

琉球大学学術リポジトリ

琉球列島の森林・林業に関する若干の所見(生物生産学科)

メタデータ	言語: 出版者: 琉球大学農学部 公開日: 2008-02-14 キーワード (Ja): 自然植生, 在来樹種の造林, マツノザイセンチュウの拡大, 国頭村森林組合, 木材チップの移出 キーワード (En): natural vegetation, plantations of native species, pine wilt nematode spread, Kunigami Village Forest Cooperative, woodchip export 作成者: 篠原, 武夫, フローレンス, ロス, 安里, 練雄 メールアドレス: 所属:
URL	http://hdl.handle.net/20.500.12000/3726

Some observations on forests and forestry on the Ryukyuan Islands

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Keywords : natural vegetation, plantations of native species, pine wilt nematode spread, Kunigami Village Forest Cooperative, woodchip export.

キーワード : 自然植生、在来樹種の造林、マツノザイセンチュウの拡大、国頭村森林組合、木材チップの移出

Summary

The distinctive vegetation of the species-rich Ryukyuan forests may be a response to the selection pressures of regular typhoons, tree instability on heavy-textured and poorly-structured soils, and cutting and burning of the forests over several centuries. While the main roles of the present forests are those concerned with nature conservation, there appears to be a social benefit in continuing wood production-based largely on conservative silvicultural and management regimes. These regimes help meet the demand for more specialised woods (e.g. cabinet and craft woods), and provide, as a byproduct, export woodchip.

1. Introduction

This paper records perceptions of forests and forestry on the Ryukyuan Islands developed during the tenure of a Japan Society for the Promotion of Science Fellowship at the Department of Forestry, Faculty of Agriculture, University of the Ryukyus. The perceptions are based on a study tour of forests and forestry on Okinawa, Ishigaki and Iriomote Islands, including visits to the Prefectural Forestry Office, Naha; the office of the Forestry Agency in Naha (with responsibility for the National Forests); the Prefectural District Offices in both northern and southern Okinawa; the Kunigami Forest Cooperative; the University of the Ryukyus field teaching and experiment station, Kunigami; the Forestry Research Institute of the Prefectural Forestry office, Nago; the Prefectural and Municipal Forestry Offices on Ishigaki Islands; and the University of the Ryukyus field experiment station, Iriomote Island.

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2 . The Ryukyuan Islands

The Ryukyuan Islands form a chain making up the southern extremity of Japan. The climate is subtropical oceanic with rainfall in excess of 2,500mm in mountainous areas. The forest areas by ownership within three island groups are given in Table 1. About 32 percent of the forest area is 'National Forest', and 23 percent is privately owned. The remainder (45 percent) is communally owned.

**Table 1 Areas of forests and fields within the Ryukyuan Islands
(Okinawa Prefecture)**

District	Area of National Forest (ha)	Area of Private and Communal Forest (ha)			Total Area (ha)
		Communal	Private	Total	
Okinawa Group	13,980	38,229	22,030	60,259	74,239
Miyako Group	—	3,952	3,114	7,066	7,066
Yaeyama Group	24,111	11,329	2,351	13,680	37,791
Total	38,091	53,510*	27,495	81,005	119,096

*Almost 90% is municipal forest. Communal Forest is same as Public Forest.

3 . The Natural Vegetation

The natural vegetation of the Islands is primarily subtropical to tropical broadleaved forest, and this constitutes about 88 percent of the forest area. Stands dominated by the native pine, *Pinus luchuensis* make up the remaining 12 percent. Given the apparently favourable rainfall and temperatures, the structure of the vegetation is at first puzzling. Trees are short-boled, with the larger trees having spreading crowns forming a distinctive closed canopy of rounded crowns. In the 'mature forests' of northern Okinawa there are few trees greater than 15m in height. The tallest tree recorded in a vegetation survey of Iriomote Islands was 18m; 92 percent of all trees in an 'overmature forest' were less than 20 cm dbh, and 75 percent were less than 10 cm dbh (Hirata *et al* 1991). There is also a very large stocking of advance growth: 183,000 seedlings per ha on one plot including stems of 43 species less than 3.0cm dbh.

An interpretation of the unusual structure and condition of the natural forests could be important in helping determine the most appropriate management strategies for them. There are a number of possible influences on the forests:

- (i) The Ryukyuan Islands are subject to regular typhoons, mainly between August

and October. Under these conditions, processes of natural selection may have favoured those individuals which developed spreading crowns on short boles in order to create a closed canopy early in a succession phase. This would now mean that short boles and poor tree form (in a commercial sense) are inherent characteristics of the trees, and that plantations of local species are likely to exhibit similar characteristics.

(ii) The soils of the Ryukyuan Islands differ appreciably from the fertile brown forest soils of the mainland forests. The red and yellow soils (red and yellow podzolics) of the Islands have a light-coloured, thin A-horizon, and are acidic, highly weathered and poor in nutrients. The heavy textured and often poorly structured B-horizon could be a factor limiting root penetration and hence tree stability under high-wind conditions. Thus typhoons and physical soil conditions could be complementary factors influencing the natural selection process.

(iii) The forests of the Ryukyuan Islands may also have a long history of ecological damage and structural change through cutting and burning. An early 18th century administrator of the Islands (Saion) refers to the 'decline of the mountains' through tree felling and burning (U.S.Civil Administration 1953). This was at a time excessive land was being cleared and farmed to pay tribute exacted by the ruling clan of Kyushu. Saion was concerned that the forests had declined to the extent that it was necessary to '...order large timber from outside the country' in order to build ships and repair palaces. He was also concerned that the existing trees lacked strong apical growth and described the 'declining mountain' as having '...a majority of trees with white, twisted or reversed branches'. The mountain forests have undoubtedly been cutover many times since the Saion era, the most severe impact, perhaps, being that associated with heavy cutting before, during and after World War II. Photographs in the U.S.Report cited earlier show extensive areas of bare mountain land — or land being recolonised by pine and evergreen broadleaved species. At this time there were 194 sawmills and 50 charcoal plants on the Ryukyuan Islands.

Against this background, it is possible that the present forest condition reflects, in part, a history of genetic depletion and ecological damage. The forest contains a large tree stocking (e.g., 7,000 to 10,000 or more stems per ha) of essentially even-aged regrowth stems developing as coppice on cut stumps, or from advance growth and seedlings. Where stands are composed of 'tolerant' species, this regeneration process may differ appreciably from that of the natural ecosystem, further contributing to the short boles, irregular and flat-topped crowns and poor tree form which characterise the forest today.

The forests are rich in species. For example, a survey of forest resources in the northern part of Okinawa (Aramoto *et al.* 1990) identified 120 species, the most frequent being *Castanopsis sieboldii* (34% of all trees), *Daphniphyllum glaucescens* (8%), *Elaeocarpus japonicus* (6%), *Schima wallichii* (6%), *Rhaphiolepis indica* (3%) and *Distylium racemosum* (3%). There were 7,397 trees per ha with a mean diameter of 7.4cm and a mean tree height of only 5.8m.

Castanopsis sieboldii is also the most frequent species on Iriomote Island (13% of all trees); other species on this Island include *Persea thunbergii* (6%), *Pinus luchuensis* (6%), *Styrax japonicus* (5%) and *Raphiolepis indica* (3%). The remaining 67 percent of all trees included another 86 species (Aramoto *et al.* 1989).

4 . The Role of the Forests

The Ryukyuan Island forests were of considerable economic significance in the past when they provided sawlogs and fuelwood for domestic needs (particularly after World War II). However, the structure and condition of the forests, and the low standing volume of trees with sawlog potential, will limit their commercial role in the future. Moreover, their roles in nature conservation, protecting soils, maintaining water supply, providing habitat for wildlife, and conserving natural landscapes and scenic beauty becoming increasingly important, further limiting their commercial role.

It follows that it is unlikely that the Ryukyuan Islands can be self-sufficient in wood production and the bulk of the construction timber must come from the mainland or overseas countries. Nevertheless, it appears to be in the public interest to maintain some wood production programs within a broad multiple use framework. Ideally, harvesting programs would be based on land use and environmental planning which integrates all forest land tenures (national and non-national). However, discussion of forest planning on the Ryukyuan Islands is beyond the scope of this Report. Rather, it focuses on ways in which the forest can be managed for wood production.

Forestry on the Ryukyuan Islands might be directed most appropriately to small-scale harvesting and regeneration of the natural forests in order to support small sawlog and specialised product industries, and the export of residues as woodchip. In this way forestry can also be directed to improving the condition of existing forests, and to rehabilitating land which has been degraded in the past.

Silvicultural practices in natural forests.

Harvesting is on a relatively small scale, based mainly on conservative silvicultural regimes. A number of silvicultural practices were observed:

Clearfelling with natural regeneration. The forest is clearfelled in small patches, for example, 1 to 2 ha, and allowed to regenerate naturally (as in the past) from coppice, advance growth and new seedling regeneration. The harvested wood provides small logs for a sawmill, and smallwood for mushroom (shiitake) culture. Silvicultural and sawmill residues are chipped for export to mainland pulpmills.

This is consistent with the pattern of operations on lands managed by the largest of the three Forest Cooperatives in the Okinawa Prefecture (Kunigami Village). The Cooperative is directly responsible for 5,676 ha of forestry land, including 5,306 ha of municipal forest and

370 ha in private ownership. As there are 370 private owners, individual forest ownership is very small. In addition, the Cooperative manages 3,486 ha of Prefectural Forest, contributing to a total area of 9,162 ha. The Kunigami Village Cooperative harvested 10,644m³ of sawlog in 1989. However, only 1,294m³ of sawnwood was produced, the residues being chipped for export. The total woodchip export in that year was 10,466 tonnes, derived from both sawlog and silvicultural residues. The small area of harvested forest which is planted (rather than regenerated naturally) varies from year to year, for example it was 46 ha in 1989. While the export of woodchip derived from natural forest is criticised environmentally, it represents an effective means of utilizing forests which provide only a small volume of tree boles suitable for sawnwood products.

Improvement treatment The productive condition of the mountain forests can be improved by thinning heavily within overstocked stands in order to stimulate the growth in diameter of the better commercial trees and species. More than 6,000 ha of forest have been given some form of improvement treatment since 1973. The response of the forest to improvement treatment is described by Hirata *et al* (1990,1991). Where the better trees were retained, there was a 10 to 36 percent increase in mean diameter, a 6 to 16 percent increase in mean height, and an increase in the proportion of economic species.

The Prefectural Administration believes it is appropriate to undertake improvement treatment on a wider scale, and to thin the forest from around 10,000 to 1,500 stems per ha. This will be a costly operation (about 200,000 yen per ha), particularly where the terrain is steep and inadequately roaded, and it is uneconomic to utilize the thinned stems in some way, for example, as woodchip. While the treatment may produce high value hardwood timbers in the future, a financial analysis might be done to establish its commercial viability—particularly where so large an investment must be directed to it.

Underplanting In this treatment, seedlings of commercial species are planted under wide-spaced trees retained following logging or improvement treatment. An underplanting program has a number of benefits. It can provide a substantial volume of commercial products; it avoids the adverse environmental impact of clearfelling; diameter-growth of residual trees can be stimulated; and there is an opportunity for enrichment of the forest with valuable species. The response of underplanted seedlings has been examined by Hirata *et al* (1990). Two years after underplanting with *Distylium racemosum*, there was an 87 percent survival, with losses attributed mainly to wild boar damage. At this stage (2 years), height growth of the seedlings was negatively correlated with stand height, and hence with the level of competition exerted by the overwood trees. Underplanting is regarded favourably in some places, for example, it could replace open plantations on Ishigaki Island. *Calophyllum inophyllum*, *Garcinia subelliptica* and *Podocarpus macrophylla* are commonly used in this treatment.

5 . Plantations of Native Species

Given the near-stagnant condition of much of the Ryukyuan forest, it would be one

logical option to replace the forest, in part, with more uniform stands of faster-growing species. This appears to have been the strategy during the Ryukyu Government period (U.S. Occupancy 1945–72) when *Pinus luchuensis* was widely planted. The pine is capable of making productive plantations on a wide range of sites and soils. Yamamori (1979) provides comprehensive information on relationships between volume production, parent materials and soil conditions, for example, volume production appears to be greater and more consistent on soils derived from granites and andesites than on soils derived from other parent materials.

Despite its success on some sites, *Pinus luchuensis* is no longer planted on a large scale. The most immediate reason is the infestation of the pines (from the mainland) by a pine wilt nematode spread by a beetle, *Monochamus alternatus*. Other reasons include the generally poor form of the bole, the irregular crown, and wood which is highly susceptible to termite attack (e.g., Yaga 1978). There has also been a change in production priorities. Hardwoods (especially more specialist and valuable species) are now favoured, both for sawnwood and pulpwood. Thus in examining present planting regimes it is useful to focus on the period 1973 to 1990, when a less pine-oriented strategy has been adopted.

Areas of man-made forest established on the Ryukyuan Islands (1973–1990) are shown in Table 2, together with the distribution of areas by species. Over the whole of the Prefecture the average annual planting on municipal and private lands has been only around 170 ha per year. A large number of species have been used, the most popular being *Podocarpus macrophylla*. *P. macrophylla* is regarded as a particularly valuable species because of its strength, termite resistance and general durability. It is planted widely despite slow growth and a foliar insect predation which must be controlled chemically. A brief discussion of two planting programs follows.

**Table 2. Forest plantings on the Ryukyuan Islands 1973–1990
(Municipal, private and company lands only*)**

(i) Areas planted (ha)						
Total	Municipal		Private	Company		
2,862	2,198		592	73		

*the bulk of planting has been on these lands.

(ii) Species planted (ha)						
<i>Pinus luchuensis</i>	<i>Cryptomeria japonica</i>	<i>Podocarpus macrophylla</i>	<i>Casuarina equisetifolia</i>	<i>Alnus japonica</i>	Other ¹ sp.	Artificial seeding
193	161	447	336	102	922	876

¹Including: *Styrax*, *Acacia*, *Erythrina*, *Cinnamomum*, *Schima* and *Distylium* sp.

1. Where planted in the wet mountainous areas of northern Okinawa, any species will be highly susceptible to weed competition. A recent large-scale mixed planting of *Podocarpus macrophylla*, *Distylium racemosum*, *Schima wallichii*, and *Pinus luchuensis* failed when it finally

succumbed to luxuriant grasses, shrubs and vines. Small scale plantings may be more appropriate where weed competition can be controlled. The Kunigami Village Forest Cooperative has established, on average, around 30 ha per year, and this is done in many small plantings which can be tended effectively. Many species have been, or are being planted in this way, including, in addition to those listed above, *Cryptomeria japonica*, *Alnus japonica*, *Cinnamomum camphora*, *Erythrina orientalis*, *Calophyllum inophyllum*, *Melia azedarach*, *Garcinia subelliptica* and others.

2. A total of 279 ha was planted between 1980 and 1990 within the southern district of Okinawa Island. This has focused primarily on revegetating grasslands on private, municipal and prefectural lands—much of which had been battle grounds during World War II. The main species planted have been *Erythrina orientalis*, *Podocarpus macrophylla* and *Distylium racemosum* in that order of priority. *Erythrina* will provide quality raw materials for lacquer work and wood turning. Because the plantations develop slowly, and boles will be short and poor—formed, only small volumes of commercial wood can be expected.

3. Forest plantings on Ishigaki Island are similarly limited to around 30 ha per year, and directed to future supply of more specialized timbers for furniture and turning.

6 . Plantations of exotic species

Exotic species have not been widely used for commercial planting on the Ryukyuan Islands — although some plantation species, such as *Erythrina orientalis*, were introduced a very long time ago and are now regarded as essentially 'natural'.

Casuarina equisetifolia is the most obvious exotic species on the Islands. It is widely planted as an ornamental and windbreak tree—standing out because of its height and resistance to cyclonic winds in exposed places. There is an introduced acacia (*Acacia confusa*), which is also widely planted as an ornamental, street and windbreak tree. Because acacias appear to fit well within the 'natural environment' of the Islands it would be worthwhile to develop an expanded introduction and testing program. There are some acacias which are widely planted for commercial and other purposes in many tropical and subtropical parts of the world. These include *Acacia mangium* and *A. aucolocarpa*. Some eucalypts have developed well in more sheltered niches within the mountain forests of the Ryukyuan Islands. *E. grandis*, *E. urophylla* and their hybrid derivatives could be highly productive under the climatic regimes of the Islands—but again, would probably succumb to strong winds under most conditions.

Apart from the indigenous *Pinus luchuensis* and *Podocarpus macrophylla*, there are few conifers planted on the Islands. The Norfolk Island pine (*Araucaria heterophylla*) is planted as an ornamental, probably because of its adaptation to strong coastal winds. There was a reference during one tour to a 'fine stand' of hoop pine (*Araucaria cunninghamii*) — but this was not seen. The southern and Caribbean pines (*P. elliotii* and *P. caribaea*) and their hybrid derivatives would probably develop well—if they did not succumb to wind.

There appears to be a distinct preference for planting indigenous species—generated, in part, by a sense of maintaining the 'natural environment' to the greatest extent possible. Indeed, on Ishigaki Island, a strand planting of *Casuarina equisetifolia* was being replaced by *Calophyllum inophyllum*, presumably on these grounds. The limited adaptation of many taller—growing exotic species to cyclonic winds and shallow or physically impeded soils is undoubtedly another factor. Nevertheless, it is appropriate to continue the programs of tree introduction and testing being carried out at a number of centres.

7 . Discussion

The distinctive short—boled,closed forests of the Ryukyuan Islands were a very significant wood resource in the past, but are much less so today. Their primary roles are now those concerned with 'the environment': conserving natural species and communities, protecting soils, maintaining water supply, providing habitat for wildlife, and conserving natural landscapes and scenic beauty.

Despite emphasis on the environmental roles of the forests, there are still perceived to be social benefits in maintaining wood production programs. Income generated by harvesting contributes to local employment, the financial viability of small forest ownerships, and the economic stability of villages and other rural communities. However, as in many other countries, a continuing wood production role for natural forests may be socially acceptable only where (i) there is a suitable balance between the conservation and production functions of the forests (ii) environmental standards of harvesting and silviculture are high and (iii) the operations are both ecologically and economically sustainable.

Against this background, it is unlikely that the Ryukyuan Island forests can be self—sufficient in wood production. Much of the demand for construction timber will continue to be met from imports, with the local forests being managed primarily as a source of more specialized woods, for example, for furniture, crafts and related uses. While there may be social concerns about harvesting trees for export woodchip, integrated sawlog—woodchip programs may be the only effective means of avoiding the wastage of wood inherent in managing forests for sawlog production alone. The export of eucalypt woodchip from Australia to Japan creates environmental conflict in Australia—though it is similarly, a 'byproduct' of sawlog production.

The emphasis on 'environment' within the forests of the Ryukyuan Islands means that silvicultural practice should be essentially 'conservative', that is,based on small and dispersed clearcutting units, or on silvicultural methods which retain some tree cover after harvesting.

Silvicultural methods which require the retention of wide—spaced trees can have both environmental and commercial benefits. The adverse impact of total clearfelling will be avoided; there will still be an economic return from harvesting sawlogs and trees for export

woodchip; diameter growth of retained trees will be stimulated, providing high quality logs in the future; and the density of weed species may be reduced. The benefits can be greater still where the harvested forest is 'enriched' by underplanting some of the more valuable species. However, for nature conservation purposes, only locally—occurring species might be planted in this way. The practice of retaining wide—spaced trees and underplanting commercially valuable species is one which might be more widely tested.

The improvement of the existing forest by non—commercial thinning of trees with smaller and poorer boles should enhance the commercial value of the forest at some future time. However, it may be difficult to justify the operation in economic terms. This does not necessarily mean that the treatment should not be carried out. Rather, the social benefits in doing so should be clearly appreciated.

It may be appropriate to develop a long term resource management strategy for the Ryukyuan Island forests. This can provide a land use framework within which the production and conservation functions of the forests are brought into balance. Australian experience shows how essential this is in resolving resource conflicts. Regional planning will not only establish an appropriate pattern of nature reserves and production forests, but also nominate the objectives of management for each area of forest. These objectives may be met, in turn, by diversifying silvicultural practice. For example, within the Ryukyuan Islands a number of silvicultural regimes ('clearfelling with natural regeneration', 'clearfelling and planting', 'shelterwood—type cutting with enrichment planting', 'silvicultural improvement treatment') might all have their place in balancing production and environmental objectives.

The future roles of Australia's natural forests are being established through integrated resource planning in this way. While this is facilitated by public (government) ownership of the bulk of the production forest, there is an increasing focus on forest in private ownership and its incorporation into the planning process. Within the Ryukyuan Islands, planning which integrates forest in national, communal and private ownership could help ensure both a comprehensive conservation strategy and a secure, stable, and ecologically and environmentally sustainable industry.

Acknowledgement

This study was undertaken by Professor Dr. Ross Florence while he held a Japan Society for the Promotion of Science (JSPS) Fellowship at the Department of Forestry, College of Agriculture, University of the Ryukyus, Okinawa in 1992. The JSPS award and the assistance of the University are greatly appreciated by him.

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琉球列島の森林・林業に関する若干の所見

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要 約

樹種の豊富な琉球の特色ある森林植生は、おそらく数世紀もの間、定期的な台風の淘汰圧、重粘質で土壌構造の悪い土壌の不安定性そして森林伐採と火入れに反応してできているであろう。現在の森林の主な役割が自然保全に関するものであるとはいえ、従来の造林及び経営方法に大きく依拠した木材生産を続けることは社会的に有益であると思われる。これらの方法は多くの特殊用材（例えば高級家具用材、工芸用材）の需要を満たし、副産物としての木材チップの供給・移出を促進する。

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