Japanese Forestry and Forest Harvesting Techniques

With emphasis on the potential use of Japanese harvesting techniques on steep & sensitive sites in Ireland

A.

B.

By Myles Mac Donncadha
Iwate University,
March 1997

COFORD
NATIONAL COUNCIL FOR FOREST RESEARCH & DEVELOPMENT

Foreword

This report marks a watershed in the dissemination of forest research information. It is the first publication of a research project, which has been partially funded by COFORD under the Operational Programme for Agriculture, Rural Development. Being also available on the internet brings the information it contains to a much wider audience and, hopefully, makes some contribution to the international issue now facing all foresters, how to grow and harvest wood in an economic manner that is sustainable and without conflict to the environment.

That this report contains a description of harvesting techniques as practised in Japan is indicative of the value of information sharing to address issues of common concern. It is an example of the good co-operation that exists in matters of international forestry and the common need to encourage an environment of knowledge seeking and knowledge sharing among our young scientists. Developing a better understanding of technical issues also promotes an appreciation of the social and cultural links between Ireland and Japan.

We owe the Japanese government, in particular their department of education our sincerest thanks for the opportunity it provided for an Irish scientist, Myles Mac Donncadha, to visit and study aspects of cable harvesting systems. The information Myles gathered during his stay in Japan is already helping Irish foresters to reassess the cable extraction concept for use in environmentally sensitive areas and in locations where ground based equipment is not appropriate.

We hope that the work that Myles has done will help more Irish foresters to consider the message he brings and that this report will act as a stimulus to adopt those practices considered appropriate to the Irish scene. Opening up new knowledge sources is the task of researchers, utilising that knowledge is the challenge to practitioners. COFORD asks that the challenge be accepted.

Fergal Mulloy
Director
November 1997

Summary

Forests cover 67% of Japan's total surface area; a surprisingly high figure for such a populous and industrialised nation. The country is five times larger than Ireland and has 123 million inhabitants, resulting in a population density which is roughly six times that of Ireland. How then, does it boast one of the developed world's highest forest area percentages? The answer lies in gaining an understanding of Japan's forest culture - a symbiotic relationship which has evolved between the Japanese and their mountains, water courses, and forests over thousands of years.

Located at the point of conflict of numerous tectonic plates, the archipelago of 3,300 islands is subject to constant volcanic and geological change. Seventy-five percent of the area is classified as mountainous or hilly, of which area 80% has a slope of 20^{o} or more. The climate ranges from sub-tropical to cool temperate with high annual rainfall (up to 10,000 mm) and a distinct summer rainy season. As the soils are light and friable erosion is a constant threat. Forestry has long been recognised as a tool in the control of erosion, flooding and drought. Historically, forests also provided fertilising materials, fuel and a regular water supply for the farming community (Anon., 1991).

Forests now occupy 25 million ha of which 41% is man-made and 54% natural forest, the remainder being unplanted or unplantable. The man-made forest hails largely from post-war planting efforts and 80% is less than 35 years old. Japanese cedar (*Sugi*) and cypress (*Hinoki*) are the main species in these areas with broadleaf species accounting for just 2% of the man-made forest area. The average growing stock of natural forests is low at 114 m^3/ha, reflecting its poor quality and age composition. The wide variety of species here include oaks, beeches and pine.

Ownership is 58% private, composed of some 2.8 million separate entities, the majority of whom have holdings which are less than 5 ha in size. Larger, more remote, mountainous forests tend to be publicly or company owned while smaller, more accessible plots are likely to be held by individuals. Local authorities or prefectural governments own 11% while the National Forest Agency owns the remaining 31%. Fully one third of the National Forest is designated as protected or protection forest. Eighty-four percent of the private forest area is managed by forest owners' associations which collectively undertake forest operations and the marketing of forest products for association members.

The forest resource is huge and the forest culture runs deep with the Japanese but in recent years the economic viability of the industry has come into question. The National Forest Agency has been in debt since 1975 and by 1994 this totalled over ¥3 trillion, roughly equal to the Irish GNP. Current Agency cutbacks include reducing the workforce from 70,000 to 10,000 and the highly controversial sale of 100,000 ha of forest land. In what may be a move to help balance its books the Agency has recently been promoting the provision of intangible forest products as its principal *raison d'etre*. Its troubled finances are typical of the difficult conditions facing the entire forest industry.

The fall in timber self-sufficiency, or ratio of domestic to imported wood in national consumption, is identified as the most obvious symptom of the current so-called "stagnation" of the forest industry. In 1955 the percentage of total domestic demand catered for by domestic timber was 94% but by 1995 this value had dropped to 22%. The kernel of the problem is the relaxation of tariffs and other restrictions on timber importation, compounded by high domestic labour costs. The opening up of trade has revealed the high cost, highly labour intensive nature of Japanese forestry and exposed it to large-scale importation of cheaper timber. In the two decades to 1992 the average internal rate of return from *Sugi* plantations has reduced from 6.5% to 1.7%. High labour costs are due to an aging workforce, high incidence of accidents and a certain catching-up effect necessary to reach pay levels in line with other primary industries. These costs, coupled with poor market conditions due to the influx of cheap imports are stagnating the domestic timber market. In today's economic climate clearfelling a mature stand may not in fact return a profit due to high crop re-establishment costs. Figure A clearly illustrates the unfavourable conditions currently prevailing in the industry (Anon., 1994) .

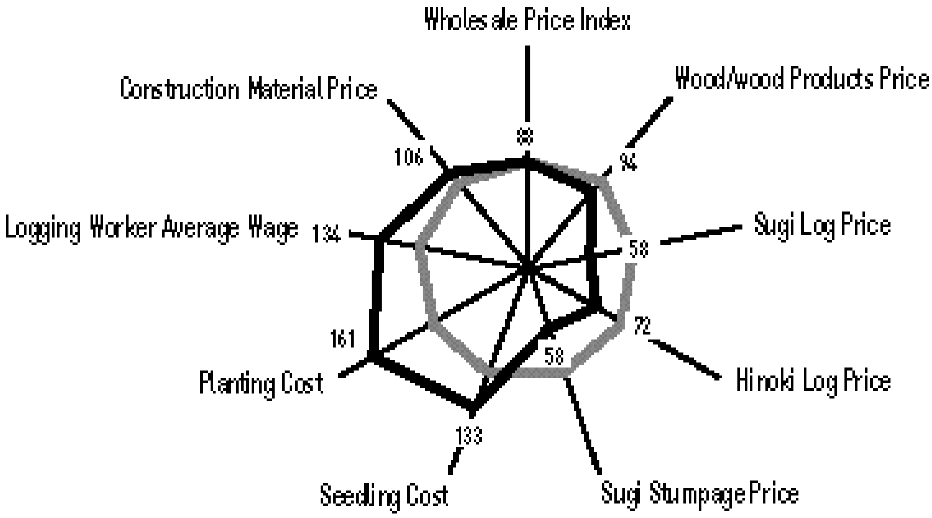

Figure A: Changes in forest economy indicators (1992 against 1980 = 100)

Annual harvesting volume is about 25 million m^3, just one third of the annual increment, while half the thinning volume is left in the wood due to the expense of further transport or processing. Ninteen-ninety two figures show that harvesting volume production on a per man-day basis was just 25% that of Sweden. The problem of forest mechanisation is being tackled vigorously and numerous low cost mechanical systems have been developed. Some of these, such as the tower yarder, self-propelled carriage, monocable and swing yarder may have useful application in Ireland. Having been sheltered for too long by prices which were out of touch with world trade, the processing sector is currently undergoing a period of severe “shake-out” with bankruptcies amounting to £1 billion in 1995. Other than those processing imported timber at the dockside, sawmills are small scale and undercapitalised. Distribution methods too are outmoded and average forest road density is low at 12 m/ha.

The physical reality of conducting forestry on Japan’s steep slopes will always be a handicap when attempting to beat imports on price. Only significant improvements in roading, mechanisation, timber distribution and processing will tip the scales in Japan’s favour.

Acknowledgements

I would like to thank the following: The department of education of the Japanese Government for making possible my visit to Japan, Professor Masao Shishiuchi for accepting me as a research assistant into his laboratory and for his great generosity and support while there, Associate Professor Shiro Tatsukawa and Masters student Akihiro Uwabe and all the fourth year students in the Forest Operations and Techniques laboratory for their friendship and practical help, Professor Jun'ichi Gotou of Kochi University and finally, COFORD, for helping fund this report.

The author may be contacted at:
‘Belgrave Mews’,
39a Seapoint Avenue,
Monkstown,
Co. Dublin
Ireland.
Tel: +353 1 280 7176
e-mail: mylesmcd@indigo.ie

Preface

This report has two aims;

1) a brief introduction to Japanese forestry, its composition, ownership and management and

2) a more in-depth review of current Japanese forest harvesting systems and equipment, with an emphasis on their relevance to application in Ireland on steep or sensitive sites.

The author visited Japan from October 1995 to March 1997 with the assistance of a Monbusho scholarship from the Japanese Government. After completing an intensive five month Japanese language course he worked for one year at Iwate University in northern Japan as research assistant to Professor Masao Shishiuchi, Chair of Forest Operations and Techniques. During this time the author conducted four field studies of forest machinery, made 20 field trips to inspect management, harvesting and utilisation systems, presented one paper at a national forest mechanisation meeting (in press), attended three forest machinery demonstrations and visited four university and national forest machinery research facilities.

Table of Contents

PART ONE: FORESTS AND FORESTRY IN JAPAN

1 General Description

1.1 Forest Resources

Japan's forest area covers over 25 million ha, or 67% of the total land area. Roughly 10.3 million ha or 41% of this is man-made and 13.4 million ha or 54% is natural forest (Anon., 1994). During the 35 years between 1960 and 1995 the total forest area has changed little although the man-made forest area has increased by 31% at the expense of the natural forest. The growing stock has increased by 89% to 3 billion m^3 during the same period and the current annual increment is 76 million m^3.

1.2 Man-made Forests

Much of the 10 million ha of Japan's man-made forest was established during an afforestation drive undertaken following World War II and now accounts for 51% of the growing stock, of which 80% is less than 35 years old. *Sugi* or Japanese red cedar (*Cryptomeria japonica*), *Hinoki* cypress (*Chamaecyparis obtusa*), Japanese Larch (*Larix kaempferi*) and various pine species comprise 98% of the area. Among these species, *Sugi* and *Hinoki* produce high quality, rot resistant timber and are the major plantation species. *Sugi* makes up 44% of the total man-made forest area and grows best on moist and fertile soils while *Hinoki* accounts for 24% and prefers drier sites. Afforestation using broadleaved trees has not been as aggressive and they cover just 2% of the man-made forest area.

The age profile of man-made forests (Figure 1) reflects the post-war boom in planting and subsequent slow-down in recent times (Anon.,1993).

At present there is an emphasis on longer rotations and multi-storey forestry; developments which will make even less land available for planting in the future and further increase forest "abnormality". The processing and harvesting sectors will in future find it difficult to scale their investment in line with raw material availability.

The long time dominance by *Sugi* of afforestation has been criticised recently as environmentally insensitive. This is partly because poor quality, natural broadleaf forest was often cleared to make way for the more profitable cedar monoculture. The removal of material for charcoal and firewood was most intense around population centres and so extensive areas of *Sugi* are now found adjacent to these urban areas. This has brought with it an additional environmental objection, albeit from an unexpected source. Due to the age profile of these stands and poor market conditions an unprecedented amount of mature *Sugi* stands are remaining uncut. The result has been the annual release of large amounts of cedar pollen into the air around these cities, provoking an allergic reaction in 1 in 10 of the population. At its peak, clouds of pollen can be seen descending on Tokyo, where there are electronic billboards, TV forecasts and telephone hotlines devoted to monitoring the pollen threat.

The allergy has only reached prominence in the last ten years, coinciding with the maturation of vast tracts of *Sugi*.

The National Forest Agency is currently being sued to force change in its afforestation policy in this regard (Stengold, 1995).

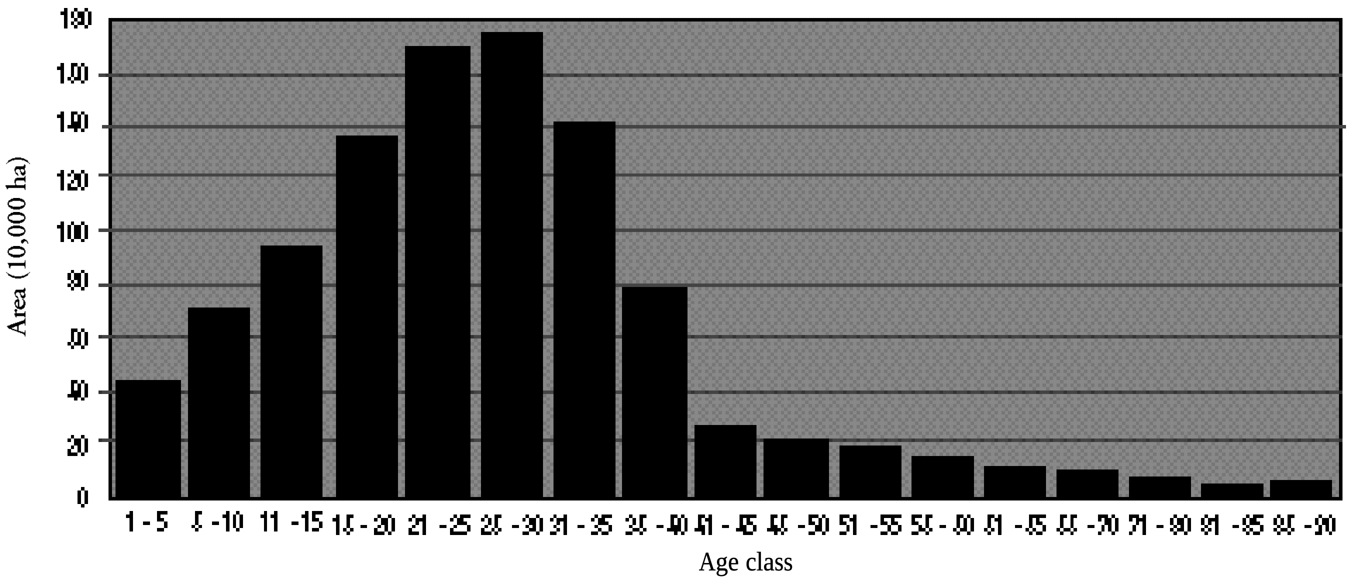

Figure 1: Man-made forest area by age in 1985

1.3 Natural Forests

Japan has approximately 13.5 million ha of natural forests, accounting for 54% of the total forest area (Anon., 1994). Its growing stock is 1538 million m^3, 49% of the total. The average growing stock volume of natural woodlands is low at 114 m^3/ha, reflecting its poor quality and age composition. About 50% of the natural forest area is composed of stands under 50 years old due to the fact that broadleaved trees were widely use for fuelwood and charcoal production in the past (Gotou, 1996a). The climax vegetation of Japan is mainly forest, reflecting the warm, wet, monsoon climate. The species vary greatly from region to region as the country's individual climatic zones range from sub-tropical to sub-arctic due to its long shape and northeast-southwest orientation. Species diversity is further enhanced by the country's central spine of mountain ranges, some reaching altitudes of over 3000 m. Mature natural forests (Figure 2) are generally found in remote locations or less developed areas of the country and are now often designated as protection forests or national parks. The main natural forest types include Kashi (*Quercus* spp.) forest, Akamatsu (*Pinus densiflora*) forest, Konara (*Quercus perrata*) forest and *hinoki* (*Chamaecyparis obtusa*) forest (Anon., 1991).

1.4 Geology and Topography

The Japanese islands, lying adjacent to the Asian continent's east coast, have been subject to frequent crustal movements since the Paleozoic era and have had volcanic activity since the Cenozoic era, producing about 200 volcanoes of varying sizes, some of which are still active. New and old volcanic material thus covers a wide area, leading to unstable and easily eroded soils. These areas are sharply dissected by rivers of all sizes and the mountain slopes are generally very steep. This turbulent geological activity also resulted in the fact that 75% of the total Japanese land area is classed as mountainous or hilly (Handa, 1988) with 60% of the forest land area classified as having a slope of 20° or more.

Figure 2: Natural mixed forest of *Picea jezoensis* and *Abies sachalinensis* in Hokkaido, northern Japan

2 Forest Ownership

2.1 Forest Ownership

The forests of Japan can be classified by ownership into three categories, namely private, public and national (Table 1). Private forests, with a total area of 14.6 million ha (58% of the forest area) are owned by 2.8 million or more separate bodies including individuals (88% of total), corporations, shrines, temples, etc.. A large majority (Figure 3) of the 2.5 million individual owners' holdings are less than 5 ha in size (average is 2.6 ha) and standards and intensity of management vary widely (Gotou, 1996).

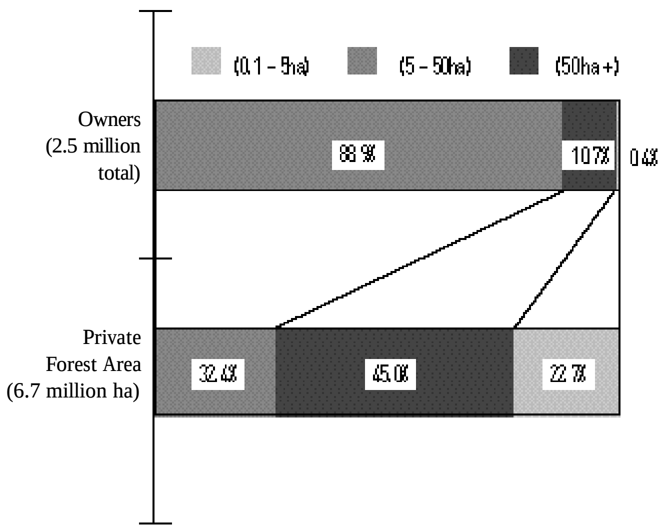

Figure 3: Forest ownership by number and size. (Source; Ministry of Agriculture, Forestry and Fisheries)

The 2.7 million ha of public forests are owned by local authorities and prefectural governments. Public forests are those which are controlled by non-national public organisation such as local government. They are often managed with particular emphasis on the public functions and services which these areas can offer. So also are the National forests, the 7.6 million ha under the jurisdiction of the Forestry Agency of the Ministry of Agriculture, Forestry and Fisheries.

2.2 Forest Owners' Associations

The private sector is dominated by a large number of small forest owners. In an effort to improve the communication, cooperation and the overall competitiveness of the industry forest owners' associations have been formed (Table 2). Through an agreement with each forest owner these associations advise on forest management, undertake forest treatment work (including the purchase of all necessary materials) and market forest products.

Table 1: Forest resources by ownership. Percentages are in brackets

		Total area		Man-made forest		Natural forest		Unproductive land	
				(000 ha)					
Total		25212	(100)	10327	(100)	13523	(100)	1363	(100)
National forest	Total	7861	(31)	2466	(24)	4728	(35)	667	(50)
Forestry Agency		7654	(30)	2439	(24)	4596	(34)	619	(46)
Others		207	(1)	27	(0.3)	133	(1)	48	(4)
Public & private forests	Total	17351	(69)	7861	(76)	8795	(65)	6956	(55)
Public		2700	(11)	1188	(11)	1402	(10)	110	(9)
Private		14651	(58)	6673	(66)	7393	(55)	586	(46)

Table 2: Forest Owners' associations profile and performance in 1995 (Anon., 1996a)

Item	Value	Remarks
Number of assoc.	1571	
Membership	1.7 million	
Forest area	11.5 million ha	84% of private forest area
Turnover (1993)	¥394 billion	IR£2.0 billion
Log production (1993)	3.3 million m^3	19% of log production from private forest
Planted area (1993)	37,500 ha	79% of total was private planting
Workforce (1993)	37,693	

As Japanese forestry continues to struggle in a highly competitive environment the role of forest owners' associations is becoming increasingly important. Three quarters of the associations employ their own workers and are regarded as promoters of forestry in their regions. The government has recently been encouraging their amalgamation to improve management efficiency.

It should be noted that although 84% of the private forest area is controlled by the forest associations they account for only 19% of the log production from private forestry. It is the larger independent owners who produce the majority of the timber although they seem to be doing little of the reforestation. The future viability of production forestry is likely to require that these forest associations play a greater role.

2.3 National Forests

About 7.86 million ha, equivalent to 21% of Japan's total land area or 31% of the forest area, are designated as National Forests and managed by the National Forest Agency. Recently, there has been heavy emphasis on the use of these forests to provide various public benefits. Today one third of this forest area is given over to protection functions where limited clearcutting and obligatory replanting are just some of the management restrictions (Table 3).

Table 3: Role of National Forests. Figure in brackets is area in 1000 ha

Public benefits	Area of Protection Forests; 3.98 million ha, (52%) 779 Protected Forests (382) 21 Forest Biosphere Reserves and two World Heritage Sites (233) 1277 Recreation Forests (411); 190 million visitors in 1993
Wood supply	About 23% of domestic wood is supplied from national forests
Contribution to rural development	25% of national forests are used by local people as profit sharing forests, community forests, rental forests, etc.
Extension & education	Six Forest Centres nationally conduct training courses.

The National Forest Agency is in acute financial difficulty. Following years of subsidisation of afforestation, the influx of imports, and high labour costs the agency began to record debts in 1975. In fiscal 1994 cumulative debts topped ¥3 trillion (IR£16 billion); close to Ireland's Gross Domestic Product. Five hundred million yen is required daily in interest payments alone. In cutback measures the agency's workforce, which once exceeded 70,000, is being reduced to 10,000. It is also extending the rotation age on much of its forest to avoid expensive re-establishment and silvicultural treatment costs. Perhaps most controversial however, has been the sale and lease of state-owned forest. In 1991 it was announced that over 20 years 100,000 ha would be sold in an effort to raise ¥800 billion. To date it has sold 13,000 ha and leased about 14,000 ha for the development of skiing and golfing facilities. The agency has refuted claims that much of the land which is sold is later preserved as public forest parks. Statistics show however, that of the land sold in fiscal 1994, 60% was converted into farmland or built upon (Ishida, 1996).

In the current climate of low domestic timber sales and general stagnation in Japanese forestry the agency is attempting to maintain support by repositioning itself as a:

- provider of protection forest, especially for water-conservation,
- guardian of forest resources on a global scale,
- maintainer of a large carbon sink to aid in the problem of global warming,
- promoter of biodiversity through the introduction of multi-storied forestry,
- provider of sites for recreation and amenity.

3 MANAGEMENT POLICY

3.1 Forest Types

For management policy purposes there are three basic types of forest. Protection forest, which is used in various ways to protect other natural resources, the public and its property from the adverse affects of Japan's weather and unstable soils. Protected forest however, has the additional role of preserving unique habitats and areas of ecological value. Other forest areas are available for commercial exploitation, subject to certain restrictions.

3.2 Multiple-use Benefits

The appreciation of forestry as a source of diverse non-timber benefits has been widening and deepening among the Japanese. This is reflected in the "National Survey Concerning Forests and Greenery" in which the percentage of respondents wishing to participate in "nurturing the forest" grew from 53% in 1986 to 66% in 1993. The 1987 "Basic Plan for Forest Resources" recognises the following four aims of forestry in addition to the production function:

1) Prevention of disasters in hilly areas;
2) Conservation of water;
3) Conservation of living environment;
4) Provision of cultural and recreational activities.

Table 4 shows that the estimate of the total annual economic benefit of these functions, excluding the value of the absorption and fixation of carbon dioxide, was US$313.6 billion (IR£202 billion) in 1991 (Anon., 1996a).

Table 4: Estimated economic value of forest functions for public benefit (1991)

Function	Estimated Value billion US$
Headwater conservation	34.1
Soil conservation	63.8
Erosion control	1.4
Public health provision	61.4
Wildlife protection	5.5
Oxygen supply	147.4
Total	313.6

3.3 Protection Forests & Forest-land Development Permission System

Due to the nature of its topography, high precipitation and young geology the concept of forestry serving a protective role is highly developed in Japan. At present 80 million ha, one third of the total forest area, is designated as protection forest. In the summer of 1994 15.8 million people were affected by water shortages and so the role of forestry in headwater conservation is highly valued, forming 73% of the total protection forest area (Anon., 1994). This, plus a further 23% assigned the role of soil run-off prevention, are referred to as "green dam" forests. The remaining 4% is made up of forests with such diverse functions as sea fish protection and fog inflow prevention. Limited tree cutting, restriction of land exploitation and obligatory reforestation after felling are some of the regulations governing these areas.

Forests other than Protection Forests are subject to the Forest-land Development Permission System which prevents the excessive development of forest lands. The development of more than one ha requires permission in advance from the prefectural government. The entire forest planning system was revised recently to designate the watershed as the central unit of management.

3.4 Protected Forests and Forest Biosphere Reserves

In 1989 the Forestry Agency completely revised the protected forest system (established in 1915) when it re-classified the protected forests into seven types. By 1994 there were 779 areas with a total of 382,000 ha designated as protected forest (Anon., 1994). The protected area is comprised of Forest Biosphere Reserves and areas which are protected because of their genetic, vegetation, animal or geological value from an ecological, research or cultural perspective. Two of the Biosphere Reserves have recently been designated as World Heritage Natural Resource sites (Figure 4).

3.5 Forestry Activities

3.5.1 Afforestation and Reforestation

The main commercial forestry species are *Cryptomeria japonica* and *Chamaecyparis obtusa* or *Sugi* and *Hinoki*, respectively in Japanese. They exhibit favourable growth of high quality timber in most parts of the country and their timber commands good prices. Initial planting density depends on final use and varies from 2,500 to 4,000 trees/ha for *Sugi* and 3,000 to 5,000 for *hinoki*. This high planting density is intended to quickly shade out the highly competitive weed vegetation.

The growing season is short and well defined in Japan but growth is lush and weeding is advised once or twice per year for the initial five to six years after planting. Pruning of all stems begins when the tree's diameter at breast height reaches about 10 cm and two or three lifts are performed.

The area afforested and reforested each year has declined from the peak of 433,000 ha achieved in 1955 to the current level of about 50,000 ha/year. This is due to the decrease in suitable areas for afforestation, the shift toward alternative silvicultural systems and the recent decrease in the profitability of forestry, particularly with regard to the relatively high cost of silvicultural treatment (Figure 5). For example, the price index of planting has risen to 929 in 1993 from the base figure of 100 set in 1965 while the stumpage price attainable for *Sugi* has fallen to an index value of 70.

The main species planted in 1992 were *Sugi* (32%) and *Hinoki* (43%) with 7% broadleaved species. *Hinoki* is being favoured in afforestation because of the high quality, "niche" status of its timber, affording it an advantage over *Sugi* when in competition with imports. The longer rotations associated with *Hinoki* is of little concern in this period of low land opportunity cost.

Figure 5: The predominance of steep slopes makes for a demanding physical environment for an aging workforce

3.5.2 Thinning

In 1992 the Forest Agency declared that nationally, 4.7 million ha needed thinning, of which 30% was "in urgent need" of treatment. The government has introduced a "Thinning Promotion Project" not only to financially support thinning itself but also to aid in the construction of roads and timber processing facilities for thinning material. During the years 1992, 1993 and 1994 a total of 0.67 million ha were thinned. The 1994 thinning harvest was 3.48 million m^3, equivalent to just 14% of the total harvested volume. Unfortunately, the high cost of further transport and processing has meant that a high proportion (51%) of this material was thinned to waste.

Initial stocking is high and so thinning is necessary to allow the correct redistribution of increment. Due to the heavy rainfall and light, unstable soils common to the country, thinning is also

Figure 4: Shirakami-sanchi World Heritage Natural Resource, northern Japan

practised to admit additional light to the forest floor, allowing ground vegetation to flourish and thus stabilise the soil structure. One further reason for thinning is that crown breakage may occur due to heavy winter snowfall and high winds acting on the dense, even canopies of unthinned stands. Ideally, thinning is practised three to four times before clearfelling.

3.5.3 Clearfell

In 1992, the most recent year for which there are data available, the clearcut area was 2 millon ha or just 8% of Japan's total forest area, contributing 91% of the total cut volume. The area reforested in the same year was recorded as 53,311 ha. The disturbing disparity between forest area felled and restocked reflects the relatively low income attainable from harvesting domestic timber and the high cost of reforestation. Figure 6 shows the strong relationship between these values and the area reforested each year. In some cases the decision not to reforest may be due to the cost of reforestation exceeding the income received from the felled timber. For this reason current policy is to extend the normal *Sugi* rotation age of about 60 years to 100 years. An additional disincentive for redevelopment is that in Japan's current climate of very low interest rates the opportunity cost of idle forest land is low.

3.5.4 Non-wood Forest Products

These products are normally an important source of income, particularly for small forest owners and account for 30% of all forest income. The promotion of this sector is now recognised as one of the driving forces for rural development in mountainous areas. The demand for non-wood forest products has been on the rise in recent years due to an increase in the appreciation of nature and natural products in Japan. Products range from fresh and dried mushrooms to chestnuts and charcoal. A mainstay of this sector however, the Shiitake mushroom (Figure 7), is under severe competition from imports.

Figure 7: The preparation of Shiitake log beds

3.5.5 Road Construction

Due to the mountainous terrain, loose soils, and heavy rain, the construction and maintenance of forest roads is expensive in Japan. By 1994 the total length of all roads used in and around forest blocks was 129,988 km. When restricted to forest roads this corresponds to a density of 4.9 m/ha but when combined with public roads a density of 12.0 m/ha is achieved. At least double this figure is regarded as the minimum necessary for full access. However, road construction has fallen off in recent years due to rising costs. In addition, an estimated £46 million in damage is caused to the nation's forest roads each year by natural disasters such as earthquakes, landslides and tidal waves.

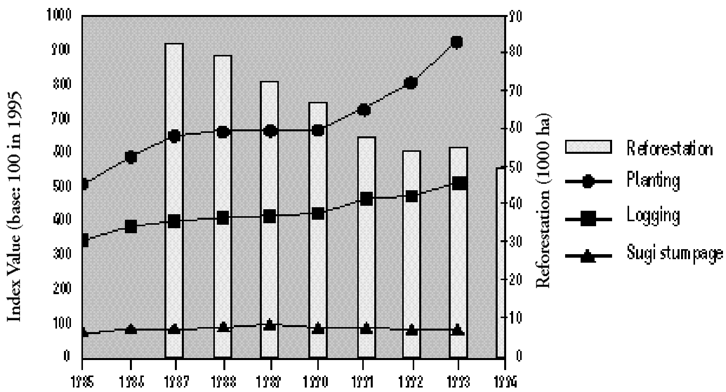

Figure 6: Planting and logging cost *Sugi* stumpage value indices and area reforested

Road construction in mountainous areas can cost over ¥50,000 or £279/m but may be as low as £26/m in easy terrain. Most of the construction cost in steep terrain is in the erection of concrete retaining walls and bridges. Some private owners have established simple road networks with densities up to 200 m/ha on easy terrain and can manage their stands intensively at a reasonable cost.

3.6 Forestry Work Force

The forestry labour force is drawn from such sources as forest owners family members, forestry company employees, owner's associations employees and contractors. These workers are organised into gangs or work as individuals, either on a full-time or part-time basis.

3.6.1 Age Structure Problem

The forestry work force has a serious age structure problem (Figure 8). There were 110,000 forestry workers in 1994, about one quarter of the figure for 1950, of whom 73% were over 50 years of age. Only 211 school leavers entered the forestry workforce in 1994.

The amount of work available varies seasonally and annually and is thus an unstable source of income. Although it has risen in recent years, pay is still low in comparison with other sectors of the economy. On the steep slopes so often encountered in Japan's forests, extreme heat and humidity in summer and snow and severe cold in winter make working conditions difficult.

The irregularity of work due to the stagnation of forestry in recent years has done further damage to the workforce as they attempt to secure stable employment elsewhere.

The "forest culture" of Japan is firmly rooted in its mountain villages, where most of the workforce live. Ever since the post-war economic boom however, these areas have seen large-scale migration of workers to cities and centres of industry. The result has been severe rural depopulation, with the number of mountain villages showing natural attrition (more deaths than births) rising from 29% (of the 1195) in 1981 to 65% in 1991. An effort was made in one progressive forestry region to introduce foreign forestry labour but this met with limited success. The forestry community is a staunchly conservative group and such schemes are likely to be met with little enthusiasm.

3.6.2 Forest Accidents

The trend of the total number of accidents in all industries is showing a decrease but the occurrence of severe injury in forestry was five times that of the all-industry average in 1994 (Figure 9). The severity of accidents has been shown to be linked to the aging forest workforce.

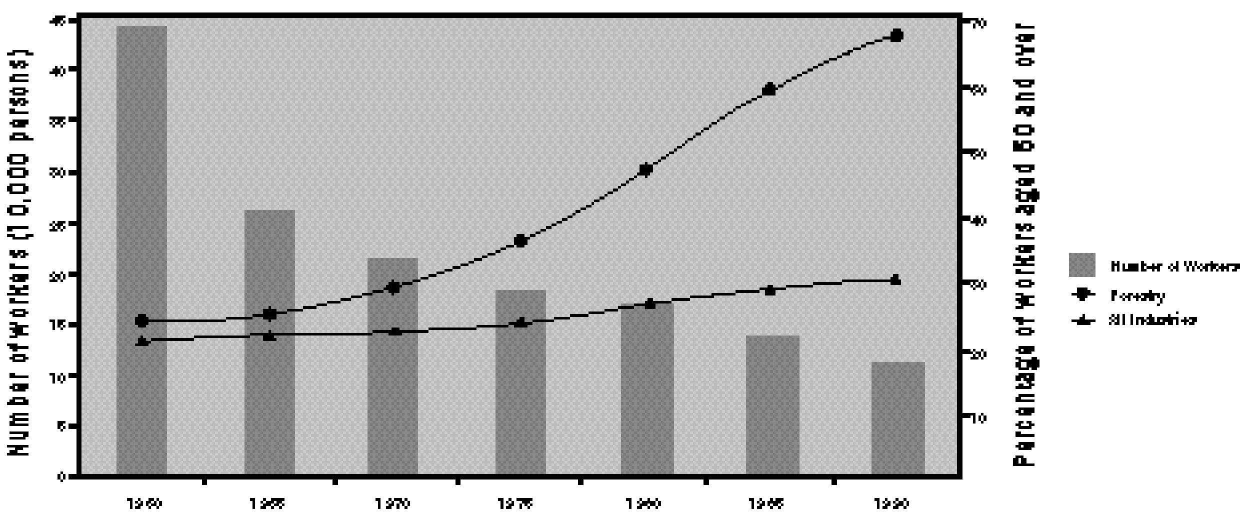

Figure 8: Age structure trend in forest workforce

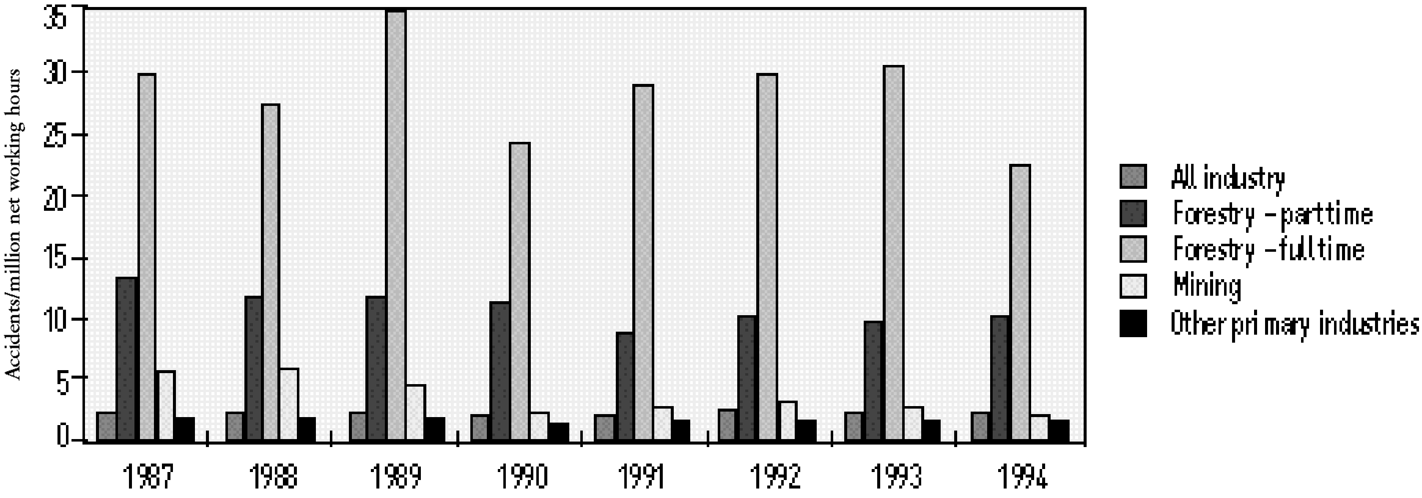

Figure 9: Accident rates in selected Japanese industry sectors

3.7 Support for the Forestry Sector

3.7.1 Government Support

The current government support given to forestry areas is classified into the following four areas:

1. Subsidy programme mainly to support silvicultural treatments, harvesting equipment and the construction of forest roads.
2. Loan programme to support forest management operations and timber processing and marketing. Individuals and enterprises receive low interest loans from government funds.
3. Tax reduction programme to increase net income from forestry and reduce the burden of inheritance tax on forest land.
4. Compensation programme for loans arranged through private financial institutions for forest operations and wood processing and marketing activities.

3.7.2 Forestry Education, Extension and Public Participation

To expand the recognition of the importance of forestry and its many functions, forestry has been introduced as a primary school subject. Wood processing is also covered at junior high school. There are 26 universities, five colleges and 81 high schools which conduct courses relating to forestry. Around 4,000 students receive degrees in forestry every year from these universities and colleges.

A “Forest Instructor Certificate” was introduced in 1991 to train specialists to provide forest visitors with knowledge concerning forests or nature and guidance on forest activities.

A major means by which public participation has recently been secured is through profit sharing contracts with forest owners.

3.8 Research

The Forestry and Forest Products Research Institute (FFPRI) is the single largest, integrated forest research body in Japan (Figure 10). Established in 1905 by the then Ministry of Agriculture and Commerce; it is comprised of seven research divisions, five regional Forest Research Centres and Tama Forest Science Garden in Tokyo, employing 500 researchers in all. The research divisions are forest environment, forest biology, bio-resources technology, forest management, forestry technology, wood chemistry and wood technology. Particular emphasis is laid on long-term monitoring environmental and ecological monitoring, wood chemistry, machine development, bio-technology and product development (Anon., 1992).

3.9 International Forestry Cooperation

Japan is a major contributor to the development of forestry in less developed countries. The total value of these efforts in 1990 was US$114.5 million as bilateral aid (expert assistance,training, capital grants, planning, low interest loans) and US$8.5 million through multilateral channels Food and Agriculture Organisation(FAO) and International Timber Organisation (ITTO). As of 1995, 20 bilateral aid projects were being conducted in 14 different countries in areas such as reforestation and social forestry.

Figure 10: Headquarters of the Forestry and Forest Products Research Institute, Tskuba.

4 Wood Supply and Demand

4.1 Domestic Wood Supplies

The share of domestic wood supplying the total national demand (about 109 million m^3 in 1994) has decreased steadily from 94% in 1955 to 22% in 1994 (Figure 11). The high-point in annual harvesting volume was 52 million m^3 achieved in 1967 but by 1994 this figure had decreased to 25 million m^3 . Private forests are contributing an ever increasing share (71%) of the total cut in relation to its share of the growing stock as the Forest Agency cuts back on activity as part of its financial recovery plan. Softwood accounts for 78% of the cut and 75% of this is used for sawn timber, while hardwood is used mainly for pulp chips.Some of the causative factors behind this trend are as follows:

Strength of the yen against foreign currencies

The rate of timber importation is known to track the yen/dollar exchange rate quite closely. The Japanese economy has been in recession since the collapse of the “Bubble Economy” in the mid-eighties. The yen remained strong against other currencies until 1995 when it began to slump in value against the dollar. This recent weakness of the yen will act to raise the price of imports thus making domestic wood more attractive. A figure of ¥120 or over to the dollar is regarded as favourable to domestic production.

Low priced imports

Large foreign timber producers such as New Zealand, Canada and the USA have long since rationalised and mechanised their operations to produce export timber at a low cost (Figure 12). Others, such as Russia, are the cause of some concern in Japan, because of their environmental policies, or lack of same.

Deregulation of timber importation

The Japanese forest industry was once heavily protected from imports through high tariffs, quotas and restrictive regulations. Until very recently only 80 US sawmills were allowed export to Japan without having their product re-graded on arrival. The Japanese authorities will now recognise many more American grading standards than previously and the number of sawmills whose timber can enter the market directly will rise to about 1000 (JiJi Press., 1997). The Uruguay Round of the GATT negotiations also secured a 50% reduction on import tariffs levied against foreign timber and further reductions are being demanded.

High domestic timber production costs

The cumulative effect of topography, labour, roading, distribution and processing problems means domestic timber is expensive.

Domestic processor delay in meeting changing character of domestic consumption

The domestic processing sector is highly fragmented and under-capitalised. Many mills lack the ability to adapt to changing market demands such as the increase in demand for pre-

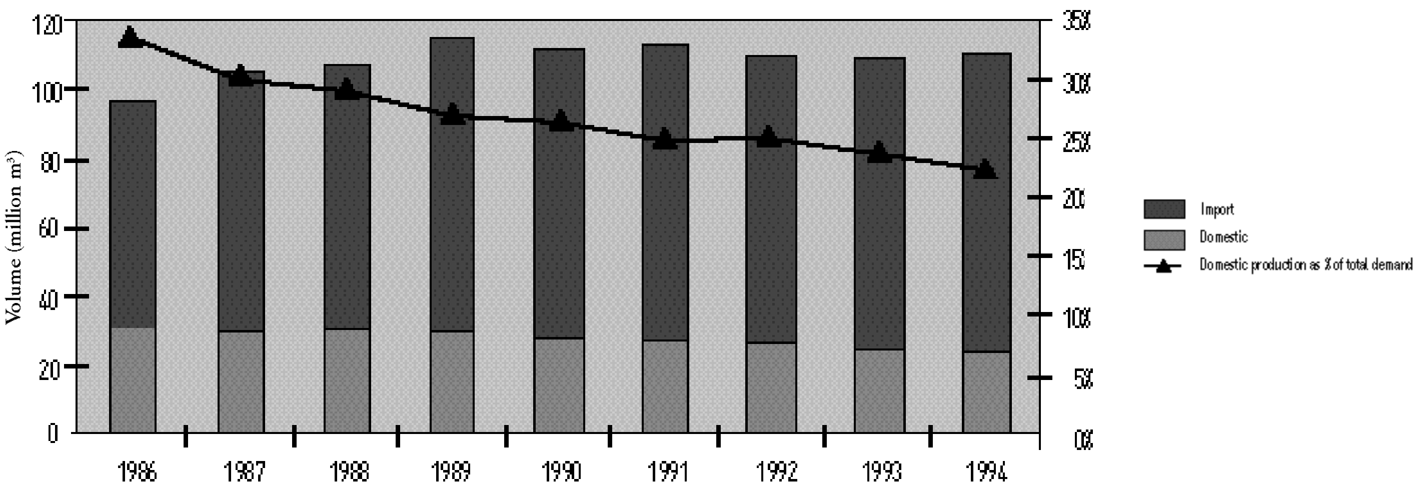

Figure 11: Overall timber demand as satisfied by imported and domestic timber. Rate of self-sufficiency is included

fabricated housing. An additional barrier is that the sales and distribution method does not normally connect the timber producer with the processor. A private producer will often sell to his local forest cooperative, who will then sell the timber on to a processor. This distribution system involves much handling, inefficient transportation, intermediate profit taking and the lack of a true relationship between end-user and producer.

4.2 Wood Imports

Japan is one of the world's main importers of timber (Figure 12). In 1994, in value terms, it bought over half (52%) of the world's roundwood exports. By value it imported US$16.9 billion of forest products in 1994, equivalent to 5.3% of Japan's total spend on imports. Recently the trend has been toward the importation of processed timber as opposed to in the round, thus giving the overseas processors the benefit of the added value premium (Figure 13). In 1980 the percentage of processed timber imported was 18%, by 1994 it had risen to 65%.

Figure 12: Water storage of imported timber

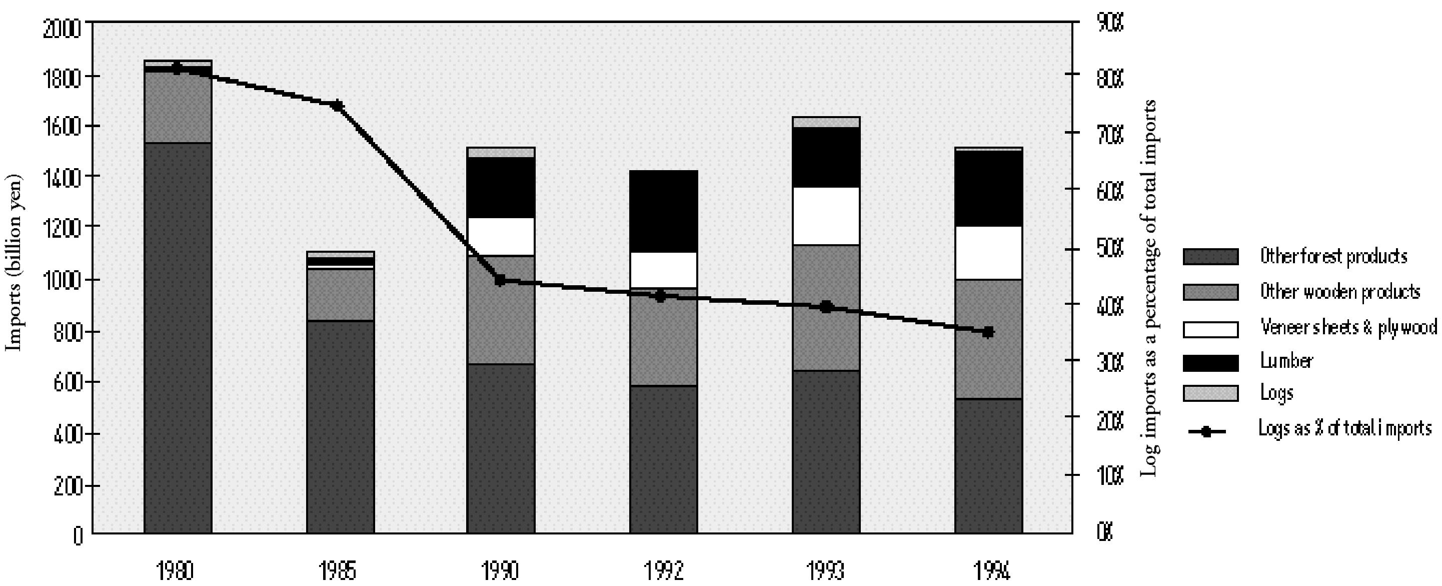

Figure 13: Timber imports by type and value

PART TWO: TIMBER HARVESTING

5 A Short History

A centralised market for timber was already established in Japan by the 15th century. Material was transported to market by water in what was known as “Rafting Forestry”. It was not until the middle of the 20th century however, that real advances were made in harvesting techniques and equipment. The first Japanese-made chainsaws appeared in 1947. Large and cumbersome, these unreliable 30 kg machines required two operators. Mechanisation began in earnest in 1954, when a large number of chainsaws were imported from the USA to clear the timber felled by a powerful typhoon which struck the northern island of Hokkaido. Their use soon spread to the rest of the country and lighter and more effective Japanese models soon appeared.

Vibration sickness or “white-finger” syndrome first came to prominence around 1965 and this, coupled with an initiative to control accidents, placed the full weight of bureaucracy behind regulations imposed in 1975 restricting chainsaw operation to two hours per day and the reversion to handsaws when felling smaller timber such as that found in man-made forests. An additional 1978 emergency regulation imposed the use of remote-control chainsaws in felling and bucking. In private forests, where workers were often employed on a piece-rate basis, these directives were not always observed.

Due to its mountainous terrain, yarders have long dominated Japan’s timber extraction techniques. Prior to the second world war yarder use was confined to National Forests but spread to all forest types in the 1950’s. Larger machines with greater span capacity were developed for use in the large-scale clearcutting which was practised in the national forest’s natural stands until about 1970. Fullpole extraction appeared in 1958, promoting the transfer of cross-cutting work from the forest to the landing.

By the early 1980’s environmental concerns over large scale clearcutting and a large thinning requirement in man-made forests began to push yarder development in a new direction. In the mid-eighties smaller, so-called “tower yarders” began to emerge and quickly became popular for thinning and short-span yarding. Remote controlled self-propelled carriages also proved popular for this type of work. Sophisticated timber harvesters, processors and forwarders so popular in western countries have only been in use in Japan since 1987 when contractors began using such machines in the gentle terrain of Hokkaido. At the opposite, southern end of the Japanese archipelago it was the damage caused by another typhoon which introduced the combination of yarder and landing processor to the country in 1991 (Gotou, 1996b) .

Forestry has long been a heavily labour intensive concern in Japan. During the rapid mechanisation of other economic sectors land based production remained the reserve of large numbers of low waged labourers. Gradually, industrialisation attracted the workforce away from land based activity and there was a concomitant rise in wages. The increase in cheap imports since the 1970’s was the final incentive to begin mechanisation in earnest. The number of large modern forest machines in 1994 is 13 times what it was 5 years previously (Figure 14). The process of mechanisation is strongly supported by government at national and local levels and grant levels for new machinery can reach 65% of the purchase price. Harvesters, forwarders, processors and tower yarders account for much of the growth.

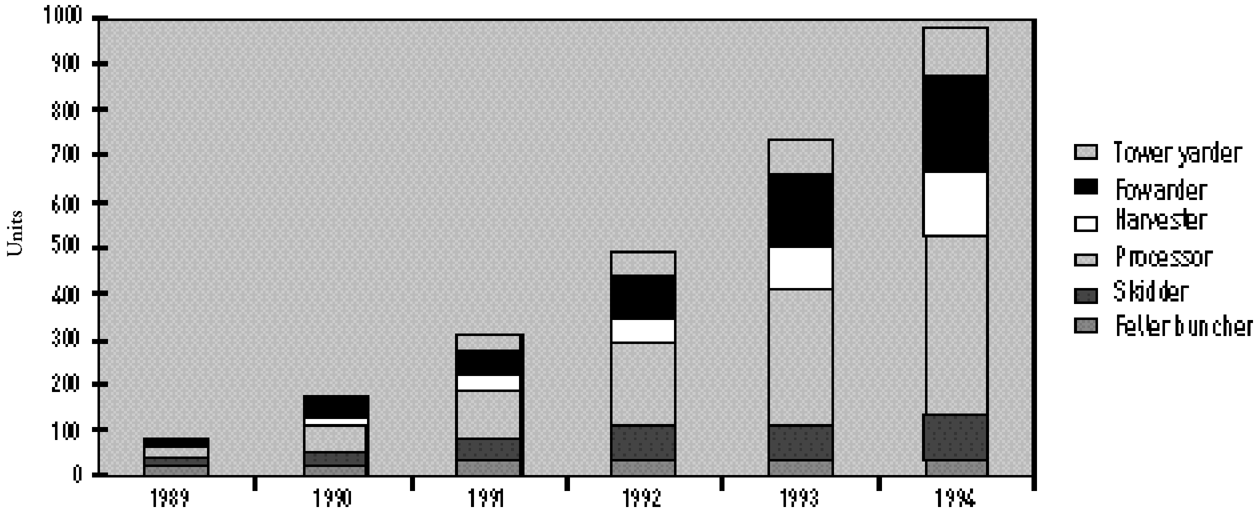

Figure 14: Numbers of large forest harvesting machines currently in use

6 Present Harvesting Systems

The range of harvesting systems currently in use in Japan can be classified by geographic region. In the neighbourhood of massive volcanoes such as Fuji, Taisetsu and Aso the terrain is flat to undulating and skidders are widely used. In the non-volcanic mountain ranges found in the less-developed areas of Tohoku, Chugoku and North Kyushu regions, the forest terrain is characterised by short slopes. Due to relatively cheap road construction costs mini-forwarders are often used here by forestry households themselves or by forestry cooperatives. The more mountainous areas such as Shikoku and North Kinki tend to have large forest tracts and are logged by large scale yarders working at spans over 500 m. Skidders and yarders use a shortwood, full-pole or whole tree approach with the latter being favoured in recent years due to the rise in the use of excavator-based processors at the landing. The difficult work of delimbing and cross-cutting in steep terrain is therefore transferred to machinery at the landing and the labour requirement is reduced. Figure 15 indicates the current labour productivity in forest harvesting operations, broken down by lot size.

In thinning, the most common extraction systems in use are the mini-forwarder, monorail, monocable, tower yarder and radio-controlled self-propelled carriages. On clearfell sites skidders and larger yarders are widely used. Yarders normally take over from skidders on slopes of over 20^{o}.

7 Harvesting Equipment

7.1 Notes

Smaller equipment is likely to be owned by private individual owners while larger machines tend to be owned by contractors or forest owners' associations. The term "mini-forwarder" is applied to vehicles with less than around 2.5 t carrying capacity. Prices were sourced in the 1996 forest machinery guidebook and are quoted in Irish pounds, not including delivery (Anon., 1996b). The exchange rates used in currency conversion are IR£1 = US$1.48 = ¥174 (September, 1997). The author holds detailed specification information on most of the equipment described. The star (★) ratings refer to the author's subjective assessment of the usefulness of introducing the particular machine or technology to Ireland. Maximum (best) rating is five stars. Equipment which would not, in the author's view, be suitable for use in Ireland does not receive any stars. Analysis of harvesting operations normally includes details on such aspects as terrain, labour intensity and cost levels when arriving at productivity and cost per unit production. Some productivity figures are provided but as the underlying conditions in Japan are so very different to those of our own island I have laid less emphasis on presenting these data.

7.2 Forwarders

The emphasis in Japanese forestry on cheap, narrow spur roads has brought with it a big market for the mini-forwarder.
This is very well catered for largely by one manufacturer, Oikawa Motors.

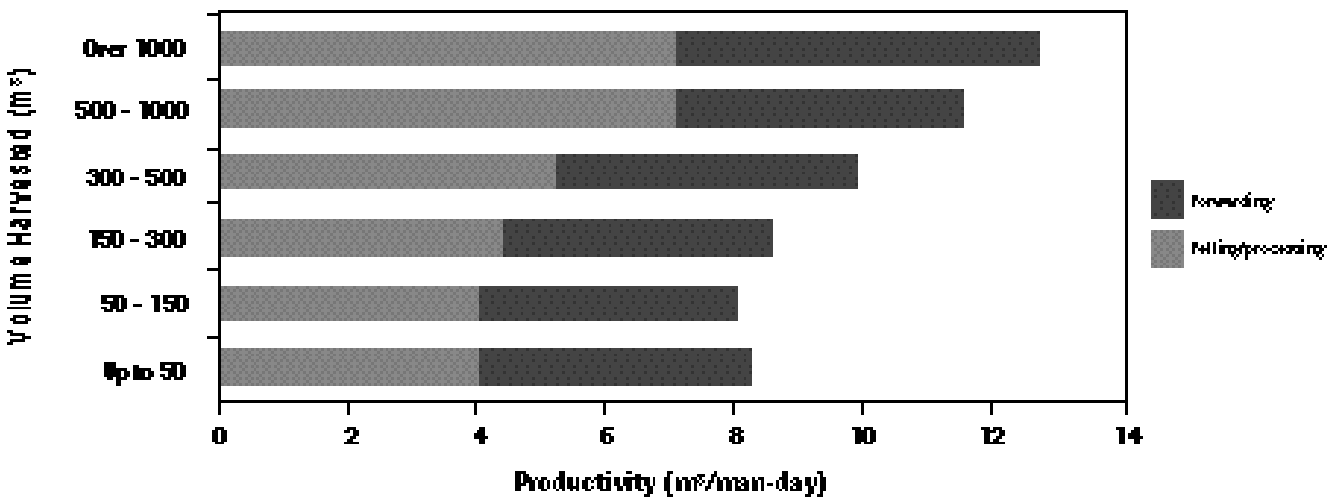

Figure 15: Mean timber harvesting labour productivity for felling and forwarding for varying lot sizes

In the author's view, the design of larger forwarders has not been as successful. Compared to the smaller models load capacity is increased but the ratio of engine power to load capacity is significantly poorer for the larger machines. There is also a tendency for poor ergonomic design and less than ideal manoeuvrability. If it is intended to use large capacity forwarders as part of an in-the-woods shortwood team then more expensive and exacting design standards must be followed. The development work being currently undertaken by Oikawa Motors and the FFPRI is one example of this new direction. One part of the problem may lie in the fact that many companies currently making efforts to produce a forwarder are large heavy equipment companies. Their machines have often originally been designed for use in construction and display an emphasis on solidity and toughness rather than on economy, payload and agility in the woods. A dedicated forwarder for use in Japan's tough forest environment must be designed from the ground up.

7.2.1 Wheeled Type

Because of the poor bearing capacity and narrow width of many of its forest and spur roads the Japanese market is limited for large wheeled forwarders. The RMF-6WD from Oikawa Motors (Figure 16) has a payload of 5 t and is powered by a 130 hp engine and comes with a choice of loaders (IR£89,385).

Figure 16: RMF-6WD from Oikawa Motors

Under Irish conditions: Due to its heavy weight and subsequently heavy footprint this forwarder would have little utility in Ireland.
Rating: not suitable

7.2.2 Crawler Type

Oikawa motors produce two fully tracked (4 crawlers, 110 or 130 hp, 3 or 5 t capacity) and one half-tracked versions (two crawlers, two wheels, 110 hp, 3 t capacity) which sell for IR£48,324, IR£67,034, and IR£64,246, respectively (Figure 17).

Figure 17: The 9 t, RMF-CA from Oikawa Motors

The only other forwarder in this class is the F40 half-track from Uotani which has a payload of 4 t using a 112 hp engine. The Finnish Nokka Joker "24 wheel-drive" tracked forwarder has been marketed here but seemingly with little success, probably due to its high cost (IR£156,425).

Under Irish conditions: The Japanese crawler type forwarders are strong but perhaps overly so. Despite their increased ground contact area their weight would preclude them from use on Ireland's soft and wet soils.
Rating: not suitable

7.3 Mini-forwarder

7.3.1 Wheeled Type

Almost all wheeled mini-forwarders sold in Japan are made by Oikawa motors. Their range runs from the loader-less 22 hp, 4 WD, 1.8 t capacity RM-8WD model (IR£16,200) to the 32 hp, 6WD, 2 t capacity RM-8WD-6 HG with choice of loader (IR£34,916). The latter machine is particularly is popular for use on the weak and narrow (2 m wide) forest spur roads. They rarely drive in the terrain but will use a winch and/or loader to gather the load in to its position on the spur road. In steep terrain a method of manual pre-hauling or "kawahagi" is used to bring the timber within easy reach of a loader. Oikawa motors also market an interesting 4WD "all-wheel-steering" model in this class.

Under Irish conditions: The RM-8WD could be of use in Ireland for the extraction of thinnings in small lots on firm ground.
Rating:★★

7.3.2 Crawler Type

These range in from the very small 7 hp, 800 kg capacity Hitachi CG 8 (IR£9,497) to the 62 hp, 2.7 t capacity Iwafuji U-3FW with Hiab 250 loader (IR£41,341).
Of the very many small scale forest owners in Japan some opt to do their own harvesting, particularly if their forest land is reasonably flat and accessible. Small scale movers are needed in rice cultivation and over the years manufacturers have adapted these machines for forestry on a similar, small scale. It is interesting to note that although Japanese designed and manufactured and popular elsewhere, the ATV or 4WD motorbike has not been adopted for forestry work in Japan. Perhaps the loose soils and more uneven terrain has favoured tracked movers over wheeled vehicles such as the ATV.

Figure 18: A typical small forwarder of the side loading type (top) and a small forwarder with trailer (bottom)

In the field of very small movers the leader is Canycom, with seven different tracked models specifically designed for forest work, followed by Sanwa with six and Seirei with two. These machines are characterised by small diesel or petrol engines delivering 7 or 8 hp, a winch option and a loading bar through which the winch cable is threaded for easier loading. The loading platform is often from front to back on the right hand side while the left hand side is taken up with the engine, controls, winch and seat (Figure 18).

Under Irish conditions: Slower moving, low capacity crawler type forwarders would best be used on small lots with poor soil conditions. Perhaps best used for winter harvesting on small, private sector, gley sites. Rating:★

7.2.2 Monorail

The monorail is a temporary track along which a motorised carriage pulls a load which is either slung below or placed above the “rack and pinion” style track (Figure 19). Set-up time with this system is long and only a narrow corridor is served by each monorail. Its most common application is in the transport of workers over steep terrain, especially to sites where long-term silvicultural operations or construction is being carried out. Travel speeds are up to 61 m/minute and due to the steep slopes on which these systems are set-up, braking equipment and capacity is of high importance. As regards timber transport the monorail has limited application in the unmanned transfer of material from a secondary landing to the roadside landing on large clearfell sites. The Unipar company offers the 5 hp, 450 kg capacity UD 1 for IR£ 3,400 while at the other end of the market, the 12 hp, 1 t capacity MG-1000 RM9 from Chigusa costs IR£ 35,922 and is capable of travel on 45% slopes.

Under Irish conditions: There are not enough long-term, extremely steep walk-ins for Irish forest workers to merit the use of this equipment. Christmas tree producers, however, may find the monorail system a cost-effective means by which to avoid long-term rutting and soil compaction while allowing unmanned transport of trees to a central depot.
Rating:★★

Figure 19: Timber transport monorail

7.5 Mobile Tower Yarder

Due to the age structure of Japan's man-made forests the area intended to be thinned has soared in recent years. Its cost effective execution poses a particular problem in small lots and in areas of mixed or short slopes. The so-called "mobile tower yarder" is widely acknowledged as one answer to this problem. Japanese manufacturers have produced sophisticated equipment of this type since 1975. Traditionally, the Japanese yarder has been of the sled type, most appropriate to long-haul skyline systems and their accompanying painstaking and time consuming set-up procedures. There is still a place for this type of yarder on large-scale clearfell sites but it is declining in popularity as this type of operation diminishes. The leading developer of mobile tower yarders is Oikawa Motors, which is an innovative and dynamic company enjoying a market share of over 60%. The tower yarder usually consists of a four drum, patented double-capstan interlocked winch mounted on a turntable at the base of a telescopic tower, which is in turn mounted on a tracked or wheeled base machine (Figures 20, 21 & 22). In the 200 m span models skyline capability is available as an extra option only. Height to tower tip is 9 to 11 m depending on model and base machine. The tower is lowered hydraulically for transport. Maximum haul distance ranges from 200 to 500 m. Design emphasis is on convenience and speed of set-up which is greatly aided by normally using a highlead system in preference to a skyline arrangement. Using the running skyline system set-up typically takes about 30 minutes to 1 hour and operation is through a detachable control panel.

Figure 20: Oikawa Motors RME-200TE during a field trial

Figure 21: Oikawa Motors RME 200 tower yarder with all terrain base machine

The mobile yarder is very often used in conjunction with a excavator based harvester. Whole trees are brought to roadside and subsequently processed into shortwood. Normal crew size in this case is three and hourly production averages about 3 m^3 in 0.1 m^3 thinnings. Full skyline operation is also possible where deflection, load size or distance is too great for the running skyline system. The subject of this author's research while in Japan was the development with Oikawa Motors of a new hybrid machine combining a processor and tower yarder which would reduce the manpower requirement from three to two and improve capital utilisation.

The carriage must be as light as possible due to the light lines used. Lightweight clamping and lateral haul capable carriages are becoming available, however, as are intermediate supports for running skyline systems, thus extending the usefulness of this system. Cost: IR£55,754 to IR£132,961. Productivity for a tower-yarder and processor system is highest at a haul distance of about 70 m, where 2.5 m^3/hour is possible, resulting in a cost per cubic metre of about IR£33.50, including felling.

Figure 22: Iwafuji TY-U3 tower yarder mounted on a crawler base using self propelled carriage

Under Irish conditions: In Ireland spans are rarely over 300 m, loads are quite light and yarding sites are small and scattered. The RM 300T truck version would be ideal for Irish yarding conditions. Set-up time is minimal and road speed is high, allowing speedy transfer. In addition, the training requirement is minimal. From an Irish perspective, a similar, Norwegian-made 303 interlock tower yarder from Igland may be more from attractive due to the proximity of an UK distributor and established technology in intermediate supports and slack pulling carriages for use with the running skyline system. These tower yarders are capable of yarding over flat or gently sloping terrain such as in environmentally sensitive sites of low ground bearing capacity shows promise but has yet to be analysed in depth.

Rating:★★★★

7.6 Excavator Swing Yarders

The mechanisation of harvesting is being promoted widely but in a period of weak market prices for timber only the most cost efficient systems will gain acceptance. The excavator swing yarder is just such a system, where the developers chose the route of minimal capital investment to maintain cost efficiency. There are two design types currently in use. The first, a commercial product sold by Komatsu (Figure 23), is excavator mounted with winches and cables which are threaded through pulleys located close to the point of attachment of the excavator tool.

Figure 23: HC 20 model swing yarder from the Komatsu company

The excavator boom is not supported other than indirectly by an integral counterbalance attached to the base machine. In practice a tree stem can be manoeuvred to help prop-up the boom. The second design, developed by Kyoto University, is similar to the first in every respect other than in the use of a support built onto the excavator boom. This design however, restricts the base machine for alternative uses. The system may be set up using a skyline and supporting guylines but this reduces the advantage gained by fast setup and easy repositioning. The swing capability of the excavator also means additional dropping area is available, thus facilitating, for example, the “cold decking” of whole trees. The attachment of the excavator can be changed to a grapple to further increase utility.

In a recent study the Komatsu HC 30 model achieved productivity of 31 m^3/6 hour day in 0.6 m^3 clearfell timber. It had two setup changes, each taking only 10 minutes and an average span of 50 m.

Under Irish conditions: This machine would have good potential for use in Ireland by cost conscious contractors working small steep sites.

Rating:★★★★

7.7 Monocable

The monocable is a yarding system which uses a continuous loop of cable threaded through the thinned stand. The stand is first thinned and piles of logs are spread along the brashed corridors which will form the cable route. In operation the chokerman requests that the cable circulation be stopped as he ties on a new load. The loads are attached by twine to the cable and are cut-off using an in-line cutter upon reaching the roadside. The winch is a simple, double drum unit which moves at low speed, resulting in very little damage to remaining trees. The cable is held above the ground by many intermediate supports attached to standing trees along its route. The intermediate supports are specially designed to allow the free passage of loads. Due to the light material involved this system is easy to set-up although quite time consuming. Capital and other ownership costs are also low but the pre-hauling of timber to the cable corridor is physically difficult. Although used in Japan the only source of information on complete monocable systems was from the USA where prices start at IR£12,162. Claimed productivity for the system, with a crew of 4 is 600 - 800 pieces or approximately 25 green tons/day.

Under Irish conditions: This system has promise in Ireland, particularly in first thinning on environmentally sensitive areas, be they steep or flat. The only misgivings are the length of the set-up time and the manual pre-hauling which is necessary to get the timber to the skidding corridor.
Rating:★★★

7.8 Radio-controlled Self-propelled Carriages

In the most basic configuration of this system the carriage pulls itself back and forth on static cables using two on-board winches (Figure 23). In addition, the carriage can be used in a further twelve distinct configurations, including monocable, direct winching, endless Tyler, lateral yarding and in use with a sled type yarder in gravity yarding and for long spans. Set-up is aided

Figure 23: Sky-carry remote controlled self-propelled carriage

with the carriage winch and so there are very few disadvantages to this equipment other than the near obligatory use of a skyline and its accompanying long set-up time. Due to the lack of a tower both head and tail spars must be also be used. The self-propelled carriage, however, has superior lateral yarding capability to a normal tower yarder.
The weight of the carriage itself is one of its main drawbacks. At up to over half a tonne, self-propelled carriages need well maintained and erected heavy duty skylines and tackle to avoid failures. Load capacity is also reduced due to the considerable weight of these units. Capacity may be increased by the use of blocks to increase pulling power by up to 3.3 times but this involves a more complex and time-consuming set-up procedure. Cost: IR£10,056 to IR£20,670. Productivity is similar to the tower yarder. In one recent study of a clearfell operation involving trees with an average volume of 0.27 m^3, the tower yarder hauled 6.5 m^3/hour over a 150 m mean haul distance while the Sky-carry carriage managed just 2.5 m^3/hour over a 250 m distance.

Under Irish conditions: This equipment is the main rival to the tower yarder and it certainly wins on the basis of purchase price. Set-up is much longer and more complicated however, and needs a skilled crew. Lateral yarding capability is far superior to the tower yarder (up to 80 m in some models) and so, if operated by a skilled crew on medium span sites, this class of equipment has good prospects.
Rating: ★★★

7.9 Excavator-base-machine Harvesters

The harvesting sector is expanding and changing rapidly, and nowhere more so than in the use of harvesters and processors. European style base machines designed for travel in the terrain are not yet popular due to their expense and the generally steep nature of forest land. There is also a certain resistance to the importation of technological products from abroad which may be produced by indigenous companies. This is especially the case with governmental bodies, often the only groups able to afford imported machines.
Probably the most popular “cut to length” system at the moment couples a roadside processor with whole tree or fullpole extraction by a yarder or sometimes a skidder . The processor base-machine in this case is invariably a Japanese manufactured excavator mounted with a harvesting head (Figure 24).

Excavator-base-machines have proven very popular due to their low price in comparison to specialised imported base machines and the ease of maintenance and repair which is possible with well known Japanese brands. As the forest terrain is often steep these machines rarely enter the stand and so the crawler type undercarriage is adequate.

The scale of public works undertaken annually in Japan is huge. Heavy plant manufacturers cater to a large and diverse market and competition is intense. The city streets of Japan are normally quite narrow and heavily congested and so these manufacturers have developed compact, double-jointed, ergonomic, high performance excavators for use in road maintenance and by utility companies. These machines would also be ideal for forest operations on gentle terrain, particularly for early thinnings or drain clearing.

Under Irish conditions: The biggest problem for motor manual fellers in first thinning is getting the tree to the ground. Purpose-built harvesters are ideal for this task but perform poorly economically in small dimension selection thinning. A compromise may be reached by using a small, relatively cheap and flexible base machine mounted with a light, small capacity, inexpensive head. These base machines would be of a smaller scale than currently used in in this capacity in Ireland.

Rating ★★★

Figure 24: Typical harvester configuration of CAT base & Keto head

7.10 Harvesting Heads

As regards harvesting heads Japan does not have a history of their manufacture and those currently in use are predominantly of foreign origin. Given the present period of rapid growth, this sector represents great opportunities for the export of such equipment to Japan, a fact which has not gone unnoticed by major Nordic manufacturers such as Valmet, Ponsse, Keto, FMG, etc., as was reflected in the heavy presence of overseas suppliers at the 1996 national forest machinery exhibition. Indigenous manufacturers are gradually developing their own, lower cost harvesting heads however, and competition will increase. They have been limited however, to simple grapple saws and felling heads thus far.

A typical forest cut-to-length excavator based harvester costs from IR£100,559 to IR£136,872; these figures may be doubled for forestry specific foreign machines. In one study of thinning on flat ground respectable productivity was achieved with a harvester and forwarder system (average treesize, 0.32 m^3, haul distance, 300 m) where the harvester achieved productivity of 28.5 m^3 and the forwarder transported 42.7 m^3/day at a total cost of IR£44.60/m^3.

Under Irish conditions: These heads are already in use in Ireland.

Rating:★★★

7.11 Pruning Machines

Although not strictly harvesting equipment, these devices are worthy of attention here. The Seirei company produce two interesting models of a self propelled or “robot” tree pruner. They consist of a two stroke 49 cc engine driving two wheels and a small chainsaw bar mounted vertically with the bar flat against the tree (Figure 25). The wheels drive the machine in a spiral motion around and up the tree, cutting branches clear as it goes. The unit is remotly controlled and once at the required height the operator can stop the chainsaw and reverse down the tree. There are two models covering a delimbing range of 7 to 23 cm and 15 to 35 cm tree diameter.

With a full tank of oil and fuel the larger model weighs 35 kg which is quite heavy but still manageable on even ground. On wet or slippy bark, traction is sometimes lost. An improvement in the tensioning device to maintain constant tension as the machine climbs (and the tree tapers) may solve this problem, as may experimentation with tyre type and pressure. This machine has a particular advantage over manual or motor-manual methods where many small diameter branches are to be cut. Cost: IR£2,771 and IR£3,324. Productivity: 6 m lift starting from 4 m, 20 cm DBH, light branching, 12 trees/hour. Two machines may be operated at the same time to further increase cost efficiency.

Figure 25: Inspecting the "robot pruner"

Under Irish conditions: The often wet and relatively smooth bark of spruce may be problematic for this machine in its present form. It does have good potential however in helping to add value to Ireland's fast-growing, heavily branched, low density timber species. Certain so-called "tree monkey" machines of this type were tested in Ireland some years ago and received mixed reviews, particularly with regard to its weight and control problems. The latest generation of improved machines are worthy of re-examination at this time. Rating: ★★★

8 Machinery Research and Development

The three Japanese words beginning with the letter K are often repeated as the focus of attention for forestry machinery developers and ergonomists. In English they translate roughly into three "D" words: dangerous, dirty and demanding. The mechanisation of forest work will, it is hoped, improve working conditions in this regard while improving productivity and the general viability of the forest industry. Mechanisation may also attract younger people into the profession and prolong the career of its older members, thus attenuating the workforce age structure problem. Research and extension work in this area is heavily promoted by Government, the Forest Agency and educational institutions.

The principal areas of research are in the development of an all purpose machine capable of being mounted with tools for harvesting or silvicultural treatment (Figure 26) to operate on steep and uneven terrain. The Silvicultural Machinery Laboratory of the Forestry and Forest Products Research Institute has designed and tested various machines including all-terrain tool carriers and various experimental machines.

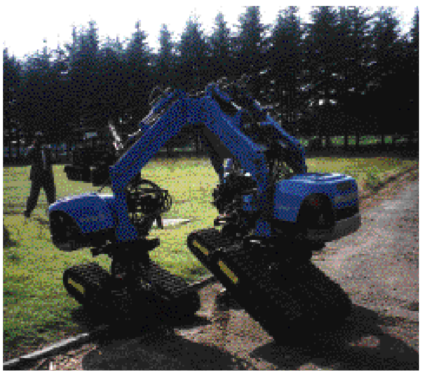

Figure 26: Experimental tool carriers

9 References

Anon., 1991. The National Land Afforestation Promotion Organisation, Green forever - Forests and people in Japan

Anon., 1992. Forest and Forest Products Research Institute, Information Leaflet, 9pp

Anon.,1994. Japan FAO Association Forests and Forestry in Japan, Tokyo, 65pp

Anon.,1995 Ministry of Agriculture, Fisheries and Forestry, 1993 Forestry White Paper, Internet reference: http://ss.ffpri.affrc.go.jp/white-p_93.html

Anon.,1996a. Ministry of Agriculture, Fisheries and Forestry, 1994 Forestry White Paper, Japanese 208pp

Anon.,1996b.Ringyokikaibinran, Publ. by Ringyo-kikaika-kyokai (The Forestry Mechanization Society of Japan), Tokyo, 1996

Gotou J., 1996a. Forestry in Japan. Internet reference: http://www.fs.kochi-.u.ac.jp/forengin/forestry.htm

Gotou J., 1996b. How to Harvest Forests in Japan, Internet reference: http://www.fs.kochi-u.ac.jp/forengin/logging.htm

Handa R., Ed., 1988. Forest Policy in Japan,
ISBN 4-88965-001-6

Jiji Press, 1997. “U.S. Welcomes Japan's Opening of Lumber Market”, Washington, January, 17, 1995

Stengold J. 1995 “Japan's Cedar Forests Are Man-Made Disaster”,
New York Times, January, 17, 1995

Ishida, 1996. “To Save Japan's Forests, Chop the Forestry Agency”, Asahi Shimbun, April 7, 1996