racemosa* L. or pottery fragments occasionally formed a layer (Tsuji & Toizumi, 1998). Stratigraphy of the standard columnar sections of this block was divided into six layers, from VI to I, from the bottom (Fig. 2). Wooden artifacts, natural woods, and charcoal fragments were concentrated in layers VIb and VIa of organic mud together with animal remains. Between VIa and Vc, a layer of dumped *Sambucus* seeds was intercalated. Layers IVa and IVb included type a lower cylindrical pottery of the middle phase of the early Jomon period, and type b lower cylindrical pottery of the middle phase of the early Jomon period was included in layer V and concentrated in layer Vb. Excluding exceptional results, conventional radiocarbon ages were between 5108 ± 106 and 4950 ± 50 yr BP (6 counts) for VIb, between 5145 ± 90 and 4960 ± 60 (3 counts) for VIa, 5050 ± 60 yr BP (1 count) for *Sambucus* seed between VIa and Vc, 4970 ± 50 yr BP (1 count) for Vc, and 4850 ± 50 yr BP (1 count) for Vb (Tsuji & Nakamura, 2001).

At the lower end of the north valley called location B, sandy or peaty sediments were divided into six layers, E, D (Dc, Db, Da), C (Cb, Ca), B (Bb, Ba), A, and S, from the bottom. Natural woods were concentrated in woody peat within layers E, D, and Bb of the standard columnar samples (Fig. 2; Tsuji & Nakamura, 2001). Conventional radiocarbon ages for E, Dc, and Bb were 5890 ± 80 to 5700 ± 60 yr BP (2 counts), 5740 ± 80 yr BP (1 count), and 4860 ± 60 yr BP (1 count), respectively. Layers Ba, A, and S intercalated layers of discarded *Castanea* seed coat or charcoal fragments, and they were dated between 5160 ± 200 to 4690 ± 60 yr BP (8 counts). In the middle part of the valley, wooden artifacts and natural woods were obtained from layers contemporaneous with discarded *Castanea* seed coat or charcoal fragments that included types a and b lower cylindrical pottery (Fig. 2; Ito, 1996; Nakamura, personal communication). Because analysis of excavated remains and artifacts together with stratigraphical records is yet to be finished, further division of horizons in the middle part of the north valley is difficult at present.

2. Iwatari-kotani no. 4 site

The Iwatari-kotani no. 4 site was on a hillside surrounding a branch valley of the Okidate River at 30–40 m above sea level, and a settlement of the middle to late phases of the early Jomon period was unearthed (Aomori Prefectural Archaeological Research Center, 2004). In the valley a dam and a flume were constructed using stakes and board, and wooden tools were deposited in the reservoir of the dam. The dam was covered in layer IIIC including type b lower cylindrical pottery, and conventional radiocarbon dates obtained from various parts of the dam were 4940 ± 40 to 4650 ± 40 yr BP (6 counts)(Fig. 2). The flume was constructed with large boards and split woods placed to cross the valley in layers IIIC and IIIB including types b and c lower cylindrical pottery. Woods used in this structure were radiocarbon dated as 4860 ± 40 yr BP (2 counts). *Castanea* seed coat fragments were concentrated within this structure and slightly downstream. Several structures, such as a wooden crossing and a flume, were constructed in the same valley. Outside these structures, ca. 20 wooden artifacts were recov-

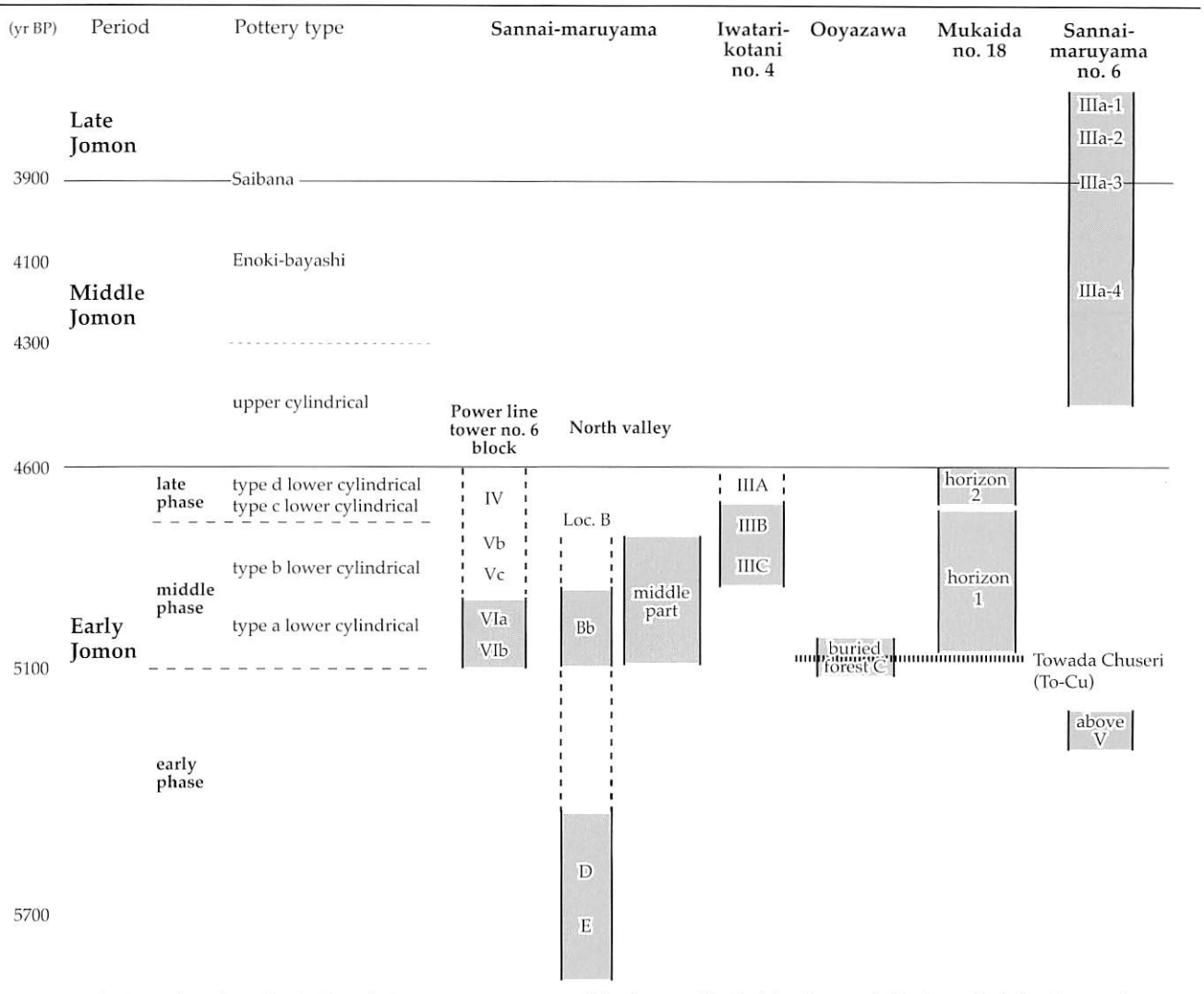

Fig. 2 Correlation of archaeological periods, pottery types, and horizons. Shaded horizons yielded studied fossil wood assemblages. Radiocarbon dates and their correlation with pottery types are based on Tsuji & Nakamura (2001).

ered with type d lower cylindrical pottery of the late phase of the early Jomon period. Because delimitation of layers IIIC and IIIB including types b and c lower cylindrical pottery was difficult and because the uppermost layer IIIA with type d lower cylindrical pottery yielded only 20 wooden artifacts, the wooden artifacts from this site are treated together.

3. Ooyazawa

At Ooyazawa three buried forests were discovered in the backmarsh of the Yokouchi River at ca. 10 m above sea level during construction of two consecutive reservoirs called Kami-ike and Shimo-ike (Goto & Tsuji, 2000). Above two buried forests of the last glacial maximum and the late glacial, the uppermost buried forest called buried forest C extended within a valley of the early Jomon period running south to north through Kami-ike and Shimo-ike and formed woody peat. In Kami-ike, Towada Chuseri pumice fall (To-Cu) was detected in the middle horizon of this buried forest, but could not be confirmed in Shimo-ike (Fig. 2). On the south face of Kami-ike, fragments of types a and b lower cylindrical pottery were concentrated above To-Cu. Conventional radiocarbon ages of peat just below To-Cu were 5080 ± 110 to 5050 ± 70 yr BP (2 counts), and peat layer just above To-Cu including types a and b lower cylindrical pottery were 5050 ± 40 to 4980 ± 40 yr BP (2 counts).

4. Mukaida no. 18 site

The Mukaida no. 18 site was a lowland site of the last phase of the early Jomon period in an alluvial plain at ca. 7 m above sea level and yielded a dugout and magnificent lacquer ware as well as pottery (No-

heji Town Museum of History and Folklore, 2004). Traces of human settlement were scarce here, and only two pit dwellings of the late phase of the early and the early phase of the latest Jomon periods were recovered along with many pits. In the alluvial plain, natural woods were recovered in silty to sandy sediments above To-Cu. Type d lower cylindrical pottery were discovered in layers VII to V of block B and layers X to IX of block C together with lacquer ware. This horizon is treated as horizon 2 in this paper (Fig. 2). Conventional radiocarbon dates of the lacquer ware and a dugout were 4880 ± 40 to 4600 ± 40 yr BP (7 counts). In block C, fossil woods were included in layers XIII to XII between To-Cu and horizon 2 that yielded type d lower cylindrical pottery. This lower horizon is treated as horizon 1 in this paper. In block C, secondarily deposited fossil woods were recovered together with type d lower cylindrical pottery in layers VI to IV just above Baegdusan-Tomakomai tephra (B-Tm) dated at the 10th century (Machida & Arai, 2003), but will not be treated in this paper.

5. Sannai-maruyama no. 6 site

The Sannai-maruyama no. 6 site is on a hillside surrounding a small valley at ca. 40 m above sea level and yielded a settlement of the middle to late phases of the middle Jomon period and a burial ground of the early phase of the late Jomon period (Aomori Prefectural Archaeological Research Center, 2002). The valley was a dumping site, and wooden artifacts and pottery fragments were discarded with food residue. Except for seven containers, all other wooden artifacts were boards, split woods, sticks, and processed woods of obscure usage. Wooden artifacts and natural woods were recovered from five layers, above V, IIIa-4, IIIa-3, IIIa-2, and IIIa-1, from the bottom (Fig. 2). A clay layer above the valley bottom yielded a few wooden artifacts and was designated as 'above V.' Layers IIIa-4 and IIIa-3 and layers IIIa-2 and IIIa-1 mainly included pottery of the middle Jomon period and that of the early phase of the late Jomon period, respectively. However, due to washing out of upper layers, secondary deposition of artifacts, and misidentification of layers, pottery fragments of the late Jomon period were often derived from layers IIIa-4 and IIIa-3, and a small portion of the middle Jomon period pottery were found in layers IIIa-2 and IIIa-1. Conventional radiocarbon ages for above V, IIIa-4, IIIa-3, and IIIa-1 were 5270 ± 40 yr BP (1 count), 4460 ± 40 to 4280 ± 40 yr BP (3 counts), 3710 ± 40 to 3660 ± 40 yr BP (3 counts), and 3670 ± 40 yr BP (1 count), respectively. In layer IIIa-3, dumped *Juglans* endocarps were concentrated sporadically.

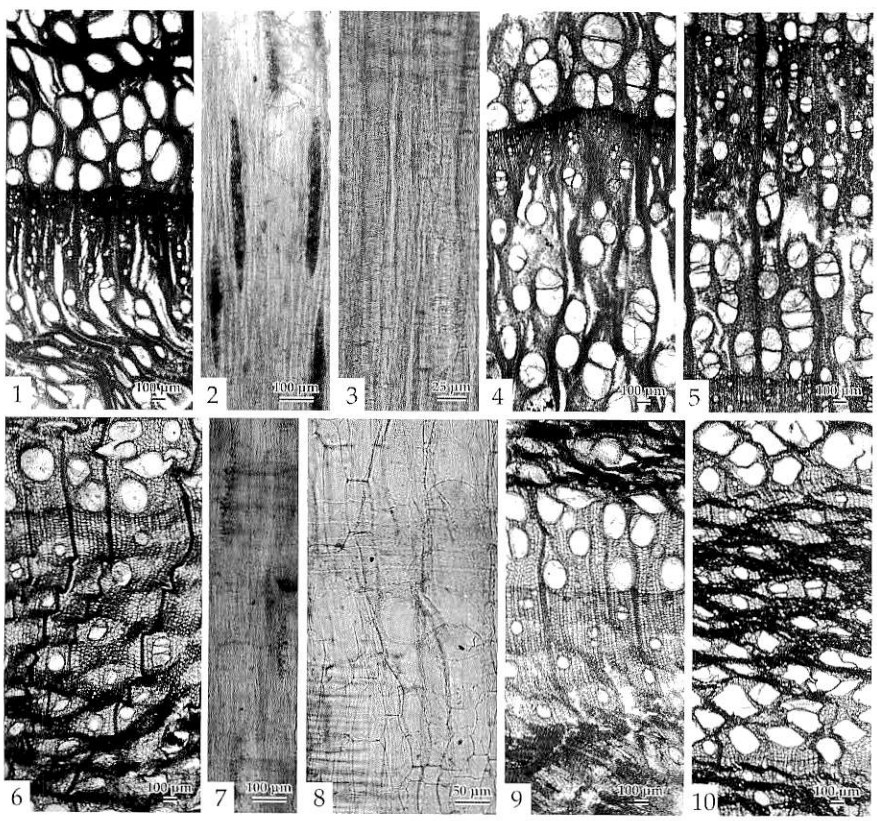

Fig. 3 *Rhus verniciflua* Stokes (1–5) and *Paulownia tomentosa* (Thunb.) Steud. (6–10) discovered at three sites in Aomori. — 1–3: round wood from the Sannai-maruyama site (AOM-622; 1: cross section (CS), 2: tangential section (TS); 3: radial section (RS)). — 4: board from the Iwatari-kotani no. 4 site (AOM-3051; CS). — 5: natural wood from the Mukaida no. 18 site (AOM-2575; CS). — 6–8: board from the Iwatari-kotani no. 4 site (AOM-3264; 6: CS, 7: TS; 8: RS). — 9: vessel-shaped container from the Iwatari-kotani no. 4 site (AOM-3524; CS). — 10: board from the Sannai-maruyama site (AOM-487; CS).

Results

1. Sannai-maruyama site

Except for one stemwood and one rootwood and two monocot fragments, wooden artifacts and natural woods of the power line tower no. 6 block were stem- or branchwoods of 32 taxa (Table 1). Because these wooden artifacts were found in a dumping site, tools or utensils with clear usage were few, and only three containers, three spatula-like tools, and two stakes were recovered. Species composition of wooden artifacts was quite similar between layers VIb and VIa, and *Castanea crenata* Sieb. et Zucc. and *Thujopsis dolabrata*

Table 1 Wooden artifacts, natural woods, and charcoal fragments of the middle phase of the Early Jomon period recovered from the power line tower no. 6 block of the Sannai-maruyama site (Noshiro & Suzuki, 1998; Maeda & Suzuki, 1998)

Taxon		Wooden artifacts																		Natural woods		Charcoal			
		VIb								VIa										VIb	VIa	VIb		VIa	
		container	board	split wood	stick	proc. wood	others	Total		container	board	split wood	stick	proc. wood	others	Total									
Cephalotaxus harringtonia	S			1				1	0.6%													1	0.5%		
Thujopsis dolabrata	S		6	1	10	6	2	25	14.6%		4	6	8	12	1	31	20.0%	1							
*Juglans mandshurica**	S			2	1			3	1.8%		2			4		6	3.9%		1	8	4.1%	3	0.5%		
Pterocarya rhoifolia	S																			2	1.0%	5	0.9%		
Salix	S																		1						
Alnus sect. *Gymnothyrsus*	S					1		1	0.6%			1				1	0.6%			4	2.1%	1	0.2%		
Alnus sect. *Distegocarpus*	S																			1	0.5%				
Betula	S																					2	0.3%		
Castanea crenata	S	1	6	17	1	50		75	43.9%	1	7	7	2	25	1	43	27.7%	5	1	135	69.9%	491	84.2%		
Fagus	S																		1			2	0.3%		
Quercus sect. *Prinus*	S			7		1		8	4.7%		1	2		2		5	3.2%	1	1	3	1.6%	3	0.5%		
Celtis	S																					2	0.3%		
Ulmus	S			4		1		5	2.9%		3	6		2		11	7.1%			6	3.1%	3	0.5%		
Morus australis	S			3		1		4	2.3%		1	4		5	1	11	7.1%		3	4	2.1%				
Magnolia	S			3				3	1.8%											3	1.6%				
	R													1		1	0.6%								
Cercidiphyllum japonicum	S			1		1		2	1.2%																
Actinidia	S													1		1	0.6%								
Hydrangea paniculata	S				2			2	1.2%					1		1	0.6%								
Schizophragma hydarangeoides	S																					3	0.5%		
Prunus	S					1		1	0.6%											1	0.5%	2	0.3%		
Maackia amurensis	S																			1	0.5%	1	0.2%		
Sapium japonicum	S																					1	0.2%		
Daphniphyllum	S																					1	0.2%		
Phellodendron amurense	S				2	1		3	1.8%			3		2		5	3.2%	1		6	3.1%	12	2.1%		
Zanthoxylum ailanthoides	S																					1	0.2%		
Picrasma quassioides	S			1	1	4		6	3.5%		1	2	1	1		5	3.2%	1	6						
Rhus javanica **	S																		1	2	1.0%	7	1.2%		
Rhus verniciflua	S					1		1	0.6%		1			1		2	1.3%								
Acer	S		1	4	1	6		12	7.0%		1	4		7		12	7.7%	1	6	7	3.6%	27	4.6%		
Euonymus	S																					1	0.2%		
Hovenia	S					1		1	0.6%	1	1	1				3	1.9%	1				2	0.3%		
Vitis	S						2	2	1.2%																
Swida controversa	S																	1	1	1	0.5%	1	0.2%		
Aralia elata	S				2			2	1.2%					1		1	0.6%			1	0.5%	2	0.3%		
Kalopanax pictus	S													1		1	0.6%								
Styrax	S			1		1		2	1.2%				1			1	0.6%					1	0.2%		
Fraxinus	S			1		6		7	4.1%		2	3		6	1	12	7.7%	3	3	7	3.6%	6	1.0%		
Paulownia tomentosa	S		1			1		2	1.2%		1					1	0.6%								
*Sambucus racemosa***	S													1		1	0.6%					2	0.3%		
Viburnum	S					2		2	1.2%																
Diffuse-porous wood	S																					1	0.2%		
Subfam. *Bambusoideae*	S					1		1	0.6%									2							
Total		1	14	46	20	86	4	171		2	25	39	12	73	4	155		17	25	193		583			

*var. *sieboldiana*, **var. *chinensis*, *** subsp. *sieboldiana*. S: stem-/branchwood, R: rootwood; proc. wood: processed wood.

(Thunb. ex L. f.) Sieb. et Zucc. together accounted for 58.5% and 47.7% of wooden artifacts in layers VIb and VIa, respectively. In both layers, *Castanea crenata* and *Thujopsis dolabrata* were used for various kinds of artifacts, but between these layers, the percentage of *Castanea crenata* decreased from 43.9% to 27.7%, whereas that of *Thujopsis dolabrata* increased from 14.6% to 20.0%. They were followed in abundance by *Acer*, *Quercus* sect. *Prinus*, *Fraxinus*, and *Picrasma quassioides* (D. Don) Benn. in layer VIb and by *Acer*, *Fraxinus*, *Ulmus*, and *Morus australis* Poirs. in layer VIa. Two taxa thought to be prehistoric introduction to Japan, *Rhus verniciflua* and *Paulownia tomentosa* (Thunb.) Steud., were used for processed woods or boards in both layers (Fig. 3). There were less than 100 natural wood fragments, and *Castanea crenata*, *Quercus* sect. *Prinus*, *Picrasma quassioides*, *Acer*, and *Fraxinus* were the most commonly occurring. Natural woods included six taxa not found among artifacts: *Salix*, *Corylus*, *Fagus*, *Rhus javanica* L. var. *chinensis* (Mill.) T. Yamaz., *Swida controversa* (Hemsl.) Soják, and *Callicarpa*.

Charcoal fragments of the power line tower no. 6 block included 43 taxa including one monocot (Table 1). In both layers VIb and VIa, *Castanea crenata* was dominant, occupying 69.9% and 84.2% respectively, and all the other taxa were less than 5%. In layer VIb *Castanea crenata* was followed in abundance by *Juglans mandshurica* Maxim. var. *sieboldiana*

Table 2 Natural woods recovered at Loc. B at the lower end of the north valley of the Sannai-maruyama site

Taxon		lower E	upper E	above E	D	Bb
*Juglans mandshurica**	R				1	2
Pterocarya rhoifolia	R				1	
Fagus	S	8	4		1	
Ulmus	R				1	
Magnolia	S					3
	R					11
Prunus	SR				1	
Acer	S	1	4		8	
	R				1	
Vitis	S					1
Helwingia japonica	S				1	
Fraxinus	S	4	7	1	6	5
	R	1	25		10	24
Total		14	40	1	31	46

*var. *sieboldiana*. S: stem-/branchwood, SR: stump wood, R: root-wood

Table 3 Wooden artifacts and natural woods of the middle phase of the Early Jomon period recovered from the middle part of the north valley of the Sannai-maruyama site

Taxon		Wooden artifacts								Natural woods	
		lacquered container	tool	board	split wood	stick	processed wood	Total		Total	
Cephalotaxus harringtonia	S						1	1	0.5%		
Picea	S									1	0.5%
Thujopsis dolabrata	S		11	21	5	71	2	110	57.9%	75	38.5%
*Juglans mandshurica**	S					1	1	2	1.1%	1	0.5%
Populus	-									1	0.5%
Alnus sect. *Gymnothyrsus*	S				1			1	0.5%	1	0.5%
Carpinus sect. *Eucarpinus*	S									1	0.5%
Castanea crenata	S	3	2	3	24	24	7	63	33.2%	85	43.6%
Fagus	S									1	0.5%
Quercus sect. *Prinus*	S				1	4		5	2.6%	6	3.1%
Ulmus	S					2		2	1.1%	4	2.1%
Morus australis	S					1		1	0.5%		
Cercidiphyllum japonicum	S					1		1	0.5%	1	0.5%
Hydrangea paniculata	S					1		1	0.5%		
Gleditsia japonica	S									1	0.5%
Acer	S									3	1.5%
Aesculus turbinata	-									1	0.5%
Hovenia	S									2	1.0%
Aralia elata	S				1			1	0.5%		
Styrax	S				1			1	0.5%	1	0.5%
Fraxinus cf. *mandschurica*	S					1		1	0.5%		
Fraxinus	S									1	0.5%
Total		3	13	24	33	106	11	190		186	

*var. *sieboldiana*. S: stem-/branchwood, -: indistinguishable. stick: inclusive of digging sticks

(Maxim.) Makino, *Acer*, *Fraxinus*, *Ulmus*, and *Phellodendron amurense* Rupr. In layer VIa it was followed in abundace by *Acer*, *Phellodendron amurense*, *Rhus javanica* var. *chinensis*, and *Fraxinus*. Compared with wooden artifacts and natural woods, charcoal fragments had more *Castanea crenata* and complete lack of *Thujopsis dolabrata*.

At the lower end of the north valley, frequent occurrence of rootwoods showed that *Fraxinus*, *Fagus*, and *Acer* formed woody peat in layers E and D (Table 2). In layer Bb, the composition of the woody peat seemed to have changed into one of *Juglans mandshurica* var. *sieboldiana*, *Magnolia*, and *Fraxinus*. Throughout these layers, *Fraxinus* rootwoods were conspicuous and always more frequent than stemwoods.

In the middle part of the north valley, the composition of wooden artifacts and natural woods was less heterogeneous that in power line tower no. 6 block and included 22 taxa (Table 3). Except for two specimens not distinguished, all were stemwoods. Beside three lacquered containers, tools such as spatula-like tools, a lacquered comb, a lacquered bow, an oar, and a digging stick were discovered among wooden artifacts. *Thujopsis dolabrata* accounted for 57.9% of wooden artifacts, mostly due to frequent occurrence of slender sticks made of its split wood, and *Castanea crenata* accounted for 33.2%, being used for various kinds of artifacts. None of the other taxa accounted for more than 3%. Among natural woods, *Castanea crenata* and *Thujopsis dolabrata* accounted for 43.6% and 38.5%, respectively, and were followed in abuncance by *Quercus* sect. *Prinus*, *Ulmus*, *Acer* and *Hovenia*. Natural woods were more heterogeneous in composition than wooden artifacts and included taxa not found among wooden artifacts or in the power line tower no. 6 block such as *Picea*, *Populus*, *Carpinus* sect. *Eucarpinus*, and *Gleditsia japonica* Miq.

Table 4 Wooden artifacts of the middle phase of the Early Jomon period recovered at the Iwatari-kotani no. 4 site (Noshiro & Ancient Forest Research, 2004)

Taxon		container	oar	axe haft	digging stick	stick	board		stake		split wood		proc. wood	round wood	others	Total	
Thujopsis dolabrata	S				3	5			1	0.6%	1	0.6%	1		4	15	2.3%
*Juglans mandshurica**	S				2	1	9	7.8%	9	5.8%	12	6.7%	6	3	2	44	6.8%
Alnus sect. *Gymnothyrsus*	S								1	0.6%						1	0.2%
Carpinus sect. *Distegocarpus*	S										1	0.6%	1	1		3	0.5%
Castanea crenata	S	2				5	63	54.3%	100	64.5%	105	58.7%	37	15	14	341	52.5%
Fagus	S													1		1	0.2%
Quercus sect. *Prinus*	S		2		16	1	8	6.9%	11	7.1%	13	7.3%	3	5	3	62	9.5%
Celtis	S								1	0.6%						1	0.2%
Ulmus	S			3			4	3.4%	2	1.3%	7	3.9%		3		19	2.9%
Zelkova serrata	S														1	1	0.2%
Morus australis	S						1	0.9%	2	1.3%						3	0.5%
Magnolia	S										1	0.6%			1	2	0.3%
Actinidia	S														1	1	0.2%
Hydrangea paniculata	S										2	1.1%				2	0.3%
Prunus	S										4	2.2%	2	1	4	11	1.7%
Maackia amurensis	S								5	3.2%				7		12	1.8%
Phellodendron amurense	S						13	11.2%	5	3.2%	11	6.1%	4	2	1	36	5.5%
	R										1	0.6%				1	0.2%
Picrasma quassioides	S								3	1.9%				1		4	0.6%
Rhus verniciflua	S	2					5	4.3%	1	0.6%	3	1.7%	2	1	4	18	2.8%
Acer	S	1					4	3.4%	6	3.9%	3	1.7%	1	1	1	17	2.6%
Euonymus	S					1	1	0.9%						1	1	4	0.6%
Hovenia	S	2			3	1	2	1.7%	5	3.2%	5	2.8%			1	19	2.9%
Swida controversa	S						2	1.7%	1	0.6%	3	1.7%	1		1	8	1.2%
Aralia elata	S						1	0.9%	1	0.6%	3	1.7%	1	1	1	8	1.2%
Kalopanax pictus	S														2	2	0.3%
Fraxinus	S						1	0.9%	1	0.6%	3	1.7%		2		7	1.1%
Paulownia tomentosa	S						2	1.7%							2	4	0.6%
Viburnum	S										1	0.6%				1	0.2%
Monocotyledon	S					1								1		2	0.3%
Total		7	2	3	24	15	116		155		179		59	46	44	650	

*var. *sieboldiana*, S: stem-/branchwood, R: rootwood, proc. wood: processed wood.

2. Iwatari-kotani no. 4 site

Beside stakes and boards for the construction of a dam and a flume, wooden artifacts of the Iwatari-kotani no. 4 site included various tools or utensils such as containers, oars, axe hafts, digging sticks, and vessel-shaped objects (Table 4). Among 30 taxa detected at this site, *Castanea crenata* accounted for 52.5% of all wooden artifacts, i.e., 54.3% of boards, 64.5% of stakes, and 58.7% of split woods, and was especially preferred for containers, sticks, and vessel-shaped objects. *Quercus* sect. *Prinus* was preferred for digging sticks and oars and accounted for 9.5% of wooden artifacts. They were followed in abundance by *Juglans mandshurica* var. *sieboldiana* and *Phellodendron amurense* for construction woods, *Ulmus* for axe hafts, and *Hovenia* for containers and digging sticks. The next common taxon, *Rhus verniciflua*, was preferred for vessel-shaped containers and boards (Fig. 3). *Thujopsis dolabrata* was preferred for digging sticks and sticks, but accounted for only 2.3% of wooden artifacts, far less than at the Sannai-maruyama site. *Paulownia tomentosa*, a probable prehistoric introduction, was used for boards and vessel-shaped objects (Fig. 3).

3. Ooyazawa

In buried forest C of Ooyazawa, stumps of *Fraxinus* and *Alnus* sect. *Gymnothyrsus* occurred evenly throughout the valley (Table 5). Below To-Cu, *Fraxinus* (64%) was more common than *Alnus* (25%) and was accompanied by *Juglans mandshurica* var. *sieboldiana*, *Castanea crenata*, *Quercus* sect. *Prinus*, and *Fagus*. The diameters of stumps and fallen stems were up to 140 and 75 cm in *Fraxinus*, 120 and 45 cm in *Alnus*, and 44 and 30 cm in *Fagus*, respectively. The diameter of fallen stems of other taxa were up to 70 cm. Above To-Cu, *Alnus* (48%) was more abundant than *Fraxinus* (39%) and was accompanied by *Castanea crenata*, *Quercus* sect. *Prinus*, *Magnolia*, and *Acer*. The diameter of stumps and fallen stems were up to 90 and 65 cm in *Alnus* and 100 and 65 cm in *Fraxinus*, respectively. The diameter of fallen stems of other taxa were up to 53 cm. In Shimo-ike, *Fraxinus* was more abundant than *Alnus*, and stumps over 100 cm and stems up to 50 cm in diameter were detected. Except for the specimen of *Magnolia*, specimens of *Juglans mandschurica*, *Castanea crenata*, *Fagus*, *Quercus* sect. *Prinus*, and *Acer* were found along the margins of the valley.

4. Mukaida no. 18 site.

In horizon 1 of the Mukaida no. 18 site, *Acer*, *Fraxinus*, *Carpinus* sect. *Distegocarpus*, and *Alnus* sect. *Gymnothyrsus* together accounted for 67.6% of natural woods (22 taxa) and were followed in abundance by *Tilia*, *Hydrangea petiolaris* Sieb. et Zucc., and *Kalopanax pictus* (Thunb.) Nakai (Table 6). In this horizon, rootwoods were rare, only three taxa. In horizon 2, *Fraxinus* (33.7%) and *Alnus* sect. *Gymnothyrsus* (16.7%) dominated among natural woods (38 taxa), and their rootwoods accounted for 12.8% and 8.4%, respectively. They were followed in abundance by *Quercus* sect. *Prinus*, *Juglans mandshurica* var. *sieboldiana*, *Fagus*, *Acer*, *Tilia*, *Carpinus* sect. *Distegocarpus*, and *Magnolia*. Rootwoods were detected in *Fagus*, *Aesculus turbinata* Blume, *Kalopanax pictus*, and *Styrax* besides *Fraxinus* and *Alnus* sect. *Gymnothyrsus*. Although rootwoods occupied 23.8% of the total specimens in horizon 2, it is not clear if a buried forest existed at this site or if the woods were derived from flooding. Two taxa outside the present range of distribution were *Abies* and *Picea*. Consistent with the

Table 5 Composition of buried forest C at Ooyazawa and diameter of the largest stumps and stems (modified from Noshiro et al., 2002b)

Taxon	Kami-ike						Shimo-ike		
	below To-Cu			above To-Cu					
	no.	%	diameter class (cm)	no.	%	diameter class (cm)	no.	%	diameter class (cm)
*Juglans mandshurica**	1		(stp: 40–50)				1	2%	unknown
Alnus sect. *Gymnothyrsus*	13	25%	(stp: 100–120, s: 40–50)	22	48%	(stp: 80–90, s: 60–70)	8	18%	(stp: 80–90, s: 40–50)
Castanea crenata	1	2%	(s: 60–70)	2	4%	(s: 30–40)			
Fagus	2	4%	(stp: 40–50, s: 20–30)						
Quercus sect. *Prinus*	2	4%	(s: 40–50)	2	4%	(s: 50–60)			
Magnolia				1	2%	(stp: 30–40)			
Hydrangea paniculata							1	2%	unknown
Acer				1	2%	(s: 20–30)			
Fraxinus	34	64%	(stp: 120–140, s: 70–80)	18	39%	(stp: 90–100, s: 60–70)	34	77%	(stp: 100–120, s: 40–50)
Total	53			46			44		

*var. *sieboldiana*. stp: stump, s: fallen stem.

Table 6 Natural woods of the middle to late phases of the Early Jomon period recovered at the Mukaida no. 18 site (modified from Suzuki et al., 2004a)

Taxon		Horizon 1		Horizon 2		Total	
Abies	S	1	0.9%	1	0.2%	2	0.3%
Picea	S			1	0.2%	1	0.2%
*Juglans mandshurica**	S	2	1.9%	28	5.1%	30	4.6%
Pterocarya rhoifolia	S			1	0.2%	1	0.2%
Salix	S	1	0.9%	2	0.4%	3	0.5%
Alnus sect. *Gymnothyrsus*	S	8	7.4%	45	8.2%	53	8.1%
	R	3	2.8%	46	8.4%	49	7.5%
Ostrya japonica	S			2	0.4%	2	0.3%
Carpinus sect. *Distegocarpus*	S	12	11.1%	14	2.6%	26	4.0%
Castanea crenata	S			2	0.4%	2	0.3%
Fagus	S	1	0.9%	19	3.5%	20	3.1%
	R			3	0.5%	3	0.5%
Quercus sect. *Prinus*	S	2	1.9%	34	6.2%	36	5.5%
Celtis	S			3	0.5%	3	0.5%
Ulmus	S			12	2.2%	12	1.8%
Morus australis	S			12	2.2%	12	1.8%
Magnolia	S	1	0.9%	14	2.6%	15	2.3%
Cercidiphyllum japonicum	S			3	0.5%	3	0.5%
Actinidia arguta	S			2	0.4%	2	0.3%
Actinidia	S	2	1.9%			2	0.3%
Hydrangea petiolaris	S	4	3.7%	4	0.7%	8	1.2%
Prunus	S			2	0.4%	2	0.3%
Pourthiaea villosa	S			2	0.4%	2	0.3%
Phellodendron amurense	S			5	0.9%	5	0.8%
Zanthoxylum piperitum	S			2	0.4%	2	0.3%
Picrasma quassioides	S	1	0.9%			1	0.2%
Rhus verniciflua	S	1	0.9%	10	1.8%	11	1.7%
Acer	S	32	29.6%	22	4.0%	54	8.3%
Aesculus turbinata	R			6	1.1%	6	0.9%
Ilex macropoda	S			1	0.2%	1	0.2%
Euonymus	S			1	0.2%	1	0.2%
Celastrus orbiculatus	S			9	1.6%	9	1.4%
Staphylea bumalda	S	1	0.9%			1	0.2%
Hovenia	S	1	0.9%	4	0.7%	5	0.8%
Tilia	S	7	6.5%	18	3.3%	25	3.8%
Stachyurus praecox	S	1	0.9%	10	1.8%	11	1.7%
Swida controversa	S	1	0.9%	1	0.2%	2	0.3%
Kalopanax pictus	S	3	2.8%	7	1.3%	10	1.5%
	R	1	0.9%	1	0.2%	2	0.3%
Styrax	S	2	1.9%	4	0.7%	6	0.9%
	R			4	0.7%	4	0.6%
Fraxinus	S	18	16.7%	114	20.9%	132	20.2%
	R	1	0.9%	70	12.8%	71	10.9%
Callicarpa	S			1	0.2%	1	0.2%
*Sambucus racemosa***	S			2	0.4%	2	0.3%
Viburnum	S	1	0.9%	2	0.4%	3	0.5%
Total		108		546		654	

*var. *sieboldiana*, ** subsp. *sieboldiana*. S: stem-/branchwood, R: rootwood. Horizon 1. Block C, layers XIII to XII. Horizon 2. Block B, layers VII to V; Block C, layers X to IX.

discovery of lacquer ware in horizon 2, *Rhus verniciflua* was found in horizons 1 and 2 (Fig. 3).

5. Sannai-maruyama no. 6 site

Except for seven containers, all the wooden artifacts of Sannai-maruyama no. 6 site showed only crude processing. In layers IIIa-4 to IIIa-2, *Castanea crenata* was used for every kind of artifact and was preferred for containers, boards, and split woods (Table 7). Other commonly used taxa were *Kalopanax pictus* for split woods above V, *Ulmus* for boards and split woods in layers IIIa-4, IIIa-3, and IIIa-1, *Aesculus turbinata* and *Fraxinus* for split woods in layer IIIa-4, *Juglans mandschurica* var. *sieboldiana* for split woods in layer IIIa-3, and *Staphylea bumalda* (Thunb.) DC. and *Acer* for split woods in layer IIIa-2. Among natural woods, *Castanea crenata*, *Ulmus*, and *Fraxinus* were conspicuous.

Discussion

1. Forest management around settlements of the early Jomon period in Aomori plain

In natural woods of the location B of the Sannai-maruyama site and the Mukaida no. 18 site, lowland elements such *Alnus* sect. *Gymnothyrsus* and *Fraxinus* dominated (Fig. 4). Coexistence of their rootwoods indicated that, during the early Jomon period, these two taxa formed marsh forests that formed woody peat below the forest floor similar to the buried forest C of Ooyazawa and those found in the Kanto plain (Tsuji, 1989, 1992; Noshiro & Suzuki, 1993; Noshiro et al., 2002b). Taxa that usually accompanied these dominant elements were *Juglans mandschurica* var. *sieboldiana*, *Fagus*, *Quercus* sect. *Prinus*, *Magnolia*, and *Acer*. Taxa that accompanied them locally at the Mukai no. 18 site were *Carpinus* sect. *Distegocarpus* and *Tilia*. These taxa must have grown on marsh margins to uplands, judging from the absence of their rootwoods and their distribution along the valley margins in buried forest C of Ooyazawa. Besides the studied assemblages of natural woods, similar marsh forests were unearthed in two horizons at the Kosannai site on the northeastern border of the Sannai-maruyama site facing the Okidate valley (Tsuji et al., 1994). The lower forest at this site was contemporaneous with buried forest C of Ooyazawa and included stumps or fallen stems of *Fraxinus*, *Quercus* sect. *Prinus*, and *Pterocarya rhoifolia*. The upper one was dated as the final phase of the early to the middle Jomon periods and included stumps or fallen stems of *Alnus* sect. *Gymnothyrsus*, *Fraxinus*, *Salix*, *Castanea crenata*, *Magnolia*, and *Aesculus turbinata*. Thus, marsh forests of *Alnus* sect. *Gymnothyrsus* and *Fraxinus* prevailed in the lowland during the early to middle Jomon periods around the Aomori plain, accompanied by several upland elements. According to the pollen analytical study at Ooyazawa situated in a

Table 7 Wooden artifacts of the middle to late Jomon periods recovered at the Sannai-maruyama no. 6 site (Noshiro et al., 2002a)

Taxon		Wooden artifacts																						Natural woods				
		above V		IIIa-4					IIIa-3					IIIa-2				IIIa-1				above V	IIIa -4	IIIa -3	IIIa -2	IIIa -1
		split wood	proc. wood	con- tainer	board	split wood	stick	proc. wood	con- tainer	board	split wood	stick	proc. wood	board	split wood	stick	proc. wood	board	split wood	stick	proc. wood					
Cephalotaxus harringtonia	S						1																	1	2		
Thujopsis dolabrata	S											1															
*Juglans mandshurica**	S									1	4														2		
Ostrya japonica	S																										1
Castanea crenata	S		1	2	11	30	3	2	3	7	17	1	1	4	10		1	1	1				8	2	4	
	SR																						1				
Fagus	S																2								2		
Quercus sect. *Prinus*	S										1									1				1			
Celtis	S																			1							
Ulmus	S				3	4				2	1	1	1						2					2	2		
	R																				1		1	1		2	
Morus australis	S				1						1				1			1				1				1	
Actinidia	S					1					1														1		
Hydrangea paniculata	S											1															
Schizophragma hydrangeoides	S																		1								
Pourthiaea villosa	S																							2			
Rosaceae	S																								1		
Maackia amurensis	S										2																
Picrasma quassioides	S																		1								
*Rhus javanica***	S														1												
Acer	S														6	1							1		1		
	SR																						1				
Aesculus turbinata	S					3			1														1				
	R					1																	1				
Staphylea humalda	S					1									5									1			
Hovenia	S											1											1	1			
Kalopanax pictus	S	3				1																1					
	R																						1				
Vaccinium oldhamii	S											1												1			
Fraxinus	S					3			1		1													4			
*Sambucus racemosa****	S																							2			
Total		3	1	2	15	44	4	2	5	10	28	5	3	4	23	1	3	2	5	2	1	2	16	20	13	4

*var. *sieboldiana*, ** var. *chinensis*, *** subsp. *sieboldiana*. S: stem-/branchwood, SR: stump wood, R: rootwood.

backmarsh (Goto & Tsuji, 2000), such marsh forests were frequently destroyed by flooding and continually reestablished themselves for at least over 1000 years during the early to middle Jomon periods.

The composition of natural woods obtained from the north valley of the Sannai-maruyama site was quite different from the composition of such marsh forests and was markedly dominated by *Castanea crenata* and *Thujopsis dolabrata* that each accounted for ca. 40% (Fig. 4). This distinct dominance of *Castanea crenata* and *Thujopsis dolabrata* is similar to the composition of wooden artifacts from the Sannai-maruyama site. This close correspondence in composition between natural woods and wooden artifacts contrasts with the usual difference in composition between them seen at such sites as the Torihama shell midden and Juno peat bed site (Suzuki & Noshiro, 1997) and seems to show a close tie between production of timber and its usage at the Sannai-maruyama site. In charcoal fragments of the Sannai-maruyama site and wooden artifacts of the Iwatari-kotani no. 4 site, however, only *Castanea crenata* dominated, accounting between 53% and 84%, and *Thujopsis dolabrata* was nonexistent or barely used along with other broad-leaved trees. Although occurrence of *Thujopsis dolabrata* was rare in pollen or plant macrofossil assemblages around the Aomori plain, its leaves were recovered from the power line tower no. 6 block of the Sannai-maruyama site (Minaki et al., 1998). Thus, the contrasting composition of natural woods and artifacts at the Sannai-maruyama site from that of marsh forests with accompanying upland elements and the conspicuous

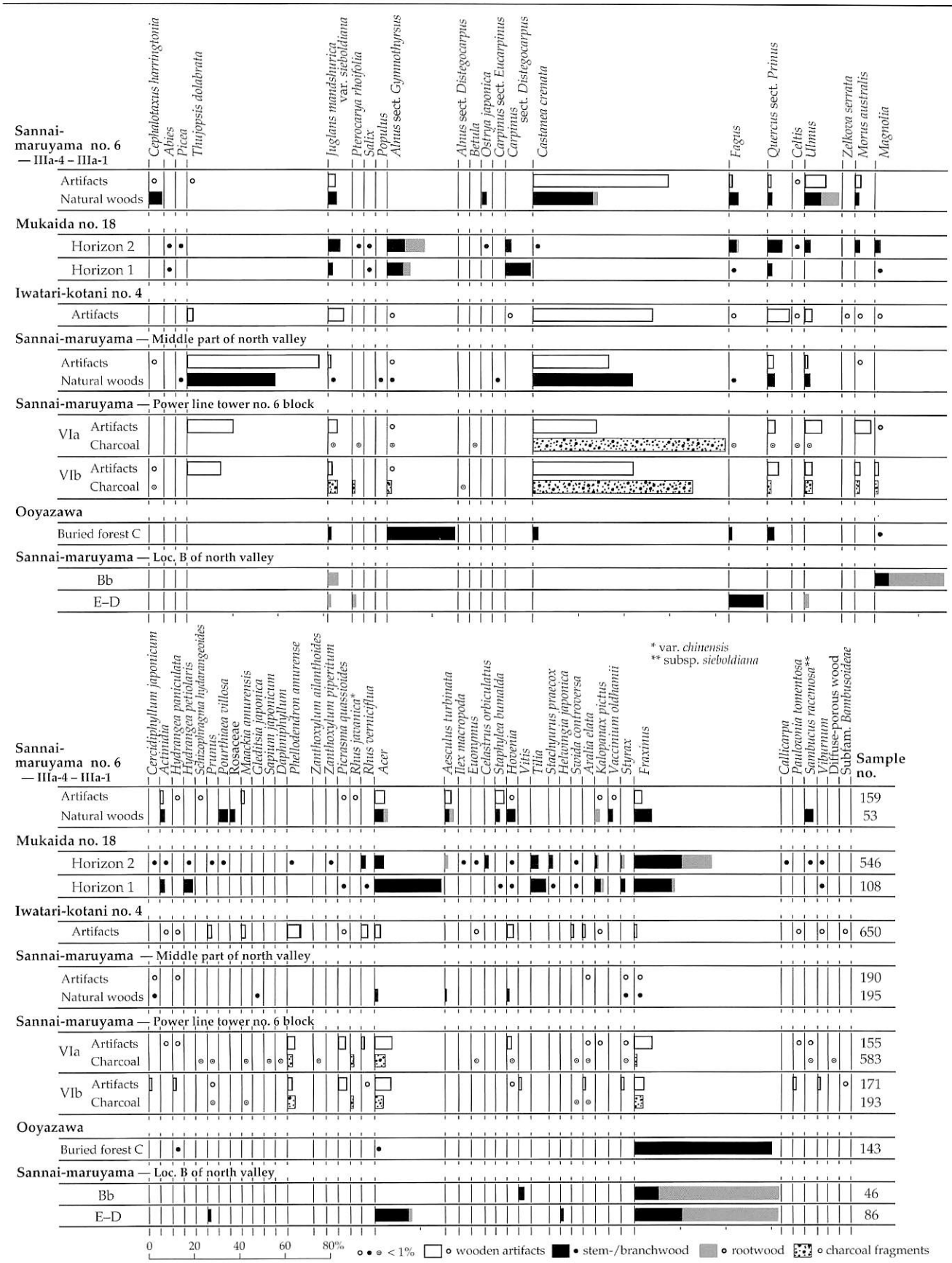

Fig. 4 Comparison of taxonomic composition of wooden artifacts, natural woods, and charcoal fragments at the studied sites.

similarity between natural woods and artifacts at the Sannai-maruyama site seem to indicate that early Jomon people maintained a *Castanea crenata–Thujopsis dolabrata* forest around the site for the manufacture of artifacts and for fuel. At surrounding sites, however, *Thujopsis dolabrata* was omitted from the forest management, and only *Castanea crenata* forests were established. The strong preference of *Castanea crenata* for wooden artifacts seems to have prevailed into the middle to late Jomon periods, as shown in wooden artifacts at the Sannai-maruyama no. 6 site and pillars for six-pillared buildings and pit dwellings of the Sannai-maruyama site (Okada, 1996; Ogasawara, 1998; Suzuki & Noshiro, unpublished).

This speculation about forest management by early Jomon people seems to be supported by the occurrence at the Sannai-maruyama and Iwatari-kotani no. 4 sites of *Rhus verniciflua* and *Paulownia tomentosa*, which are considered introduced from China. Similarly, studies of pollen assemblages at the Sannai-maruyama site and Ooyazawa showed that *Castanea* replaced previously dominant *Fagus* and *Quercus* subgen. *Lepidobalanus* as settlements were established around the Sannai-maruyama site (Tsuji, 1996; Yoshikawa & Tsuji, 1998; Goto & Tsuji, 2000; Yoshikawa et al., 2006). Accoring to the pollen assemblages, *Castanea* continued to dominate while the settlements were maintained at the Sannai-maruyama site, but were replaced by *Aesculus turbinata* when people abondaned the settlements at the end of the middle Jomon period. Thus, human management of *Castanea crenata* forests around settlements seems to be a general phenomenon since the early Jomon period around the Aomori plain.

Considering various usages of forest resources in the Jomon period, Suzuki & Noshiro (1997) presented a schema depicting vegetation and forest usages around settlements. They imagined that grassland and sparse forests for fuel wood collection and tool materials grade into secondary forests for tools and construction timber within a one to two kilometer radius of settlements and that secondary forests grade into natural forests within a two to four kilometer radius. At the Sannai-maruyama site, *Castanea crenata* and *Thujopsis dolabrata* were used abundantly for construction work and manufacture of tools, but *Castanea crenata* was also used for fuel wood. Thus, at the Sannai-maruyama site, sparse forests and secondary forests seem to have consisted of *Castanea crenata* and of *Castanea crenata* and *Thujopsis dolabrata*, respectively. At the contemporaneous Iwatari-kotani no. 4 site, 3 km apart from the Sannai-maruyama site, however, only *Castanea crenata* was used intensively for construction work, and *Thujopsis dolabrata* was barely used for a few sticks. Jomon people seem to have managed and used forests fit for their employment in a narrower area outside their settlements than depicted by Suzuki & Noshiro (1997). Wood of *Castanea crenata* was used in large quantities for general purposes, e.g., building timber, tools, and fuel wood. However, other taxa were selected for the manufacture of specific tools: *Rhus verniciflua* and *Hovenia* for containers, *Quercus* sect. *Prinus* for oars and digging sticks, *Ulmus* for axe hafts, and *Thujopsis dolabrata* for sticks. Materials not available in managed forests must have been sought in natural forests which extended outside the managed forests without much intervening secondary forests.

2. Preference for *Castanea crenata* timber in central to northern Honshu

A preference for *Castanea crenata* during the Jomon period was first documented in central Honshu (Suzuki & Noshiro, 1987; Chino, 1991; Noshiro et al., 1992; Yamada, 1993; Suzuki & Noshiro, 1997). At the Juno peat bed site, Saitama, for example, over 200 stakes made mostly of round woods with a diameter of 10–15 cm were driven into the peat layer from the upland toward the center of the lowland during the late Jomon period, and *Castanea crenata* accounted for three fourths of these stakes (Saitama Prefectural Board of Education, 1984). At the Akayama site, Saitama, *Castanea crenata* was used for ca. 41% of 1175 various construction woods of the late to latest Jomon periods, including those for a jetty and a pool for the processing of *Aesculus* fruits, yet it accounted for 11% of 4158 natural woods derived from lowland forests (Kawaguchi City Board of Education, 1989; Noshiro & Suzuki, 1989, 1993). Summarizing identification of charred building timber in 27 burned houses of the early to late Jomon periods from central to northern Japan, Chino (1991) showed that, except for a few houses, *Castanea crenata* was the dominant element for house building. In a recent excavation at the Aota site, Niigata, *Castanea crenata* accounted for ca. 35% of 444 housing pillars of the latest Jomon period, followed by *Quercus* sect. *Aegilops* (21%) and *Quercus* sect. *Prinus* (17%), whereas it accounted for 3% of 456 natural woods mainly derived from lowland forests (Suzuki et al., 2004b). At this site, the growth curves of trees used for pillars showed that *Castanea crenata* grew thrice faster than *Quercus* sect. *Aegilops* and sect. *Prinus*, which had growth rates as similar to those they have in present natural forests, and that *Castanea crenata* trees grew faster or as fast as those in present secondary forests (Kimura et al., 2004). Some of the *Castanea*

crenata pillars grew to 20 cm in diameter in 10 years, growth not attainable without human management. At the Korekawa-nakai site, Hachinohe, Aomori, of the latest Jomon period, *Castanea crenata* was used as commonly as *Aesculus turbinata* for lacquer ware and as commonly as *Cryptomeria japonica* for spatula-shaped artifacts; it accounted for 50% of 72 processed woods besides three pillars and one lacquered bracelet (Suzuki et al., 2002). Here *Castanea crenata* was dominant in natural woods and pollen assemblages, accompanied by its fruit remains. Thus, management of *Castanea crenata* forests was a general phenomenon around settlements of central to northern Honshu during the early to latest Jomon periods.

Recently, Jomon people's preference for *Castanea crenata* trees are being analyzed from several aspects other than supply of wood and food. An experiment on the efficiency of felling trees with stone axes showed that *Castanea crenata* trees are easier to fell and with less wear on stone blades than other broad-leaved trees (Kudo, 2004; Miyama, 2004). Among trees with a diameter of 20 cm, for example, *Quercus serrata* and *Prunus* needed 1.5 and 1.7 times more strokes than *Castanea crenata* to fell. For construction woods used for a dam of the late Jomon period at the Shimo-yakebe site, Tokyo, *Castanea crenata* woos was selected not just for its durable character, but also for its ease of splitting (Sasaki & Noshiro, 2004a). *Castanea crenata* trees accounted for 12 of 13 main frames and 57% of 225 stakes used for the dam. While 11 of 13 main frames were round woods, 63% of *Castanea crenata* stakes were split woods made from trees 10–20 cm in diameter, and most other stakes were round woods from trees less than 10 cm in diameter. Although trends were less clear at the Iwatari-kotani no. 4 site, 83% of 95 *Castanea crenata* woods used for a similar dam and a flume were split woods, whereas 52% of other taxa were round woods (Sasaki & Noshiro, 2004b). At this site, 60% of ca. 130 flat grain boards including those omitted from the above counts due to the difficulty of reconstructing the original diameter of material trees were *Castanea crenata*. Thus, splitting of *Castanea crenata* timber seems to have been quite common. In future studies, usage and management of forest resources during the Jomon period should be sought from various aspects, based on the recognition of human management and intensive use of *Castanea crenata* forests around settlements.

3. Coexistence of two introduced plants, *Rhus verniciflua* and *Paulownia tomentosa*

Among the sites studied around the Aomori plain, both *Rhus verniciflua* and *Paulownia tomentosa* were detected at the Sannai-maruyama and Iwatari-kotani no. 4 sites (Figs. 2, 3). Both species were used for vessel-shaped bowls, boards, and processed woods (Noshiro & Suzuki, 1998; Noshiro & Ancient Forest Research, 2004). Although *Rhus verniciflua* woods were detected at nearly 20 sites of the Jomon period in central to northern Honshu (Noshiro & Suzuki, 2004; Noshiro et al., in press), occurrence of *Paulownia tomentosa* is still rare, not just in the Jomon, but also in the Yayoi to Kofun periods (Minaki & Nakagawa, 2000). The earliest record of *Rhus verniciflua* wood in Japan is a natural wood of the incipient Jomon period at the Torihama shell midden (Noshiro et al., in press). The earliest record of *Paulownia tomentosa* wood is a natural wood from the Awazu kotei site, Otsu, Shiga, of the earliest Jomon period (Ito, 1993). Identification of macrofossils of these species is difficult, and their only records during the Jomon period are two fruits of *Rhus verniciflua* at the Iwatari-kotani no. 4 site (Yoshikawa & Ito, 2004) and 85 seeds of *Paulownia* at the Awazu kotei site of the earliest Jomon period or a period before that (Minaki & Nakagawa, 2000). Except for the Awazu kotei site, *Paulownia tomentosa* is usually accompanied by *Rhus verniciflua* during the Jomon period, and beside the Sannai-maruyama and Iwatari-kotani no. 4 sites, both were detected at the Korekawa-nakai site of the latest Jomon period (Suzuki et al., 2002) and the Akayama site of the late to latest Jomon periods (Noshiro & Suzuki, 1989, 1993).

Similar to *Rhus verniciflua* (Noshiro & Suzuki, 2004), *Paulownia tomentosa* is regarded as a prehistoric introduction to Japan (Kitamura & Murata, 1971; Ohwi, 1984; Yamazaki, 1993). Although variations are reported in present Japanese *Paulownia* trees (Kumakura, 1978, 1979), they are regarded as infraspecific variation in *Paulownia tomentosa* (Hu, 1959; Kitamura & Murata, 1971; Tsoon et al., 1979; Ohwi, 1984; Yamazaki, 1993; Hong et al., 1998). Cultivated or wild trees of *Paulownia tomentosa* occur widely in central China along the Chang Jiang below 1800 m above sea level (Hu, 1959; Tsoon et al., 1979; Hong et al., 1998). Besides *Rhus verniciflua* and *Paulownia tomentosa*, there are other introduced plants in the Jomon period. At the Awazu kotei site, *Paulownia* seeds were accompanied with remains of such introduced plants as fruits and seeds of *Lagenaria siceraria* (Molina) Standl., fruits of *Arctium lappa* L., fruits of *Perilla frutescens* (L.) Britton var. *japonica* (Hassk.) Hara, and seeds of *Chenopodium album* L. Around the Aomori plain, fruits and seeds of *Lagenaria siceraria* and fruits of *Arctium lappa* L. were detected at the Sannai-

maruyama site (Minaki et al., 1998), and seeds of of *Lagenaria siceraria* were found also at the Iwatari-kotani site (Yoshikawa & Ito, 2004). According to the present literature, *Paulownia tomentosa* has been cultivated mainly for its wood, but also for traditional medicine (Shibata, 1949; Hu, 1959). Although artifacts made of *Paulownia tomentosa* wood are known, its existence in the Jomon period is still quite rare and sporadic, and the purpose of its introduction and cultivation in the Jomon period remains to be clarified.

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Appendix. Correspondance between English and Japanese terms used in this paper

Cephalotaxus harringtonia (Knight ex Forbes) K. Koch	イヌガヤ
Abies	モミ属
Picea	トウヒ属
Thujopsis dolabrata Siebold et Zucc.	アスナロ
Juglans mandshurica Maxim. var. *sieboldiana* (Maxim.) Makino	オニグルミ
Pterocarya rhoifolia Siebold et Zucc.	サワグルミ
Salix	ヤナギ属
Populus	ハコヤナギ属
Alnus sect. *Gymnothyrsus*	ハンノキ属ハンノキ節
Alnus sect. *Distegocarpus*	ハンノキ属ヤシャブシ節
Betula	カバノキ属
Ostrya japonica Sarg.	アサダ
Carpinus sect. *Eucarpinus*	クマシデ属イヌシデ節
Carpinus sect. *Distegocarpus*	クマシデ属クマシデ節
Castanea crenata Siebold et Zucc.	クリ
Fagus	ブナ属
Quercus sect. *Prinus*	コナラ属コナラ節
Celtis	エノキ属
Ulmus	ニレ属
Zelkova serrata (Thunb.) Makino	ケヤキ
Morus australis Poir.	ヤマグワ
Magnolia	モクレン属
Cercidiphyllum japonicum Siebold et Zucc.	カツラ
Actinidia	マタタビ属
Hydrangea paniculata Siebold	ノリウツギ
Hydrangea petiolaris Siebold et Zucc.	ツルアジサイ
Schizophragma hydarangeoides Siebold et Zucc.	イワガラミ
Prunus	サクラ属
Pourthiaea villosa (Thunb.) Decne.	カマツカ
Maackia amurensis Rupr. et Maxim.	イヌエンジュ
Gleditsia japonica Miq.	サイカチ
Sapium japonicum (Siebold et Zucc.) Pax et K. Hoffm.	シラキ
Daphniphyllum	ユズリハ属
Phellodendron amurense Rupr.	キハダ
Zanthoxylum ailanthoides Siebold et Zucc.	カラスザンショウ
Zanthoxylum piperitum (L.) DC.	サンショウ
Picrasma quassioides (D. Don) Benn.	ニガキ
Rhus javanica L. var. *chinensis* (Mill.) T. Yamaz.	ヌルデ
Rhus verniciflua Stokes	ウルシ
Acer	カエデ属
Aesculus turbinata Blume	トチノキ
Ilex macropoda Miq.	アオハダ
Euonymus	ニシキギ属
Celastrus orbiculatus Thunb.	ツルウメモドキ
Styaphylea bumalda DC.	ミツバウツギ
Hovenia	ケンポナシ属
Vitis	ブドウ属
Tilia	シナノキ属
Stachyurus praecox Siebold et Zucc.	キブシ
Helwingia japonica (Thunb.) F. G. Dietrich	ハナイカダ
Swida controversa (Hemsl.) Soják	ミズキ
Aralia elata (Miq.) Seem.	タラノキ
Kalopanax pictus (Thunb.) Koidz.	ハリギリ
Vaccinium oldhamii Miq.	ナツハゼ
Styrax	エゴノキ属
Fraxinus	トネリコ属
Callicarpa	ムラサキシキブ属
Paulownia tomentosa (Thunb.) Steud.	キリ
Sambucus racemosa L. subsp. *sieboldiana* (Miq.) H.Hara	ニワトコ
Viburnum	ガマズミ属
Diffuse-porous wood	散孔材
Subfam. Bambusoideae	タケ亜科
stem-/branchwood	枝・幹材
stump wood	根株材
rootwood	根材
Sannai-maruyama site	三内丸山遺跡
Power line tower no. 6 block	第 6 鉄塔地区
North valley	北の谷
Iwatari-kotani no. 4 site	岩渡小谷（4）遺跡
Ooyazawa	大矢沢
Mukaida no. 18 site	向田（18）遺跡
Sannai-maruyama no. 6 site	三内丸山（6）遺跡
Kosannai site	小三内遺跡
Torihama shell midden	鳥浜貝塚
Juno peat bed site	寿能泥炭層遺跡
Akayama site	赤山陣屋跡遺跡
Aota site	青田遺跡
Korekawa-nakai site	是川中居遺跡
Shimo-yakebe site	下宅部遺跡
Awazu kotei site	粟津湖底遺跡
Towada Chuseri pumice fall (To-Cu)	十和田中掫テフラ
wooden artifact	木製品・加工木
natural wood	自然木
charcoal	炭化材
lacquer	漆
lacquer ware	漆器
container	容器
board	板
split wood	割材
processed wood	加工木
tool	道具
stick	棒
oar	櫂
axe haft	石斧柄
digging stick	堀棒
stake	杭
round wood	丸木
diameter class	直径階