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Articles

Article

A Photo Based Measurement System using a Measuring Camera

Masayoshi Takahashi*[1], Kazuhiko Saito*[1], Norihiko Shiraishi*[2], Toshiro Iehara*[1] and Fumitoshi Takahashi*[1]

ABSTRACT

In 1993, Minolta Camera Co., Ltd. produced a special camera , MC-100, as a prototype. It can record the size of the object that it focuses on and the distance between the camera and the object. Using this and other instruments, we developed a photo based measurement system for measuring trees. We measured diameter and tree height and the results showed that the accuracy of this system is good enough for survey or study usage. The advantages of this system are 1) it is possible to measure indirectly, 2) it is possible to measure and record at the same time and the record has a lot of information other than the measurement value, 3) it is simple and easy to operate and can be used by one person. The disadvantages are 1) it is not cost effective because each measurement requires a photos, 2) it is very hard to measure in dark conditions. However, this system has potential for general measurement of stands and forests.

Keyword: diameter measurement, height measurement, measuring camera, forest mensuration system, forest inventory

INTRODUCTION

Although many instruments have been developed for measuring a tree and/or forests, it is still necessary to develop a new measurement instrument with high accuracy which is easy and quick to use.

In 1993, Minolta Camera Co., Ltd. produced a special camera , MC-100, as a prototype (Fig. 1) . It can record the size of the object that it focuses on and the distance between the camera and the object. Thus, only taking a photo, it can measure indirectly without any target or mirror. In addition, provides a visual record as well as the measurement value. SANO *et al.* (1995) use a measuring camera to measure trees and found that it was useful for measuring seedlings or defects in trees such as length of scratch marks and widths of frost cracks. However, it was difficult to measure tree height with a measuring camera because of the limits in the range of measurement and measurement accuracy.

We combined this camera together with an angle sensor, an image scanner and a computer to produce a new photo based measuring system for forest inventory.

Fig. 1 The measuring camera MC-100

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This paper describes the method and accuracy of our new measurement system. First, the details of our system, including its basic method of measurement, are presented. Then we examine its accuracy and method to correct systematic errors in both diameter and height measurements of trees. In the last section, the capabilities of this system are discussed.

COMPONENTS OF THE SYSTEM

The system is composed of 4 devices (Fig. 2), which are the measuring camera, MC-100, an angle sensor, a color image scanner and measurement software for a personal computer.

First, we take a photo of the measurement object with MC-100. At the same time, we record the angle of elevation using an angle fitted to the camera. MC-100 is a special camera made by Minolta Camera Co. Ltd. based on an auto focus camera. Operations of this camera are basically same as other AF camera. Measurements can be made with MC-100 using 4 types of exclusive lenses (Table 1).

MC-100 has two modes for measurement, scale and distance mode (Fig. 3). In distance mode, it can measure the distance from the lens to the object in focus. When the

Table 1 Exclusive lenses for MC-100

Name of Exclusive Lens	Range of measurement
50mm macro F2.8	0.2- 1m
100mm macro F2.8	0.4- 2m
500mm reflex F8	4 -99m
35-200mm zoom F4.5-5.6	1 -15m

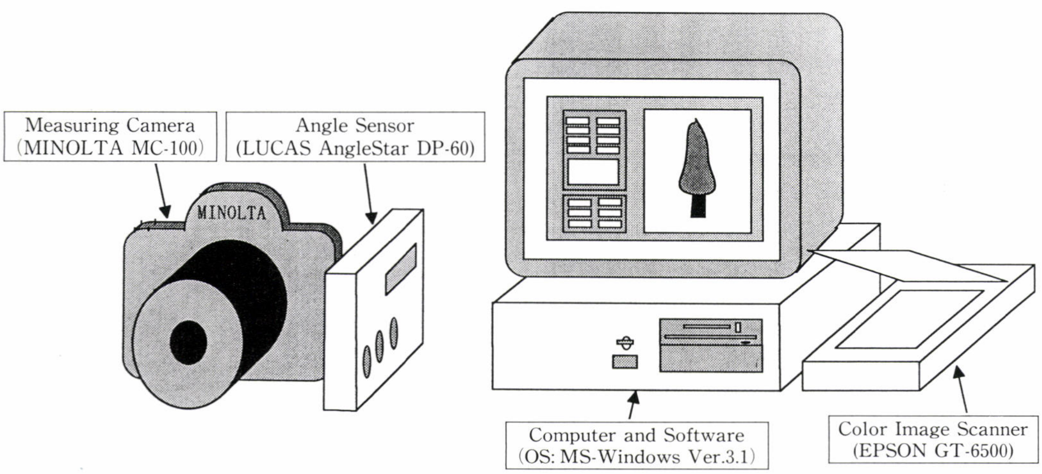
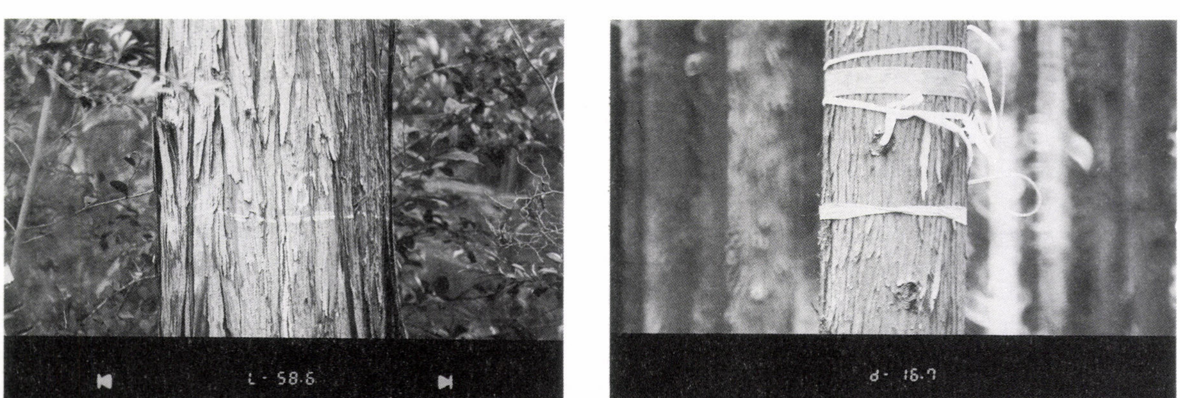


Fig. 2 The components of the system



Scale mode

Distance mode

Fig. 3 Photographs taken by the measuring camera distance from an object to the lens is "a", the focal length value is "f", and the extension value is "x", then

$$\frac{1}{a}+\frac{1}{(f+x)}=\frac{1}{f} \quad (1)$$

We can calculate the distance from the object to the lens by

$$a=(f+x)\frac{f}{x} \quad (2)$$

The relationship between the length of the object "L" and the length "l" on the film is

$$\frac{L}{l}=\frac{a}{(f+x)}$$

Substituting (1) for (2) then the size of the object can be calculated as

$$L=\frac{fl}{x}$$

The camera can also display a numerical value in the view finder and display panel. The focal lens value "f" is reported from the lens to the camera and the extension value "x" is calculated from the AF drive encoder output. The relationship between the value of AF drive encoder output and the extension value "x" is not linear and is automatically corrected by the camera. Some additional ideas have been devised for improving its accuracy.

In scale mode, the part of object to be measured must be fitted to the scale mark on the view finder. If this cannot be done, it is possible to calculate the size of the object by proportional allotment using the scale mark.

The photographs are measured using software we developed. Photo images are entered into the computer, using a color image scanner. The software runs on MS-Windows. The operations can be done mainly by dragging or clicking a mouse. If needed, measurement values can be corrected automatically by the software.

THE ACCURACY AND CORRECTING METHOD OF THE MEASUREMENT

The Accuracy of Diameter Measurement

We measured diameters after taking the photos by calculating the object size from the scale mark using proportional allotment. To evaluate its accuracy, we tested diameter measurements in 2 ways.

First we evaluated the basic accuracy of the camera by measuring cylindrical objects of regular shape in a room. We tested the camera with a 500 mm lens using 4 objects of differing diameters; 10.7, 15.6, 20.7 and 31.9 cm. The distances varied from about 4 m to 40 m and the angle of elevation was 0. Fig. 4 shows the distribution of the errors from 112 measurements. The average error was -1.7 mm and the standard deviation was 4.4 mm. The variance of errors became larger with measuring distances, but there was no significant relationship between error and

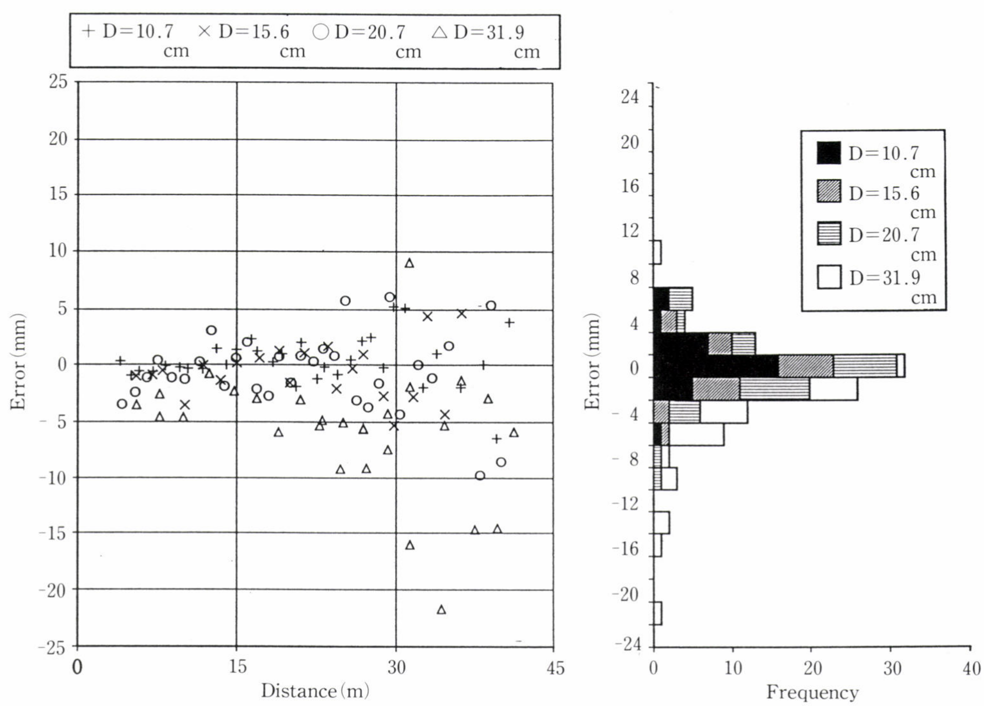


Fig. 4 Distribution of errors in the measurement of the diameters of 4 objects of known size

diameter. Some measurements especially those for the 31.9 cm object had large errors. We think this was because the edges of the objects were unclear in the poor light conditions.

Measurements of this kind can contain 2 kinds of systematic error (SHIRAISHI 1995; SAITO et al. 1995). One is overestimation. When we take a picture (Fig. 5), we can't see the real diameter-ends B and C from the viewpoint A, and we identify G and H as the diameter-edges. The other type of systematic error is an underestimation. When we take a picture, the camera focuses on P and identify IJ as the diameter. The actual diameter is BC, but smaller IJ is measured. This error can be corrected using this expression.

$$BC = 2r = \frac{IJ^2 + IJ\sqrt{IJ^2 + (2l)^2}}{2l}$$

The distribution of errors after correction is shown in Fig. 6. At first, the measurement errors were biased negatively. After correction, they became normally or slightly positive for near distance. The average error became -0.3 mm and the standard deviation was 4.3 mm.

According to the specifications of the camera, the standard measurement error is 2% for near distances and 5 % for farther distances. Our results were within this range.

Then we applied it to two actual tree measurements. Test site 1 was a 35-year-old hinoki (*Chamaecyparis obtusa*) plantation in Tsukuba Experimental Forest. We took 29 measurements at 1.2 m height using the 500 mm lens at variable distances from about 10 m to 30 m. Fig. 7 shows the measurement errors excluding the systematic errors. The average error was +6.6 mm and standard deviation was 4.4 mm The distribution of the errors show an obvious positive bias. In this case, we have to consider the effect of detached bark. When we used a caliper for diameter measurements, it was pressed against the stem. Thus there was a significant difference between the ordinal caliper measurement and the measurement using this sys-

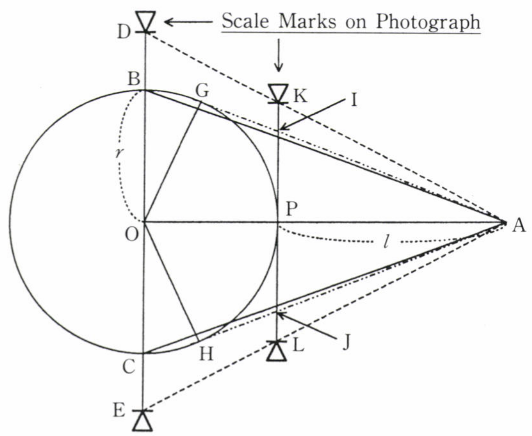
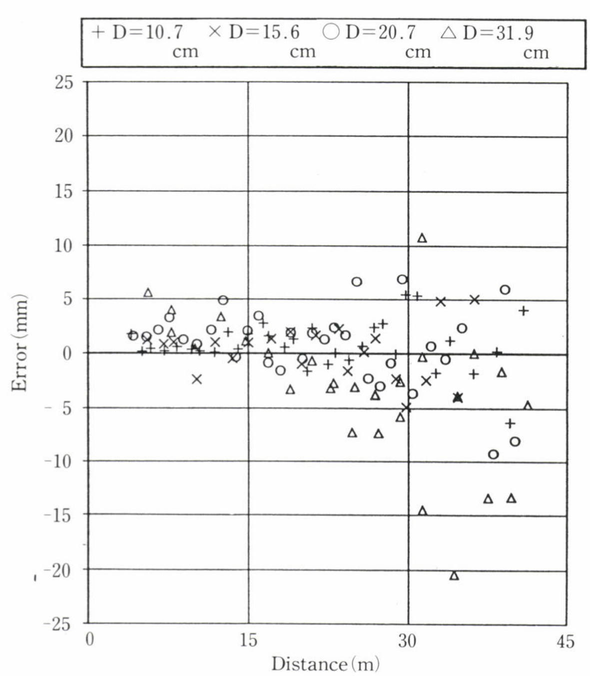


Fig. 5 Cross-section of a stem as viewed by a measuring camera



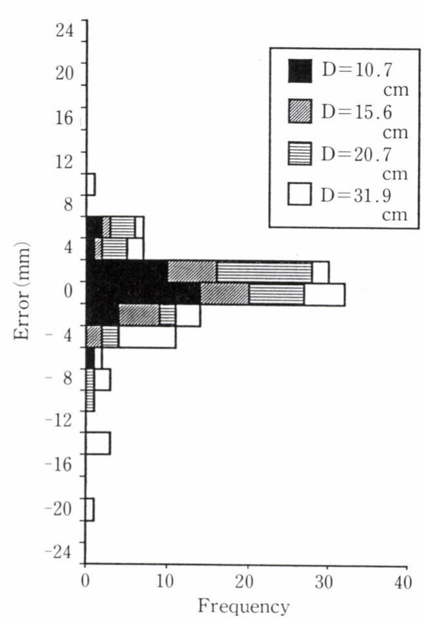


Fig. 6 Distribution of diameter measurement errors after correction for systematic errors

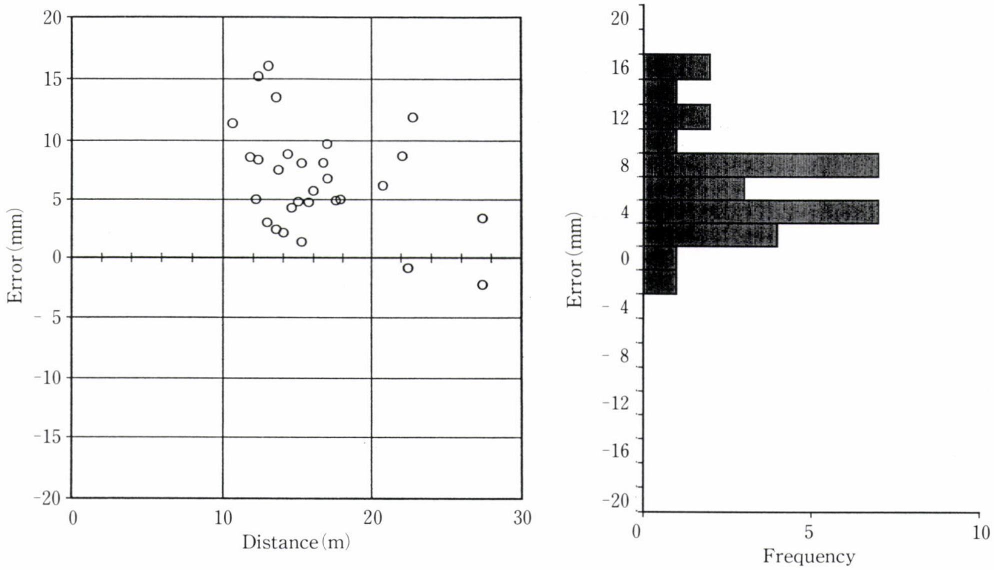


Fig. 7 Distribution of diameter measurement errors in test site 1

tem. Fig. 8 shows the distribution of the thickness of he detached bark. Fig. 9 shows the distribution of measurement errors excluding systematic errors and the effect of detached bark. The mean was +1.6 mm and standard deviation was 4.6 mm Once again that the standard measurement error of the camera became grater as the distance to the object increased.

Test site 2 was a 31-35-year-old sugi (*Cryptomeria japonica*) plantation in the Former Forest Breading Center's Test Field. Using the 500 mm lens, we took diameter measurements at the 1.2, 3.2 and 5.2 m above ground. The measuring distance varied between about 15 m and 24 m and the diameters ranged between about 13 cm and 35 cm We compared the camera measurements with field measurements obtained with caliper. Fig. 10 shows the measurement errors after correction for the systematic errors and the effect of bark. Mean error was +0.15 mm and standard deviation was 0.49 mm There was no significant relationship between measurement error and its height.

The Accuracy of Tree Height Measurement

Two methods were devised for measuring tree heights. Method 1 was to calculate height by trigonometry using angle data from the angle sensor and distance data from the measuring camera. When the angle of the tree top is α, the angle of the tree bottom is β, and the distance is D with elevation γ, we can calculate tree height H as

$$H = D\cos\gamma(\tan\alpha + \tan\beta)$$

Method 2 was to calculate height from a photograph including a stick of known length and the tree, using proportional allotment. Tree height is calculated as

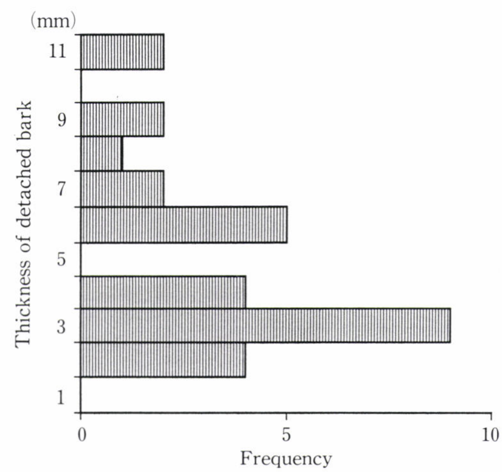


Fig. 8 Distribution of the thickness of detached bark

$$H = L\frac{(X1 - X3)}{(P1 - P2)} \qquad (3)$$

where L is the length of the stick and $X1$, $X3$, $P1$ and $P2$ are as shown in Fig. 11. There are relationships between X, Y and the f value of the lens, f, as shown below.

$$\frac{X}{f} = \frac{\sin\theta_1}{\sin(\pi - \theta_1)} \qquad (4)$$

$$\frac{Y}{X} = \frac{\sin\theta_3}{\sin\theta_4} \qquad (5)$$

Where θ_1, θ_2, θ_3 and θ_4 are shown by Fig. 11. Further,

$$\theta_3 = \frac{\pi}{2} - \theta_1$$

$$\theta_4 = \frac{\pi}{2} + \theta_1 - \theta_2$$

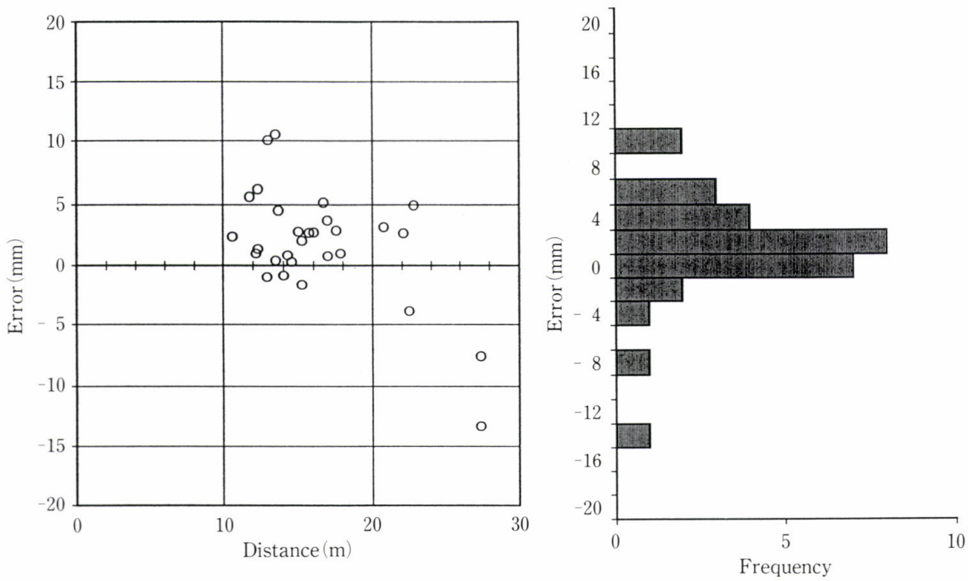


Fig. 9 Distribution of diameter measurement after correction of systematic errors in test site 1

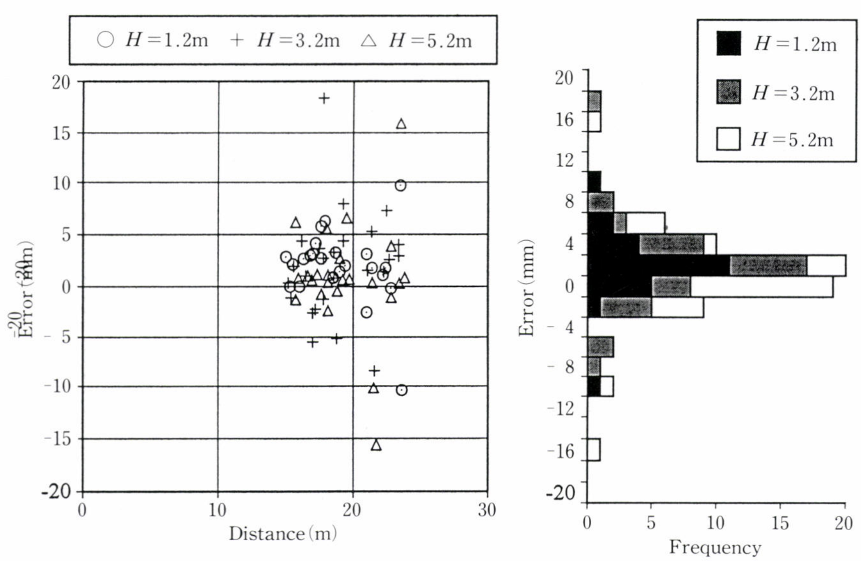


Fig. 10 Distribution of diameter measurement after correction of systematic errors in test site 2

so expression (4) and (5) become

$$\frac{x}{f}=\frac{\sin\theta_1}{\cos(\theta_2-\theta_1)} \qquad (6)$$

$$\frac{Y}{X}=\frac{\cos(\theta_2-\theta_1)}{\cos\theta_1} \qquad (7)$$

From expression (1),(6) and (7), we can calculate a tree height by the expression

$$X=\frac{f\ y}{(f\cos\theta_2+y\sin\theta_2)} \qquad (8)$$

In practice, after entering the photo image in to a computer, we measured the length from the center of a photograph to *X1*, *X3*, *P1* and *P2* on the display using measurement software. Tree height was automatically calculated from expression (3) and (8) by the software. We tested both methods and evaluated their accuracy.

First, we applied Method 1 to measure 31-35-year-old sugi (*Cryptomeria japonica*) plantation stands in the former arboretum of the Forest Tree Breeding Institute using a 500

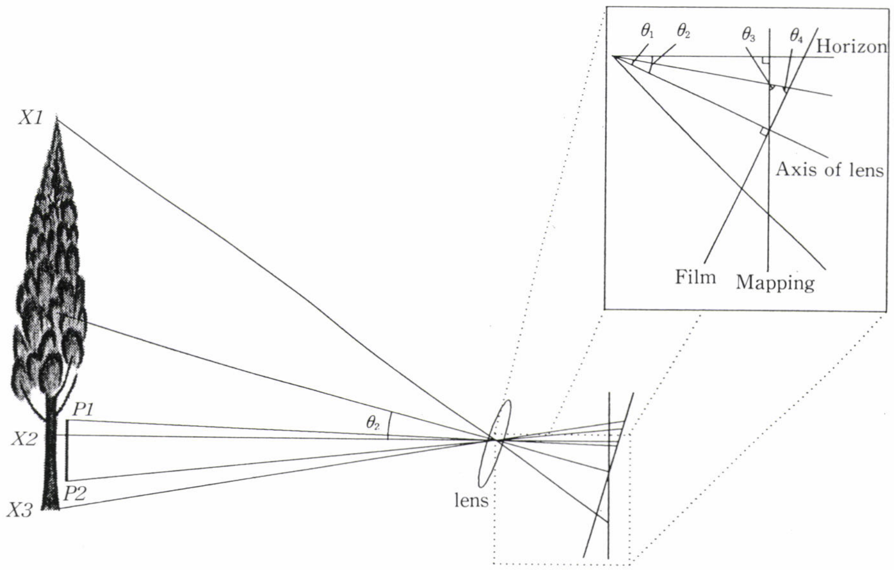


Fig. 11 Vertical-section of a stem as viewed by a measuring camera

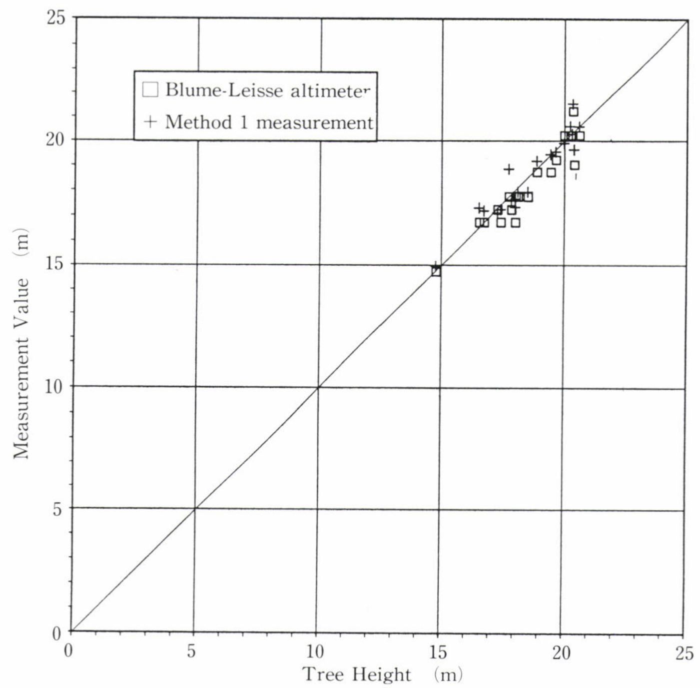


Fig. 12 Distribution of height measurement errors from Method 1

mm lens. For comparison, we also measured tree heights by Blume-leiss altimeter. Afterwards the trees were felled and their real height measured.

Fig. 12 shows the result of 20 measurements. The average errors were +0.25m (1.26%) using Method 1 and -0.33m (-1.89%) by Blume-leiss altimeter. Standard deviation was 0.62m for Method 1 and 0.52m for Blume-leiss altimeter.

We used Method 2 to measure trees in the arboretum of the Forestry and Forest Products Research Institute using a 35-200 zoom lens. Since it was impossible to fell the trees, we measured the real height with a laser instrument.

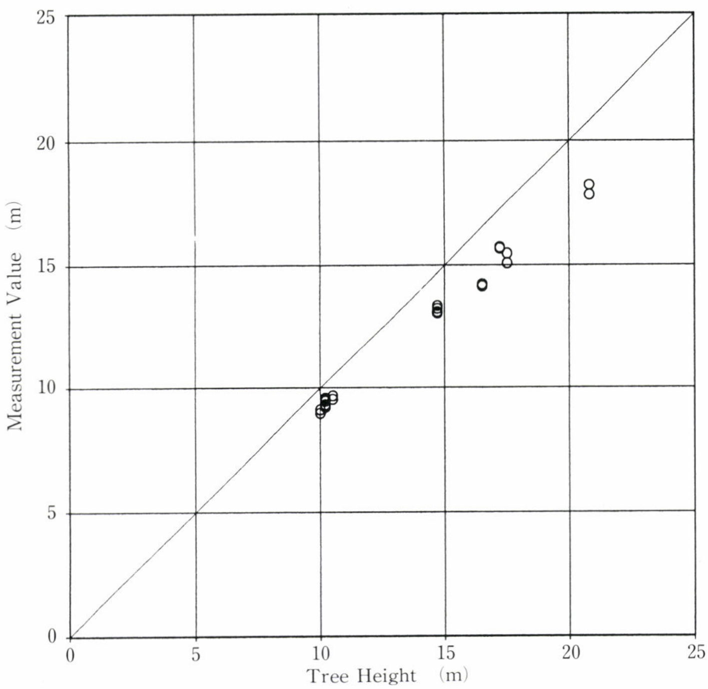


Fig. 13 Distribution of height measurement errors from Method 2

The result of 26 measurements are shown in Fig. 13. The average error was -1.4m (-10.25%) and standard deviation was 0.68m.

DISCUSSION AND CONCLUSIONS

The results of the diameter measurements show that it is possible to measure diameter with sufficient accuracy, although the results include the effect of bark and there is a slight positive bias. When we compared the results of measurement using caliper and this system, the latter must be adjusted to remove the effect of detached bark. SHIRAISHI (1995) used a measuring camera to measure tree diameters and pointed out its potential for measuring upper-diameters. From our test of its accuracy, we conclude that this is possible even by one person with a little practice. In addition, measurement software that we developed make it easy to calculate and error correction of the raw measurement data.

Height measurement using Method 1 showed that it is possible to measure height with similar accuracy to other techniques. Results have a slight positive bias because of the poor definition of the scale mark on the photograph and mechanical errors. Combining Method 1 height measurement and diameter measurement, it is possible to measure upper-diameters at any height.

Height measurement by Method 2 was not accurate enough for routine measurement. The low accuracy may be due to distortion of the lens, halation, poor definition of the stick, or poor light conditions for the photograph, but we cannot be certain of the exact cause from our examinations. The amount of error is likely to depend on the conditions at measurement. However, the field work for Method 2 is quite simple and requires only a short time. Therefore, it could be useful for pre-surveys, where lower accuracy is acceptable. The techniques used for Method 2 could also be applied to other measurements such as crown length, width and shape. In addition, the analysis of the measurement data is simple and easy by measurement software.

The advantages of this system are 1) it is possible to measure indirectly, 2) it is possible to measure and record at the same time and the record has a lot of information other than measurement value, 3) operations are simple and easy and it is possible to measure by one person. The disadvantages are 1) it is not cost effective because each measurement requires a photograph, 2) it is very hard to measure in dark conditions. With further improvements, this system has great potential for the general measurement of stands and forests.

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Article

Hunting, Wildlife Management and the Federal Hunting Act in Germany

Tobias Zorn* and Yutaka Ishii*

ABSTRACT

Forests are ecosystems with multiple basic functions, namely wood production and conservation of the environment, including the soil, water functions and so on. Forest Policy provides the interface between the natural and social sciences in forestry. Its interrelations include the needs for products and services and incorporates wildlife management. Wildlife management is closely related to forestry and should be coordinated and integrated with forest management. Past developments in forestry can be characterized as a change from forest exploitation to modified forest management, or a change from emphasizing the productive to incorporating different functions. Sustainable forest management and the development of overall land use policies was developed hundreds of years ago. In Germany, hunting played an important role in the development of an integrated forest management policy.

In Japan, multiple-use forestry is a basic concept in forest policy. Water conservation, wood production and soil protection are emphasized, but wildlife management does not seem so important in Japanese forest management. Recently, the extent of damage by game has been highlighted in Japan. In this light, this paper focuses on wildlife management activities and the hunting act in Germany, in an attempt to make a contribution to the development of a wildlife management system for Japan.

Keyword: hunting, game, hunting act, Germany

A SHORT HISTORY OF HUNTING IN GERMANY AND ITS CURRENT PROBLEMS

The interaction of wildlife/game and human beings forms the basis of wildlife management. Hunting practices depend on social and legal realities. In Germany, the history of hunting is much longer than the two hundred-year-old history of sustainable forest management.

In the 17th and 18th centuries, Germany was ruled by kings and sovereigns. Each had his own opinion on hunting management and a few were energetic hunters. Roe deer was the preferred game species for all the sovereigns, and could only be hunted by the sovereign and his guests. Game species which were not of interest to the sovereign were hunted by professional hunters and foresters. Historical and socio-political circumstances influenced the hunting and wildlife management of these times.

In this time of kings, sovereigns and nobility, farmers had no legal rights. Farmers had difficult lives and sometimes were pushed to the edge of survival. Damage by game to forests and farmland had to be accepted as a "normal" process which provided the nobility with the pleasure of hunting. Game species were regarded as "things" - "things" with which anyone could do whatever he wanted. The quality and quantity game populations were the most important considerations. Regulations went as far as restricting the population to their private sphere, so as to exclude people from the forests at certain times, or to restrict them to paths in order not to disturb the game. The restrictions were so severe that farmers had to accept that game fed on farm crops and heavily damaged or completely destroyed the farmland area (SCHWENK 1993).

Every hunter should behave according to the principles of hunting. Hunting ethics and the environmental acceptability of the aims and methods of hunting are now critical to the future of hunting (SCHWENK 1993). The

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relationships between humans and animals has changed through time and differs between cultures. Two hundred years ago, wildlife management in Germany aimed to provide enough game for the nobility to hunt.

Extensive post-colonial clearing and heavy settlement in combination with the development of infrastructure, such as streets and regulated waterways, changed the local environment, with many consequences for natural biotopes. The human impact on wildlife has been unquestionably high.

During the Second World War, for example, only a modest number of roe deer were hunted by German citizens (SCHWENK 1993). Between 1940 and 1950 political and social problems were being faced and hunting was limited to guest hunters, a few professional hunters and foresters. By comparison, during the period of occupation (1945-1951), a great number of roe deer were killed by soldiers of the occupation forces. This illustrates how political circumstances can influence hunting practices, even in modern times.

In Germany, the forests are the main habitat for wildlife and game. However, high game populations cause substantial damage in the forests. Over the last decade, there has been a change in forest management guidelines. The new guidelines promote gradually replacing clear-felling systems by selection systems, which allow regeneration under the shelter of large trees. This change was introduced because it was considered to be a closer representation of the natural system and it was expected to reduce browsing damage. Ecologically sensitive systems such as alpine forests suffer from overpopulation by cloven-hoofed game (LINN 1991). Species, such as fir (*Abies alba*), beech (*Fagus sylvatica*), maple (*Acer pseudoplatanus*) and ash (*Fraxinus excelsior*) are important for the regeneration of these mixed natural forests (KECH and EISFELD 1991).

According to investigations carried out during the national forest inventory of 1986-1990, high percentages of exposed young trees showed effects of overbrowsing. Firs and deciduous tree species were most affected (BUNDESMINISTERIUM 1994). A state-wide evaluation of browsing in Bavaria in 1986 showed that large animals had a strong influence on regeneration: on average, 57% of all plants over 20 cm were browsed in the upper third of the plant and 36% were browsed at the terminal bud. In ten percent of spruce stands, bark damage by red deer was recorded (BAVARIAN STATE GOVERNMENT 1989). In forests with large populations of roe deer (*Capreolus capreolus L.*), overgrazing prevented natural regeneration of trees and the ground flora was extremely poor. There was a significant correlation between forest decline and game damage. The large population of roe deer was the result of mismanagement caused by a poor understanding of the population dynamics and the ecological requirements of the species (ROUCHER *et al.* 1991). Browsing damage impedes the development of mixed forests (BAVARIAN STATE GOVERNMENT 1989, BUNDESMINISTERIUM 1994, FEDERAL MINISTRY OF AGRICULTURE AND FORESTRY 1990).

The interests of other parties, such as foresters, hunters, wildlife conservationists, nature and wildlife photographers and recreationists also influence wildlife management. The different interests of these groups sometimes provoke conflicts which can result in the deterioration of their relationships. However, all interest groups can make constructive contributions to wildlife management (LINN 1991). Wildlife management professionals, such as hunters and foresters, should understand how the animal populations will develop, and know how to maintain the quality of the environment. To maintain a suitable environment it is important that wildlife managers deal with the elementary ideas and fundamental relationships between the species and its environment (NYLAND *et al.* 1983). Hunting can help keep wild animal populations in balance with the resources of the habitat.

Farmers and forest owners suffer considerable economic losses from the grazing of planted trees and agricultural crops by wild animals. These individuals also incur additional costs, such as fencing and replanting of failed areas, as a result of browsing by wildlife.

Highly cultivated, monocultured and industrialized landscapes have become secondary biotopes for autochthonous wildlife species (GOSSOW 1991). The historical view is that wildlife management and forest science are closely connected and that they are important socio-politically. This view has arisen from the interactions between hunters and the animals, between hunters and the environment, and between hunters and society (SCHWENK 1993).

WILDLIFE, GAME AND HABITAT MANAGEMENT

Most people no longer depend upon wild animals for food supply or meat production, although in rural and remote areas of Germany hunting does provide supplementary food for the local population. Since the domestication of animals such as cattles, pigs, chicken, and changes in eating habits, game species such as deer, hare and wild boar have become delicacies. Wildlife also provide non-commercial benefits, but it is difficult to assign a specific monetary value to wildlife. The non-commercial benefits of wildlife include a psychological and aesthetic value, and an improved environment (NYLAND *et al.* 1983).

Hunting of a number of species of animals is permitted in Germany, including 25 fur animals and 22 feather animals. Table 1 shows the most commonly hunted animal species.[1]

Table 1 Hunted species statistics (new Federal States and former territory of the Federal States)

species	1990/91	1991/92	1992/93	1993/94	1990/91	1991/92	1992/93	1993/94
former territory of the Federal States					*new Federal States*			
red deer	31,089	29,517	30,243	33,320	32,461	28,870	29,117	29,255
fallow deer	15,148	15,576	15,544	17,250	19,761	19,559	20,685	21,985
moufflon	2,179	2,052	2,247	2,533	4,080	3,581	4,348	4,658
wild-boar	152,315	175,469	106,117	192,164	153,425	137,299	142,719	147,068
roe-deer	781,263	801,840	785,481	804,245	144,332	150,556	200,602	106,106
hare	593,426	511,782	548,414	531,930				
rabbit	846,548	720,487	756,085	700,112				
pheasant	362,892	278,286	389,660	342,213				
partridge	29,328	18,283	21,453	24,527				
duck	559,726	528,930	530,473	481,400				
pigeon	772,241	916,549	809,793	757,471				
fox	319,457	298,924	340,686	428,941				
marten	48,187	43,747	42,440	42,163				

Source: Deutscher Jagdschutz-Verband, in: Statistisches Bundesamt 1995

The species hunted can be divided into two groups: big game, and small game.

Big game includes cloven-hoofed game, such as European bison, moose, red deer, fallow deer, sika deer, chamois, ibex, moufflon and wild-boar, with the exception of roe-deer; in addition, eagles are also included in big game. All other game is classified as small game (BUNDESMINISTERIUM 1985).

The most common game species in Germany are: red deer (*Cervus elaphus* L.), fallow deer (*Dama dama* L.), roe-deer (*Capreolus capreolus* L.), moufflon (*Ovis ammon musimon* PALLAS), wild-boar (*Sus scrofa* L.), brown hare (*Lepus europaeus* PALLAS), rabbit (*Oryctolagus coniculus* L.), fox (*Vulpes vulpes* L.), and beech marten (*Martes foina* ERXLEBEN) for fur game species, and partridge (*Perdix perdix* L.), pheasant (*Phasianus colchicus* L.), dove and pigeon (*Columbidae*), and wild-duck (*Anatinae*) for feather game species.

All wild animal species have a certain living-territory, called its habitat. The habitat satisfies the physical and biological requirements of the species and the highest state of productivity is provided if the animals and the habitat elements are in balance. A habitat with a good range of conditions satisfies the functional needs of most animals (NYLAND *et al*. 1983). In forests, the condition of the vegetation cover is a valuable indicator of the carrying capacity.

Diversity in the habitat, limits of suitable habitat, territorial behavior of the animals, and the overlapping of home ranges are all important elements in wildlife habitat. The carrying capacity of a habitat can be used to judge the balance between wild animal populations and area. The dynamics of wild animal populations are characterized by population increases and decreases over time. The balance and interactions between predators and prey varies with species and with the capacities of the ecosystem (NYLAND *et al*. 1983).

Seasons and the change in daylight hours have a great influence on wildlife. Animals migrate between winter, spring, summer and autumn to cope with changes in the climate and vegetation. The migration can be over long or short distances depending on the species. Unfortunately, due to the anthropogenic influence of feeding game animals and destruction of habitat units, some animals lose their migration instinct. For example, red deer use different habitats in different seasons, although historically the differences were much clearer and characterized by migrations. In summer the deer moved to high elevations in the mountains, and during winter they migrated to lower areas. The migration avoided a concentration of animals in one place.

Wild boars (*Sus domestica*) also prefer different biotopes from season to season. From February to April they mostly root in coniferous forests and from August they feed more intensively in deciduous forests (SZCZEGOLA 1991). Special attention has to be paid to the wild boars on account of the damage they cause in fields and forests. Although the damage in forests is less than in fields (KOHALMY 1991), they unquestionably exist.

HUNTING ACT

Hunting Rights

According to Germanys Hunting Act, people with the right to hunt shall care for, protect and hunt those animals living in a wild state and which are allowed to be hunted on a specified area of land. People with the right to hunt are also obliged to care for and protect game (BUNDESMINISTERIUM 1985). Forest owners, hunting cooperations, the owners of hunting rights, as well as the hunting authorities, are the executive organs for hunting (BAVARIAN STATE GOVERNMENT 1989).

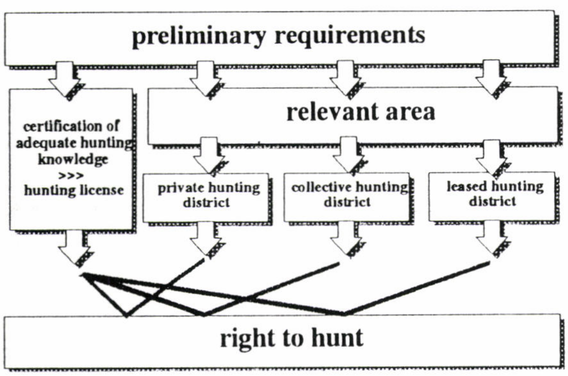

Fig. 1 Preliminary requirements, which lead to the right to hunt

As Figure 1 shows, the hunting license and access to a hunting district are the two preliminary requirements for hunting.

A considerable number of professional hunters and hunting guests and a lesser number of hunting rights controlled by the state provide the foundation for wildlife management in Germany. The number of hunters and hunting areas in Germany is shown in the following table (Table 2).

Landowners are entitled to hunting rights on their own estate. On land for which there is no established ownership, the right to hunt belongs to the States, but hunting can only be practiced in specially designated hunting districts (BUNDESMINISTERIUM 1985)

Hunting Districts

Hunting districts in which hunting can be practiced are either "estate owners private hunting districts" or "collective hunting districts". These two categories comprise almost 90% of all hunting districts, as Table 3 clarifies.

Hunting districts are not only agricultural and forested areas, but may include natural and artificial watercourses, roads, railway installations and similar areas which do not constitute separate hunting districts in themselves. A district should be continuous and represent one area, with a link to other areas to keep a balance between other hunting districts. Private hunting districts form con-

Table 2 Number of hunters and hunting area in Germany

state	Hunters (number of persons)			Hunting Area (in 1,000ha)
	1980	1990	1994	1994
Germany	296,477	317,257	325,767	32,082
Baden-Württemberg	29,211	31,400	31,258	3,349
Bayern	46,087	48,362	50,377	6,800
Berlin		1,201	2,126	19
Brandenburg		11,000	12,000	2,269
Bremen	1,308	1,304	1,260	21
Hamburg	3,301	2,749	2,849	39
Hessen	18,482	20,840	20,793	1,787
Mecklenburg-Vorpommern		9,500	9,500	1,908
Niedersachsen	52,204	56,179	56,126	4,250
Nordrhein-Westfalen	70,155	74,000	76,132	3,301
Rheinland-Pfalz	15,948	16,555	16,959	1,980
Saarland	3,327	3,454	3,631	246
Sachsen		7,200	7,346	1,430
Sachsen-Anhalt		9,000	8,617	1,900
Schleswig-Holstein	16,454	16,013	18,195	1,457
Thüringen		8,500	8,598	1,327

Source: Deutscher Jagdschutz-Verband, in: Statistisches Bundesamt 1995

Table 3 Hunting districts of the states, the estate owners private and collective

	1987		1988		1989		1990	
	mill. ha	in %	mill. ha	in %	mill. ha	in %	mill. ha	in %
hunting districts of the states and the country	2.36	10	2.36	10	2.34	10	2.31	10
estate owners private hunting district and collective hunting districts	21.21	90	23.57	90	21.2	90	20.9	90
total hunting districts	23.57	100	23.57	100	54	100	23.21	100

Source: Deutscher Jagdschutz-Verband, in: Bundesministerium fur Ernährung, Landwirtschaft und Forsten 1991

tinuous stretches of land of at least 75 hectares, and are the property of one person. Because of the geographical and topographical conditions, the minimum size of private hunting districts in alpine regions is larger. To satisfy the criteria for a private hunting district, the land should be contiguous, and not interrupted by natural or man-made boundaries. Private hunting districts extending over more than one state are subject to the legal provisions of each state within which it lies (BUNDESMINISTERIUM 1985). Collective hunting districts are formed by a continuous stretch of land of at least 150 hectares. They include all land holdings which do not belong to private hunting districts. A collective hunting district can be divided into several independent hunting districts, if each "under-district" has a minimum size of 250 hectares. In the case of a private hunting district, the owner has the right to hunt. In the case of a collective hunting districts the hunting syndicate has the right to hunt. All the individual land owners, within the collective hunting district constitute the hunting syndicate, which allows judicial representation. The hunting syndicate is elected by the members of the collective hunting district.

Hunting Leases

If the landowner does not have a personal interest in hunting, he can lease his right to hunt, in its entirety, to a third party, or he may reserve for himself a part of the hunting rights on his own property. Leased hunting districts must be at least the same size as a private hunting district or at least 250 hectares in the case of collective hunting districts (BUNDESMINISTERIUM 1985).

The hunting lease is drawn up as a written contract for at least nine years. A lessee can only be a person with an annual hunting license which they have possessed for at least three years, and which was issued by the competent authority. The license must be carried when hunting and shown on request to officially empowered persons for control. The competent authority has to be notified of any hunting leases.

Hunting License

The hunting license is a document issued yearly which permits hunting. It must be renewed each year. A temporary hunting license can be issued for fourteen consecutive days. To obtain a license, a hunter must pass an examination consisting of a written, an oral and a practical section, a shooting test. Hunters are tested for an adequate knowledge of animal species, the biology of game animals, game conservation, game management and hunting, the prevention of game damage, agriculture and silviculture, weapon regulations, weapon techniques, the handling of weapons (including hand fire-arms), the handling of hounds, the treatment of game once it is killed with special reference to hygiene measures, the use of game meat as food, and the laws on game and animal protection, nature conservation and the maintenance and care of natural amenities.

A hunting license for minors, who have completed their sixteenth year but are not yet eighteen years old, can be issued with special conditions. These persons are not allowed to hunt in large hunting or game driving parties, and must hunt in the presence of an experienced supervisor.

To receive a hunting license, a hunter must provide assurance that they are trustworthy and physically able to handle weapons. Persons who cannot provide such assurance or from whom the hunting license has been withdrawn may not receive the right to hunt.

Additionally, hunters must have adequate hunting liability insurance (1 million German Marks for personal injury and 100 000 German Marks for damage to property). This insurance may be taken out only with an insurance company which is authorized to handle hunting liability insurance within the jurisdiction of the Law on the Supervision of Private Insurance Companies (BUNDESMINISTERIUM 1985).

The Federal Hunting Law listed other reasons to refuse a hunting license, including the following items:
"...
1. persons who are not yet eighteen years old;

2. persons who are not German nationals within the meaning of Article 116 of the Basic Law (i.e. the Provisional Constitution of the Federal Republic of Germany);
3. persons who have not been resident or habitually domiciled within the jurisdiction of the Federal Forest Act for at least three years;
4. persons who have gravely or repeatedly violated the regulations.
5. persons who have wrongfully or irresponsibly used weapons or ammunition;
6. persons who handle weapons or ammunition without due caution and will not take care to hold these objects in safe keeping;
7. who are not entitled to have actual control over these objects (BUNDESMINISTERIUM 1985)
..."

If grounds for refusal of the hunting license become apparent after the hunting license has been issued, the issuing authority is obliged to declare the hunting license invalid and to confiscate it, without refunding the license fee. The authorities may also impose a ban on the reissue of the hunting license for a limited period (BUNDESMINISTERIUM 1985).

Restrictions on Hunting

The Restrictions on Hunting are prohibitions, including weapons or techniques which are forbidden for hunting (BUNDESMINISTERIUM 1985), or obligations such as not disturbing game, not killing under conditions which are totally against the hunting ethic and not using supporting tools which make hunting easier.

For the benefit of the animals, it is important not to disturb game in its places of refuge, nesting, breeding or resting. Searching, photographing, filming or similar activities, are therefore prohibited, particularly if a species is endangered or threatened. Hunting in nature reserves, game reserves, national parks and wildlife-parks is controlled by the States.

The aim of wildlife management is to maintain the population of each game species and to protect those species which are threatened. Hunting can help regulate the population, and a quota defined by the competent authority and the hunting advisory council, specifies the number of cloven-hoofed game animals (with the exception of wild-boars) which can be killed (BUNDESMINISTERIUM 1985).

In the Federal State of Germany, details are specified by legislation in the individual States. The States use a notification system to control and regulate the number of game hunted, so that the actual harvest can be compared and adjusted to meet the quota. The results, differentiated by game species and sex are published in hunting lists. For game species whose populations are out of balance or which seem to be threatened, hunting can be completely prohibited in specified districts or in specified hunting grounds, or the number of animals allowed to be killed can change. The numbers of game killed in state forests is regulated by the States.

In Germany, the hunting year is from April 1 to March 31 and is designated by the Federal Ministry with the consent of the Upper House of Parliament. Hunting seasons and closed seasons are regulated according to the biological timetable of wildlife development; however, the State may issue waivers in closed seasons for special reasons, such as the control of contagious diseases, avoidance of excessive game damage, for scientific, educational and research purposes, or if the equilibrium of the population is disrupted. The general use and development of land within each state is important too, so the States may fix hunting seasons in individual cases and permit exceptions (BUNDESMINISTERIUM 1985).

Closed seasons enable the biological development of game species and protect the animals during the dropping and breeding seasons, until the young have become independent. Exceptions can be made, for example, for the wild-boar, rabbit, fox or wood-pigeon, if damage to forests and croplands is expected.

Game and Hunting Damage

Game and hunting damage can be quite severe for other land owners and one of the duties of wildlife managers is to prevent game damage. Both the person entitled to hunt and the other land owner have a duty to prevent game damage, by keeping away or driving off game from endangered forests or agricultural cropland (BUNDESMINISTERIUM 1985).

To prevent excessive game damage, the game population must be reduced to a specified level within a specified period. These guidelines serve the public good, particularly to the interests of agriculture, forestry and the requirements of nature conservation and the maintenance and care of natural amenities. If the person entitled to hunt does not fulfill his duty, the competent authority may reduce the game population at his expense (BUNDESMINISTERIUM 1985).

Another restriction on game management is that wild-boars and rabbits may not be released into the wild. The practice of releasing wild or colonizing exotic animal species in open country is restricted or prohibited by the States, to avoid disrupting the ecosystem.

Game damage, on land belonging to a collective hunting district, must be paid for by the hunting syndicate. Each syndicate member pays in proportion to the area of land which he represents in the syndicate (BUNDESMINISTERIUM 1985).

Game damage on private hunting districts is paid for by the owner or the person who is in charge of the private hunting district. In the case of leasing, the lessee must take responsibility.

However, the farmers and foresters are also responsible for preventing damage to their crops or land. If the injured party has not rendered effective measures against game damage, compensation wont be paid. Under this regulation, compensation will not be paid for damage done to vineyard gardens, orchards, tree nurseries, tree-lined avenues, isolated trees, forest plantations, or outdoor horticultural or commercial plantings, if the customary protective devices, which under normal circumstances are sufficient to keep game away, have not been provided (BUNDESMINISTERIUM 1985).

Persons who practice hunting have a responsibility to do it in such a way that fields or forests wont be damaged or destroyed. Otherwise, they are liable to compensate for improper hunting practices resulting in damages.

The injured party must make a claim to the competent authority within one week of noticing the damage to his property. In the case of forestry, claims can be made twice a year, in May and October. The competent authority must be notified of the exact time and the person to be held liable for compensation. (BUNDESMINISTERIUM 1985).

CONCLUSION

The aim of including hunting in wildlife management is to use hunting as a tool to maintain the viability and stability of ecosystems. Changes in wildlife populations are an early-warning signal of changes in environmental quality (NYLAND *et al*. 1983). The loss of sensitive wild species gives early warning of environmental changes which may be due to exploitation and careless land use. Since different species react differently to environmental change, it is possible that the ecosystem can be continually degraded, or sustained. Management needs to monitor the habitat for species. Constant, annual monitoring provides an early warning to the condition of the wildlife ecosystems. Hunting regulations and wildlife management should preserve critical habitat and protect these species.

Knowledge about population dynamics is the foundation for wise decisions about wildlife management. From this base, decisions on active and passive measures can be made, and management plans can be implemented. A common tool is the inventory, for example, inventories of the forest cover vegetation conditions, or inventories of the population of a wild animal species, by direct counts of the individuals. The identification and observation of these animals gives excellent data. Analysis of the results allow the carrying capacity of the site to be determined and allows sustained yield management.

To get a good overview of population changes, these inventories must be repeated. A one time inventory only provides data about the status quo; to understand the dynamics, more than one inventory is necessary. Management programs must be based on the assessment of habitat elements and their extent, to determine the future planning and improve the conditions in the habitat to reach a naturally orientated habitat (NYLAND *et al*. 1983).

The state of the vegetation is an indicator of the game population. For that reason, the state of the vegetation, especially the regenerating vegetation, is used as an index of population density. Assessment of browsing damage to young trees and the state of the regeneration are the main items used to plan the annual game harvest in Germany (BAVARIAN STATE GOVERNMENT 1989). One method for getting information about roe deer density is to survey terminal shoot browsing. On sample plots, the browsing of terminal shoots within and outside of control fences is surveyed. Typically, the browsing pressure outside the fence is especially severe in deciduous trees and most damage occurs during the winter time (KECH and EISFELD 1991).

Measures for the prevention of damage by game were defined by the Bavarian State Government (1989). Combined techniques of technical and biological measures are installed. "...

- Regulating game density in the available natural habitat,
- preservation and improvement of the game habitat by maintaining natural forests through:
* regenerating locally adapted mixed stands,
* using long-term regeneration,
* promoting fruit-bearing deciduous trees (oak, beech, wild fruit trees)
* preserving soft deciduous species (willow, aspen) which do not harm the development of stable new stands,
* leaving branches and twigs of felled trees on the ground,
- protecting young stands from browsing and bark peeling by fencing, and treatment of individual plants,
- planting of game feed and browsing areas,
- providing species-oriented fodder for severe winter conditions,
- establishing winter enclosures for red deer,
- keeping and creating game refuge zones, e.g. by guiding recreational traffic and declaring game sanctuaries,
- educating citizens to a better understanding and more responsible behavior towards nature, primarily in leisure sports.

..."

Due to development, industrialization, and intensified human activities, biodiversity is decreasing. Mankind, and especially the hunter, become responsible for regulating wild animals. Man has taken over the role previously held by "natural disasters", "blowdowns", "insect infestations", "wildfires", and "predators". Hunting should be matched to ecological requirements. Unfortunately, the motivation of hunters is not always led by ecological aspects only, but also by the traditional thinking of hunting as the collection of trophies, an attitude which is still strong in the hunting world (FEDERAL MINISTRY OF AGRICULTURE AND FORESTRY 1990).

To achieve higher numbers of suitable wildlife species, structural biotope characteristics prove to be the most relevant measure of habitat suitability, possible species diversity and specific carrying capacity (GOSSOW 1991).

The diversity of habitats can be improved by increasing the width of edges between different forest communities; i.e. increasing the transition zone between one kind of land use and another, which increases the range of habitat conditions (NYLAND *et al*. 1983).

The discussion nowadays usually focuses on the arguments about:

- reintroducing the most dangerous predators (lynx, wolf) of the roe deer,
- reducing the feeding of nutritive winter fodder (only if the winter conditions are very severe and the mortality would increase dramatically) and
- enlarging the size of hiding places, providing micro-habitats.

To achieve the goal of high quality wildlife and hunting management, forest and wildlife managers have to work together.The concept of 'wise' or 'sustainable' use has become the principle of hunting management. Hunting cant be viewed as separate from agricultural, forestry and water management activities, as it is closely related to these activities. Hunting is a traditional use of nature and can be used as a method of managing wildlife populations (LINN 1991). Hunting also means respecting wildlife as a basic natural resource and understanding hunting as a rational use of wildlife, which implies taking responsibility for game management on certain areas. In the long run, since the ecosystem supposed to reach an equilibrium with a sustainable animal population, it should come back to its natural self-carrying equilibrium. The integration of hunting in forest management has to be improved. The rising demands for wildlife management in forestry have to be faced rigorously. Experience managing game species in Germany shows that not all species can be managed successfully under the same guidelines. It is therefore necessary to develop individual strategies for each game species. Furthermore, wildlife management must be integrated properly into forest management if it is to be successful. Reducing game populations to ecologically justifiable levels has become absolutely necessary (BAVARIAN STATE GOVERNMENT 1989, BUNDESMINISTERIUM 1994, FEDERAL MINISTRY OF AGRICULTURE AND FORESTRY 1990). In the future, wildlife management must be based on forest territories and scientific and technical progress used to improve management methods. Hunting is part of the complicated network which includes socio-economics, forestry and game biology.

The following thoughts are the conclusions of our analysis of hunting, wildlife management and the Federal Hunting Act in Germany. These can make a valuable contribution to wildlife management in Japan.

1) Multiple-use forestry extends beyond the commercial function of wood production and the protective function of water resources, to include wildlife management, amongst other things. Wildlife management principles, including hunting regulations, should be incorporated in forest management.

2) Before critical stocking levels are reached, or browsing changes the tree species composition, wildlife management guidelines should be developed. These guidelines should be developed by both hunters and foresters in cooperation.

3) There is a need for an effective method of estimating game populations. The condition of the forest vegetation is a variable, which affects and is affected by the wildlife populations. A survey of the condition of the vegetation and the status of tree regeneration, so called 'vegetation expertise', could be a useful method for wildlife management for Japan.

4) The forest edge is a part of the forest, which is important for the wildlife. Highly structured forest edges of different tree species are valuable areas for grazing in times of need. Forest edges should be established to serve this purpose and help improve the landscape of both the forests and the agrarian areas.

5) Increasing outdoor activities in Japan may increase browsing and grazing pressure in particular forest areas. Strictly protected wildlife zones, where the human outdoor sports activities do not have any disturbing effect should be designated.

6) Fencing and other protective measures are very expensive, especially in extensive areas, such as Hokkaido. In these areas, population control, e.g. by hunting, may be the only effective means of regulating animal populations.

7) Wildlife management must become a part of forest training. Specifically, education at universities should include hunting and wildlife management as a theoretical component of forest science.

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APPENDIX

Content of the Hunting Act

Federal Hunting Act (BUNDESMINISTERIUM 1985)

(**Revised version of September** 29, 1976, **valid as from April** 1, 1977)

Part I The Right to Hunt

Section 1: Substance of the Right to Hunt

Section 2: Species

Section 3: Holder of Hunting Rights; Exercise of the Right to Hunt

Part II Hunting Districts and Conservation Associations

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Section 5: The Shaping of Hunting Districts

Section 6: Districts Designated as Sanctuaries; Suspension of Hunting

2. *Private Hunting Districts*

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Section 10: Accruals from Hunting

4. *Game Management Associations*

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Part III Participation of third Parties; In the Exercise of Hunting Rights

Section 11: Hunting Lease

Section 12: Notification of Hunting Leases

Section 13: Lapse of the Hunting Lease

Section 13a: Legal Status of Joint Lessees

Section 14: Change of Landowner

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Section 16: Hunting License for Minors

Section 17: Refusal of the Hunting License

Section 18: Confiscation of a Hunting License

Part V Restrictions on Hunting, Obligations in the Practice of Hunting and Disturbance of Game

Section 19: Prohibitory Points

Section 19a: Disturbance of Game

Section 20: Locally Barred Hunting

Section 21: Regulation of Numbers Killed

Section 22: Hunting Seasons and Close Seasons

Section 22a: Prevention of Avoidable Pain or Suffering in Game

Part VI Game Protection

Section 23: Substance of Game Protection

Section 24: Contagious Diseases of Game

Section 25: Persons Empowered to Protect Game

Part VII Game and Hunting Damage

1. *Prevention of Game Damage*

Section 26: Fending off Game

Section 27: Prevention of Excessive Game Damage

Section 28: Other Restrictions on Game Management

2. *Compensation for Game Damage*

Section 29: Liability to Compensation for Game Damage

Section 30: Damage by Game from a Game Reserve

Section 31: Extent of the Liability to Compensation

Section 32: Protective Devices

3. *Hunting Damage*

Section 33: Liability to Compensation for Damages

4. *Joint Provisions*

Section 34: Assertion of Damages

Section 35: Procedure in Actions for Game and Hunting Damages

Part VIII Commercialization and Protection of Game

Section 36: Enabling Legislation

Part IX Hunting Advisory Council and Huntsmens Societies

Section 37 Hunting Advisory Council and Huntsmens Societies

Part X Provisions for Pains and Penalties

Section 38: Criminal Offenses

Section 39: Offenses against Police and Administrative Regulations

Section 40: Confiscation

Section 41: Ordering Withdrawal of the Game License

Section 41a: Hunting Ban

Section 42: Provisions for Pains and Penalties by Individual States

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Section 43: Expire of Hunting Leases

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Article

Public Attitudes toward Forest Policy Issues: An Analysis of Attitude Structure using Survey Data

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ABSTRACT

Recent research has been aimed at understanding public attitudes towards foresty policy. Although a number of surveys have gathered many responses to simple questionnaires about relevant issues, no studies have tried to explore the complex nature of public beliefs and thoughts on forest policy related issues. The purpose of the present paper is to further our understanding of public attitudes toward forest policy by examining the structure of the public's attitudes. Our focus is the public support of forest managment.

The analysis using contingency tables and logit equations identified some typical internal relationships between attitude components in the respondent's overall attitude toward the issues. Our major findings were that firstly, agreement with public support for forest management by both monetary contribution and voluntary work was related to a belief in the need for silvicultural treatments to keep forests healthy, a belief in the consumer's responsibility, and appreciation of the values of the forest environment. Secondly, the people who supported voluntary work were a subset of the people who agreed to monetary support. Agreement with public support by voluntary work also seems to be characterised by particular kinds of personal tastes, particulary strong interests in nature.

Keyword: attitudes, forest policy, public participation, cost-sharing, volunteer

INTRODUCTION

It has been shown in a number of survey results that city residents are becoming more aware of the importance of forests as an indispensable component of the living environment. Furthermore, some survey results have shown that many citizens are willing to help forest management by sharing some of management costs needed to keep forests healthy (e.g. the results of the latest nationwide survey as summarized by the Prime Minister's Office (1996)). Besides the willingness to raise funds, a small but significant number of people now take part in the tours to mountain villages to support forest management by working voluntarily in the forest. Some people even move to mountain villages from urban areas and get jobs at forestry related employers such as forest owners' associations.

Increased environmental awareness after the period of rapid economic growth has made people more concerned about how to manage and use forests and various recreational activities in forests are now more popular than ever. These trends are apparently enhanced by the incessant flow of information about relevant topics, through all forms of media. It is noteworthy that the vast information flow through the mass-media seems to have not only activated people's concerns about forests, but has also played a significant role in the construction of people's knowledge, beliefs, and opinions on forests and forest policy related issues (AKASAKA 1995). On the other hand, timber production is now extremely unprofitable. Forestry employers can only offer very low wages to workers, in spite of the riskiness and difficulty of works in forests, and thus there are very few entrants to the forestry job market every year. As a result, public support in various forms such as cost-share programs, profit sharing, and volunteer programs becomeof critical importance to forest manage-

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ment in many situations, both on public and private lands. Taking into consideration both public willingness to support forest management and the management's need of support, it is now apparent that the public is beginning to take an important role in forest management and forest use in Japan.

As urban people come to have their own beliefs and opinions on forests and forest policy related issues and even become involved in forest management in some cases, it is important to understand public attitudes toward forest policy. Accordingly, a number of questionnaires have been done by both researchers and governments (e.g. see a review by AKASAKA (1987)). Although these surveys have supplied many results to simple questions, no studies have been made to try to explore the complex nature of public beliefs and thoughts on the forest policy related issues.

The international attitude comparison studies organized by Shidei, Ishida, and Kitamura may be the first large-scale and comprehensive investigation of public attitudes toward forest environment (SHIDEI 1981, KITAMURA 1986). Their survey focused on the differences in feelings, preferences, and opinions regarding forests and forest management between four developed countries: Japan, Germany, France, and Sweden. The major findings were that attitudes toward forest environment are a result of the natural settings and national characteristics such as religion and popular recreational activities. They also reported some differences in attitude which were seemingly related to the size of the city of residence, specifically differences observed between people in Tokyo and in other parts of Japan. Hence, while they found that the social and natural environments were important determinants of the attitudes toward the forest environment, they did not explicitly deal with internal organization of attitude, nor focus on policy issues.

AKASAKA (1987, 1995) suggested that attitudes toward forests are complex. Based on questionnaire results provided by several local and Japanese governments, he inferred that some responses in questionnaires seem to be based on the respondents' actual experience, but others based on knowledge acquired through education and information transmitted by mass-media. However he didn't study the internal organization of attitude.

Owing to the information provided through the media and education, and from people's actual experiences in forest, it is reasonable to assume that people have more or less a set of knowledge, beliefs, and opinions on forests and forest policy related issues. HAYASHI (1979, 1996) investigated the structure of attitude toward nature using a quantification method. He found that whether one agrees or not to treating forests is not related to one's religious attitudes, and that the attitudes of people living in Tokyo that maintaining forests beautiful reqired the recession of human treatments is related to a feeling of awe toward nature. These were the first attempts to deal explicitly with the internal structure of attitude toward nature. Our concern is more specific to forest policy related issues. By examining the internal state of public attitudes toward the forest policy related issues, the purpose of the present paper is to further our understanding of public attitudes toward the issues, with a particular focus on the issue of public support for forest management. We first discuss the theoretical framework used to investigate attitudes which are complex in nature, referring to social psychology literature on attitude, in particular the multicomponent view of attitude and the theories on consistency in attitude structure. Then we examine the relationships between attitude components toward forests and forest policy issues, analyzing the results of a questionnaire we conducted in Otsu, Shiga.

THEORETICAL FRAMEWORK

The concept of attitude is dominant in social psychology, because attitude is supposed to influence, or at least have something to do with, human behavior, the major concern of psychology. As SCHLEGEL and DITECCO (1982) observed, the literature concerning the attitude-behavior relationship suggests that attitude needs to be viewed as being 'comprised of a multicomponent structure with these various components having a differential validity for external criteria, including behavior'. Although the definition of attitude has provoked a great deal of controversy and is still controversial, the most common view defines attitude in terms of three distinct types of evaluative response to an attitude object: affective, cognitive, and behavioral responses. Affective responses are expressions of feelings such as liking or disliking, or any kinds of physiological responses to the attitude object; cognitive responses consist of beliefs and thoughts regarding the attitude object; and behavioral responses can be measured by overt actions, or by verbal expressions of behavioral intentions towards the attitude object (HEWSTONE and STEMPHESON 1996). The attitude object can be anything from a physical entity to an abstract idea.

Although there are no strong objections to this type of three dimensional or tripartite model of attitude, and the definition is referred to widely, from introductory texts to research articles, the validity of tripartite model is not conclusive. Empirical results provide equivocal evidences, as shown by the controversy in BAGOZZI and BURNKRANT 1979, DILLON and KUMAR 1985, and BAGOZZI and BURNKRANT 1985. In relation to the validity of the tripartite model, it is reasonable to suppose that the convergency and divergency between the three dimensions of attitude depends on the attitude domain studied. Further, the relevance of affective, cognitive, or behavioral dimension varies with the attitude domain of interest (OLSON and ZANA 1993). For example, whilst a variety of affective evaluations are obtained when the attitude domain is, say, a friend of the participants, affective evaluations are less meaningful when the attitude domain is an abstract idea such as some policy issues. In addition, as BRECKLER (1984) discussed, for some attitude domains it seems impossible to measure affective responses in a form other than a written or verbal response. Because the written or verbal response has passed through subject's cognitive system, the affective and cognitive responses become empirically indistinguishable in a strict sense.

Thus, depending on the attitude domain examined, the tripartite model of attitude isn't equally suitable to and doesn't always facilitate the analysis of empirical results. Nevertheless, the following four points should be noted in relation to the idea of tripartite or multidimensional model of attitude. First, attitude is defined in terms of evaluating responses to some attitude object. Second, the evaluative responses can take various forms, affective, cognitive, or behavioral form. Thus any information derived from observing affective, cognitive, and behavioral responses may be useful for infering the subject's attitude. As mentioned above, the relevant classes of response vary with the attitude domain studied. Third, SCHLEGEL and DITECCO (1982) stated that 'a large number of cognitions and beliefs may exist in relation to any given attribute object or action.' Structure of attitudes system is the main focus of attitude research in the 1980s and 1990s (MCGUIRE 1985). Finally, it has not been explicitly mentioned above, but it is commonly assumed that there is, to some extent, convergency or consistency between attitude components. This point will be discussed further in relation to consistency theory. But before doing so, it seems to be valuable to discuss the implications of the above points to forest policy issues.

For our case, since it concerns rather abstract ideas about forest policy, it is reasonable to expect that the responses will be mostly the cognitive, and affective responses, like reflexes or any kinds of physiological responses, are less relevant. Moreover, since the issues are general and contain various points of argument, it is plausible to assume that attitudes toward forest policy related issues consist of a fairly complex set of beliefs and opinions which may be interrelated. For instance, the extent that people agree with the idea that 'forests should be preserved without allowing any harvesting', may be correlated with their beliefs on the impacts of harvesting on the forest ecosystem, the functions of the forest ecosystem, or the need for silvicultural treatments to maintain a healthy forest. It is also plausible that attitudes may be related to whether someone likes or dislikes natural forests. Thus, some kinds of affective responses may be relevant to understanding people's attitude structure, or predicting cognitive responses. Likewise, past experience or behavioral intentions concerning forests might provide information useful for examining cognitive responses to forest policy related issues. Therefore it seems worthwhile examining a broad range of responses concerning forests and forest policy issues as a whole. However, it should be noted that the implicit assumption in this type of analysis is that there is a consistency between response elements, and that we can understand the relationships between the elements in reasonable way.

It is common to presume that there is some degree of consistency between affective, cognitive, and behavioral components. This is especially the case when the elements of attitude are allowed to go through and be mediated by one's cognitive system, or in other words, one is allowed to have chance to reflect on the relations among attitude elements (BRECKLER 1984). Further, the more frequently the attitude object is thought about, the more likely a consistency is to be observed (BRECKLER and WIGGINS 1989). When the cognitive system plays a role in developing attitude structure, a variety of so-called cognitive consistency theories provide theoretical underpinnings to the presumption of consistency or congruity between attitude elements; affective-cognitive consistency theory (ROSENBERG 1960), balance theory (HEIDER 1946), symbolic psycho-logic theory (ABELSON and ROSENBERG 1958). All consistency theories resemble each other in that they rely on the assumption that people are uncomfortable with inconsistency; when there is inconsistency in one's attitude structure, a person feels uneasy, and will modify some of the attitude components to restore consistency.

To examine consistency in attitude structure, SCHLEGEL (1975) and SCHLEGEL and DITECCO (1982) analyzed attitudes toward marijuana use, and showed that increases in complexity of attitude structure 'did not necessarily result in greater inconsistency and less structure'. With increased marijuana involvement, cognitive activity about marijuana use expanded and accordingly the complexity of attitude structure typically became greater. However, this was not necessarily followed by inconsistencies in attitude. That is, the extent to which elements in the attitude space were related to each other was fairly stable across the different levels of marijuana involvement. In the case of forest policy issues, people usually have a variety of experiences and knowledge of forests, forestry, forest management, and forest policy; whether it is by way of mass-media, education, or direct experience. Thus, attitude structure, especially the cognitive component of it, i.e., knowledge, beliefs, and thoughts, can be differentiated and complex, but it doesn't necessarily mean public attitude toward forest policy are inconsistent.

Therefore, even if people's beliefs are inconsistent with scientific knowledge, or different people have different attitudes, we don't see any transcendental reason to expect inconsistent between attitudes about forest policy. Assuming that total dissonance or inconsistency in attitude structure which cannot be understood in any reasonable way is unusual, it seems interesting to study the internal state of attitude structures regarding forests or forest management issues. Although there are a good number of studies done to delineate public opinions on forest or forest management (both by researchers and governments), few attempts have been made to describe attitude structures regarding forests or forest management issues.

DATA AND METHODS

A questionnaire was conducted in Otsu, Shiga in November, 1995. Otsu is the capital city of Shiga prefecture and is next to the city of Kyoto. It is fairly urbanized and has a populatioin of 270,000. Otsu faces to the Lake of Biwa, the largest lake in Japan, which has been repeatedly the focus of attention in terms of its water pollution. It is sometimes said that the people in Otsu have relatively high environmental awareness compared to most Japanese. This characteristic of the city may have affected the responses in our survey, but it does not prevent the analysis of internal state of attitude structures regarding forests and forest policy.

We wanted to study the attitudes of people living in urban areas, and as the city includes forested areas like Mt. Hiei on its outskirts, we surveyed only people from the town plannning area of Otsu. We selected 15 neighborhoods from this area using a table of random numbers. In each neighborhood, surveyors dropped a questionnaire into the mail box of each house starting from a randomly selected point. The sample size was 820, of which 442 responses were available for analysis. The characteristics of the sample population, in terms of sex and age, are summarized in Table 1.

The questionnaire consisted of 48 questions, of which 10 directly concerned forest policy issues. The following BLF1 to BLF10 are the 10 statements, and for each we asked if one agrees, disagrees, or is uncertain. The statements concerning urban people's contributions to forest management are BLF9 asking about monetary contribution and BLF10 asking about voluntary work.

Table 1 Characteristics of the sample population

Sex	male	273(62)
	female	165(37)
Age	≤20	8(2)
	20<≤40	85(20)
	40<≤60	192(45)
	60<	145(34)

Note: Percentages in parenthesis

BLF1. Urban people should know more about forests, such as the make-up or system of forests including animals and plants in forest.
BLF2. Urban people should know more about the human use of forests, such as timber production.
BLF3. Japan should import all timber it consumes and use domestic forests exclusively for land conservation and recreation.
BLF4. Depopulation of rural areas induces degradation of forests.
BLF5. Harvesting helps maintain healthy forests.
BLF6. Forests should be preserved by keeping humans out.
BLF7. Forests should be managed using treatments.
BLF8. The present generation should reduce timber consumption for the sake of future generations.
BLF9. Urban people should contribute money to implement treatments in forests.
BLF10. Urban people should help implementing treatments in forests by volunteering to do some of the work.

In the analysis presented below, our main focus is on the attitudes about public support of forest management; especially BLF9 concerning monetary contribution and BLF10 concerning the public support in the form of volunteer work. We first analyze interrelations between the 10 statements using two-way contingency tables. The two-way contingency table is a simplistic way of analyzing dependency between two factors because other variables which affect the two analyzed factors aren't controlled. However, one to one dependent relations between beliefs are easily checked in contingency tables. We then developed two logit equations (AGRESTI 1990); one using BLF9 as dependent variable and the other BLF10. In these two equations, variables representing the respondent's past experiences and behavioral intentions as well as belief variables are included as independent variables.

RESULTS AND DISCUSSION

Dependencies

Table 2 shows the responses to the 10 forest policy questions. Most people agreed with some of the statements, such as BLF1, BLF2, and BLF7, but statements like BLF5 and BLF6 and the statements about public support, BLF9 and BLF10, were contentious. To examine the relationships between beliefs, we made two-way contingency tables for each parir of statements, and tested the independency of the contingency tables. Table 3 summarizes the P-values for the chi-square tests of independency. The smaller the P-value is, the greater the possibility that there is dependency between the two beliefs tested. Focusing on the public support issue, four points emerge about the relationships between beliefs.

Whilst BLF9 and BLF10 asked about the pros and cons of urban people's contribution to silvicultural treatments, BLF7 asked about the necessity of such treatments for managing forests. Therefore it isn't surprising that the response to BLF7 was related to the responses to both BLF9 and BLF10 (Table 3). Tables 4, 5, and 6 show the contingency tablefor each combination of BLF7, BLF9, and BLF10. Examination of these tables reveals that most people who favored urban people's contribution to forests, either by funding or by voluntary work, believe in the need of silvicultural treatments to manage forests. Also, most people who favored the contribution by voluntary work also favored a monetary contribution. These relationships can be summarized as follows.

{people who agree to BLF7} $\supseteq$ {people who agree to BLF9} $\supseteq$ {people who agree to BLF10} .

Thus, the results support the supposition that support for urban people contributing to silvicultural treatments is based on the belief that such treatment is necessary. The result that agreeing to BLF10 implies agreeing to BLF9 is not necessarily intuitive, but since voluntary work is a more direct commitment to forest management than a monetary contribution, it suggests that people who agree to both BLF9 and BLF10 are more involved in managing forests than people who agree to BLF9 only.

BLF8 asked whether one agreed with the reduction in

Table 2 Patterns of agreement and disagreement to belief questions

	Agree	Disagree	Uncertain
BLF 1	415(94)	8(2)	17(4)
BLF 2	410(93)	12(3)	18(4)
BLF 3	73(17)	298(68)	65(15)
BLF 4	375(85)	34(8)	30(7)
BLF 5	139(32)	213(49)	80(19)
BLF 6	210(48)	150(34)	78(18)
BLF 7	390(89)	22(5)	27(6)
BLF 8	340(78)	34(8)	61(14)
BLF 9	279(64)	52(12)	108(25)
BLF10	147(34)	149(34)	140(32)

Note: Percentages in parenthesis

Table 4 Contingency table between BLF7 and BLF9

		BLF7	
		Agree	Disagree
BLF9	Agree	266	7
	Disagree	40	10

Note: P−value=0.000

Table 5 Contingency table between BLF7 and BLF10

		BLF7	
		Agree	Disagree
BLF10	Agree	141	4
	Disagree	128	12

Note: P−value=0.033

Table 6 Contingency table between BLF9 and BLF10

		BLF9	
		Agree	Disagree
BLF10	Agree	127	7
	Disagree	79	43

Note: P−value=0.000

Table 3 P-values for chi-square tests of independency between pairs of beliefs

	BLF2	BLF3	BLF4	BLF5	BLF6	BLF7	BLF8	BLF9	BLF10
BLF1	*	0.704	0.593	0.597	0.073	0.230	0.111	0.018	*
BLF2		0.745	0.903	0.048	0.362	0.504	0.033	0.135	*
BLF3			0.326	0.320	0.117	0.074	0.624	0.699	0.514
BLF4				0.527	0.444	0.000	0.000	0.001	0.537
BLF5					0.243	*	0.125	0.857	0.333
BLF6						0.015	0.052	0.153	0.000
BLF7							0.453	0.000	0.033
BLF8								0.010	0.003
BLF9									0.000

Note: *incapable of testing because of 0 entries in contingency table current timber consumption for the sake of future generations. This statement also had some relationship to both BLF9 and BLF10 (Tables 7 and 8). One possible explanation is that people who agree with reducing timber consumption are more environmentally concerned and thus are more likely to be willing to contribute to managing the nation's forests. Alternatively people who agree with reducing timber consumption may have some sense of guil as consumers, and thus feel a responsibility to contribute to forest management.

BLF4, which asked if one believed depopulation in rural area causes forest degradation, was also found to be related to BLF9 (Table9). This dependency suggests that people who agree with this causality are more likely to agree to monetary contribution than those who deny the causality. There may be a belief that healthy forests are maintained by rural people and that urban people should help them by giving monetary assistance.

Agreement with BLF10 (voluntary work) wes also associated with agreement in BLF 6, which asked if one thinks forests should be preserved by keeping humans out (Table10). There is no obvious explanation for why the two beliefs are connected, but since BLF6 suggests a strong environmental position, the significant overlap between those who agree with BLF6 and those who agree with BLF10 might suggest that people who agree with BLF10 have the strong environmental concerns. However, it should be noted that although a belief in the strict preservation of forest is related to agreeing with voluntary work, a belief in the compatibility between timber harvesting and forest health (BLF5) is not related to a belief in voluntary work. The statement of BLF5 suggests that wise use is a form of conservation, whereas BLF6 suggests a belief in preservation. Thus it appears that those who support voluntary work are more likely to be those who support preservation, rather than conservation through wise use.

Table 7 Contingency table between BLF8 and BLF9

		BLF8	
		Agree	Disagree
BLF9	Agree	230	18
	Disagree	38	9

Note: P−value=0.010

Table 8 Contingency table between BLF8 and BLF10

		BLF8	
		Agree	Disagree
BLF10	Agree	134	6
	Disagree	107	19

Note: P−value=0.003

Table 9 Contingency table between BLF4 and BLF9

		BLF4	
		Agree	Disagree
BLF9	Agree	249	40
	Disagree	15	10

Note: P−value=0.001

Table 10 Contingency table between BLF6 and BLF10

		BLF6	
		Agree	Disagree
BLF10	Agree	95	55
	Disagree	43	67

Note: P−value=0.000

Beliefs, Experiences, and Intentions

The multicomponent view of attitude, coupled with the consistency theory, suggests that beliefs about forest policy issues are related to the affective and behavioral components of a person's attitude toward forests. Although we could not obtain appropriate variables to measure the affective responses, we did gather some data on the respondents' past experiences and behavioral intentions. Combining these data with the above results, we estimated logit equations for the likelihood of favoring public support for forest management, to see what attitude elements are related to the formation of opinions about forest management. One equation estimates the likelihood of agreeing to monetary contributions, and the other estimates for the likelihood of agreeing to voluntary work. Since more than one attitude component seems to simultaneously affect the formation of opinions, a logit model is a more appropriate way of investigating complex relationships between attitude elements than a simple two-way contingency table.

Table 11 shows the maximum likelihood estimation results for the two logit equations. Before discussing the results, the dependent and independent variables should be explained. One dependent variable represents the likelihood of agreeing to monetary contribution. It is a dummy variable coded 1 if the respondent agreed to BLF9, or 0 if the respondent disagreed to BLF9. The other dependent variable is also a dummy variable which represents the respondent's attitude towards voluntary work (BLF10).

Eleven variables were selected as independent variables. These are summarized in Table 12. The variables BLF6 to BLF8 are defined in the same way as the dependent variables, and were included because the above results verified that the response patterns to these issues were related to the responses to BLF9 and/or BLF10. The variables with names begining with EXP indicate the expe-

Table 11 Coefficients and t-values for variables in logit equations modelling agreement with public support for forest management by monetary contribution (BLF9) and voluntary work (BLF10)

Variable	Dependent variable BLF9	BLF10
Constant	-2.515	-4.844
BLF6	0.641	1.285***
	(1.601)	(2.908)
BLF7	2.410***	1.741**
	(3.647)	(2.450)
BLF8	1.188**	1.735***
	(2.264)	(2.930)
EXPCLT	0.793	0.860
	(1.093)	(1.582)
EXPFRY	-0.997**	-0.461
	(-2.526)	(-1.427)
EXPLRN	0.924*	0.877**
	(1.852)	(2.376)
INTCLT	1.041	0.658
	(1.258)	(1.207)
INTFRY	0.226	12.794
	(0.197)	(0.077)
INTLRN	-0.014	0.720*
	(-0.026)	(1.704)
INTMOV	0.875	1.016**
	(1.293)	(1.967)
INTTIM	-1.547	-2.382*
	(-1.199)	(-2.382)
$\ln L$ (null)	-111.12	-162.50
$\ln L$ (model)	-95.11	-132.00

Note: t-values in parenthesis
*** denotes significance at the 0.01 level
** denotes significance at the 0.05 level
* denotes significance at the 0.10 level

Table 12 Independent variables used in logit equations modelling agreement for public support of forest management

variable	definition
BLF6	coded 1 if the respondent agreed that "forests should be preserved by keeping humans out"; 0 otherwise
BLF7	coded 1 if the respondent agreed that "forests should be managed using silvicultural treatments"; 0 otherwise
BLF8	coded 1 if the respondent agreed that "the present generation should reduce timber consumption for the sake of future generations", 0 otherwise
EXPCLT	coded 1 if the respondent had experienced collecting activities; 0 otherwise
EXPFRY	coded 1 if the respondent had experienced forestry practices; 0 otherwise
EXPLRN	coded 1 if the respondent had experienced educational activities; 0 otherwise
INTCLT	coded 1 if the respondent wanted to do collecting activities; 0 otherwise
INTFRY	coded 1 if the respondent wanted to do forestry practices; 0 otherwise
INTLRN	coded 1 if the respondent wanted to do educational activities; 0 otherwise
INTMOV	coded 1 if the respondent wanted to move to rural area; 0 otherwise
INTTIM	coded 1 if the respondent wanted to have forest for timber management; 0 otherwise

riences of the respondent. In the questionnaire there were 31 outdoor activities listed and we asked respondents to check all activities that they had done in private but not as extracurricular activities in schools. The 31 activities are divided into 5 groups according to the type of activity. The variable EXPCLT represented collecting activities and was coded 1 if the respondent had experienced in collecting mushrooms, wild plants, nuts, and berryies, insects, firewood, or fallen leaves; or 0 if the respondent had not experienced any of these activities. EXPFRY represented forestry activities, and was coded 1 if the respondent had either planted, weeded, or harvested trees; or 0 if the respondent had not experienced any of these activities. EXPLRN represented educational activities, and was coded 1 if the respondent had participated in forestry educational activities or nature watching; or 0 if the respondent had not experienced either. We also included two other categories of past experience, but these were more common activities (e.g. hiking, camping) than those represented by the three variables above and were not significant in the logit equations They were therefore omitted from the final equations. For each of the 31 activities, we also asked if the respondent wanted to do it in the future if they had never experienced it. The responses were used in the same way as above to construct the variables INTCLT, INTFRY, and INTLRN for the three categories of collecting activities, forestry activities, and educational activities, respectively. Since respondents were asked to check activities that they haven't experienced but would like to, three INT- variables and three EXP- variables should be complementary and represent the respondent's behavioral attitudes towards forests.

Two additional variables representing behavioral intentions were also constructed. Respondents were asked to check any of four things that they wanted to do. Of the four, two were used to further characterize the respondent's behavioral attitude. The variable INTMOV was coded 1 if the respondent said they wanted to move to a rural area, and the variable INTTIM was coded 1 if the respondent wanted to participate in timber management.

The behavioral variables, INT- and EXP- represent the respondent's personal tastes or interests, in contrast to the belief variables which represent one's beliefs and opinions on policy related issues. Specifically, all the behavioral variables are related to respondent's nature-orientedness; but different variables are supposed to represent different kinds of nature-orientedness.

The estimated coefficients for BLF7 and BLF8 and associated t-test statistics (Table 10) show that if the respondent agreed to BLF7 (BLF8), they were more likely to agree to BLF9 and BLF10 than those who disagreed with BLF7 (BLF8). This is consistent with the results of the contingency table analysis. We propose that this result suggests that people who recognized the need for silvicultural treatments to maintain healthy forests, or who felt some sense of guilt and thus responsibility as timber consumers, were more likely to be in favor of public support for forest management.

The coefficients of EXPLRN were also significant for both equations, and INTLRN was also positive and significant in the equation for voluntary work. Variables representing collecting and forestry activities did not have significant and positive coefficients. These results suggest that those people who agree with public support for forests are people who regard forests as areas for learning or nature watching. This is consistent with the common observation that in contemporary Japanese society the value of forest to urban peoplelies in the non-economic, environmental functions of forest, rather than the timber and various non-timber productive functions. This contrasts with the traditional values of productive functions for rural communities, which continues to some extent these days (SUGAWARA 1995). Overall, agreement with public support for forest management seemed to be associated with appreciation of the environmental values of forests.

In the equation for voluntary work, the coefficients for BLF6 and INTMOV are positively significant, and that for INTTIM is negatively significant. The contingency table between BLF9 and BLF10 showed that people who agreed to BLF10 were a subset of people who agreed to BLF9. Thus, the variables that are significant only in the equation for voluntary work may help us identify what factors make people agree to not only monetary contribution but also voluntary work. INTMOV represents people who consider moving to rural areas. These people seem to have strong a interest in nature, or be tired of urban life, and yearn for living in rural area surrounded by abundant nature. It is reasonable to suppose that these people are more likely to feel comfortable in forests and are thus less likely to mind working in forest than ordinary people. This probably explains a significantly positive coefficient for INTMOV in voluntary work equation.

Supporters for voluntary work can also be characterised as people who believe in preservation (BLF6) and have no intention of becoming involved in timber management (INTIM). Thus the supporters of BLF10 are typically people who want to keep nature intact. The significantly negative coefficient for INTTIM indicates that supporters of voluntary work do not base their stance on the economic or utilitarian value of forest; i.e. supporters of voluntary work are not interested in timber management. To sum up, people who favor public support for forest management by voluntary work are less likely to be interested in management for timber production, and are more likely to be interested in preserving nature.

CONCLUSION

We analyzed urban people's attitudes toward forest policy issues based on the multicomponent view of attitude. Swe analysed the relationships between components of attitudes toward public support for forest management by monetary contribution or voluntary work. We used contingency tables and logit equations to describe these relationships. We can gain a better understanding of public opinions on forest policy issues if we can clarify how attitudes are related to each other, i.e. how opinions, beliefs, tastes, and interests in forests are related. This is more effective than just obtaining mere frequencies of occurrences of opinions.

The main findings of our analysis are firstly, that agreement with public supportfor forest management by monetary contribution and agreement with public support by voluntary work are related to beliefs in the need for management to keep forests healthy, consumer responsibility, and the value of the forest environment. Secondly, although these three elements are related to agreement with monetary support and voluntary work, those people who support voluntary work are a subset of those who agree to monetary support. Support for voluntary work also seems to be characterised by particular personal tastes, specifically strong interests in nature. These findings are consistent with the observation that the recent diversification of individual values has resulted in more voluntary forest crews in work.

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Article

Condition and Dynamics of the Russian Far East Forests in 1966-1993

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ABSTRACT

The Russian Far East Forests are a great ecological and natural resource of significance to the for Asia - Pacific region. Evaluation of the condition and dynamics of these forests helps in the evaluation of sustainable forest use trends in nature protection activities and the identification of research needs. In this paper, the condition of the Forest Service land as at January 1993 is described and the forest dynamics between 1966 and 1993 is analyzed. On the basis of the analysis of the forests' condition and dynamics, the ecological and timber potential of the Far East forests is evaluated.

Keyword: Russian forestry, Russian Far East forest, Forest resources

INTRODUCTION

This article is the result of scientific collaboration between Niigata University and the Far East Forestry Research Institute (Khabarovsk city). The Japan - Russia International forum "Current condition of Siberia forests" which took place in Niigata (AUGUST 1994) emphasized the importance of studying Siberian and Far Eastern forests by joint Russian-Japanese efforts. Siberian and the Far Eastern forests are of great interest to Japan, firstly because of their ecological significance in the Asia - Pacific Region, and secondly because these forests represent a vast timber resource.

The Russian Far East forests have been described in many scientific publications, including detailed descriptions of their condition and dynamics (KZECHETOV *et al.* 1975, The Far East forests 1969, Krechetov *et al.* 1975, SHEINGAUZ and CHYOLYSHEV 1984, SHEINGAUZ 1989, etc.). However, most of these publications are in Russian and are mostly inaccessible to readers in other countries.

The Russian Far East is defined here as including the limits of Primorski and Khabarovski krais; The Amurskaya, Kamchatskaya, Magadanskaya and Sakhalinskaya oblasts; the SAKhA Republic (Yakutia); the Jewish autonomous oblast and the Koryaksky autonomous district (Fig. 1). This territory covers 506.9 m.ha of mainly of undeveloped and almost unexplored forests (Table 1). Most of the forests were surveyed remotely using space and air photo interpretation. Inventory data are between 1 and 30 years old. A small part of the forests was surveyed by ground inventory. These inventory data are between 1 and 20 years old. On the basis of existing data collected at different time periods, once every five years inventory accounts are compiled for the whole of Russia. Comparison of inventory data collected at different times, was done by extrapolation, after taking into account fires, logging, diseases, pests, natural ageing and other factors which influences the dynamics of forests of the Forest Service land. Since the effects of these factors on the Forest Service land was hard to predict precisely, the precision of extrapolated inventory data was low.

Therefore, the peculiarities of forest inventory in the Russian Far East should be remembered and analysis limited to evaluating proportions and trends as indices of structural qualitative changes.

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Fig. 1 Sketch map of Russian Far East territorial unit

RESULTS AND DISCUSSION

Forest Condition

The forest condition described here is for 1 January 1993, the date of the compilation of the last forest resources inventory.

Forest Service land makes up most of the land area in the Far East. The smallest proportion of land that is in Forest Service control is in the Magadanskaya oblast (61%) and in the Jewish autonomous oblast (64%, Table 1). In the Khabarovski krai and the Koryakski autonomous district, 96% of the land is in Forest Service contrail. In the Far East as a whole, 82% of the area is managed by the Forest Service.

The Far Eastern Forest Service land is under the jurisdiction of several land holders. Its main portion (498.2 m.ha or 98%) belongs to the Russian Federal Forest Service and its subdivisions in the Russian Federation (krai, oblast, republic, etc.). Although the area under the jurisdiction of other land holders is vast (8.7 m.ha) ,it makes up only 1.7% of the total Far Eastern forests. Such management centralization allows a common forestry policy. Only the condition and dynamics of the forests of the Russian Federal Forest Service are analyzed in this paper.

Forest Service land consists of forest and nonforest lands. Nonforest lands include swamps, waters, stony outcroppings on steep slopes, sands, grazing grounds, agricultural fields, roads, cleared strips and other lands not intended for growing tree shrub species. Some districts have a high proportion of nonforest land, the Koryaksky autonomous district (61%), and the Magadanskaya (48%) and Kamchatskaya (37%) oblasts (Table 2). Overall, nonforest land covers 30% of Forest Service land in the Far East (147.3 m.ha).

Forest land consists of closed stands, brush thickets, unclosed stands, dead stands and open woodlands. Unclosed and dead stands include open woodlands with densities less than 0.3 and land not covered by forest because of natural or anthropogenic destruction (fires, windthrow, loggings etc.). Unclosed and dead stands are very common in Khabarovski krai (14%), Magadanskaya oblast (14%), Amurskaya oblast (12%), SAKhA Republic (Yakutia) (12%) and Sakhalinskaya oblast (11%). Overall, 40.2 m.ha (11%) of closed stands in the Far East are thinned or damaged. These areas slowly convert back to closed stands, resulting in the area of close stands enlarging.

Open woodlands are stands with a density less than 0.3 which have formed naturally because of severe conditions (high in the mountains, on stony outcroppings, in forest tundra, on overmoist soils et.). Open woodlands of the Far East make up about 36.6 m.ha (Table 2). Precise inventory of these lands was not done. In the Forest Service

Table 1 Distribution of land between management agencies in the Russian Far East

Territorial units	Territory				
	Total area	Nonforest Service land area	Forest Service land base		
			Total	The Russia Federal Forest Service	Other ministries and agencies
1	2	3	4	5	6
Primorski krai, m.ha	16.5	3.3	13.2	11.9	1.3
%	100	20	80	72	8
Khabarovski krai, m.ha	78.8	3.3	75.5	73.9	1.6
%	100	4	96	94	2
Amurskaya oblast, m.ha	36.2	4.5	31.7	30.7	1.0
%	100	12	88	85	3
Kamchatskaya oblast, m.ha	17.1	0.8	16.3	15.0	1.3
%	100	5	95	88	7
Magadanskaya oblast, m.ha	119.9	46.2	73.7	71.7	2
%	100	39	61	59	2
Sakhalinskaya oblast, m.ha	8.7	1.3	7.4	6.9	0.5
%	100	15	85	79	6
SAKhA Republic (Yakutia), m.ha	310.3	52.4	257.9	257.0	0.9
%	100	17	83	83	2)
Jewish authonomous oblast, m.ha	3.6	1.3	2.3	2.2	0.1
%	100	36	64	61	3
Koryakski authonomous district, m.ha	30.1	1.2	28.9	28.9	1)
%	100	4	96	96	2)
Far East, m.ha	621.2	114.3	506.9	498.2	8.7
%	100	18	82	80	2

1) less than 0.05 m.ha
2) less than 0.5%
Source: Data base of the Far East Forestry Research Institute, 1995

land base inventory of 01.01.1993 they were included as open land (forest land not covered by forest vegetation). They are common in Magadanskaya oblast (26%) and in SAKhA Republic (Yakutia, 12%).

The area of plantations in the Far East Forest Service land base is insignificant (0.19% of forest lands). Almost two thirds of the plantations are included as closed forest stands, but the rest have not yet closed their canopy and are 5-7 years old. Only in Sakhalinskaya oblast and in Jewish autonomous oblast is the share of plantations is relatively high (2 and 1% of forest lands accordingly, Table 2). However, even there the plantations do not influence forest use as they are too young for exploitation.

The most valuable resource of the Far East Forest Service land base are account for between the closed stands of natural origin. The forests 59% (Magadanskaya oblast) and 97% (Primorski krai) of the forest area. The average for the Far East is 78% (Table 2).

Coniferous stands are the most common type of closed stands in the Far East (72%,Table 3). However, in Koryakski autonomous district, the coniferous stands are only 4% of the forest area. In this area, brush thickets of *Pinus pumila* (73%) and stands of broadleaf species (mostly birch,23%), prevail. In Kamchatskaya oblast the share of coniferous species is also small (8%) and stone birch (*Betula ermanii*) (51%) and brush thickets (28%) dominate. Relatively few coniferous stands occur in Jewish autonomous oblast (37%), in Magadanskaya oblast (43%) or in Primorski krai (58%). In Jewish autonomous oblast stands of dwarf oak of coppice origin (*Quercus mongolica*) and various birches and other broadleaved species are common; in Magadanskaya oblast, shrubs thickets of Pinus pumila are common. The area of broadleaf stands in Primorski krai is high. Most coniferous stands (64% of all Far East conifer stands) are located in SAKhA Republic (Yakutia) where coniferous species make up 87% of the closed forest area.

Larch stands (*Larix*) dominate the coniferous stands of the Far East, accounting for 85% of the area of coniferous species. However, in Sakhalinskaya oblast and in

Table 2 Area of Forest Service Land in each vegetation class in each district of the Russian Far East

Territorial units	Land base of the Russian Federal Forest Service								
	Total Forest Service land base	natural forest land				plantdtion forest land			nonforest land
		total	closed stands	open wood lands	unclosed and dead stands	total	closed stands	unclosed stands	
1	2	3	4	5	6	7	8	9	10
Primorski krai, m.ha	11.9	11.5	11.2	–	0.3	54.1[1)]	43.0[1)]	11.1[1)]	0.4
%	100	97	94	–	3	0.5	0.4	0.1	3
Khabarovski krai, m.ha	73.9	57.4	47.2	2.4	7.8	192.5[1)]	107.9[1)]	84.6[1)]	16.3
%	100	78	64	3	11	0.3	0.2	0.1	22
Amurskaya oblast, m.ha	30.7	25.3	21.7	0.6	3.0	95.1[1)]	57.9[1)]	40.6[1)]	5.3
%	100	83	71	2	10	0.3	0.2	0.1	17
Kamchatskaya oblast, m.ha	15.0	9.4	8.9	0.3	0.2	66.4[1)]	35.1[1)]	31.3[1)]	5.5
%	100	63	59	3	1	0.4	0.2	0.2	37
Magadanskaya oblast, m.ha	71.7	37.0	22.0	9.7	5.3	25.5[1)]	4.7[1)]	20.8[1)]	34.7
%	100	52	31	14	7	0.04	0.007	0.03	48
Sakhalinskaya oblast, m.ha	6.9	6.0	5.3	–	0.7	199.6[1)]	141.7[1)]	57.9[1)]	0.7
%	100	87	78	–	9	2.9	2.1	0.8	10
SAKhA Republic (Yakutia), m.ha	257.0	190.8	145.3	23.0	22.5	3.6[1)]	3.6[1)]	–	66.2
%	100	74	56	9	9	0.001	0.001	–	26
Jewish authonomous oblast, m.ha	2.2	1.7	1.6	–	0.1	38.3[1)]	20.1[1)]	18.2[1)]	0.5
%	100	76	72	–	4	2	1	1	22
Koryakski authonomous district, m.ha	28.9	11.2	10.2	0.6	0.4	4.0[1)]	1.9[1)]	2.1[1)]	17.7
%	100	39	35	2	2	0.01	0.006	0.007	61
Far East, m.ha	498.2	350.2	273.4	36.6	40.2	682.5[1)]	415.9[1)]	266.6[1)]	147.3
%	100	70	55	7	8	0.1	0.08	0.05	30

1) thousand ha
Source: Data base of the Far East Forestry Research Institute, 1995

Primorski krai, dark coniferous forests of spruce (*Picea*) and fir (*Abies*) dominate. In Sakhalinskaya oblast and Primorski krai the area of dark coniferous forests is 55% and 48% of the coniferous stands, respectively In Primorski krai and Jewish autonomous oblast the area of *Pinus koraiensis* is relatively high - 34 and 33% respectively. *Pinus koraiensis* forests are the most valuable of the Far Eastern forests because of their diversity and unique flora and fauna. Although *Pinus koraiensis* is dominant in these stands,it is often only 30-40% of the timber volume. The rest of the timber volume in these stands is made up by many coniferous and broad-leaved species, with species accounting for 1 to 30% of the timber volume.

A significant portion of closed forests in the Far East is made up by old stands which are referred to as mature and overmature forests. The proportion of forest which are mature or overmature ranges from 63% in Koryakski autonomous district to 33%l in Amurskaya oblast. The average for the Far East is 46% (Table 4). From the point of view of a standard clear harvesting system, such a proportion of mature stands is excessive. Among younger stands, the so called "average aged" ones prevail: for coniferousand broad-leaved stands with hardwood species these are stands from 41 to 80 years and for stands broad-leaved species with soft wood, these are stands from 21 to 40 years old. The proportion of average aged stands is greatest in the closed forests of Kamchatskaya oblast (39%) and least in Koryakski autonomous district (16%). The average for the Far East is 27%. Between the average aged and mature stands there are the so called "approaching maturity" stands which are aged 20 for coniferous and hard broad-leaved species or 10 for soft broad-leaved species. These stand are available for logging according the acting Rules of Harvesting in the forests of the Far East (Timber Harvesting Rules,1993). The proportion of "approaching maturity" stands is greatest in the closed forests of Koryakski autonomous district (21%), and least in Kamchatskaya oblast and SAKhA Republic (Yakutia) (6% in each), The average for the Far East is 9%.

The rest of the closed forests are young and they account for between 1% (forests of Koryakski autonomous district) and 24% (both Amurskaya and Sakhalinskaya

Table 3 Dominant species of the closed forests of each district of the Russian Far East

Territorial units	Closed stands of the Russian Federal Forest Service										
	Total closed stands	coniferous stands					deciduous stands				brush thickets
		total	Pine		spruce, fir	larch	total	oak	birch	other	
			koraiensis, sibirica	other							
1	2	3	4	5	6	7	8	9	10	11	12
Primorski krai, m.ha	11.2	6.5	2.2	1)	3.1	1.2	4.7	1.9	1.7	1.1	1)
%	100	58	20	2)	27	11	42	17	15	10	2)
Khabarovski krai, m.ha	47.3	35.4	0.6	1.1	8.5	25.2	6.3	0.3	4.4	1.6	5.6
%	100	75	1	3	18	53	13	1	9	3	12
Amurskaya oblast, m.ha	21.8	14.4	1)	0.7	0.5	13.2	5.3	0.4	4.7	0.2	2.1
%	100	66	2)	3	2	61	24	2	21	1	10
Kamchatskaya oblast, m.ha	8.9	0.7	-	1)	0.2	0.5	5.7	-	4.5	1.2	2.5
%	100	8	-	2)	2	6	64	-	51	13	28
Magadanskaya oblast, m.ha	22.0	9.4	-	1)	-	9.4	0.3	-	1)	0.3	12.3
%	100	43	-	2)	-	43	1	-	2)	1	56
Sakhalinskaya oblast, m.ha	5.4	3.8	1)	0.1	2.1	1.6	1.3	0.1	1.1	0.1	0.3
%	100	70	2)	2	39	29	24	2	20	2	6
SAKhA Republic (Yakutia), m.ha	145.3	125.8	0.4	10.0	0.4	115.0	2.0	-	1.9	0.1	17.5
%	100	87	1	7	2)	79	1	-	1	2)	12
Jewish authonomous oblast, m.ha	1.6	0.6	0.2	1)	0.2	0.2	1.0	0.4	0.4	0.2	1)
%	100	37	13	2)	12	12	63	25	25	13	2)
Koryakski authonomous district, m.ha	102.2	0.4	-	-	-	0.4	2.4	-	2.1	0.3	7.4
%	100	4	-	-	-	4	23	-	20	3	73
Far East, m.ha	273.7	197.0	3.4	11.9	15.0	166.7	29.0	3.1	10.8	5.1	47.7
%	100	72	1	4	5	61	11	1	8	2	17

1) less than 0.05 m.ha
2) less than 0.5%
Source: Data base of the Far East Forestry Research Institute, 1995

oblasts). From the point of view of a standard clear harvesting system, the age structure of the forests in the Far East is far from perfection. From the point of view of environmental protection, the forests age structure is also not perfect because the environment is better protected by climax forests. Hence an age structure analysis would be useful for concrete economic analysis of the forests, however, this is not the purpose of this article.

The Far East forests are of low productivity because of the severe natural conditions. Average yields of mature stands and shrub thickets range from 14 to 278 cu.m/ha (Table 5). There is no clear pattern of increased productivity from North to South, and the productivity of coniferous stands is not always higher than that of broad-leaved stands. Mountainous topography, significantly differing climatic conditions, uneven bedding, thickness of permafrost and other natural conditions result in a wide variation in forest productivity without any clear spatial trends.

Pinus koraiensis (*Pinus sibirica*) stands are the most productive formation, except in Amurskaya oblast where timber productivity is higher from fir and poplar stands, and SAKhA Republic (Yakutia) fir stands. Generally,dark coniferous stands spruce and fir are inferior in productivity only to *Pinus koraiensis* forests, except in Khabarovski krai where dark coniferous stands are outstripped by poplar stands. The productivity of mature larch stands is often lower than that of broad-leaved stands. Data in Table 1 briefly characterizes the pattern of productivity in the Far East forests. There is a mosaic of productivity classes across territorial units which is even stronger within smaller regions.

In spite of the low productivity of the Far East forests, the total timber yield is significant (20.5 bill.cu.m., Table 6). The yield of coniferous stands (83%) is large than the area they represent (72%). This means that the overall productivity of the coniferous stands is higher than that of the rest of the closed forests.

High yields of nontimber resources, such as medicinal

Table 4 Age class distributions of the closed forests of each district of the Russian Far East

Territorial units	Closed stands of the Russian Federal Forest Service					
	Total closed stands	Young stands		average aged stands	approaching maturity stands	mature stands
		the 1 st age class	the 2 nd age class			
1	2	3	4	5	6	7
Primorski krai, m.ha	11.2	0.2	0.5	4.1	1.7	4.7
%	100	2	4	37	15	42
Khabarovski krai, m.ha	47.3	3.7	4.5	12.7	4.7	21.7
%	100	8	9	27	10	46
Amurskaya oblast, m.ha	21.8	2.3	2.9	7.0	2.3	7.3
%	100	11	13	32	11	33
Kamchatskaya oblast, m.ha	8.9	0.1	0.1	3.5	0.5	4.7
%	100	1	1	39	6	53
Magadanskaya oblast, m.ha	22.0	1.0	2.2	5.7	3.4	9.7
%	100	5	10	26	15	44
Sakhalinskaya oblast, m.ha	5.4	0.4	0.9	1.6	0.5	2.0
%	100	7	17	30	9	37
SAKhA Republic (Yakutia), m.ha	145.3	14.4	14.9	38.2	9.1	68.7
%	100	10	10	27	6	47
Jewish authonomous oblast, m.ha	1.6	0.1	0.2	0.5	0.2	0.6
%	100	6	13	31	13	37
Koryakski authonomous district, m.ha	10.2	1)	1)	1.6	2.2	6.4
%	100	2)	2)	16	21	63
Far East, m.ha	273.7	22.2	26.2	74.9	24.6	125.8
%	100	8	10	27	9	46

1) less than 0.05 m.ha
2) less than 0.5%
Source: Data base of the Far East Forestry Research Institute, 1995

Table 5 Average yield (m^3/ha) of standing timber in mature stands of dominant species in the Russian Far East

Territorial units	Forest Service land base of Federal Forest Service											
	coniferous					broadleaved						*Pinus pumila*
	Pinus koraiensis	Pine (*Pinus*)	Spruce (*Picea*)	Fir (*Abies*)	Larch (*Larix*)	Oak (*Quercus*)	Ash (*Fraxinus*)	Hardwood birches	Softwood birches	Linden (*Tilia*)	Poplar (*Populus*)	
1	2	3	4	5	6	7	8	9	10	11	12	13
Primorski krai	250	112	200	179	190	131	140	170	146	160	178	62
Khabarovski krai	278	140	188	169	129	111	138	160	129	152	200	24
Amurskaya oblast	193	124	183	212	129	59	-	-	129	131	210	62
Kamchatskaya ob.	-	-	193	-	167	-	-	85	91	-	167	75
Magadanskaya ob.	-	-	-	-	53	-	-	-	45	-	155	15
Sakhalinskaya ob.	-	-	210	229	155	114	-	73	91	-	141	56
SAKhA Republic (Yakutia)	181*	132	134	190	86	-	-	-	100	-	130	14
Jewish authonomous obl.	202	-	177	167	150	100	125	169	120	163	133	-
Koryakski authonomous district	-	-	-	-	48	-	-	92	70	-	105	62

* *Pinus sibirica*
Source: Data base of the Far East Forestry Research Institute, 1995

Table 6 Species composition of the closed stands in each district of the Russian Far East

Territorial units	Closed stands of the Russian Federal Forest Service										brush thickets
	Total closed stands	coniferous stands					deciduous stands				
		total	Pine koraiensis, sibirica	Pine other	spruce, fir	larch	total	oak	birch	other	
1	2	3	4	5	6	7	8	9	10	11	12
Primorski krai, bill.cu.m.	1.8	1.2	0.5	1)	0.5	0.2	0.6	0.2	0.2	0.2	1)
%	100	67	28	2)	28	11	33	11	11	11	2)
Khabarovski krai, bill.cu.m.	5.0	4.3	0.1	0.1	1.5	2.6	0.5	1)	0.3	0.2	0.2
%	100	86	2	2	30	52	10	2)	6	4	4
Amurskaya oblast, bill.cu.m.	2.0	1.6	1)	0.1	0.1	1.4	0.3	1)	0.3	1)	0.1
%	100	80	2)	5	5	70	15	2)	15	2)	5
Kamchatskaya oblast, bill.cu.m.	0.6	0.1	-	1)	1)	0.1	0.4	-	0.4	1)	0.1
%	100	17	-	2)	2)	17	67	-	67	2)	16
Magadanskaya oblast, bill.cu.m.	0.5	0.3	-	1)	-	0.3	1)	-	1)	1)	0.2
%	100	60	-	2)	-	60	2)	-	2)	2)	40
Sakhalinskaya oblast, bill.cu.m.	0.6	0.5	-	1)	0.4	0.1	0.1	1)	0.1	1)	1)
%	100	83	-	2)	67	16	17	2)	17	2)	2)
SAKhA Republic (Yakutia), bill.cu.m.	9.2	8.9	0.1	1.0	1)	7.8	0.1	-	0.1	1)	0.2
%	100	97	1	11	2)	85	1	-	1	2)	2
Jewish authonomous oblast, bill.cu.m.	0.2	0.1	1)	1)	0.1	1)	0.1	1)	1)	0.1	1)
%	100	50	15	2)	25	10	50	15	15	20	2)
Koryakski authonomous district, bill.cu.m.	0.6	1)	-	-	-	1)	0.2	-	0.2	1)	0.4
%	100	2)	-	-	-	2)	33	-	33	2)	67
Far East, bill.cu.m.	20.5	17.0	0.7	1.2	2.6	12.5	2.3	0.3	1.6	0.4	1.2
%	100	83	3	6	13	61	11	1	8	2	6

1) less than 0.05 bill.cu.m.
2) less than 0.5%
Source: Data base of the Far East Forestry Research Institute, 1995

plants, food items and a rich and diverse fauna are found in the Far East forests (SUKHOMIROV 1984). All these riches are provided by the Forest Service land base. The opportunities of multipurpose forest use depend on the condition of the Forest Service land base.

At the moment it is impossible to evaluate the condition of the Far East forests from the current inventory data, because one cannot evaluate it as bad or good. It is obviously bad that there is a lot of waste nonproductive land (burnt, logged or other areas). It is also bad that the sites of former original stands are behind reproduced by secondary species of lower value (broad-leaved, shrubs and other). However the forest area yields of timber and nontimber resources are still very high and sufficient, or in some cases even too much, for various needs. Hence it is impossible to describe the forests condition only as bad.

Yet it is obvious that the condition of the forests worsened when the share of low producing tracts increased. To evaluate the forests condition meaningfully,the dynamics most be evaluated, and the probability of critical situations occurring must be predicted.

Forest Dynamics

Forest use can be divided into 3 categories: raw resources, social and ecological uses. In the 1950s and 1960 s, the main use of forests was as a raw resource, but now ecological uses have become important.

It is important to understand the dynamics of the forests if the ecological value of the forests is to be evaluated. Thus, it is important to know the forest area and to evaluate how it has changed either quantitatively or qualitatively.

The area of forest can be evaluated relative to the total area of the region,i.e."area under forest". There exist various classifications of area under forest. According to one of them, developed for Russia conditions (TZEPLYAEV 1965)), sites with less than 2% of the area under forest are regarded as forestless; 2-15% are sparsely forested; 16-30% are averagely forested; 31-45% are forested and sites with 45% are heavily forested. According to this classification, Magadanskaya oblast is averagely forested, Kamchatskaya oblast is forested and the rest of the territorial units of the Far East are heavily forested (Table 7). From here, data for Khabarovski krai are and Jewish autonomous oblast, and data for Kamchatskaya oblast and Koryakski autonomous district are combined.

During the 27 years from 1966 to 1993 the area under forest increased in all districts. From an ecological standpoint, such dynamics should be regarded as positive. It's reasonable to assume that the area under forest increased because of natural forest reproduction and reduced losses from fires in Forest Service land base.

The area under forest cannot grow endlessly. The potential for growth is in the nonclosed and dead forests. The area of such forest in Khabarovski krai, Amurskaya and Sakhalinskaya oblasts suggests that area under forest of these districts could reach the same levels as level of Primorski krai and SAKhA Republic (Yakutia) (55%). In Kamchatskaya and Magadanskaya oblasts (forested and averagely forested respectively, the area under forest should not change.

The area under forest should be regulated according to economic expediency. A purposeful reduction of area under forest in the future could be justified as an attempt to satisfy optimum area under forest criteria. In the Russian forest zone, the optimum area under forest was found to be between 50-55% (SHEINGAUZ 1978, TARASENKO 1976, ZHILTZOV 1989, etc.). This criterion is suitable for Primorski krai, Khabarovski krai, Amurskaya krai and Sakhalinskaya oblast and forest area should not be decreased below this level. In Kamchatskaya and Magaanskaya oblasts and SAKhA Republic (Yakutia), such criteria still need to be developed.

Although area under forest is an index used to describe the of ecological protectiveness of an area, it doesn't measure the degree of such protectiveness and is only a reference point for such a purpose. The effectiveness of forests in environmental protection is influenced not only by their total area but also by the structure of vegetation. Ecological functions are better achieved by virgin forests in climax condition with a high canopy density. Replacement of the original species with secondary ones, and decreases in age or density cause the environment at protection to weaken.

To evaluate the species composition dynamics, we used conventional points of dominating species (SHEINGAUZ 1986). Points sums ratios for different years in the Forest

Table 7 Changes in forest area (percentage of forest area which is closed stands) for each district, 1966-93.

Territorial units	years					
	1966	1973	1978	1983	1988	1993
Primorski krai	74	74	72	73	75	77
Khabarovski krai	52	52	51	55	60	61
Amurskaya oblast	55	56	56	61	62	62
Kamchatskaya oblast	40	40	41	42	42	42
Magadanskaya oblast	18	17	15	15	19	19
Sakhalinskaya oblast	55	59	57	63	64	65
SAKhA Republic	38	42	46	48	47	47
Far East	39	41	41	43	45	45

Source: Data base of the Far East Forestry Research Institute, 1995.

Table 8 Changes in the species composition of the Far East forests, 1966-93.

Territorial units	years					
	1966-1972	1973-1977	1978-1982	1983-1987	1988-1992	1966-1992
Primorski krai	0.99	0.98	1.00	1.04	0.99	1.01
Khabarovski krai	0.98	0.99	0.98	1.02	0.91	0.89
Amurskaya oblast	0.98	0.99	1.00	0.97	0.93	0.92
Kamchatskaya ob.	1.00	1.00	0.98	0.85	0.89	0.75
Magadanskaya ob.	0.99	1.00	1.00	0.91	1.00	0.90
Sakhalinskaya ob.	1.00	1.00	1.00	0.99	0.99	0.99
SAKhA Republic (Yakutia)	1.00	1.00	0.96	0.98	1.00	0.94

Unit is times. Each numeral shows how to times each year composition changing next term.
Source: Data base of the Far East Forestry Research Institute, 1995.

Table 9 Changes in age structure of the Far East forests, 1966-93.

Territorial units	years					
	1966-1972	1973-1977	1978-1982	1983-1987	1988-1992	1966-1992
Primorski krai	0.96	0.98	0.96	0.99	0.96	0.86
Khabarovski krai	0.98	0.98	0.96	0.96	0.98	0.87
Amurskaya oblast	0.87	0.98	0.98	0.99	0.99	0.82
Kamchatskaya ob.	0.98	0.94	0.89	1.00	0.73	0.60
Magadanskaya ob.	1.01	0.88	1.00	0.91	1.00	0.80
Sakhalinskaya ob.	0.96	0.98	0.91	0.98	0.97	0.82
SAKhA Republic (Yakutia)	0.96	0.98	0.98	0.96	0.99	0.89

This table was calculated in the same way as table 8.
Source: Data base of the Far East Forestry Research Institute, 1995.

Service land base inventory gives a coefficient of species composition dynamics between the years (Table 8). The species composition was constantly getting poorer. The greatest changes were in Kamchatskaya oblast where species with high scores, decreased and species with low scores increased.

Conventional points were also used to analyze forest cover age structure dynamics (SHEINGAUZ 1986). Mature stands are rated higher and young stands lower. Age structure change rates were higher than changes in species composition and more uniform (negative,Table 9).

To analyze canopy density dynamics we used, for lack of a better index, the average yield of timber per ha of forest covered land. Changes in average timber yield between different years in the Forest Service land base inventory were evaluated by their ratio and measured by coefficients (Table 10). The average yield dynamics were chaotic, but this analysis helped us understand forest cover quality dynamics.

The average arithmetical value of the coefficients in Tables 8-10 integrate the changes in forest cover quality (Table 11). Generally, the trends are negative, but without clear criteria it is impossible to evaluate accurately the current qualitative condition of the forests. Even in Magadanskaya oblast where the quality coefficient decreased by 25% over 23 years, it is impossible to make a conclusion about the quality of the forest. However, from an ecological standpoint, reduction in forest quality should be regarded as undesirable and should prompt action to regulate the forests.

From a timber production stand point, trends in operational forests are important. Currently in Russia all mature and overmature stands are regarded as operational forests excluding the stands which are not logged for ecological, economic or other reasons (GOSKOMLES USSR 1991). The most important operational forests of the Far East are the coniferous stands. Even in Kamchatskaya oblast where the proportion of coniferous stands is low, mostly these stands are logged.

Changes in area of the mature coniferous stands were persistently negative (Table 12). The greatest changes occurred in Primorski krai. In 1966 the krai had the greatest operational potential but currently it is fifth. These changes were caused by intensive logging of *Pinus koraiensis* stands between 1960 and 1980.

Despite these negative trends, the timber potential of mature coniferous stands in the Far East remains high. Excluding Kamchatskaya and Magadanskaya oblasts, the proportion of mature coniferous stands in all regions exceeds the theoretical level sufficient for continuous and inexhaustible use (17-20%). The current annual allowable cut is less than half the potential in all regions including Kamchatskaya and Magadanskaya oblasts.

Table 10 Changes in average timber yields of the forest lands of the Russian Far East, 1966-93.

Territorial units	years					
	1966-1972	1973-1977	1978-1982	1983-1987	1988-1992	1966-1992
Primorski krai	0.97	1.01	0.97	0.98	1.01	0.93
Khabarovski krai	1.01	1.02	0.95	0.93	0.97	0.88
Amurskaya oblast	0.84	1.02	1.00	0.99	0.98	0.83
Kamchatskaya ob.	0.98	0.95	1.17	1.01	1.00	1.09
Magadanskaya ob.	0.84	0.92	0.98	0.74	1.00	0.56
Sakhalinskaya ob.	0.98	0.98	0.91	1.00	0.93	0.81
SAKhA Republic (Yakutia)	0.93	0.94	0.91	0.91	1.00	0.74

Calculation is (Average timber yield in 1972) / (Average timber yield in 1966)

Source: Data base of the Far East Forestry Research Institute, 1995.

Table 11 Changes in the integrated quality index of forest cover in the Russian Far East, 1966-93.

Territorial units	years					
	1966-1972	1973-1977	1978-1982	1983-1987	1988-1992	1966-1992
Primorski krai	0.97	0.99	0.98	1.00	0.99	0.93
Khabarovski krai	0.99	1.00	0.96	0.97	0.95	0.88
Amurskaya oblast	0.90	1.00	0.99	0.98	0.97	0.86
Kamchatskaya ob.	0.99	0.96	1.01	0.95	0.87	0.81
Magadanskaya ob.	0.95	0.93	0.99	0.85	1.00	0.75
Sakhalinskaya ob.	0.98	0.99	0.94	0.99	0.96	0.87
SAKhA Republic (Yakutia)	0.96	0.97	0.95	0.95	1.00	0.86

These values are average arithmetical value of coefficients in table 8.9.10

For example; 1996-1972: Table 8=0.94; Table 9=0.99; Table 10=0.94; Table 11=(0.94+0.99+0.94)/3=0.96

Source: Data base of the Far East Forestry Research Institute, 1995.

Table 12 Changes in the proportion of forest land which is mature coniferous stands, 1966-1993.

Territorial units	years					
	1966	1973	1978	1983	1988	1993
Primorski krai	45	42	40	31	31	24
Khabarovski krai	37	36	34	33	33	31
Amurskaya oblast	40	31	29	28	27	26
Kamchatskaya oblast	5	5	6	4	4	4
Magadanskaya oblast	18	16	10	11	12	12
Sakhalinskaya oblast	33	33	32	30	29	26
SAKhA Republic (Yakutia)	45	44	41	39	33	33

Source: Data base of the Far East Forestry Research Institute, 1995.

CONCLUSION

This article described the condition of the Far East Forest Service land base as at 1 January 1993. This summary of the forests will remain current until the next inventory on 1 January 1998. Forests dynamics will be included in the inventory only after 1998.

A monitoring service is not yet organized in the Far East which can effectively follow annual changes of forests condition simultaneously over the whole territory of the region. The analysis of forests dynamics in this article used discrete features of the original data substantiate trends and the scope of forestry activities.

Our evaluation of the condition and dynamics of the Far Eastern forests was a general one, oriented toward the key needs of our society. The Far East forests were differentiated into categories which described the quantity of forest and its quality for particular functional values. Forests condition and dynamics categorized by protective function was not consideration this analysis. This type of analysis is important for a better understanding of forest use issues and will be undertaken separately. Such an analysis also be useful for developing methods, view because ways of differentiating between forest functions are insufficiently studied not only in the Russian Far East but also in other regions of the world.

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Article

Forest Management and Forestry

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ABSTRACT

In recent years, it has been recognized that forestry management and the economic situation for forestry is deteriorating in Japan. However, the concept of forestry management is being used in a sense that is quite vague. We recognize that forest management is specialized and differs from other businesses in economic theory, and also that the conditions for it cannot be analyzed only by economic theory. In this paper, we examine the historical conditions which prompted the development of modern forest management and forestry from a socio-economic viewpoint. The most obvious factors contributing to the development of forest management include devastation of the forests and subsequent wood shortages. In addition to wood shortages, the modernization of land ownership, the agricultural revolution, the fuel revolution, and a long-term increase in wood prices contributed to the development of modern forest management. In Japan, the reforms of the Meiji Restoration and rapid increase in demand for timber following World War II were the most important factors influencing the development of modern forest management. The historical conditions in which forest management developed in Japan have now changed, but 10 million ha of plantation forests remain. Forest owner's cooperative associations could serve as a link between regional forest resources, forest management and forestry.

Keyword: forest management, forestry, historical conditions of forest management

INTRODUCTION

According to the World Agriculture and Forestry Census there was 10.25 million ha of man-made forests in Japan in 1990. Of the total area, 11% was more than 41-years-old (up 1.5% from 1980) and 3.5% was more than 61-years-old (up 1.1% from 1980). The 1994 Statistical Survey of Forestry Structures also found that the area of forests more than 41-years-old (holding over 20 ha) had increased from 7% in 1985 to 11.6% in 1994.

However, the Statistical Survey of the Economy of Forest Households in 1993 found that the forestry income of the large-scale forest owners was decreasing rapidly. Large-scale forest owners in Japan own more than 100 ha of forest. Ownership of between 100 and 500 ha is considered the minimum for independent management under the current economic circumstances (FUKUSHIMA 1994). In 1993, the average household income from forestry for this group was 2.06 million yen, which was 48% of the previous year's income, and below the 3.59 million yen earned in 1965.

When viewing these figures, it should be remembered that the age when there are no man-made forests available for logging has passed and that, regardless of the area of forests, forestry practices are gradually becoming more difficult to implement. We suggest that the findings of these recent surveys indicate that forestry management needs to be reconsidered. In other words, we need to define forestry management from a socio-economic viewpoint.

ARGUMENTS SURROUNDING FORESTRY MANAGEMENT

The Forest Policy Council report in 1986, Basic Course of Forestry Policy: Overcoming the Forest Crisis, classified forestry management into three categories and focused on devising management policies for each category. The three categories were: 1) management by those engaged mainly in forestry who do not depend on other sources of income; 2) complex management by those who also depend on other sources of income, such as agriculture,

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livestock, or forest by-products such as mushrooms; and 3) management by those who do not depend on forestry but who own forest properties.

The Forestry White Paper in 1986 also classified forestry management into three categories, according to the forest area and type of labor employed. The three categories were 1) forest-based management: centered around the large-scale group, with sustainable production activities based mainly upon forestry and using mainly employed labor; 2) complex management: centered around the mid-scale group, with production activities a part of complex systems involving agriculture, etc., mostly using their own labor; and 3) small-scale management: centered around the small-scale group, with intermittent production based on commissions and contracts with forest owner's cooperative associations. (FORESTRY AGENCY 1987)

Following the revision of the Forest Law in 1991, the current River-Basin Forest Management System was implemented as a basic policy. The three types of forestry management were incorporated in this policy, and the importance of the role of the forest owner's cooperative associations was emphasized. In the 1994 Forestry White Paper, forestry management was classified into 1) forest-based management; 2) complex management combined with agriculture etc.; and 3) management by the forest owner's cooperative associations. (FORESTRY AGENCY 1994)

In these cases, how do policy planners define forestry management, which is the basis of the classification? In the Forestry White Paper, forestry management was defined as the management of forests owned by forestry households or forestry companies (FORESTRY AGENCY 1994). By this definition, forestry management includes both the ownership and management of forests. Consequently, if forest owners plant, tend, sell stumpage, or produce logs themselves, they are considered to be involved in forestry management. The ownership of natural forests and repetition of felling and the naturally regenerating trees is also called forestry management. However, most issues related to forestry management concern man-made forests. Thus, the term of forestry management is being widely used but is quite vague.

It is generally considered that forestry management in Japan is difficult because the large volume of imported timber keeps the price of domestic timber low. As a result, the internal rate of return for Japanese cedar, a common management index, dropped below 1% in 1992. If forestry management is regarded as a business which should pursue profits, as would any other industry in a modern, capitalist society, then investments in planting and tending should be regarded as capital investments. However, if this was case, most forestry management in Japan should have failed by now.

A concern of forestry economists in Japan is whether planting and tending investments over the relatively long period of a forest rotation can be regarded in the same way as investments in other industries. There are two opposing views: one that they can be regarded as similar, and one that they must be seen as different because they are special interest-bearing capital investments similar to agricultural land capital improvements.

These point emerged in arguments about the mechanisms for determining wood prices for the two categories of forestry, namely logging of natural forest and plantation forestry, proposed by ISHIWATA (1952). SUZUKI (1962) was critical of making a distinction between the two types forestry which exist in one industry. Instead, he regarded forests as similar to agricultural land and viewed silvicultural capital as terre-capital, which differs from industrial capital. In this view, silviculture activities are equivalent to forest improvement, or land improvement.

RYUKO (1989) examined forestry land rent theories, and concluded that wood prices are regulated by the sum of marginal investments and absolute land rent when logging natural forests and that the stumpage price for plantation forests is not determined by competition but by the so-called count-backwards price from the market when logging of natural and plantation forests coexists. The rotation period for plantation forests is a long period of time and this means that silviculture capital is special capital which cannot have its own price regulating mechanism. Ryuko did not go further in describing the economic characteristics of silviculture or whether it represents interest-bearing capital. However, he did clarify that capital invested in silviculture is special, with characteristics that set it apart from industrial capital. In this sense, he supports a modified version of SUZUKI's argument.

Those who follow the view of SUZUKI define management in which the forest owner carries out planting and tending activities as "forest management" (*shinrin keiei* in Japanese), and log production as "forestry management" (*ringyo keiei* in Japanese). In these definitions. "forest management" is "specialized management" which provides the infrastructure for log production.

In this paper, we outline the historical conditions under which "forest management" developed. Hereafter, the "forestry management" will be referred to as "forestry"

HISTORICAL CONDITIONS FOR DEVELOPMENT OF FOREST MANAGEMENT

Forestry was established as an industry at approximately the time when the Society of Mercantilism was formed, during the collapse of feudal societies in Europe.

Firstly, forestry was an industry which supplied raw materials, such as charcoal and fuelwood, to the early mining industry. In many cases forestry was subsumed by the management of the mining industry. In England in the 17th century, the steel manufacturing industry was constantly on the move looking for forests for fuelwood and charcoal (KADOYAMA 1979). In Prussia, the "der Gutsherr" and the Royal Household manufactured steel in the latter half of the 18th century, expropriating forests and using them as sources of charcoal and fuelwood (HOZYO 1960).

Secondly, forestry produced wood for urban-based demands, including the shipbuilding industry. From the 16-th to 18th centuries, large numbers of wooden merchant and war ships were built, as each European nation strove for supremacy over the oceans and seaborne trade. At that time, the major manufacturing industries were the textile and shipbuilding industries, of which the shipbuilding industry in Holland was dominant (MATSUI 1991). In 17th century Europe, the principal wood production sites were in present-day western Germany, Scandinavia, and on the southern coasts of the Baltic, which had rivers for drifting logs and the best ports to export (PARRY 1967).

In order to maintain a steady supply of shipbuilding materials, charcoal, fuelwood, and construction materials, forest management was attempted in some areas with the implementation of a rotation system for harvesting. However, in the latter half of 18th century, the devastation of forests proceeded unchecked in Europe. The increasing shortage of wood became a serious political and social problem which shook various governments on the continent. The shortage of wood was "actually a problem of European culture, and it was even more important than the historical issue that rocked that era … whether Napoleon would be victorious, or the powers allied against him" (SOMBART 1921).

Thereafter, when we discuss forest management, we will define it as the management of man-made forests, especially after the period of wood shortages in the modern era. Now we will turn to the historical and social conditions for formation of the modern forest management.

The most obvious factors contributing to the development of the forest management include the devastation of the forests and the wood shortages. However, in some countries, forest devastation and shortages of wood led to the collapse of the civilizations (PERLIN 1989). We cannot, therefore, explain the development of forest management solely on the basis of preceding wood shortages. The central question is, how was it possible in that period, in Europe (especially in Germany), to develop modern forest management?

In addition to wood shortages, there were four other developments. First, there was the modernization of land ownership in which the feudal property system was changed to the modern property system, doing away with the common forest and range system. This in turn led to the development of a system of absolute private ownership and the elimination of the use of forests by farmers. The modernization of land ownership and the dissolution of the commons system in England was achieved through the enclosure movements at the end of the 15th century and the end of the 18th century. In Prussia it was achieved after the emancipation of farm slaves, beginning 1807, and the break up of the command of "die Allmende" in 1821. Under the modern property system, farmers lost their rights to collect wood, fertilizer, or grasses and their rights to grazing in the forests, which were previously common rights (GONNERE 1912, ITO 1971, SHOJI 1970).

Secondly, the agricultural revolution led to the decline in the use of the forests by farmers, particularly with regard to livestock grazing in the forests. Consequently, agricultural land use and forestry land use were separated. This change was mainly due to revolutions in agricultural, including the development of the field rotation system and the change from open grazing to livestock breeding in a cattle shed or dairy farming.

Thirdly, there was a fuel revolution. This was the change from using wood fuel in cities to using fossil fuels, and the switch from using charcoal in the mining industry to using coal and coke. This was an important element of the industrial revolution. This change, along with the use of steam engines, allowed England to take the initiative in the industrial revolution. Previously, steel manufacturing required massive amounts of wood fuel, but by the latter half of the 1780's, wood fuel was replaced by coal as the primary energy source, which enabled England to become a major industrial center. The use of coal was not significant in France and Prussia until 1855. Finally, by the 1860's, coal had supplanted wood as the primary fuel (LANDES 1965).

Fourth and lastly, a long-term increase in wood prices accompanied the higher demand spurred by the increase in the urban population, the expanding railway network and the developing paper pulp industry. In this way, the conditions for the development of forest management were formed.

However, at the same time, different factors emerged which hindered the development of forest management. The marked progress in social productivity and improvements in transportation during this time meant that the range of production activities in forests could be extended to include the abundant natural forests which until then had been outside the range of economic activities. This resulted in a sharp increase in production. And while forestry is equipped with a mobility not unlike other industries, forest management is closely tied to the region in which it is developed, and is not easily put into practice in another region. Consequently, the extensive expansion of a variety of forestry systems served as a major factor in determining the development of forest management.

The development of modern forest management is the result of a long process which varied from country to country, and was closely related to the development of capitalism. The historical conditions for the development of forest management were basically the same in Japan, although there were differences because of the time-lag in economic progress and differences in geographic and habitat factors.

THE DEVELOPMENT OF FORESTRY AND FOREST MANAGEMENT IN JAPAN

Following the Meiji Restoration (1868) the Japanese economy rapidly embraced capitalism. It quickly moved from a stage of mercantilism to liberalism, and onto imperialism by the close of the Meiji era (OUCHI 1962). Advanced capitalist countries were already in the age of steam engines and steel by the early Meiji, and were about to begin the era of steel ships and railways. The industrial promotion policies led by the Meiji government were based upon importing advanced technology developed in the industrial revolution from Europe.

Consequently, the relationship between the development of capitalism and the use of forest resources in Japan differed from more advanced countries. In Japan, there was no age of large wooden ships in the mercantilism stage, and serious wood shortages were not encountered as they had been at the beginning of the industrial revolution. However, the immediate introduction of railway technology, and the extension of railways meant that additional uses for wood were rapidly developed in Japan.

Until the late part of Meiji era (1868-1912), forestry activities in Japan had been limited to the prefectures in the main islands. As a result, there was a shortage of wood resources in those prefectures by the latter part of the Meiji era. This problem was especially serious for the paper pulp industry, which had been established as a modern industry (SUZUKI 1967). With the transportation revolution and improvement of the trunk railway network, sawmills were established all over the country. However, during this period of rapid development, wood shortages became conspicuous in the sawmill industry, and many companies went bankrupt due to wood shortages (IIJIMA 1968).

Near the end of the Meiji era, when the Japanese economy was moving on to the stage of imperialism, forestry expanded into the semi-colony of Hokkaido and the colony of Karafuto (Sakhalin). This was the beginning of capitalist forestry production. This expansion had two goals. One was to develop forestry production for export, and the other was to resolve of the wood shortage problem in the main islands of Japan. Export forestry involved the production and export of railway ties to Qing, Korea and Kanton-shu, at a time when European countries and the U. S. dominated Asian nations. The second goal required expanding production and improving transportation of wood produced in Hokkaido and Karahuto to meet the increasing demand for paper pulp and construction materials in the large cities of the main islands. The importing of wood from Southeast Asia and North America began in the Taisho era (1911-1925) and was the beginning of Japan's dependence of foreign forestry products (KOSEKI 1962, HAGINO 1957, HAGINO 1961). On the other hand, the production of fuelwood, used as an energy source in Japanese households, made up a large percentage of domestic production. In particular, charcoal production increased rapidly with the rise of the city population after the last part of the Meiji era (AKAHA 1970).

However, forestry in Japan was unable to continue its expansion in later years. Imperialist wars in Asia and Japan's defeat in World War II halted further promotion and expansion of forestry. The economy remained closed from the war period to the first period of economic growth, and forestry was once again a purely domestic endeavor. Shortages of wood resources emerged once more. Thus, in the modern history of Japan, there were two phases when forestry was restricted, namely the latter part of the Meiji era, and from the period of the wartime regime to the first period of economic growth.

The development of forest management accompanied the development of forestry in the Meiji era, when land ownership first began to be modernized. At this time there was a Land Tax Reform, in which forest and range land was divided into government property and private property and commons in forests were broken up. In the middle and latter part of the Meiji era, the first planting drive in modern times occurred, and this was accompanied by the development of large-scale forest ownership.

Other factors were also important in the development of forest management, including the fuel revolution and the decline in the use of forests by farmers. Later, there was a rapid increase in wood demand during the period following reconstruction after the war. This was crucial for the development of modern forest management. Thus, although the history of forest management in Japan is very old, and can be traced back to the middle of the Tokugawa era (1600-1868), the reforms of the Meiji Restoration and rapid increase in demand for timber following World War II are the most important periods influencing modern forest management.

In the initial period after the war, the Japanese economy was closed. The demand for timber had to be satisfied by production from domestic forests. Consequently, there was fierce competition over wood resources, which was resulted in a rapid increase in wood prices.

Large-scale forest owners who had continued forest management of their estates since the Tokugawa era and forest owners who carried out planting projects in the Meiji era both enjoyed prosperity at this time. Throughout the

Korean war and the first period of economic growth, they were able to sell whatever trees they felled. At this time, the fuel revolution occurred and there was a transition from the use of wood and coal to petroleum. The use of forests by farmers declined as chemical fertilizers became available. However, there was high demand for construction timber and wood prices continued to climb. Labor was abundant and planting rates reached 300,000～400,000 ha per year. The low cost of planting labor and the soaring wood prices suggested that the internal rate of return for planting would be high.

FOREST MANAGEMENT AND FORESTRY POLICIES

Although the situation was complex, the national forestry policies of the time encouraged the nation-wide development of forest management. The national policies were aimed at preserving the land and upholding public welfare. They included policies to improve the infrastructure of forestry production through government subsidies and development and promote forest resource policies through government investment. This structure was quite different from the pre-war period, in which forest management was subsidized by public investment.

These policies, coupled with the traditional "*ie*" (household) and surplus populations found in the mountain villages, resulted in the expansion of the planted area at a scale that was unprecedented in the world. However, this expansion was aimed at increasing wood production and land use policies gave little recognition to the welfare of farmers or agricultural production. The private ownership of forest land was strengthened considerably; a situation that continues to have repercussions.

Farms with forest holdings enthusiastically promoted planting activities during this period. The huge profits from forest management established before the war attracted considerable attention and encouraged landed farmers to become involved in forest management. The internal rate of return for planting was assumed to rise to 6～8%, a level which suggested that not only large-scale forest management but also small-scale farms with forest holdings could run as profitable businesses. During the development of the Forestry Basic Act (1964), policy planners and researchers actively discussed subsistence farmer forestry and family-managed type forestry (AGRICULTURE, FORESTRY, and FISHERY BASIC PROBLEMS SURVEY OFFICE 1961).

The concept of forestry management as an industry, as used in the Forestry White Paper, also spread during this time. The leading indicator of the forest holding farm households was internal rate of return (HANDA 1981). However, in the closed economy, it proved to be no more than a management theory projecting soaring wood prices. During the war and the first period of economic growth, the historical pattern of extending and developing forestry, which had begun at the end of the Meiji era, came to a temporary halt. The liberalization of the wood trade from 1960 promoted expansion of the industries and forestry once again developed rapidly.

Consequently, it was inevitable that the Forestry Basic Law would be seen as lacking international perspective and historical awareness. In the new framework of free trade under the GATT and the Japanese economy, it was time to reconsider forest management (SUZUKI 1965).

Due to the rapid increase in the level of imports, the self sufficiency rate in wood dropped below 50% at the beginning of the 1970's and the center of forestry production shifted from within Japan to the Pacific nations. The large quantities of cheap imported woods began to control the domestic market and domestic forestry production began to focus on producing special quality woods which were not in competition with foreign wood in the timber market.

These market conditions began to influence forest management, raising the cost of infrastructure development. Very few forest managers, who produced most of the high quality products such as Japanese cypress, could cope with such market conditions. By the beginning of the 1980's, although the prices for high quality woods peaked, the forest owners were incapable of taking advantage of the market conditions. In these situation, some forest managers shifted to long rotation management, and other owners began to neglect the management of their forests in favor of regarding the forests as assets.

At the beginning of the 1960's, most forest owners were the forest holding farm households, and there was an affinity between the "*ie*" (household) and forest management. The value accumulated in forests was expected to be passed down to future generations and the input of labor into the forests was therefore valued. However, since then there has been a collapse of the "*ie*" (household) system as an increasing proportion of household members become involved in outside salaried work, consequently the value of forests as assets has declined.

Consequently, forestry policies were modified to increase subsidies for weeding and thinning of forests. In the 1980's the Regional Forest Policy was developed, which was aimed at improving the supply of timber from upstream areas to the processing and distribution centers in downstream areas. This was followed by the River Basin Forest Management Policy of the 1990's The age-class structure of man-made forests is skewed and the focus of current forest policy is improve forestry , distribution and manufacturing systems. The main aim of current polices is to improve both the production of industrial materials from forest resources and the supply of these materials to markets in the cities.

Most policies focus on the technical aspects of forest management, such as promoting the production of high quality woods, shifting from a short rotation system to a long rotation system and shifting to multiple-storied forests. There has been not attempt to review the basis for the understanding of forest management.

CONCLUSION

The understanding that planting and tending investments are no different from industrial investments has been proved incorrect not only theoretically, but historically and realistically as well. It is important to understand forest management in a theoretical and historical context. It then becomes clear that planting and tending investments. or forest management, have special characteristics and cannot regulate wood prices by themselves. The historical conditions in which forest management developed in Japan have changed, but 10 million ha of plantation forests remain. Based upon such theoretical and historical facts, what is being sought now is a discussion of forestry and forest management. In this context, attention should be paid to the following changes that were seen from the 1980's.

First, forest management by individuals is no longer a viable enterprise, even if extensive areas are owned. Most forest owners in Japan own small areas of forest and the value of their forests is falling. Many owners, therefore, are abandoning the management of their forests, and forest policy now focuses on improving the management of regional forest resources. Secondly, government subsidies for planting and tending have expanded to include weeding, thinning. As a result, the management of private forests is becoming more "government-managed" . Thirdly, plantation forests established after the war are approaching rotation age and there are increasing efforts to improve forestry based on this resource.

The River Basin Forest Management Policy initiated in 1991 reflects these changes. Since the middle of 1960's, forest owner's cooperative associations carrying out Forestry Structure Improvement Projects have not only taken the forest owner's place, but have also reinforced the business character of forestry. Currently, forest owner's cooperative associations are expected to play an important role in the establishment of a consistent system of production in the upstream areas to supply processing and distribution industries in the downstream areas. However, it is important to understand that forest owner's cooperative associations are cooperative associations of owners of regional forest resources, and they are restricted to managing regional forest resources. Forest owner's cooperative associations could serve as a link between regional forest resources, forest management and forestry.

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Article

Reconstruction of a Tertiary Fossil Forest from the Canadian High Arctic using Three-dimensional Computer Graphics

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ABSTRACT

Recent innovations in three-dimensional computer graphics have enabled reconstruction of a 45 million-year-old fossil forest on Axel Heiberg Island, Canadian Arctic Archipelago. Detailed study of one of the well-exposed fossil forest horizons formed the basis for a blueprint showing the position and diameter of each exposed stump. The results of this study provide insight into stand structure and density of this high-latitude fossil forest through visualization of the spatial configuration of the stand. The data from the fossil forest were calibrated with measurements taken from extant trees of the same species growing at Tsuruoka Campus, Yamagata University, Japan. The results are presented here as three-dimensional computer graphic representations and indicate that this Axel Heiberg Island fossil forest was a multi-storied climax stand with seedlings and juvenile trees growing under a forest canopy.

Keyword: stand structure, fossil forest, computer graphics, gap regeneration, multi-storied forest

INTRODUCTION

Fossil evidence of once lush warm-temperate forests growing at polar latitudes throughout the Northern Hemisphere clearly demonstrates that the Earth was much warmer than today during the early Tertiary (BASINGER 1986). On Axel Heiberg Island, one of the northernmost islands of the Canadian Arctic Archipelago, exquisitely preserved fossil forests of Eocene age (45 million years ago) were discovered in sediments of the Buchanan Lake Formation near the Geodetic Hills (79°55'N, 89°02'W; Fig. 1). The in situ stumps and leafy litter mats represent the ancient forest floors of poorly drained, low energy mean-

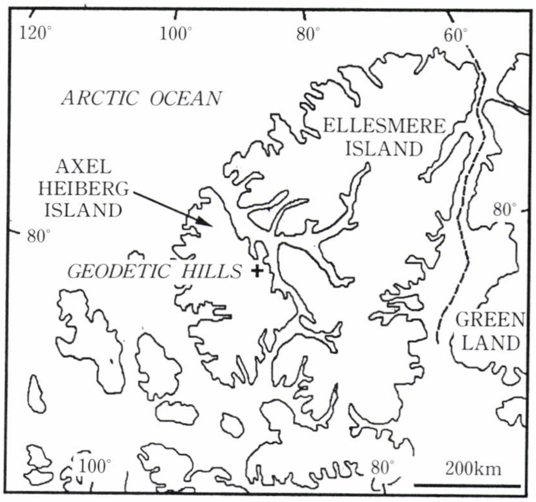

Fig. 1 Fossil forest site

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derplain swamp forest communities. These remains have, and continue, to provide significant data for paleoenvironmental and paleoclimatic interpretations (BASINGER 1991, LEPAGE and BASINGER 1991, 1995, BASINGER *et al.*, 1994).

Computer models and graphics have been in use to simulate living forest stands (NOBORI 1990, 1991). Although they have never been used to reconstruct fossil forests based on tree-stump data alone, the three-dimensional representation of the forest stand should facilitate visualization of stand structure and provide insight into the nature of a fossil forest. Of particular interest was whether these polar forests were young even-aged stands which were regenerated after a natural catastrophe such as fire or flooding, or if it was a mature climax forest rejuvenating itself gradually with gap regeneration such as we see in living mature forests.

LOCALITY DATA

The Geodetic Hills Fossil Forests occur in the upper coal member of the Buchanan Lake Formation which consists of interbedded lithic sandstone, mudstone-siltstone, and lignite arranged in a fining-upward sequences (RICKETTS 1986, 1991). The in situ stumps are best exposed at one end of a NE-SW trending ridge in a coaly horizon which is informally called the "N layer" (Fig. 2). Extensive wind erosion has exposed this part of the outcrop removing the softer sediments and most of the litter mat, leaving the more resistant stumps standing out in relief.

Plant megafossils recovered from this site include remains of the dominant conifers *Metasequoia* MIKI ex HU & CHENG and *Glyptostrobus* ENDLICHER, and minor occurrences of *Chamaecyparis* SPACH, *Carya* NUTTALL, *Pinus* L., as well as a few unidentified angiosperm taxa (BASINGER 1991, LEPAGE 1993). Wood of *Metasequoia* and *Taxodium* has also been identified (YOUNG 1991).

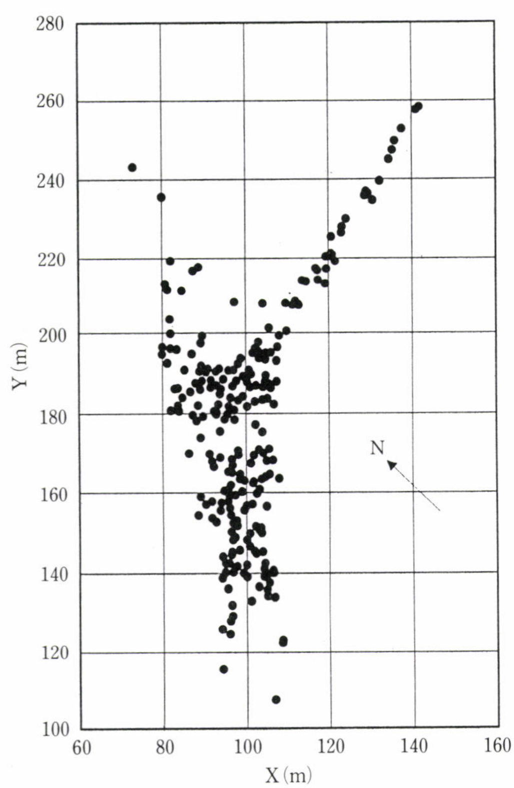

Fig. 2 Plan view of the level-N forest with each dot representing stumps

METHODS

A preliminary assessment of the N-level forest was provided by FRANCIS (1991), and she concluded that tree density and productivity were comparable to that seen in modern deciduous forests. In order to address some of the problems recognized by Francis, we resurveyed the site during the summers of 1992 and 1993. The objectives included a more rigorous identification of the buried stumps and precise measurement of stump locations and diameters. Due to small variation in the topography of the site, some of the stumps including their root systems were fully exposed, while others remained completely buried. The height of the stumps, as well as their top and basal diameters were measured. Buried stumps were exposed, but in some cases the permafrost precluded exposure of the base and root system. In these instances the height of the stump and top diameter were measured, while the basal diameter was estimated using the following regression which was derived from the exposed stumps:

$$BD = 2.9006 + 1.4579 \times SHD$$

($r = 0.9645^{**}$, significant at 1% level)

where BD = basal diameter, and

SHD = stump height diameter.

THREE-DIMENSIONAL REPRESENTATION OF FOREST STAND

MITCHELL's (1975) study on an experimental plot of Douglas fir (*Pseudotsuga menziessii* Franco) involved a series of observations over a long period of time and enabled him to reconstruct the pattern of forest-stand structure and growth using three-dimensional analysis. In this study he modeled the form of trees graphically and illustrated their location and growth based on field data. Since then, several methods of three-dimensional computer graphics have been developed. Of these, the most common employs parallel movement, three-dimensional axis rotation, projection transformation, and transformation of the

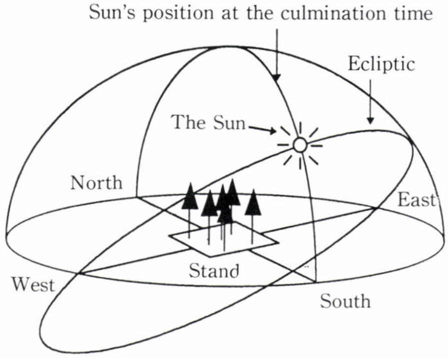

Fig. 3 View point (i.e. solar position) employed in the present simulation.

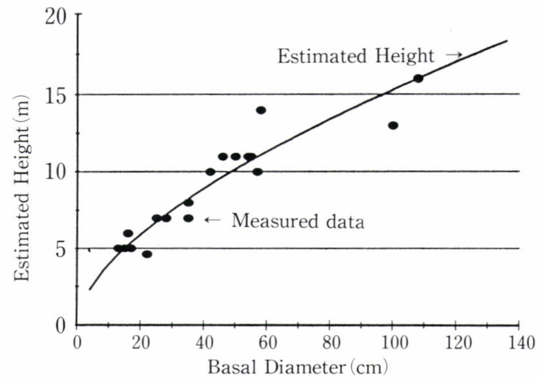

Fig. 4 Relationship between basal diameter and tree height as measured on 18 live trees (dots) and the best fit curve for the relationship.

coordinate system.

In this paper a three-dimensional computer graphics program developed by NOBORI (1990, 1991) was used to reconstruct the N-level fossil forest. The program provides a view of the forest as seen from the position of the sun at any time of the day (Fig. 3). Since the sun does not set in the High Arctic during the summer months, this program enabled us to model and view the forest around the clock. In the original program the conifers were represented by an icon of a seed cone and broad-leaved species as elliptic icons, but in this paper all stumps are interpreted as being those of *Metasequoia* (Figs. 5, 6).

ALLOMETRIC RELATIONSHIP BETWEEN BASAL DIAMETER AND TREE HEIGHT

The height of the trees was estimated using an allometric relationship based on the basal diameter of the stem. This relationship was determined from measurements made in 1994 of the basal diameter and height of 19 extant *Metasequoia* and *Taxodium* trees growing in the open at Tsuruoka Campus, Yamagata University, Japan. Least square determination of the relationship turned out to be:

$$H = 1.0210 \times BD^{0.5875}$$

($r = 0.9452^{**}$, significant at 1% level),

where H = tree height, and

BD = basal diameter of the stem.

This relationship is graphically depicted together with data obtained from the living trees (Fig. 4).

Because of competition or lack thereof, crown shape differs between trees growing in the forest and in the open. Consequently, it is not reasonable to represent the crown shape of the fossil trees using the relationship obtained from the trees growing in the open. Therefore, the crown width and height in our reconstruction were fixed respectively at 1/3 and 1/2 of tree height.

RESULTS AND DISCUSSION

A feature unique to the polar latitudes is 24 hour sunlight during the summer months. The computer-simulated three-dimensional view of the N-level forest at different times of the day during the summer solstice is illustrated in Fig. 5. To show the forest structure in more detail, a 20×20 m quadrat consisting of 52 trees at the central portion of the N-layer forest was enlarged (Fig. 6).

In this enlargement a number of small trees occur beneath the canopy, while a number of middle-sized individuals occupy some of the more open areas. This spatial distribution pattern indicates that the canopy of the forest was not fully closed and provided sunlight gaps which were taken advantage of by the mid-sized trees. This type of forest structure is very common in modern mature forests, where occasional breaks in the forest canopy provide light leaks to the lower levels of the forest. These gaps are often the result of natural death or storm damage of the canopy constituents.

The major objective of this simulation was to determine whether the N-level fossil forest represented a pioneer or climax stand. Comparison of our reconstruction with that of a modern mature spruce forests damaged by typhoons in Hokkaido (NATSUME 1985, MATSUDA 1989) shows close similarity in the spatial distribution of the constituent trees and canopy structure. As has been discussed above, the highly variable tree size distribution along with broken canopy indicates that the fossil forest was more likely to have been an uneven-aged climax forest with seedlings waiting for the canopy to be broken up and mid-sized trees rapidly taking over existing gaps, than a relatively young even-aged forest generally characterized with more even distribution in tree size and even continuous forest canopy.

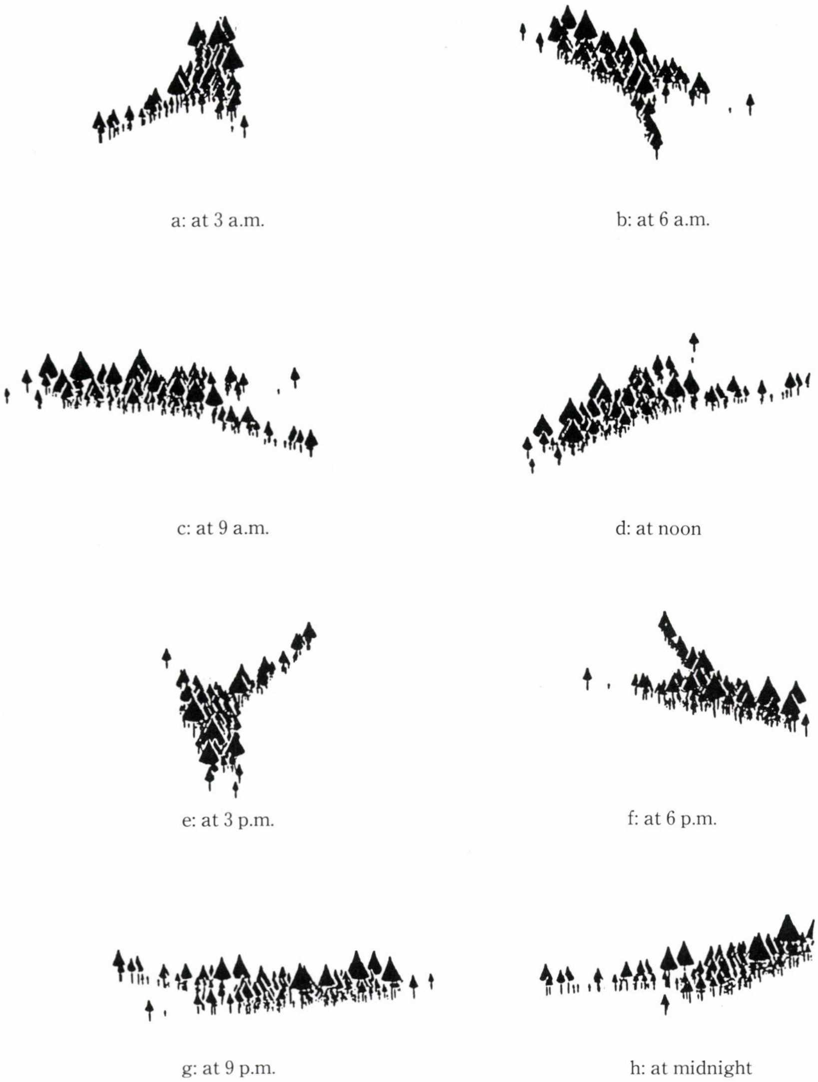

Fig. 5 Three-dimensional view of the reconstructed fossil forest as observed from the solar position at different times of the day.

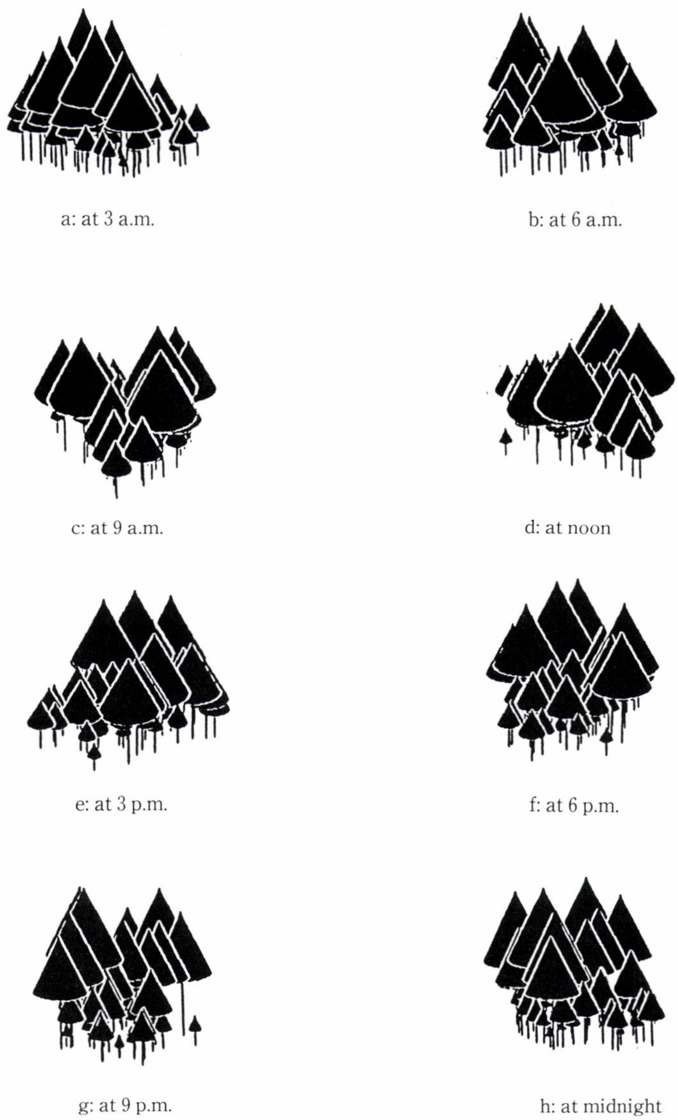

Fig. 6 20×20m section at the center of the fossil forest as observed from the solar position at different times of the day.

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Article

Construction of Yield Tables for Sugi (*Cryptomeria japonica*) in Kumamoto District using LYCS

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ABSTRACT

This study reports the construction of yield tables using LYCS (Local Yield table Constructing System), a computer program based on a diameter growth model. The method and LYCS was developed by SHIRAISHI and is based on yield tables which are extended using a growth model. Hence, yield tables developed by LYCS don't contradict the original yield tables. According SHIRAISHI, modifying LYCS to a species and an area requires precise analysis of growth models and lots of data. It became clear, however, that analysis of existing yield tables and data to develop a parameter of main growth model for mean diameter could be used in LYCS. On the basis of this, yield tables for sugi (*Cryptomeria japonica*) in Kumamoto district were constructed. Although it was necessary to modify some equations, the fundamental structure of LYCS was not changed. Three types of yield tables for different density control plans were constructed and should be appropriate for prediction. Changes in the dimeter distribution were predicted to be smaller than those observed. This study proves that the SHIRAISHI method and LYCS are flexible and useful for practical application.

Keyword: yield table, LYCS, growth model, system yield tables, *Cryptomeria japonica*

INTRODUCTION

Yield tables, both conventional yield tables and empirical yield tables in general, have been used for management of plantations in Japan. Yield tables estimate stand growth for specific tree species on a specific area under a specific management regime, using site, stand age and density as variables (NAGUMO and MINOWA 1990). They assume, however, a fixed management plan for density control and are not suitable for yield prediction under alternative density control systems. Most management plans do not follow the yield tables and other yield prediction methods that can be used for a broader range of management systems are required.

To improve yield tables, various prediction methods based on growth models were developed. KONOHIRA named them "System yield tables" (KONOHIRA 1992). The basic characteristic of a system yield table is that it is a computer-program with an algorithm to estimate the growth process in the future in case of various types of management for the forest stand under various conditions (KONOHIRA 1995b).

SHIRAISHI developed the Local Yield Table Constructing System (LYCS), on the basis of a growth model for mean diameter (SHIRAISHI 1983, KONOHIRA 1993, 1995a). LYCS is based on existing yield tables and extends their range without contradicting them. It requires less data to define parameters compared with other methods based on original growth models. Because constructing yield tables requires lots of data, use of base yield tables makes good use of the original data used to construct them.

This method, however, has not been applied to forests other than the Tokyo University Forest in Chiba, which provided the data used to develop LYCS.

The aim of this paper is to construct practical yield tables by applying LYCS and to discuss the method and the possibility of its general application.

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DATA

The area studied was in the Kumamoto district, Kyushu island, southwest Japan. Sugi (*Cryptomeria japonica*) yield tables constructed by the Forest Agency and the Forestry and Forest Products Research Institute (1955) were used as the base yield tables.

The main growth model requires a lot of growth data to define a parameter. The Forestry and Forest Products Research Institute manages permanent plots all over Japan for measurement of stand growth and analysis of management systems (Forestry and Forest Products Research Institute 1996). The number of trees, DBH and tree height of all trees in the permanent plots are measured every five or ten years. Data from the permanent plots was available to determine the parameter of the growth model. However, there were few plots in Kumamoto district for which original yield tables were available, so data from permanent plots in neighboring areas of Kumamoto district were used for this study. Table 1 lists the permanent plots used to determine the parameter.

LYCS AND APPLICATION

Equations in LYCS

LYCS has the following important equations (Shiraishi, 1985, 1992, 1995a):

1. Mitscherlich's equation expressing height growth curve of yield tables.

$$H = M(1 - L\exp(-kt)) \quad (1)$$

where H: stand height, t: stand age and M, L, k: parameters.

2. Decreasing number of trees in yield tables as per the Gompertz function.

$$N = \exp(a(1+b\exp(-ct))) \quad (2)$$

where N: number of trees, t: stand age and a, b, c: parameters.

3. Stand density control reference curve (Shiraishi, 1983) which describes the relationship between stand density and mean DBH.

$$\log N + a\log D = K \quad (3)$$

where N: number of trees, D: mean DBH and a, K : parameters.

4. Percentage increment of mean DBH as per the Gompertz function.

$$r = m\exp(-kt) \quad (4)$$

where r: percentage increment (%/year), t: stand age (years) and m, k:parameters.

5. Construction of the growth model for diameter increment using results from equations (2)-(4).

$$r = m\exp(-kt) + p(K - \log N - a\log D) \quad (5)$$

A characteristic of this model is that the growth rate of mean DBH depends on the distance between the actual stand condition and the stand density control reference curve.

6. LYCS estimates diameter distributions using the following transformation.

$$De_i = a\,Db_i + b \quad (6)$$

where De_i: diameter of class i at the end of a period (cm), Db_i: diameter of class i at the beginning of period (cm) and a, b: parameters.

Application to Specific Area

Although these relationships and equations are derived in Shiraishi's analysis, the method can be simplified if there are yield tables already in existence. In other words, analysis of yield tables can give the parameters of equations (1) - (4), and parameters m, k, K and a of equation (5) are already known. Therefore, parameter p can be derived using the following equation.

$$p = (r - m\exp(-kt))/(K - \log N - a\log D) \quad (7)$$

Although the value of r is important in equation (7), it may be difficult to derive, but permanent plots of the Forestry and Forest Products Research Institute may be used to derive r.

Thus, analysis of original yield tables and permanent plot data can be used to develop the main growth model (7). LYCS is applicable to any district if the parameters are replaced with the appropriate local values. In this way, LYCS was modified for sugi plantations in the Kumamoto district.

LEADING PARAMETERS

Height Growth Curve

Stand height growth curves from the original yield tables are shown in Fig. 1. The height growth curve of the original yield tables was expressed as a reciprocal equation, but could be expressed by Mitscherlich's equation, allowing parameter M to be calculated as a linear equation based on site.

$$H = M(1 - 0.9675\exp(-0.01100\,t)) \quad (8)$$

$$M = 56.40 - 8.000\,S$$

where H: stand height (m), t: stand age (years) and S: site (1 - 3).

Decrease in the Number of Trees

Fig. 2 shows difference diagrams for decrease of the number of trees in the original yield tables. The decrease in the number of trees at all sites was logarithmic and could be expressed by the Gompertz function. There were also correlations between parameter a and site, and between

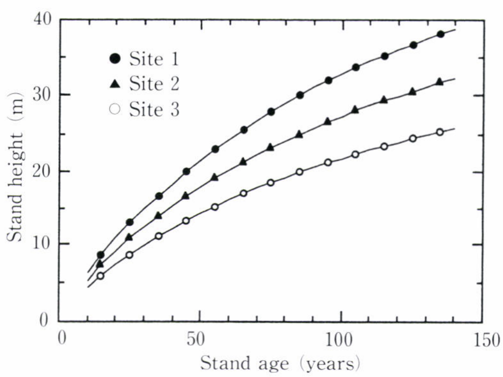

Fig. 1 Stand height growth in the sugi (*Cryptomeria japonica*) yield tables of the Kumamoto district

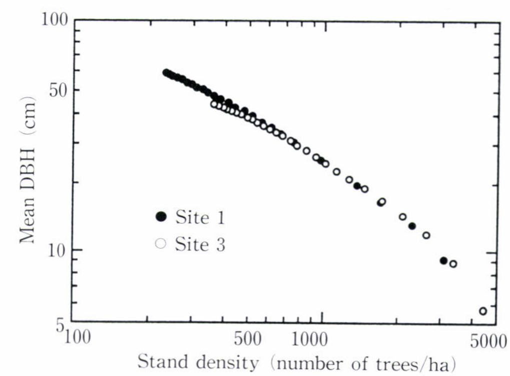

Fig. 3 Relationship between stand density and mean DBH in the sugi (*Cryptomeria Japonica*) yield tables of the Kumamoto district

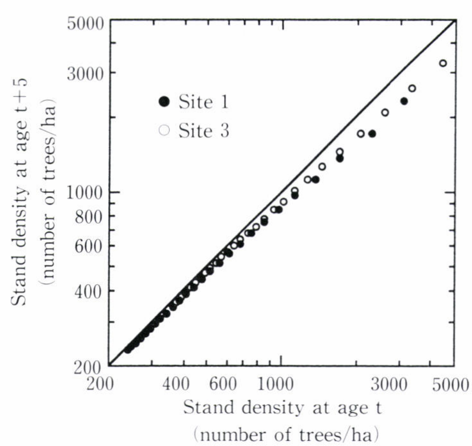

Fig. 2 Difference diagram for decrease in the numbers of trees in the sugi (*Cryptomeria japonica*) yield tables of the Kumamoto district

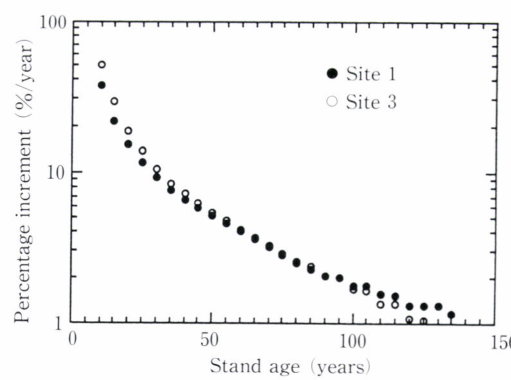

Fig. 4 Percentage increment of mean DBH in the sugi (*Cryptomeria japonica*) yield tables of the Kumamoto district

parameter b and site. The following equation was derived to model the decrease in the number of trees.

$$N = \exp(a(1 + b\exp(-0.02514\,t))) \quad (9)$$
$$a = 5.302 + 0.2114\,S$$
$$b = 0.6199 - 0.02936\,S$$

where N: stand density (number per hectare), t: stand age (years) and S: site (1 - 3)

Relationship Between Stand Density and Mean DBH

The relationship between stand density and mean DBH is shown in Fig. 3. The relationships of both site 1 and site 3 were close to linear, except at very high density and very low density. This differed from SHIRAISHI's findings (1983), but does not cause problems if the period to be modelled is limited.

The following equation was calculated using data to 100-years of age from the original yield tables. Parameter a and K also had linear relationship with site.

$$\log N + a \log D = K \quad (10)$$
$$a = 1.479 - 0.08305\,S$$
$$K = 5.026 - 0.1111\,S$$

where N: number of trees (number per hectare), D: mean DBH (cm) and S: site (1 - 3).

This equation can be referred to as the "Stand density control reference curve" for sugi stand in the Kumamoto district.

Percentage Increment of Mean Diameter

Percentage increment of mean DBH in the original yield tables is shown in Fig. 4. The percentage increments were calculated as follows.

$$r = ((De/Db)^{1/T} - 1) \cdot 100 \quad (11)$$
$$Db = Dm$$
$$De = (Dm \cdot Nm + Ds \cdot Ns)/(Nm + Ns)$$

where r: percentage increment (%/year), T: calculation period (years), De: mean DBH at the end of the period (cm), *Db*: mean DBH at the beginning of the period (cm), *Dm*: mean DBH of main trees (cm), *Ds*: mean DBH of sub trees (cm), *Nm*: number of main trees (number per hectare) and *Ns*: number of sub trees (number per hectare).

As Fig. 4 shows, the percentage increment declined steeply to age 35, continued to decline steadily until age 100 and then declined more gently. This result also differed from SHIRAISHI's findings (1983), probably because the growth of Sugi in this district is very fast, especially while the trees are young. The cutting period in this district is normally 40 to 60 years or 80 years at the most. Therefore, the calculation period for these equations should be limited to under 100 years old.

Therefore, the parameters of the equations were calculated for two periods, under 40 and from 40 to 100 years of age. Although there were correlations between parameter m and site, and between parameter k and site in the earlier period, there were no correlations between parameters and site in the later period.

$$r = m \exp(-kt) \quad (12)$$

Stand age under 40 years old.

$$m = 6.151 + 1.6030\,S$$
$$k = 0.04448 + 0.003631\,S$$

Stand age from 40 to 100 years old

$$m = 3.074$$
$$k = 0.02209$$

where r: increment percent of mean DBH (%), t: stand age (years) and S: site (1 to 3).

Parameter p of the Growth Model

The data from the permanent plots listed in Table 1 and equation (7) were used to compile a frequency histogram of the calculated parameter p, shown as Fig. 5. The histogram was roughly normal and the mean was 2.808. Hence, parameter p for the period up to age 40 was estimated to be 2.808. For the period from 40 to 100 years of age, parameter p was estimated to be 0.8453.

Parameter p represents the effect of the difference between the actual stand condition and the stand density control reference curve. The parameter p in the older period was much less than in the younger period. This suggests that the effect of stand density on DBH growth is less in the older period than in younger period.

The growth model of mean DBH, which is the main growth model in LYCS, was then compiled as follows.

$$r = m \exp(-kt) + p(K - \log N - a \log D) \quad (13)$$
$$a = 1.479 - 0.08305\,S$$
$$K = 5.026 - 0.1111\,S$$

Stand age under 40 years old.

$$m = 6.151 + 1.6030\,S$$
$$k = 0.04448 + 0.003631\,S$$
$$p = 2.808$$

Stand age from 40 to 100 years old

$$m = 3.074$$
$$k = 0.02209$$
$$p = 0.8453$$

where r: Percentage increment of mean DBH (%), t: stand age (years), N: stand density (number per hectare), D: mean DBH (cm) and S: site (1 to 3).

In this model, several parameters respond linearly to site. Therefore, decimal representation of site, such as 1.5 or 2.5, may be convenient for practical use.

Prediction of Diameter Distribution

LYCS can also predict DBH distribution. If data about diameter distribution is not available, LYCS assumes an initial Weibull distribution. If data is available, however, LYCS can predict diameter distribution using actual data as the initial distribution.

The prediction of diameter distribution is as follows. First, the growth model for diameter increment, equation (5) or (13), predicts the mean diameter at the end of a period. Then the LYCS program searches for the diameter distribution whose mean is closest to the predicted mean diameter by stepwise changing of the parameters in trans-

Table 1 Permanent plots in the Kumamoto district

Plot name	Stand age at mensuration
Kikuchi suigen	31,36,41
Kikuchi fukaba	66,71,76
Koishihara	30,35,40,45
Saigo onsen	21,26,31,36
Teradoko 1	27,32,37,42
Teradoko 2	25,30,35,40
Mizunashihira	20,25,30,35,40,45
Kawazoe	22,27,32,37
Seburiyama	64,69,74

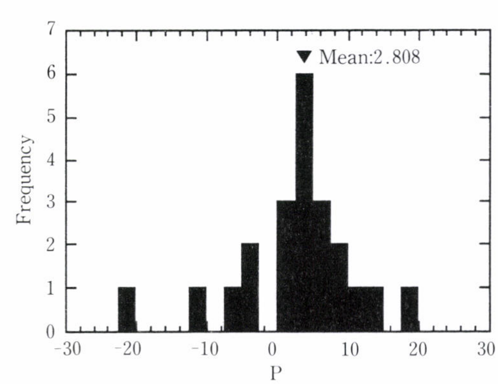

Fig. 5 Frequency distribution of parameter p calculated from the permanent plot data

formation equation (6).

The processing and algorithm of the LYCS program is practical and suits computer calculation, and was therefore used in this study.

CONSTRUCTION OF YIELD TABLES AND GOODNESS OF FIT

Construction Yield Tables

The LYCS for sugi in Kumamoto was developed by replacing the original equations and their parameters with the ones derived above. To evaluate it, three different yield tables were constructed for different density control plans.

Table 2 shows a yield table for the same density control plan that was the basis of the original yield table for Sugi in the Kumamoto district. Predicted DBH growth was very similar to the original table, and this shows that the yield predicted by LYCS will follow the original table if the management follows the same stand density control reference curve, i.e. the standard density control plan.

Table 3 and 4 show predictions of DBH growth when thinning is conducted three times. In Table 3, the density control was assumed to be normal and in Table 4 it was assumed to be heavy.

The predicted DBH growth curves under each plan are shown in Fig. 6. The figure shows that different density control plans affect DBH growth, in a way which matches the common sense of forest managers.

Prediction of DBH Distribution and Goodness of Fit

Fig. 7 shows the predicted and observed DBH distributions. The broken line shows the observed distribution at 34-years of age, and the thin line shows the distribution at 41-years of age in same district. The thick line shows the distribution at age 41 predicted using the 34-year-old distribution as an initial value.

The predicted distribution was a little different to the

Table 2 Yield table constructed by LYCS for standard density control systems for sugi (*Cryptomeria japonica*) stands in the Kumamoto district
Note: The density control plan is the same as the original yield table for sugi in Kumamoto district.

Site:2

	Main stand					Thinned trees						Total					
Age (years)	Mean DBH (cm)	Height (m)	Basal area (m^2/ha)	Stand density (number of trees/ha)	Volume (m^3/ha)	Mean DBH (cm)	Stand density (number of trees/ha)	Thinning ratio (%)	Basal area (m^2/ha)	Volume (m^3/ha)	Cumulative volume (m^3/ha)	Stand density (number of trees/ha)	Basal area (m^2/ha)	Volume (m^3/ha)	Total volume (m^3/ha)	Current annual increment (m^3/year)	Mean annual incremant (m^3/year)
10	7.9	5.4	20.2	3,906	63.3							3,906	20.2	63.3	63.3		6.3
																16.4	
15	11.4	7.5	28.3	2,661	117.5	8.5	1,245	31.9	7.3	27.8	27.8	3,906	35.6	145.3	145.3		9.7
																18.6	
20	15.0	9.3	35.6	1,965	175.3	11.7	696	26.2	7.6	35.1	62.9	2,661	43.2	210.5	238.3		11.9
																20.2	
25	18.3	11.0	42.3	1,564	239.8	14.7	401	20.4	6.8	36.5	99.4	1,965	49.0	276.3	339.2		13.6
																18.9	
30	21.3	12.6	47.6	1,306	296.5	17.6	258	16.5	6.2	37.6	137.0	1,564	53.8	334.2	433.6		14.5
																18.0	
35	23.9	14.0	51.3	1,123	349.3	20.0	183	14.0	5.8	37.2	174.2	1,306	57.1	386.6	523.7		15.0
																15.7	
40	26.0	15.4	53.3	983	389.9	22.1	140	12.5	5.6	38.1	212.3	1,123	58.9	428.0	602.3		15.1
																16.4	
45	28.1	16.7	55.0	873	434.0	24.1	110	11.2	5.2	38.0	250.3	983	60.2	472.1	684.5		15.2
																15.1	
50	29.7	17.8	61.4	873	509.6							873	61.4	509.6	760.1		15.2
																15.2	

Table 3 Yield table constructed by LYCS under an ordinary thinning regime for sugi (*Cryptomeria japonica*) stands in the Kumamoto district

Site:2

Main stand						Thinned trees						Total					
Age (years)	Mean DBH (cm)	Height (m)	Basal area (m^2/ha)	Stand density (number of trees/ha)	Volume (m^3/ha)	Mean DBH (cm)	Stand density (number of trees/ha)	Thinning ratio (%)	Basal area (m^2/ha)	Volume (m^3/ha)	Cumulative volume (m^3/ha)	Stand density (number of trees/ha)	Basal area (m^2/ha)	Volume (m^3/ha)	Total volume (m^3/ha)	Current annual increment (m^3/year)	Mean annual incremant (m^3/year)
10	7.9	5.4	20.2	3,906	63.3							3,906	20.2	63.3	63.3		6.3
																16.4	
15	10.5	7.2	35.6	3,906	145.3							3,906	35.6	145.3	145.3		9.7
																23.7	
20	14.0	9.1	42.8	2,661	215.4	10.1	1,245	31.9	10.3	48.3	48.3	3,906	53.0	263.7	263.7		13.2
																20.2	
25	16.2	10.5	57.4	2,661	316.4							2,661	57.4	316.4	364.7		14.6
																23.8	
30	18.9	12.2	57.3	1,965	359.8	15.1	696	26.2	12.9	75.8	124.1	2,661	70.2	435.6	483.9		16.1
																18.7	
35	20.4	13.5	66.7	1,965	453.1							1,965	66.7	453.1	577.2		16.5
																18.3	
40	22.1	14.9	62.2	1,564	465.6	18.4	401	20.4	11.3	78.9	203.0	1,965	73.5	544.4	668.5		16.7
																17.9	
45	23.4	16.1	69.7	1,564	555.2							1,564	69.7	555.2	758.1		16.8
																18.9	
50	24.6	17.3	77.0	1,564	649.6							1,564	77.0	649.6	852.6		17.1
																17.1	

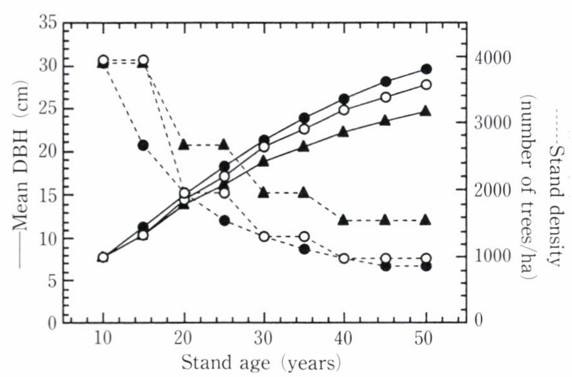

Fig. 6 Predicted diameter growth under different density control plans

● A standard density control plan of the original yield table

▲ Three heavy thinnings

○ Three standand thinnings

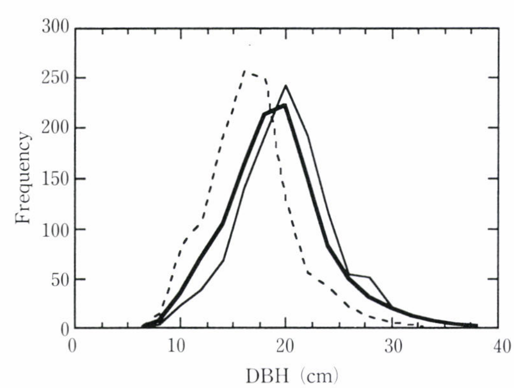

Fig. 7 Predicted and observed DBH distribution curves

━ Predicted at age 41.

── Observed at age 41.

- - - - Observed at age 34.

Table 4 Yield table constructed by LYCS under a heavy thinning regime for sugi (*Cryptomeria japonica*) stands in the Kumamoto district

Site:2

	Main stand					Thinned trees						Total					
Age (years)	Mean DBH (cm)	Height (m)	Basal area (m^2/ha)	Stand density (number of trees/ha)	Volume (m^3/ha)	Mean DBH (cm)	Stand density (number of trees/ha)	Thinning ratio (%)	Basal area (m^2/ha)	Volume (m^3/ha)	Cumulative volume (m^3/ha)	Stand density (number of trees/ha)	Basal area (m^2/ha)	Volume (m^3/ha)	Total volume (m^3/ha)	Current annual increment (m^3/year)	Mean annual incremant (m^3/year)
10	7.9	5.4	20.5	3,960	64.2							3,960	20.5	64.2	64.2		6.4
																16.6	
15	10.5	7.2	36.1	3,960	147.1							3,960	36.1	147.1	147.1		9.8
																23.9	
20	14.6	9.3	34.1	1,965	173.9	10.9	1,995	50.4	19.5	92.5	92.5	3,960	53.6	266.4	266.4		13.3
																18.1	
25	17.2	10.8	47.2	1,965	264.4							1,965	47.2	264.4	356.9		14.3
																20.7	
30	20.4	12.6	44.3	1,306	278.7	16.9	659	33.5	15.0	89.3	181.8	1,965	59.2	368.0	460.6		15.4
																17.1	
35	22.5	13.9	53.4	1,306	364.1							1,306	53.4	364.1	546.0		15.6
																16.5	
40	24.8	15.4	48.7	983	361.4	21.4	323	24.7	12.1	85.1	266.9	267	60.8	446.6	628.5		15.7
																15.5	
45	26.3	16.6	55.1	983	438.9							983	55.1	438.9	705.9		15.7
																15.6	
50	27.8	17.7	61.5	983	516.8							983	61.5	516.8	783.8		15.7
																15.7	

observed one, but the goodness of fit may be sufficient to allow this method to be used for prediction.

CONCLUSION

It was found that the SHIRAISHI method and LYCS could be applied satisfactorily to sugi in the Kumamoto district. Some models and equations needed to be modified to be practical, but this did not change the fundamental structure of LYCS.

This study proved that the SHIRAISHI method and LYCS is flexible and practical. If there are existing yield tables and data for stand growth is available, LYCS may be used to easily develop dynamic growth models for yield tables.

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My thanks are due to Dr. Norihiko SHIRAISHI for providing original LYCS program and helpful suggestions, and successive staff of the Forest Management and Economics Laboratory of Kyushu Research Center, Forestry and Forest Products Research Institute, for continuous mensuration of the permanent plots that provide data for the parameter in the main model.

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