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The Importance of Oregon's Forests in US and International Markets: Meeting the Needs of Future Consumers of Forest Products and Environmental Services

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The Importance of Oregon's Forests in US and International Markets: Meeting the Needs of Future Consumers of Forest Products and Environmental Services

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EXECUTIVE SUMMARY

The consequences of decisions regarding the management of forest resources in Oregon are local, national and international. This is to say that unilateral policies implemented to achieve an objective associated with Oregonian forest management programs will have unintended consequences elsewhere. This study examines the unintended consequences that arise from a simulated policy to maintain Oregon's harvest levels constant over the next 4 decades.

Forest economies other than Oregon and their associated environments are affected by our local choices. With a projected increase in the demand for wood products, what does it mean for Oregon to constrain its participation by restraining timber harvest? This study projects a future scenario for the global forest sector with and without Oregon's increased participation to describe the impact the Oregon forest sector has on national and international markets. It also discusses several potential impacts on the environment associated with the changes in wood flows. This study addresses the following questions: What does a reduction in Oregon's timber output mean for forest products markets locally, across the US and internationally? Which regions pick up the market share vacated by Oregon? What tradeoffs exist between timber production and the environment? What is Oregon's role in providing forest products, environmental protection, social and economic benefits into the future for its citizens and the global community?

To estimate the effect of Oregon's annual harvest level on US and foreign markets, we first analyze the future demand for wood products to 2040, and identify the producers of wood products that meet this demand. We next constrain the annual harvest level in Oregon to be constant throughout the projection period (2000 to 2040), and note the changes in harvest volumes in markets outside of Oregon. Once recorded, environmental measures for the areas that increase harvest activities are examined. We also note the potential social and economic benefits associated with changes in market shares.

An estimate of future global demand for wood fiber is based on annual projections of gross domestic product (GDP) of 3.5% and two historical trends in consumption of wood fiber. Consumption is estimated to reach between 2.0 and 2.8 billion cubic meters (Bm^3) over the next 5 decades, adding from 0.5 to 1.3 Bm^3 by the end of the 50-year period.

Many regions participate in meeting this growing demand for wood products, including Oregon, in this business-as-usual scenario. Focusing on softwood saw logs, the South contributes over 100 million cubic meters (MMm^3) or 17.7 billion board feet (BBF) followed by Canada (40 MMm^3 or 7.1 BBF) and the US West (including Oregon) (10 MMm^3 or 1.8 BBF). This study estimates that the southern states will meet more than half of the projected demand growth.

When Oregon's annual harvest levels are maintained constant—i.e. harvest levels are not allowed to expand to meet the projected demand growth—two effects occur in the market. The first effect is an increase in timber prices. This is followed by responses from other regions and alternative material producers to increase production. The South captures 43% of the decline in Oregon's annual harvest levels. Alternative material producers—i.e. lost wood demand—capture 32% of the lost market. They are followed by Asia and Canada, which capture 15% and 10% respectively of the projected demand growth without an increase in Oregon's annual harvest levels.

These results suggest there are several competing regions with the capacity to increase harvest volumes that an Oregonian forest manager must contend with including southern states, Canada and countries outside of the US with established plantations. Recent data on import trends confirm increased market activity from several countries with expanding forest resources. Latin America, as a region, has increased its exports of softwood lumber and plywood to western ports from less than $10 million in 1990 to over $100 million in 2002 for softwood lumber and from nearly no activity in 1997 to over $8 million in softwood plywood (mostly from Chile). While Brazil's share appears to have peaked in 1999 at less than $25 million (mostly lumber), other countries have increased exports to western ports including Chile (both lumber and plywood), Uruguay (lumber) and Argentina (plywood). Softwood lumber entering western ports from Australia and New Zealand has increased from negligible numbers in 1990 to nearly $150 million in 2002. Imports of softwood plywood from New Zealand topped $1 million in 2002. These trade flows are small but significant since they signal new market suppliers to the US through western ports that directly compete with Oregonian products.

Within the southern states, annual harvest levels are projected to increase over the next twenty years in those states outlying the traditional timber-producing central states of Georgia and Alabama. Fringe regions in eastern Texas and the Carolinas are expected to increase annual harvest volumes by 15% or more in some areas more than offsetting declines in Georgia, Alabama and Mississippi.

We examine several environmental measures for those regions expected to increase market share due to constant annual harvest levels in Oregon. In general, since regions that compensate for Oregon's lower harvest volume have shorter rotations and lower volumes per acre at harvest time, there will be more acres disturbed by harvest activities than would have been if the harvest activity were to occur in Oregon. Conservation concerns in the South are growing as they continue to augment their share of the US market. They include a decline in ecosystem communities that are endangered and not under public management. Also, with much wood growing in emerging plantation regions around the world, and their rankings in biodiversity and other indices low, there is concern that the shift to Asian and Latin American producers may lead to lower conservation efforts abroad. Carbon dioxide and other green house gas emissions also increase with greater use of alternative materials like steel and concrete. Estimates place the additional emissions as high as 1.4 million metric tons annually by 2040.

A loss in future market share also has implications for investment strategies in Oregon, with its social and economic consequences. One conclusion of the analysis suggests that the South, with continued growing demand for wood fiber, will increase its management intensity of forests augmenting productivity. Without the larger market for Oregon producers such management investments become more questionable in Oregon with a concomitant effect on its own forest productivity. While prices for timber may go up, the revenues that landowners receive maybe reduced since they are not able to harvest the same volumes as before. In addition, the lower harvest level removes any incentive for new capacity expansion in Oregon, amounting to 7 to 8 average-sized mills. There are also extensive areas of plantations internationally. These areas are likely to come into play in the near future representing low-cost sources of wood and attracting investments to produce wood products for a globalized market.

These results suggest that planners need to evaluate the tradeoffs associated with an unexpected change in harvest levels for Oregon. Since there is a need to meet growing demand and Oregon can increase its annual harvest level to meet a part of the growth in demand, any program that limits its potential to supply wood products will allow other regions and countries to expand their harvest levels, with an associated environmental tradeoff and shift in social and economic benefits. The question becomes whether the tradeoffs are favorable for Oregon and the global community or not. These tradeoffs need to be considered in order to reach environmental, social and economic goals, which may extend outside of Oregon's boundaries. This study, combined with others that detail Oregon's environmental management, should prove useful in answering that question.

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1. INTRODUCTION

This report presents the results of an analysis outlined in the Statement of Work for the Interstate Agreement between the Oregon Department of Forestry and the Center for International Trade in Forest Products (CINTRAFOR) at the College of Forest Resources, University of Washington. More specifically, the work provides the Oregon Department of Forestry with an analysis of Oregon forests and forestry in the US and international context. It is one of many forest assessment projects undertaken by the Oregon Board of Forestry to assess the sustainability of the management of Oregon's forests.

The Oregon Department of Forestry is interested in understanding the impact a change in Oregon's annual harvest level might have on the US and the international forest products sector, and in particular, how any change in the volume harvested might affect socio-economic and environmental measures important in the management of Oregon's forests within this international context. The study traces the impacts of a change in annual harvest levels in Oregon through US and international markets. The effects of the change in the volume harvested are discussed in economic and environmental terms. This discussion includes the following themes: biological diversity, long-term investment opportunities and maintenance of Oregon's existing forestland base within the international perspective, global carbon cycles and long-term socio-economic benefits. The analysis provides a first cut at the environmental measures. Additional work is required to develop environmental measures that are comparable regionally and linked to the forest products sector. One such measure, carbon, is presented and discussed in greater detail.

The project supports Oregon's efforts to achieve sustainable forest management through:

1. The Board of Forestry's Forestry Program for Oregon (FPFO) — The FPFO is the Board's policy document and action plan. The FPFO was revised in 2002 around the concept of forest sustainability using the Montreal Process criteria and indicators as a framework for evaluation of the current condition and of progress toward sustainable forest management.

2. The Institute for Natural Resources — Created by the 2001 Oregon Legislature, the Institute was established to provide information and technical tools to assist decision-making on natural resource issues. This forest assessment project will provide data and models essential for the Institute's work.

3. Oregon Forestry Benchmarks — The Oregon Progress Board was created in 1989 to guide and monitor Oregon's strategic plan, Oregon Shines. A key element in the Progress Board's mandate was to create the Oregon Benchmarks, a set of quantifiable measures for the community, economy, and environment. Previous forestry benchmarks have lacked precise data by which to measure progress toward sustainability and other goals.

This forest assessment project will help provide some of the information necessary to evaluate Oregon's forestry benchmarks in both a US and international context.

2. STUDY OBJECTIVES

The objectives of the study are:

1. to determine what happens to wood flows in the US and internationally from a change in timber supply in Oregon paying particular attention to substitution by different regions and different products; and

2. to discuss several environmental measures with the changes in wood flow in the US and internationally paying particular attention to changes in land use, potential biodiversity impacts, management practices and carbon flows.

3. OVERVIEW OF METHODS AND REPORT OUTLINE

We first outline the study method providing some detail on the economic model used to construct future scenarios of the world's forest sectors. We then report the results of the analysis with the model. The section on results presents the changes in production and trade associated with changes in Oregon's forest sector and identifies the regions that will compete with Oregon for the growth in demand for forest products. Section 5 presents the data collected on environmental measures for regions represented in the global forest sector model, and is followed by a discussion of what it means in terms of environmental implications for the shift in annual harvested volume from Oregon to elsewhere. We draw conclusions from the study in Section 6 and present research options for future studies.

3.1. THE ECONOMIC TRADE MODEL

The analysis uses the CINTRAFOR Global Trade Model (CGTM) to measure the effect of an annual change in Oregon's harvest level on the US and international production, consumption, trade and prices of timber, lumber and plywood (see Appendix 1). These changes are presented and discussed in terms of economic impacts on the forest sector and impacts on the environment. Discussion of the results draws on recently completed studies on international plantation yields, a life cycle assessment of wood products and the southern forest resource assessment.

Geographically, the analysis includes the US and international markets for softwood lumber and plywood and the environmental aspects associated with forestlands used in the production of these products. While the CGTM includes the entire world, the study focuses on the North American, Asian and Latin American markets. The Latin American and Southeast Asian markets are examined primarily as a producer of substitute wood products and their associated environmental tradeoffs with Oregon. The European regions of Finland and Sweden are briefly mentioned in the discussion of our results based on their demonstrated potential to provide substitute wood products. The environmental analysis includes an examination of land use, measures of biodiversity and carbon cycling from forests to products to end-use.

To use CGTM, a baseline projection of the forest sector is first made. We analyze the results of the baseline by comparing it to a no-demand growth alternative scenario. Then, the change in Oregon's annual harvest volume is incorporated into a third projection. We measure the effects on US and international markets by comparing the no-harvest increase projection with the baseline projection that allows harvest levels in Oregon to grow to meet future demand. The structural changes in supply and demand are discussed and the regions and products that require further analysis are identified.

The baseline projection utilizes 2000 as the start year. CGTM databases were updated from 1993 to 2000 to meet the objectives of this study. Projections are made annually for 4 decades to 2040. Specifically, we use the changes in production and trade patterns associated with the change in supply of saw logs from Oregon to identify the regions that pick up the shortfall in timber supply.

3.2. THE ENVIRONMENTAL ANALYSIS

The analysis consists of a discussion of several environmental measures on regions identified as potential sources of substitute wood by the CGTM. It also discusses how substitution away from wood products affects global warming through carbon emissions.

The study produces rankings of these emerging regions using various data on environmental criteria. The rankings and other studies are used to enhance the understanding of the social and environmental impacts of a reduced annual harvest level in Oregon on US and international forest product markets and the services that forests in these regions produce.

We also study carbon in forests and forest products and present the implications of changing the harvest level in Oregon on global warming. We use a study underway by the Consortium for Research on Renewable Industrial Materials (CORRIM, Inc) that reports environmental performance measures, including a global warming potential index, for renewable building materials and alternatives. The CORRIM report links forest growth and harvesting through to the construction of structures for two regions in the US with competing steel and concrete processes using life cycle inventories. The results of the CORRIM research are applied to changes produced by the CGTM in response to a lower future harvest in Oregon to derive an impact on carbon emissions associated with a change in wood use.

3.3. THE SOCIAL AND ECONOMIC ANALYSIS

Recent work by CINTRAFOR has examined the biological and economic fiber supply available from plantations established outside of the US. The CINTRAFOR study produces alternative scenarios of the potential supply of wood fiber by key emerging regions where active plantation programs exist using the United Nations Food and Agricultural Organization (FAO) data on planted area, our own assumptions on rotation ages and growth rates, and a timber projection model. These new plantations are a potential substitute for Oregonian timber volume entering the US and international markets, and comprise the competition at the fringes of Oregon's forest products markets.

3.4. THE REPORT OUTLINE

The remainder of the report is organized as follows: Section 4 presents the estimated US and global wood substitution as a result of changes in annual harvest levels in Oregon. It is divided into two subsections. The projected demand for wood products is discussed in the first. A presentation of how Oregon's market share is distributed under constrained conditions is the second. Section 5 presents the US and global environmental implications. Further discussion of the study results is presented in Section 6, and conclusions are drawn in Section 7.

4. ESTIMATED US AND GLOBAL WOOD SUBSTITUTION

We estimate the substitution effect of maintaining Oregon's annual harvest levels constant by creating a future scenario with and without the increase in harvest volume from Oregon's forests. Several steps are involved in this process and we describe them briefly below. Following this, we present the results of the scenario analysis that maintains a constant Oregon annual harvest level throughout the projection period and estimates the changes in wood products market shares and their environmental implications.

4.1. THE EFFECT OF AN INCREASE IN DEMAND ON MARKET DISTRIBUTION

To understand the importance of Oregon's forest sector in the US and international context we first ask the following question: How will future demand in wood products be distributed among current producers? We answer this question by creating three scenarios of the future using the CGTM. The first scenario considers growth rates in demand that correspond to historical observations. In this scenario, the western region of the US, which includes Oregon, and other regions expand harvest levels as markets for wood products increase due to the larger global economy. The second scenario maintains the consumption of wood products equal to 2000 levels. A comparison of the two scenarios allows us to discern those regions that expand production to meet a potential future demand. Since Oregon forests produce a part of the supply needed to meet future demand, the comparison also allows us to estimate the size of Oregon's contribution. A third scenario constrains Oregon's harvest to 2000 levels, while allowing demand to increase and other regions to expand their harvest levels. We then take the projections of this third scenario and compare them to the previous two scenarios to determine how Oregon's market share is redistributed between other regions and alternative material suppliers.

4.1.1. Historic Demand and View of the Future

The study begins with an overview of global demand for industrial wood fiber. This analysis is conducted without the use of the CGTM so as to provide a simple check on the model's own demand projection by using an aggregate global measure. It is also useful since it illustrates the nature of historical demand and the range of uncertainty in the future, albeit at a very aggregate level—the globe.

Data on global consumption of industrial roundwood reveals a structural break in consumption patterns during the early 1990's. Part of this break is the result of the collapse of the former Soviet Union. The shut down of not only its consumption but also its production sectors has had a visible impact on global consumption. Also, efforts to produce timber in a sustainable fashion in tropical forests and environmental restrictions on softwood timber harvests significantly constrained timber supply in the 1990s, leading to reduced global consumption of forest products.

Figure 4.1 charts the historical relationship using world gross domestic product (GDP), as the measure of global income converted to real US dollars using purchasing power parity, and consumption of industrial round wood in millions of cubic meters. The figure also includes two extensions of the historical growth rate based on two different sample periods. Industrial raw material is defined as timber that produces paper and paperboard products, solid wood products and other miscellaneous products, (i.e. no firewood). Data on GDP is taken from various World Bank and Organization on Economic Cooperation and Development (OECD) publications. Industrial wood consumption data is taken from FAO publications.

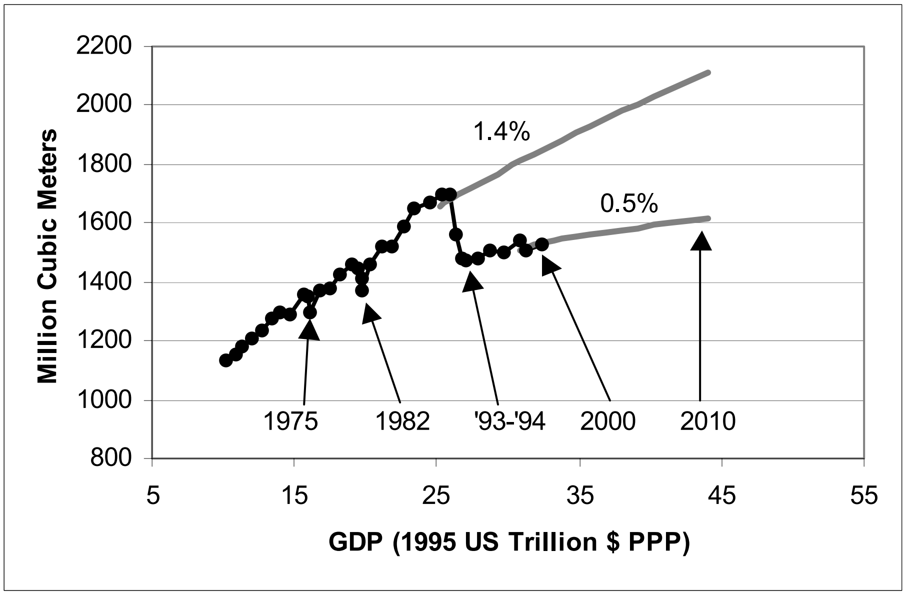

Figure 4.1. Consumption of industrial roundwood by economic activity from 1965 to 2000 and projections (grey lines) to 2010.

The figure suggests that currently (2000) the global forest sector is below its historic consumption trend, and has been for a significant period of time. For example, prior to 1990, the forest products industry was increasing its use of wood by 1.4% annually with an average 3.5% rate of growth in the world economy. An extension of this consumption rate would have placed global consumption at around 2.1 billion cubic meters (Bm3) (371 billion board feet (BBF)) by the year 2010. Instead, we consumed about 1.5 Bm3 (265 BBF) in 2000 and are on track to consume 1.6 Bm3 (283 BBF) by 2010. About 635 million cubic meters (MMm3) (112 BBF) of the estimated 1.5 Bm3 of industrial roundwood consumed in 2000 is softwood saw logs (41%).[1]

The last decade of the 20th century produced significant changes in the global forest sector, which may prove to be permanent. Foremost, the demise of the Soviet Union had a large impact on global production and consumption of wood products. Also, efforts to produce timber in a sustainable fashion in tropical forests and environmental restrictions on timber harvests significantly constrained timber supply. These two changes are evident as the line representing the long-term relationship between consumption and income rotates and shifts downward in the early 1990s. The effects of the collapse of the Soviet Union and other factors resulted in a sharp decline in global consumption of industrial roundwood.

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[1] Volumes measured for the global market analysis as well as model simulations are reported in cubic meters. Numbers in parenthesis that follow cubic volume measures are corresponding board foot volume measures. One board foot is equivalent to 0.005663 cubic meters for logs and 1 board foot is equal to 0.00236 cubic meters for lumber. Since metric units do not consider any overrun, the board foot measure for saw logs is approximately the lumber equivalent of those logs. Care should be taken when converting the board foot measure on the saw log to board foot measure on a lumber basis.

Not evident in the chart is the fact that new sources of fiber were introduced to replace a part of the reduction in timber supplied from the Pacific Northwest, Russia and tropical regions. As these new sources of wood fiber were introduced to supply global demand, there have been adjustments in how the fiber is used. The shortage of wood produced by the collapse of the former Soviet Union and stricter regulations on harvesting wood resulted in higher prices and allowed wood-saving technologies to take hold. Data for the last decade on wood consumption and GDP suggest that, on average, the forest products industry worldwide was increasing its use of wood as a raw material at an annual rate of 0.5%, a sharp decrease compared to its consumption rate observed during the previous three decades. A projection of industrial use suggests global consumption of around 1.6 billion cubic meters by 2010, a level observed in the mid 1980s. The 0.5% growth assumption, also based on a global average 3.5% GDP growth rate, assumes that the structural changes associated with wood supply and wood use are permanent.

In addition to the structural change, there are cyclical movements of consumption associated with the global business cycle. There have been several dips in consumption as evident in Figure 4.1. The first two dips are responses from wood using industries to higher energy costs, which led to worldwide recessions in 1975 and 1982. A global slowdown in 1991 is also a factor in the decline in consumption, yet these cyclical events tend to average out over time. With recent outlooks on GDP and consumption for 2001 and 2002, it is likely that consumption is still below the 0.5% trend line.

We produce longer-term consumption projections by extending the global average for economic growth over the next several decades and using the historical trends in consumption. By 2050 the range of consumption produced by our assumption of either a 0.5% or 1.4% rate of increase is from 2.0 Bm^3 (353 BBF) to 2.8 Bm^3 (499 BBF), respectively, with a global economy of nearly five times the size observed in 2000. The bottom end of the range indicates an increase of 500 MMm^3 (88.3 BBF) over the fifty-year period. The top end of the range suggests an additional 1.3 Bm^3 (230 BBF) to meet demand.

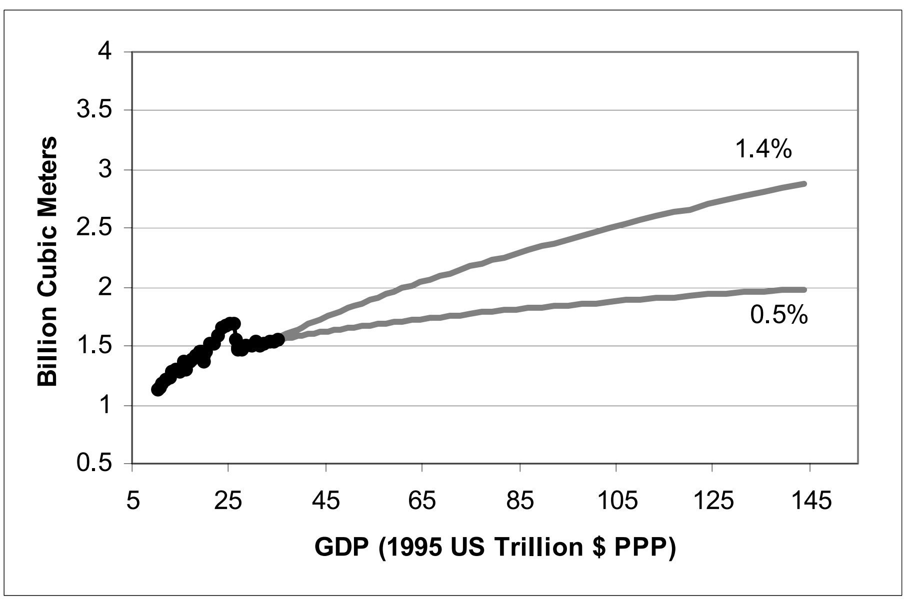

Figure 4.2. Consumption of industrial round wood by economic activity from 1965 with projections to 2050 based on average GDP growth of 3.5%.

Since our study examines only softwood roundwood and not all the categories of industrial roundwood (i.e. hardwood roundwood is not evaluated in the present study since Oregon has a limited harvest volume relative to other regions of the US and the world), we come back later to compare the CGTM projections of consumption with the simplistic model presented above. But first we breakout the CGTM demand projections by aggregated regions.

4.1.2. Demand Growth for Important Softwood Lumber Consumers

We now switch from a discussion on roundwood demand at the global level to the CGTM demand projections for lumber use. We begin by presenting the projections and underlying demand assumptions for aggregated regions in the CGTM. Demand growth in the model is represented by shifts in the underlying demand curve, and is projected by economic activity in end-using sectors. Figures 4.3 to 4.5 aggregate three major consuming regions of the world illustrating the projected aggregate demand shifts.

The US is the largest market for softwood lumber in the world and is projected to continue to be so over the next 4 decades. Figure 4.3 illustrates the historical consumption data from 1970 to 2000, the position of the demand curves for the 1970s, the mid 1990s, and the projected position given model results for 2040 for the US. The figure illustrates the prospect for demand growth in the three US regions combined (North, South and West). Lumber demand for the combined three regions is expected to increase by 34 MMm^3 (14.4 BBF) by 2040, with growth in each region nearly equal. By 2040 lumber consumption in the US will near 165 MMm^3 (70 BBF) and average $127 per cubic meter (m^3) ($300 per thousand board feet (mbf)).

The scatter of connected consumption and price data also illustrates the variability in prices and occasional contraction in consumption that occurs in the sector due to economic fluctuations. We attempt to represent the extent of this variability by illustrating the position of the demand curve where prices in 2040 may vary from $100 per m^3 ($250 per mbf) to $150 per m^3 ($350 per mbf) and consumption may vary by as much as 10 MMm3 (4.2 BBF).

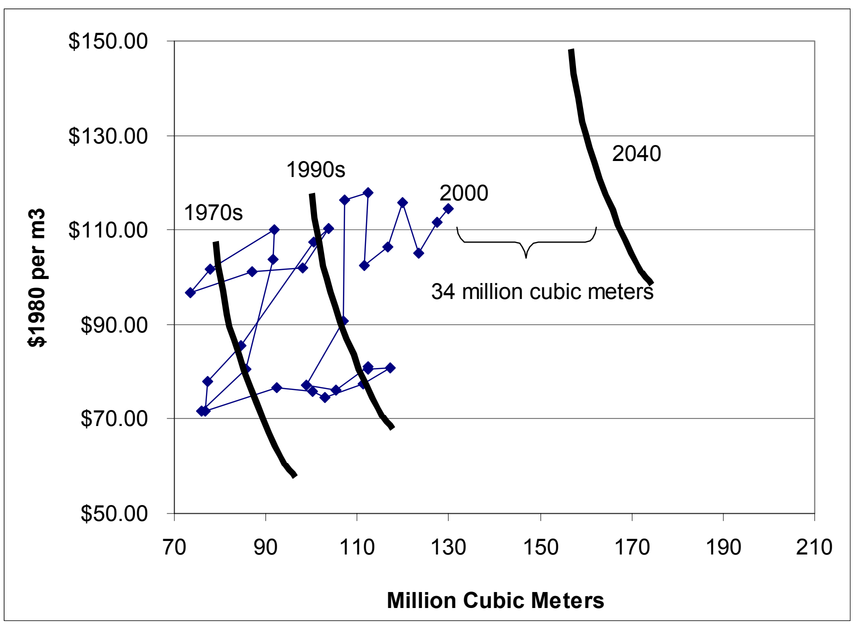

Figure 4.3. Demand growth in the US for softwood lumber with historical data, the position of the demand curve for 1970's, mid 1990's and the projected position for 2040.

Softwood lumber demand growth projections outside the US are significantly less. In Europe, the increase in consumption will reach about 20 percent more than 2000 levels. Figure 4.4 illustrates the position of the demand curves in 1990 and 2040 (without the scatter data detail).

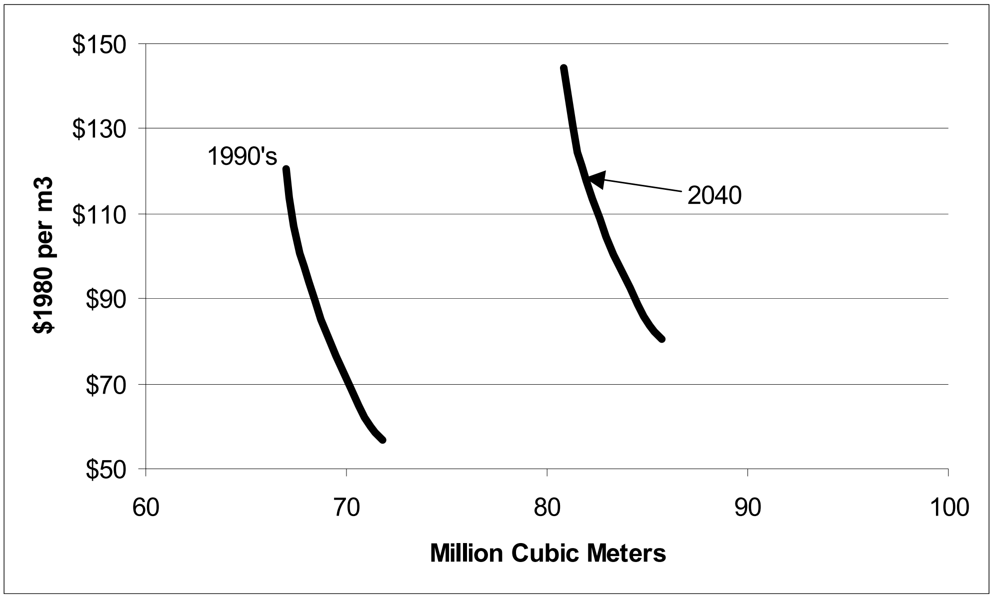

Figure 4.4. Demand growth in Europe for softwood lumber indicating the position of the demand curve for 2000 and 2040.

Projections of demand growth for the Asian-Pacific region are illustrated in Figure 4.5. Since growth in Japan and Korea are likely to be stagnant and not return to pre-2000 levels for a decade or so, growth for the entire region is also significantly less than the US. Even with the expectation that China will double its consumption of softwood lumber products by 2040, growth for the region is estimated at about 15 MMm^3 (6.4 BBF), as shown in Figure 4.5.

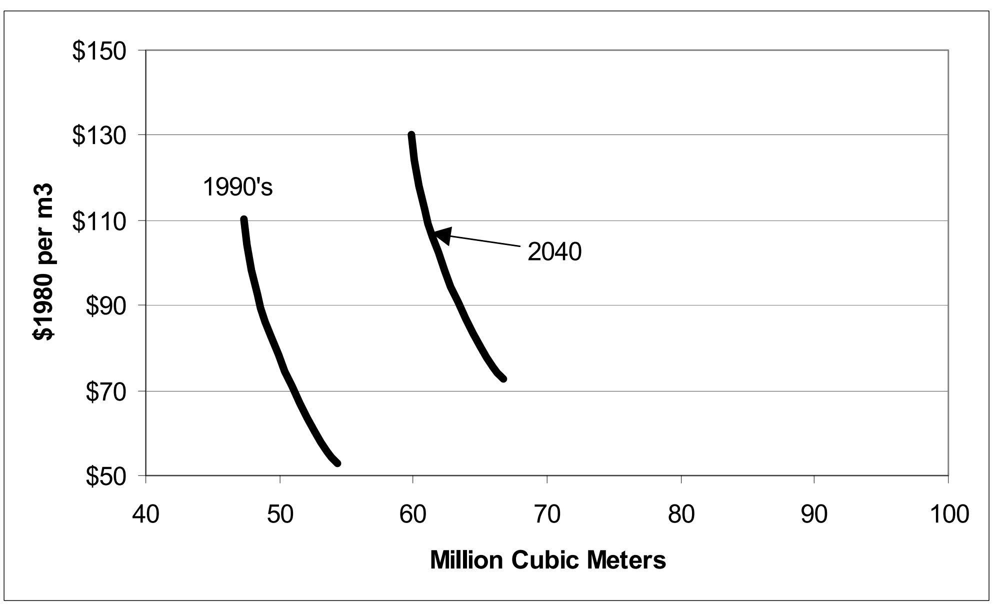

Figure 4.5. Demand growth in Asia Pacific for softwood lumber indicating the position of the demand curve for 2000 and 2040.

There is an associated derived demand for saw logs required to produce the projected lumber consumption (and structural plywood as well). Projected consumption of saw logs distributed by regions and associated with the increase in lumber consumption projections is provided in Figure 4.6. Worldwide an additional 190 MMm^3 (33.6 BBF) of softwood saw logs are harvested by the end of the forecast period 2040. The South expands harvest by over 100 MMm^3 (17.7 BBF) followed by Canada with over 40 MMm^3 (7.1 BBF). The US West responds with about 10 MMm^3 (1.8 BBF). Asia, Europe and other region make up the rest of the projected harvest. Trade activity increases by about 15 MMm^3 (2.6 BBF). The harvest increase corresponds to a growth rate of about 0.5% in roundwood consumption with a 3.5% growth in economic activity as indicated in our discussion on aggregate demand in Section 4.1.1.

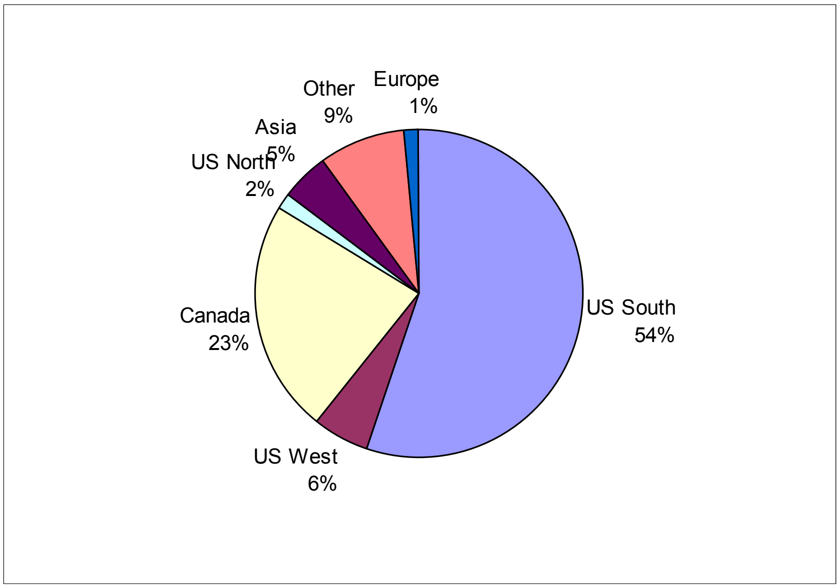

Figure 4.6. The distribution of saw log harvest volumes required to meet the projected global demand increase in softwood lumber in percent.

4.2. THE EFFECT OF LOWER OREGON ANNUAL HARVEST LEVELS IN MEETING FUTURE DEMAND

The previous section presented the projection for demand growth of softwood lumber and its corresponding saw log harvest volumes around the globe, and how this increment in demand may be met regionally. It indicates that the US West region (which is composed of Oregon, Washington and northern California) may contribute an additional 10 MMm^3 (1.8 BBF) of softwood saw logs or 6% of the increased demand by the end of the projection period (2040). In this section we introduce a constraint that does not allow Oregon's annual harvest level to increase. We then reexamine the production and trade activities that occur to meet the projected demand over the next 40 years. This allows us to identify where substitute sources exist and evaluate their contributions.

The examination differs from the previous analysis in that Oregon's annual harvest level is constrained not to exceed their 2000 level. As a result there are two types of substitution effects that take place. First, there is a price effect that lowers consumption. Second some producers from other regions will increase their harvest levels in response to higher prices.

Figure 4.7 illustrates the redistribution of market shares while harvest levels are constrained in Oregon. Less timber production raises prices and lowers log consumption by 3 MMm^3 (0.530 BBF) representing lost demand that is not made up by other producers. The major redistribution occurs in the US, where southern producers make up 43% of Oregon's harvest reduction. Canada and Asia have a 10% and 15% increase in production, respectively; reflecting that, as each region experiences higher prices, they extract more timber. Lumber production declines by 1.54 MMm3 (0.652 BBF), and plywood production falls by 0.4 MMm3. In the west, logs are further diverted from the export markets to the domestic market in response to a domestic log shortage. While most of the export diversion has already occurred due to harvest restrictions during the 1990s, further reduction of timber harvests in the region suggests that log export activity is eliminated.

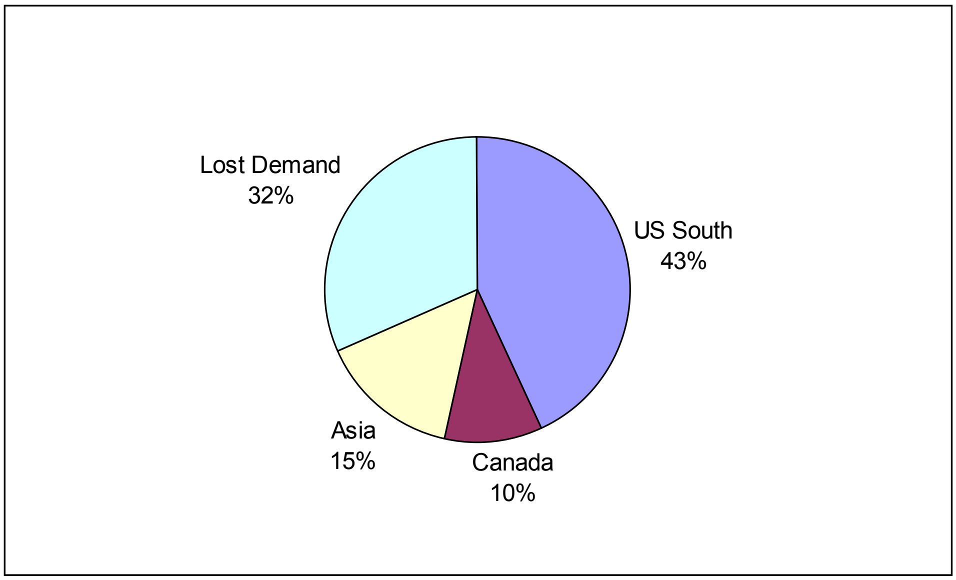

Figure 4.7. Distribution of Oregon's harvest reduction to US, other regions and substitute products.

These results suggest a bigger share of global and US forest products markets by overseas producers at the expense of Oregon's potential growth in future market share. Who are these competitors and are model results supported by recent trade activity data? Section 4.3 elaborates on international producers of wood fiber.

4.3. EMERGING REGIONS EXPERIENCE INCREASES IN EXPORTS TO US WESTERN PORTS

Examining US customs data reveal important trends in imports from Asian and Latin American producers to US western ports. We identify several countries that are key among those that have the resources and distribution channels to service US markets. They include Australia, New Zealand, Chile, Uruguay, Argentina, and Brazil.

There are many softwood lumber producers in Latin America, but the major countries that export to western ports are Chile, and to a much lesser extent, Brazil. Softwood lumber imports from Chile at US western ports reached nearly $100 million in 2002. The growth in imports occurred in the 1990s and was sparked by two events. The first event was the protection of spotted owl habitat that lowered timber harvests and raised prices for wood products in the US and around the world. The second event was the financial crisis in Asia and Japan's continued weak economic performance that pushed lumber destined for Japan, Korea and China into US markets. Softwood lumber imports from Brazil at US western ports peaked in 1999 at less than $25 million and fell to just about $5 million two years later.

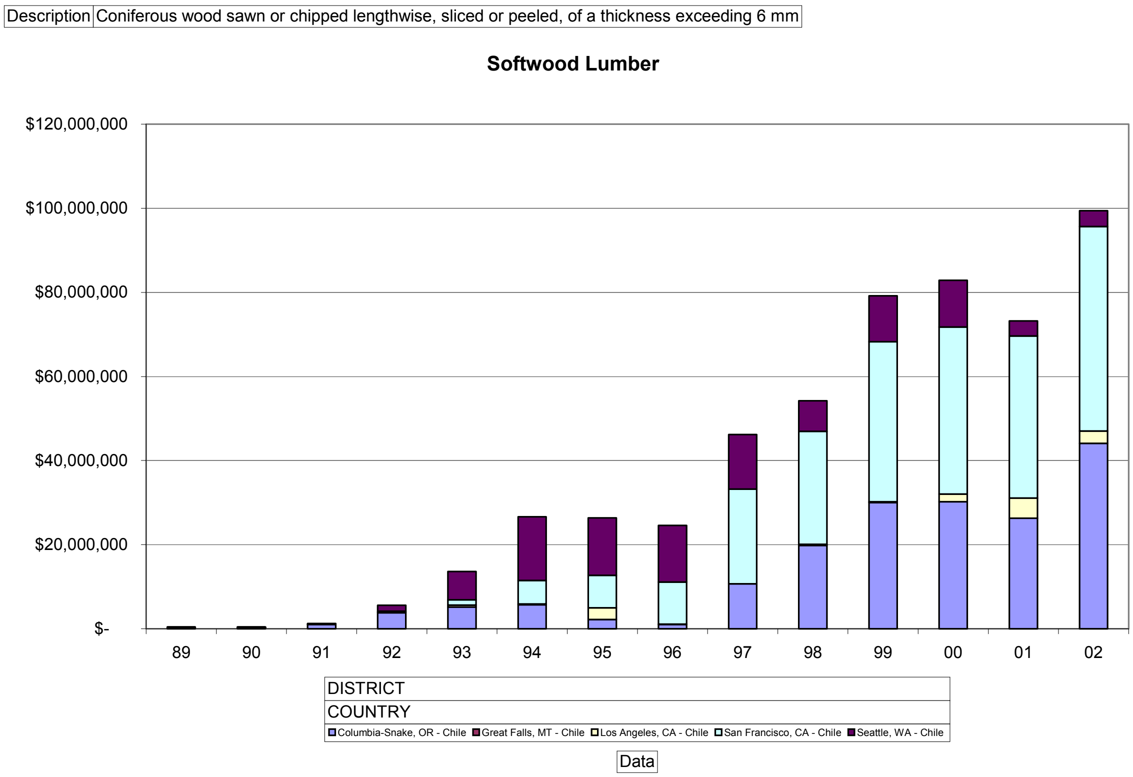

Figure 4.8. Softwood lumber imports by western US ports from Chile.

New Zealand has also increased its exports to US western ports. About $150 million worth of lumber came from New Zealand in 2002, again favored by the price hike in 1993 due to implementation of habitat conservation plans and the financial crisis in Asia.

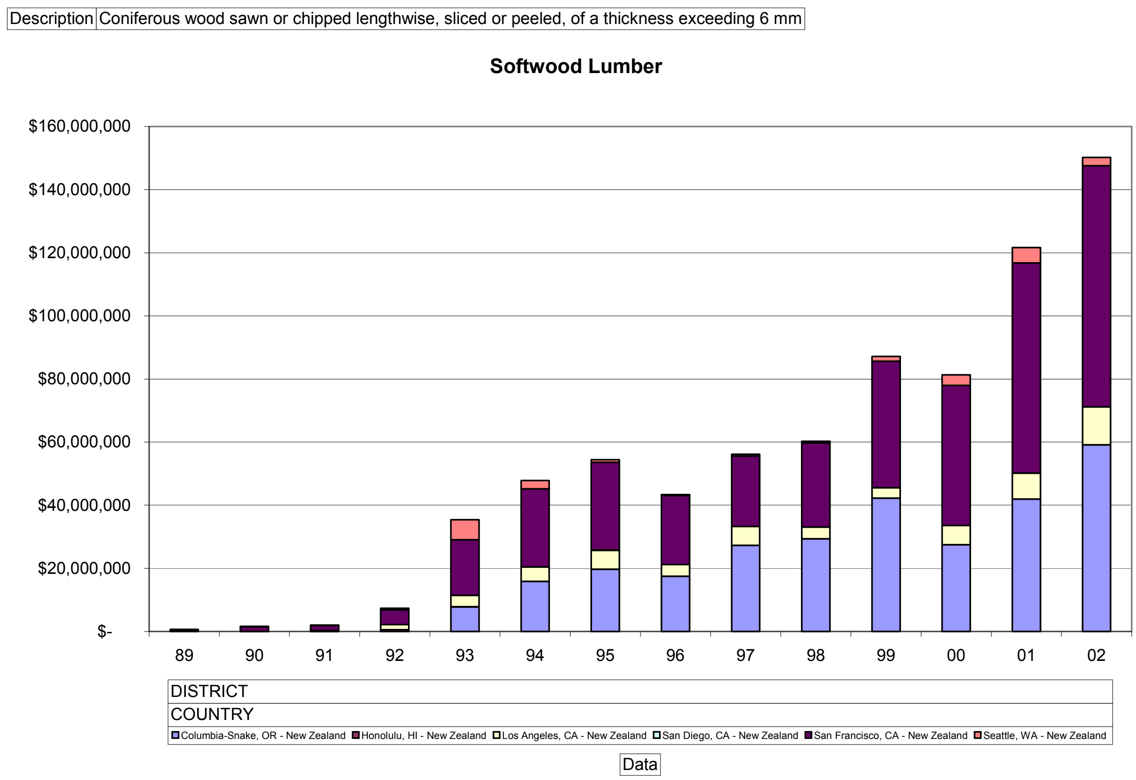

Figure 4.9. Softwood lumber imports by western US ports from New Zealand.

These trade flows are small but significant since they signal new market suppliers to the US through western ports that directly compete with Oregonian products. While Canada's export of softwood lumber to the US has fluctuated between $1.4 and $1.8 billion over the past ten years, New Zealand and Chile combined have been able to increase their exports to US western ports to over 13% of all the major lumber exporters to these ports.

One other country deserves mention since it is beginning to show signs of trade activity in softwood lumber. Uruguay, which had no trade activity in 1993, quickly developed up to $2 million in softwood lumber trade in 1999. While this is extremely small relative to the $2.4 billion worth of lumber produced in Oregon in 1999 (wholesale value), it illustrates a region that may by classified as a marginal producer of lumber to the US market that is likely to step up should Oregon's harvest become constrained.

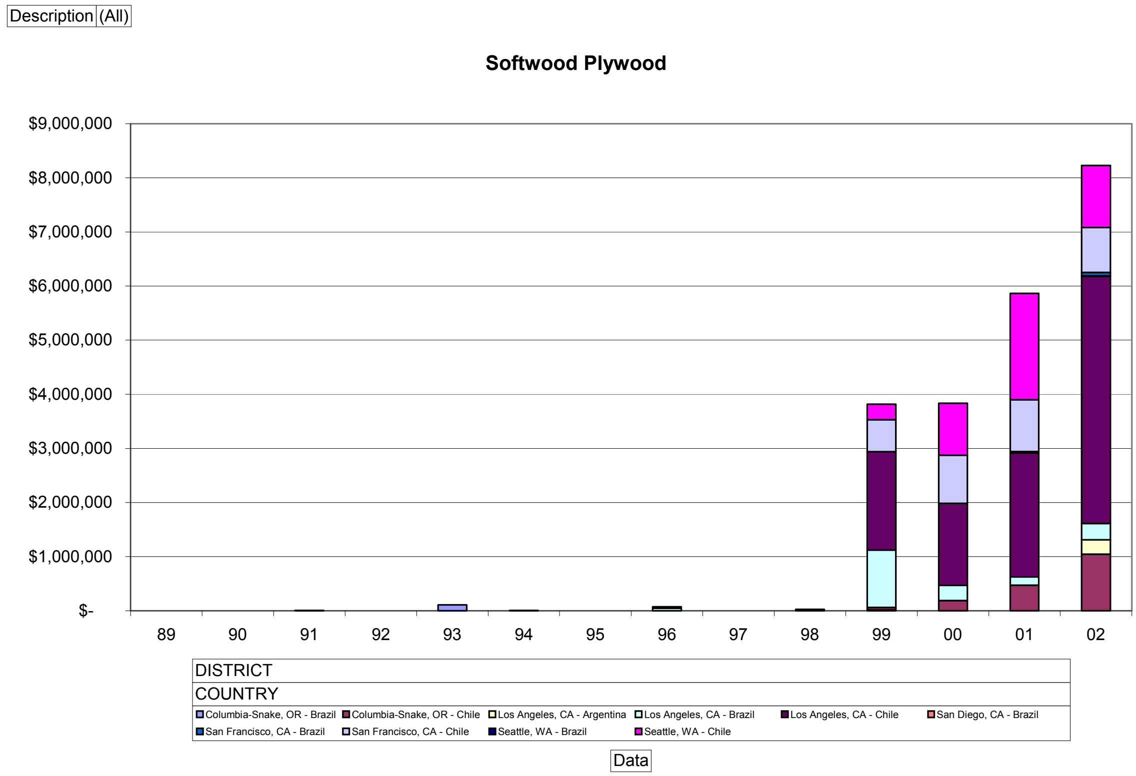

Figure 4.10. Softwood plywood imports by western ports from Brazil and Chile.

Softwood plywood has also made inroads into western ports from Latin American countries and New Zealand. As Figure 4.10 illustrates, imports by western ports in the US from Latin American countries, primarily Chile and Brazil, have grown dramatically to over $8 million in 2002. New Zealand added an additional $1 million in 2002.

Up to now the demand analysis has indicated the potential size and origin of substitute sources indicating the major competitors for Oregon wood products. They include the US South, Canada, Asian and Latin American producers. Unlike earlier analysis of potential new suppliers of wood products, European producers do not appear to be able to compete in the restructuring of market shares. We attribute this result to price level differences between 1993, when previous analyses were implemented, and 2000, our current base year. Product prices have reverted to lower levels following the supply shocks from timber harvest reductions and the demand collapse associated with Asia's financial crisis. As a result, price levels are not high enough to motivate on average any supply response from European producers. While the CGTM considers real exchange rates to be equilibrium, the weaker dollar relative to the Euro also implies higher costs to European producers selling into US markets and constraining their expansion into US markets.

In summary, the global demand for wood products is growing, likely at a rate much lower than that observed prior to the 1990s. Oregon's potential contribution to this US and international demand growth is estimated to reach 10 MMm^3 (1.8 BBF) of softwood saw logs annually over the four decades. Should Oregon not contribute to meet the demand growth, US southern states, Canada and other countries will expand their harvests, but not enough to completely make up the 10 MMm^3 (1.8 BBF) shortfall, leaving suppliers of alternative products an opportunity to expand into the wood products markets. The redistribution of future market share will produce environmental and social effects to which we now turn our discussion.

5. ESTIMATED US AND GLOBAL ENVIRONMENTAL IMPACTS

The previous section described how a harvesting constraint in Oregon leads to a shift in the wood products market distribution around the world. To adjust to the supply shortage, the world reacts by reducing consumption since prices rise, and by sourcing wood from other areas within and outside of the US. This section presents a discussion of the potential environmental impacts on those regions identified in Section 4 that increase their harvest levels. We begin our discussion with the US South.

5.1. THE US SOUTH

To discuss the environmental consequences in the US South, we first describe how the projected growth in timber demand in the South may be distributed among the various southern states. Figure 5.1 reproduces output from an analysis conducted with the CGTM and a Southern Regional Timber Supply (SRTS) model. The data is presented at the forest inventory analysis unit level (i.e. each number represents a inventory analysis unit). It reports the change in removals observed in 2010 using 1995 as the base inventory year. Numbers reported in the figure lower than 100 indicate a percentage reduction in harvest volume by 2010. Numbers greater than 100 indicate a higher harvest volume in 2010. A number equal to 100 indicates the same level of harvest as in 1995. The projection for the south-wide region is to increase harvest volume by 14 percent on average. Several analysis units reduce their harvest levels (in Georgia and Alabama for example) while other units increase their harvest volumes (in North Carolina for example). The figure illustrates the reduction in removals in the central region while survey units in the surrounding area increase harvest volumes. The projection suggests a redistribution of south-wide harvest volumes due to limiting inventory in several areas.

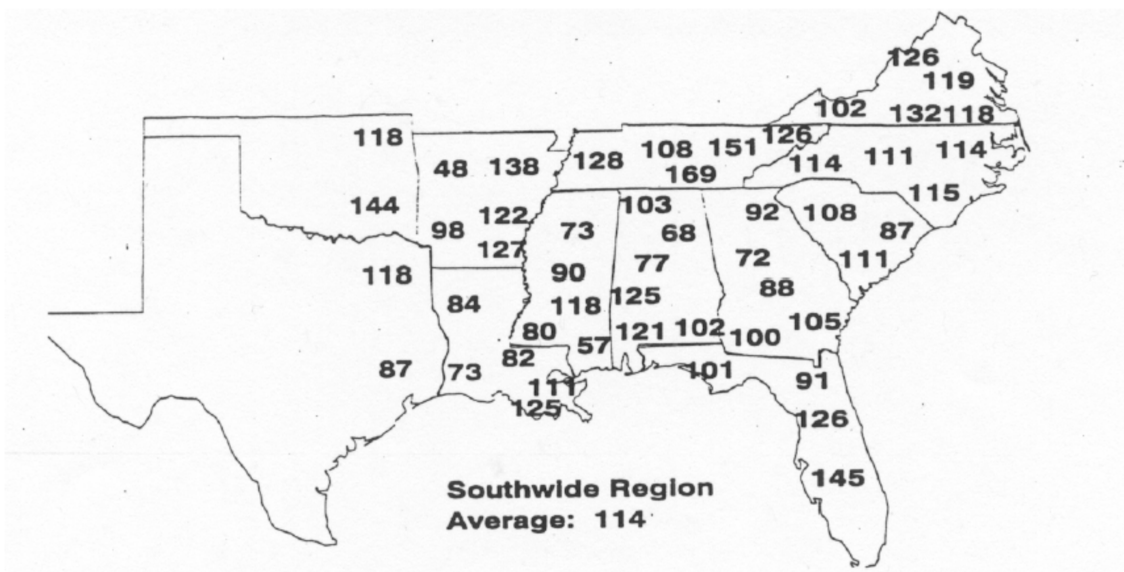

Figure 5.1. Regional harvest distribution of higher demand on softwood resources in the South.

Figure 5.2 reports the changes observed in inventory levels by region. On average the South experienced a 14 percent decline in inventory from 1995 to 2010 according to SRTS. The areas hardest hit are located in the central region.

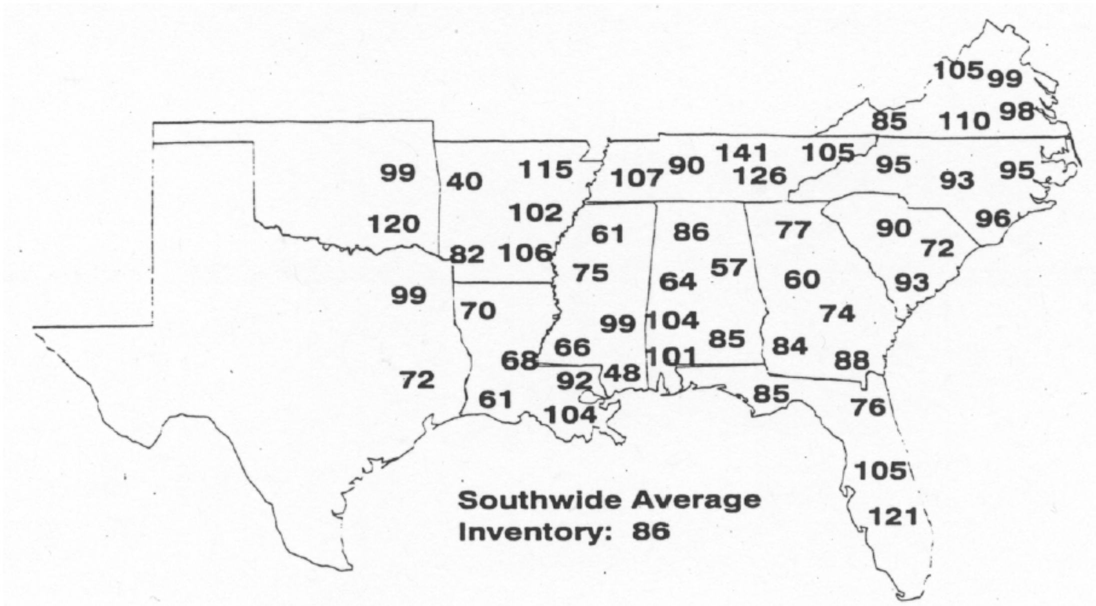

Figure 5.2. Regional inventory changes associated with a higher demand on softwood resources in the South.

Areas that will expand harvest levels in the South are at the fringes of the southern wood basket, and include eastern Texas and the Carolinas among others. Inventory projections also indicate that these areas are likely to reduce inventories to levels below those observed in 1995. How states increase the harvest level is determined by short- and long-run factors. In the long run, regions may increase aggregate output of softwood timber from genetic improvements, more intensive use of mechanical and chemical means, greater use of fertilization, and higher harvest frequencies. Over the shorter term, which is what the modeling result above is suggesting, the south will increase its harvest by shifting to areas where inventory levels make an increase in the harvest level possible. The south is also forecast to lose 31 million forest acres to non-forest uses. Nevertheless, it is a region with the capacity to expand harvests, which raises conservationists' concerns.

Both the long- and short-term harvest volume adjustments have implications for the environment. Area-wise, the increased demand for timber from the South implies a greater number of acres harvested than would be harvested in Oregon. Stocking levels at rotation age are roughly twice as large in Oregon as in southern states and harvests are less frequent in Oregon due to the longer rotation period. These differences in land productivity and management practices are likely to produce unequal tradeoffs between saved areas in Oregon and harvested ones in the South. Larger harvested areas imply a greater area of habitat destruction at harvest with some concomitant impact on biodiversity. More frequent harvests imply that the restoration of habitat and biodiversity to older age classes is less probable. Instead, environmental conditions associated with the stand structures of short-rotation plantations will prevail, with some probability that biodiversity will be reduced.

According to the South Forest Resource Assessment (SFRA) 132 terrestrial vertebrate species exist that are considered to be of conservation concern in the South. Greater economic pressure to increase harvests will likely exacerbate these concerns. Many of these species are found in Texas and other southern states subject to increased harvest pressures. A dozen species of salamanders are classified as critically imperiled in Texas (SFRA, Table 1.3). More frequent harvests are not likely to improve their conditions unless appropriate management techniques are introduced.

In addition the SFRA has identified ecosystem communities that have declined by 70 percent or more in the South since European settlement. Critically endangered are old-growth deciduous forests in the southeast, the Southern Appalachian spruce-fir in Tennessee, North Carolina and Virginia, the Longleaf pine forests and savannas of the southeastern coastal plain and others found throughout the south. More frequent harvests are also likely to impinge on these ecosystem communities that are in decline.

The southern forest sector is characterized by public ownership (state, federal and others) that averages about 10% among the different states. This compares to Oregon's public ownership of 61% with 31% of forest area maintained in reserve status. Many of the non-timber functions of forests are maintained on these landscapes under public management. Greater pressures on forested habitat and biodiversity on private lands are likely to result with many of the ecological systems predicted to decline by as much as 8 percent by 2020 in the South, as a result of a greater volume of timber extracted, and the more frequent harvest activities. While all southern states have adopted silviculturally-best management practices and have forestry-trained landowners, loggers and consultants, these practices are geared toward providing for environmental protection during timber production versus biodiversity and other criterion objectives. Southern industrial and non-industrial timberland owners are expected to continue to invest in and expand the area of pine plantations at the likely expense of natural habitats.

The South has the resources to extract more wood from plantations into the future. Extracting a greater amount of wood has potential environmental impacts, and if this greater extraction is associated with lower harvested volumes in Oregon then an environmental tradeoff will exist between Oregonian and southern timber harvest activities. Measuring this tradeoff can best be described qualitatively since comparable regional measures are lacking. For example, it is likely that the area harvested in the South would be larger than the area required to harvest the same volume in Oregon. It is also likely that the areas harvested are harvested more frequently than in Oregon. In addition, there are plant and animal species and habitats that will come under greater stress due to an expanded harvest. The values needed to make a quantitative assessment of the tradeoffs between the two regions are lacking. Data that is currently collected include number of species and area measures but lack a valuation measure that can be used to compare salamander species with bird species for example, or fir-hemlock with oak-hickory forest types.

5.2. INTERNATIONAL EMERGING PLANTATIONS

In section 4.3 we identified competitors to Oregon's forest products market shares based on our economic analysis of the global forest sector. The US is increasing imports from Asian and Latin American producers, particularly since the US has been the price-setting country for many forest products while markets in Asia and Europe have had lackluster economic growth. A curtailment in Oregon's participation in meeting future demand implies greater market share for these international forest sectors. In this section we present characteristics of important emerging plantations, their timber supply outlook and implications for the environment.

Plantings in emerging regions occur primarily on abandoned, degraded agricultural lands often with government subsidies. These plantations differ considerable from Oregonian forest plantings in that they are primarily managed on intensive, short rotations with wood fiber rather than saw log production in mind. Almost all of the planted species are exotic. Forest management for timber production is less constrained with respect to biodiversity and habitat protection, but may lead to similar concerns regarding soil and water conservation as in Oregon. Since Oregon forestlands are managed for a larger set of non-timber attributes, many positive externalities exist for water, soil, scenic and natural habitat conservation in Oregon while lacking in exotic plantations.

Data on forest areas in plantations present an opportunity to assess the availability of wood fiber from regions that can increase market share due to a policy that maintains Oregon's annual harvest levels constant. Plantation data for each region in CGTM is presented graphically in Appendix 4. Table 5.2 summarizes the data by listing the planted areas for selected countries and regions that are likely to increase their market share in the future, the average annual deforestation rate, forest area changes and the percentage of national protected land areas. These variables represent some of the parameters that are used to monitor a region's progress towards an environmentally set target such as an indicator or criterion.

Table 5.1. The area planted by industry and Non-Industrial Private Forest (NIPF), deforestation, area change, total and protected areas.

Region	Planted Areas (1000 ha)[a]	Average Annual Deforestation (1000 ha)	Forest Area (% Change 75 –87)	Total Forest Area (1000 ha)	National Protected System (% of land area)
Brazil	4,180	2,530	-4.2	514,480	6
Chile	1,747	50	0	7,550	18
So. South America	1,154	212	-13.9	64,700	8
Australia	1,043	NA	-9.6	41,658	6
New Zealand	1,540	NA	2.4	7,200	11
OREGON	3,452	NA[b]	NA[b]	11,180	31[c]
USA	18,387	NA	8.8	302,307	11

Sources. FAO, Sharma (1990), FIA summaries. [a]as of 1995-1999. [b]see Figure 5.3. [c]areas in reserve status.

The data suggests that only Brazil has more plantations in the private sector than Oregon. Brazil is also a country with historically high deforestation rates. Many of the planted areas in Brazil occur in the mid-western and south-western portions of the country, while its deforestation occurs in the Amazon region in the northern part. Many of the plantations in Brazil were initially established with the help of government subsidies. Brazil's forest area continues to shrink, primarily due to the large extent of the Amazon region and development pressures there. The area under protection by the national authorities is about a quarter of Oregon's share and slightly over half of the US share. Market share gains for Brazil are likely to come from the plantation regions but can also promote greater expansion of planted areas into other areas, including native habitats.

Table 5.1 also presents data that suggests the area in forest in New Zealand is increasing. New Zealand has about half the plantation area than Oregon and is likely to expand as demand for wood fiber rises in the US and Asian Pacific region. Many of the planted areas occur on degraded agricultural areas using exotic species, and are managed under short rotations. Combined with Chilean plantation areas, the two countries contain about the same plantation area as Oregon and are likely to continue expanding it. Differences arise from the use of exotic species in Chile and New Zealand versus native tree species in Oregon and short- versus long-rotation management. Regulations that manage forest resources are different than Oregon's forest management laws providing a different level of protection for environmental attributes. Also, as examined below, the area of private timberland in Oregon is declining whereas in these two countries it has expanded significantly over the past decade.

Finally Table 5.1 suggests that Oregon has a higher percentage than any of the other regions listed of land area in reserve status (31%). Chile also has a high percentage of its land area protected by a national system. Oregon, however, is also dealing with pressures that convert forestlands into other uses. It has lost over 2 million acres during the period 1953 to 1997 (see Figure 5.3).

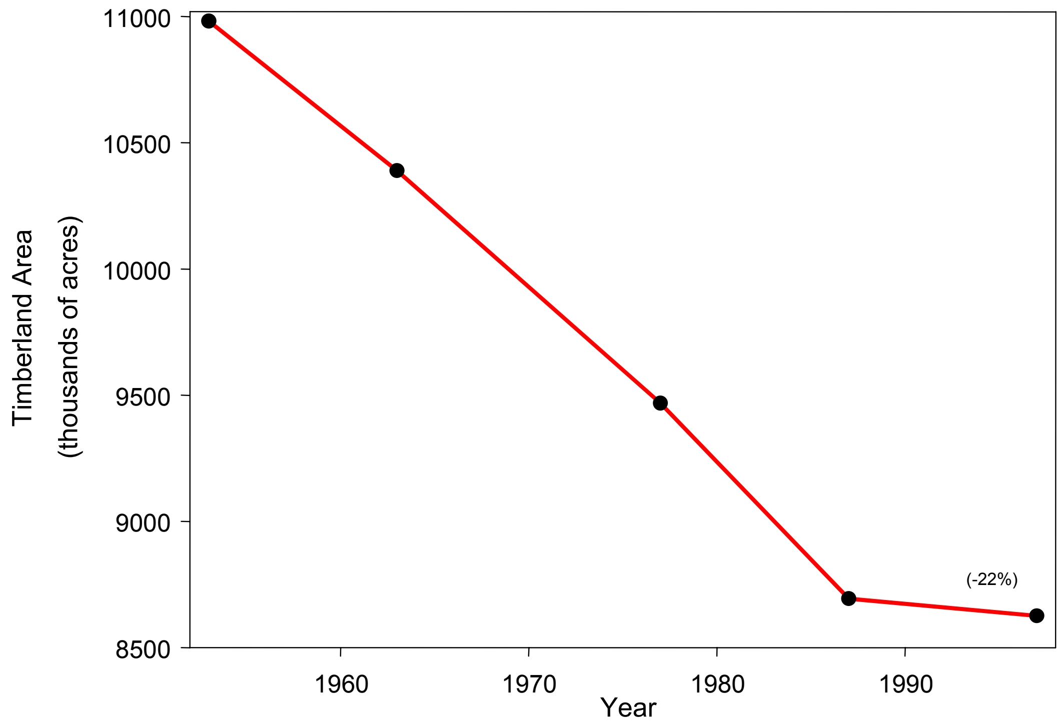

Figure 5.3. Change in private timberland area in Oregon, 1953-1997. The potential shift to international producers of a share in future wood products markets implies a greater use of plantation wood using exotic species. There is a potential for more demands placed on native habitats. In addition, more intensive management techniques geared toward timber production will be employed. Lower volumes per acre and more frequent harvest activities imply a greater number of interventions in forested habitats than would occur in Oregon. These activities carry an increased potential for biodiversity impacts to which we now turn.

5.3. BIODIVERSITY, OTHER INDICATORS AND RANKINGS

The Montreal Protocol established criterion and indicators to help manage the increasing pressures on forest resources. They set targets such as maintaining biological diversity and indicators to help evaluate a country's progress towards meeting environmental standards. Recently, biodiversity measures for numerous countries have been made available through databases such as the World Resources Institute's Earth Trends (http://earthtrends.wri.org/). We reproduce several biodiversity indices in Table 5.3 and initiate a discussion of them in this section. Appendix 3 contains the environmental measures under consideration by the Department of Forestry. Additional data on biodiversity summarized for the CGTM regions is available from the author in a worksheet format.

Table 5.3 present four measures. The first measure reported is the percentage of threatened bird species in a country or region. It is calculated from bird species density estimates and the total area of a country or region. The US, for example has less than 8 hundredths of a percent of threatened bird species. The Taiwan/Hong Kong region has 50% of their bird species under threat. Australia and Brazil are rank similarly with the US, and Chile and New Zealand are rank higher, meaning that Chile and New Zealand have a greater percentage of threatened bird species. Canada has the lowest percentage of threatened bird species in Table 5.3.

The table also provides bird species density. One may consider it a measure of the degree of biodiversity for birds. The US has an average 68 bird species per 10,000 sq. km. and is ranked fourth (number in parenthesis). The Northern South American region has 460 species per 10,000 sq. km. The difference between the US and Northern South America indicates a much greater diversity of bird species in the later region. Canada and New Zealand are two regions with less bird density than the US, while Chile and Australia are ranked 6th and 7th respectively.

The Managed Habitat Area measure is the extent of managed areas divided by total land area. One may think of this measure as how much land area is being used to promote conservation. The higher the percentage, the more land resources devoted to habitat conservation. The US is ranked 24th with over 4% of its land area managed for habitat conservation. Canada is ranked 23rd, while Chile, with its extensive areas under protection, is ranked 27th with 7% of its land under habitat management. Australia, Brazil, Southern South America and New Zealand all rank low, with less than 1% of their lands under management.

Plant species density is the number of plant species per 10,000 sq. km. It is a second indicator of the degree of biodiversity reported here. A higher percentage relates to a higher degree of biodiversity. Both Brazil and Southern South America have a higher ranking than the US, which is ranked 9th.

Table 5.2. Four measures of biodiversity with position listed in parenthesis.

Region	Threatened Bird Species (Percentage)	Bird Species Density	Managed Habitat Area (Percentage)	Plant Species Density
Eastern Africa	0.0019	222	0.0233	2231
Northern Africa	0.0056	141	0.0113	1398
Southern Africa	0.0011	122	0.0190	4797
Western Africa	0.0024	220	0.0167	2310
AUSTRALIA	***0.0008 (5)***	***72 (7)***	***0.0010 (1)***	***1741 (8)***
BRAZIL	***0.0008 (3)***	***162 (14)***	***0.0020 (2)***	***6058 (24)***
Central America/Mexico	0.0745	376	0.0200	7074
CANADA	***0.0001 (1)***	***44 (1)***	***0.0400 (23)***	***335 (1)***
CHILE	***0.0034 (12)***	***71 (6)***	***0.0710 (27)***	***1269 (5)***
China	0.0004	114	0.0095	3340
Eastern Europe	0.0157	164	0.0047	2563
Western Europe	0.0084	197	0.0324	2846
Finland	0.0017	78	0.0230	345
Former Soviet Union	0.1052	169	0.0188	2949
Indochina	0.0086	216	0.0257	3306
Indonesia	0.0021	271	0.0190	5196
India	0.0188	252	0.0260	2871
Japan	0.0120	75	0.0130	1679
Malaysia	0.0065	430	0.0180	7194
Middle East	0.2141	152	0.0184	2961
NEW ZEALAND	***0.0325 (22)***	***51 (2)***	***0.0080 (6)***	***802 (4)***
Philippines	0.0452	64	0.0030	2907
No. South America	0.0042	460	0.0668	10735
So. SOUTH AMERICA	***0.0068 (16)***	***164 (15)***	***0.0070 (5)***	***2311 (12)***
Sweden	0.0014	71	0.0280	498
Taiwan/Hong Kong	0.4995	295	0.0660	5713
USA	***0.0008 (4)***	***68 (4)***	***0.0430 (24)***	***2036 (9)***

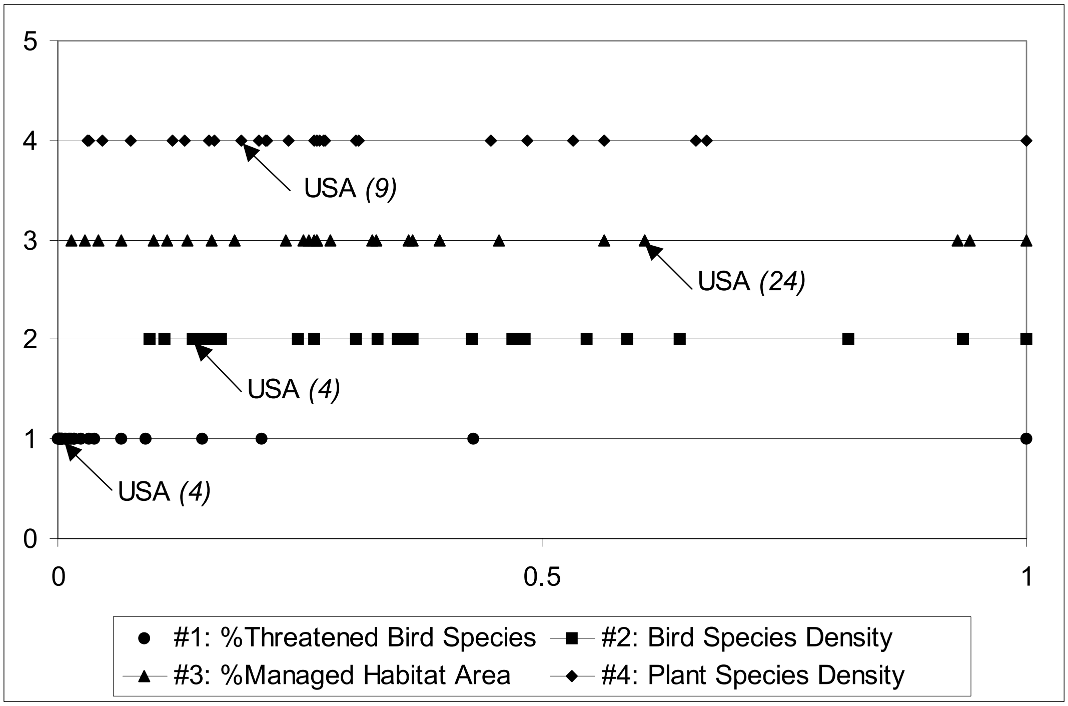

Figure 5.4. Ranking of CGTM regions by 4 measures of biodiversity.

Figure 5.4 summarizes the four measures, and illustrates the relative position of the US among all CGTM-defined regions by converting the measures in Table 5.2 into an index where 1 equals the maximum value observed for each measure. In three of the four measures, a lower ranking implies a higher biodiversity grade: Percentage of Threatened Bird Species, Bird Species Density and Plant Species Density. Lower density measures imply lower complexity and lower probability of adverse impacts from alternative land uses. For Percentage of Managed Habitat Area, a higher ranking signifies a higher biodiversity grade. The figure illustrates a low ranking for threatened bird species and high ranking for managed habitat area. Both measures of the degree of biodiversity (#2 and #4) suggest simpler biodiversity communities than other regions.

Finally, Canada is another region that is likely to pick up market share foregone by Oregon. In Canada, much of the authority over forests has been delegated to the provincial levels. For example, the BC government owns nearly 95% of the province's forestlands. The implication for a greater market share from Canadian forests on the environment is dependant on federal, provincial and First Nation policies. Unlike the exotic species and short rotations that characterize the international plantations described above, the majority of Canada's forest that provides timber are first generational and likely to continue for some time into the future, particularly in the western provinces. The forests contain native species experiencing harvesting for the first time with implications for habitat destruction and biodiversity reduction. While ranked high in several of the biodiversity indices presented in Table 5.2, Canada is likely to experience greater pressures on biodiversity management as their extensive margin for forest products declines in the future.

5.4. GLOBAL WARMING POTENTIAL AND CARBON DIOXIDE

Lost lumber market share to alternative products implies greater greenhouse gas emissions in the form of carbon dioxide since alternative products are more energy intensive in the extraction and manufacturing processes. CORRIM, Inc. currently is analyzing the life cycle inventories associated with two house shell comparisons, a concrete versus wood shell and a steel-framed versus wood-framed shell. All shells use wood in their construct. In comparison with the concrete shell, an additional 1.6 thousand board feet (mbf) of lumber is used in wood construction. In comparison with the steel-framed shell, an additional 8.5 mbf of lumber is used in wood construction. A larger number of concrete and steel shells will be constructed in the face of a lumber shortage since concrete and steel framed-units use less wood. As a consequence however, more carbon dioxide is emitted into the atmosphere elevating the greenhouse warming potential since concrete and steel houses have higher fossil fuel energy intensities during their manufacture.

To illustrate the effect of demand substitution on non-wood products we use the CORRIM data to convert lower lumber used by the housing market into additional carbon dioxide emissions. The lumber loss (32% of the reduction in Oregon harvests) to the housing market amounts to 1.54 MMm^3 or 0.652 BBF annually. The 0.652 BBF would construct about 61,509 wood shells, based on an average of 0.0106 BBF of lumber per housing shell (compared to the steel-framed shell) or 101,085 wood shells, based on an average of 0.00645 BBF of lumber per shell (compared to the concrete shell).

Wood is still required for the steel-framed shell construction, and this amounts to an additional 0.129 BBF for the 61,509 steel-framed homes. Since we assume there is no new lumber available we obtain the additional 0.129 BBF from a further reduction of wood housing, or another 12,186 wood-framed shells that are substituted annually. The potential market for new steel shells amounts to 73,695 shells (61,509 plus 12,186). Similar calculations for concrete suggest a potential market gain of 176,312 concrete shells annually.

A preliminary estimate of carbon dioxide equivalent emissions from steel framed-housing shells is 31 metric tons of carbon versus 22 for wood-framed housing shells. The additional 73,695 steel units would release an extra 0.66 million metric tons of carbon dioxide equivalent to the atmosphere annually. A preliminary estimate of carbon dioxide equivalent emissions from concrete shells is 19 metric tons versus 11 tons for wood. If lost demand were to be captured by concrete shells, then an additional 1.4 million metric tons of carbon dioxide equivalent would be emitted to the atmosphere annually. The larger emission associated with the concrete shells is a result of the larger number of housing shells that can be constructed out of concrete given the size of the lumber market reduction.

5.5. REGIONAL INVESTMENT OPPORTUNITIES

The reduction in Oregon harvests also has implications for investments at the mill and forest levels. Oregon's lost market share—lost to alternative materials producers and other regions—implies about 3.5 MMm^3 (1.48 BBF) less lumber is produced. The diversion of export logs to domestic producers reduces the impact on local mills. However, because most of the redirection of saw log exports to the domestic market has already occurred during the 1990s the potential reduction in the impact due to lower harvests is small. Nevertheless, the 3.5 MMm^3 of less lumber produced implies a lost opportunity to maintain and expand productive capacity in the region of about 7 to 8 modern mills[2] with the employment opportunities associated with it.

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[2] Assuming a modern mill producing 400,000 board feet per 8-hour shift, operating 2 shifts, 5 days a week and 50 weeks a year.

In addition, as noted before, many countries in Latin America and Asia have embarked on extensive planting programs. The success of these programs will ensure an abundant supply of wood fiber to meet projected demand growth. Table 5.3 presents the biological potential of selected emerging plantation areas. In total, there is an estimated 938 MMm^3 (165 BBF) of potential wood fiber available annually for harvests from these 8 countries by the end of 2020. The projections are based on specific assumptions about growth rates, rotation ages and areas planted in 1995. The projections indicate that in the short- to medium-term (from now to 20 years from now), there may be up to 400 MMm^3 (71 BBF) of available wood in the Asian wood basket. These wood resources are close to China and represent 3.5 times the timber consumed in China in 1997.

Table 5.3. Annual potential harvestable volume from 8 regions with extensive plantation areas (estimated for the year 2020).

Country	Rotation Age	Volume MMm^3
China	35- 50	0
Indonesia	25	98
Australia	25	195
New Zealand	25	140
Argentina	25	137
Brazil	25	190
Uruguay	25	32
Chile	25	146
Total	25	938

This added wood fiber supply has several consequences for investment strategies. One, they provide an incentive for new investments in management and processing since these plantations represent wood fiber that is already in the ground. Development strategies by emerging countries may include incentives and subsidies to attract investments to their regions.

At the forest level, Oregon loses the incentive to manage its forestlands without the access to a larger market. Other regions, notably the South, will rely on more intensive management through the use of genetically improved seedlings, greater use of mechanical and chemical controls, more intensive fertilization and shorter rotations. These investments in forest management will be profitable if demand places upward pressures on prices, as suggested by the model simulations. Without the demand effect, returns on these forest investments are likely to be smaller, and even act as a disincentive. While prices for timber may go up, the revenues that landowners received maybe reduced since they are not able to harvest the same volumes as before.

6. DISCUSSION

We have presented data on demand growth, a likely scenario of Oregon's participation in that demand growth and which regions may take advantage of Oregon's simulated decision not to participate in future demand growth for wood products. The underlying assumption is that by relinquishing part of any future market share growth Oregon will improve its environmental and social welfare. However any gains in its environmental and social well being must be compared to changes in these attributes in those regions that pick up the slack in wood products markets, including the use of alternative products to wood.

Unilateral processes are used to set policy goals associated with the management of forest resources under sustainability criteria. A specific criterion is monitored using an indicator variable that measures progress towards the goal. Without consideration of market forces in wood products, a policy goal set by one region may have unintended consequences on another's progress towards their goal. This study has shown that, because of the global nature of wood products markets and Oregon's participation in national and international wood products markets, their decision to manage forest resources and the volume of timber harvested will cause markets to adjust locally, nationally and internationally.

Table 6.1. Comparison of regional attributes due to simulated lower Oregonian harvests.

<table>
<tr><th>Region</th><th>Land Area</th><th>Biodiversity</th><th>Social</th><th>Global Warming</th></tr>
<tr><td>US South and Canada</td><td rowspan="6">More land area required to harvest an equivalent volume from Oregon. More frequent harvests due to shorter rotations.</td><td>Several species currently identified as threatened. Expansion of harvests into areas with native forest types.</td><td rowspan="6">Greater investments in forest sector with more jobs. An average of 7 to 8 modern mills will be lost in Oregon and established elsewhere.</td><td rowspan="6"></td></tr>
<tr><td>So South America</td><td rowspan="5">Mostly plantations with exotic species</td></tr>
<tr><td>Chile</td></tr>
<tr><td>New Zealand</td></tr>
<tr><td>Australia</td></tr>
<tr><td>Brazil</td></tr>
<tr><td>Global</td><td></td><td></td><td></td><td>0.6 to 1.4 million tons of carbon equivalent emitted to the atmosphere annually.</td></tr>
</table>

Table 6.1 qualifies, and in the cases of carbon dioxide emissions and mill investments, quantifies the tradeoffs associated with lower Oregonian annual harvest levels. It summarizes the effects by regions where substitution takes place according to the simulation results, and in the case of alternative material suppliers, a global impact due to the nature of carbon emissions. In some instances, we are not able to make meaningful quantitative comparison due to the lack of a comparable valuation measure.

The direction of the effects can be inferred however. Oregon is a highly productive region for timber. Any substitution that takes place will require more land and more frequent harvest activities. There is no region signaled by the model simulation that implies timber substitution by a region more productive in timber growth than Oregon. Conversely substitution by other regions and products occurs irrespective of the productivity of Oregon's forests. As a result, land use indicators in other regions will suggest more land area required for timber production and more frequent harvests. These indicators may not move in the direction to support criteria that aim at maintaining biodiversity, for example.

The current status of biodiversity in the South suggests that there will be trade-offs with Oregon. Several species have been identified as threatened in the South. However, there is a need for both geographical and temporal scales to measure the tradeoffs associated with unilateral policies to satisfy management criteria. Current indicators that chronicle the temporal changes within a region are not necessarily adaptable to regional comparisons. So while more acres are cut in the South and other regions to meet the reduced output from Oregon, its impact on biodiversity is hard to evaluate since there does not exist a value that compares salamander species with bird species. For now, it becomes sufficient to note that there are likely to be more acres disturbed by harvest activities and that the harvest activity will occur more frequently in an area that has identified threatened species.

Regions that substitute wood products for Oregonian products outside the US are utilizing exotic plantation species. Again a tradeoff will exist where Oregonian land managers manage for a diversity of values within native habitats versus land managers in other regions utilizing exotic species in areas that once supported native habitats.

The one exception is the case for global warming. This arises from the fact that a carbon molecule is the same irrespective of where it is located. Work in progress by CORRIM, Inc. also provides the methods to estimate tradeoffs associated with less wood use in the economy. Because steel and concrete products that substitute for wood products are more energy intensive and release carbon dioxide during manufacturing process, the steel and concrete products lead to greater global warming potential than wood products. Comparable indices for biodiversity and other environmental attributes are lacking, however.

7. CONCLUSIONS

The study examines the role Oregon's annual harvest levels have in satisfying the demand for forest products in the US and internationally. It presents a forecast of future demand and determines which regions harvest timber to meet the consumptive needs of the forest products markets.

From this analysis we conclude that consumption of forest products is likely to grow at some positive rate. A simple forecasting model postulates a range from 0.5% to 1.4% over the next four decades based on past behavior as plausible boundaries for CGTM projections. These rates imply that world consumption of industrial roundwood will reach anywhere from 2.0 to 2.8 billion cubic meters by 2050, adding from one half to 1.3 billion cubic meters over 2000 consumption levels. The CGTM model forecast aligns itself with the lower bound associated with the 0.5% annual growth in consumption, and this forecast is used to project future market shares for Oregon and other forest products producers.

Oregon's role in meeting the global need for forest products is estimated at 10 MMm^3 (1.8 BBF) of softwood annual harvest volume by 2040. This implies an expansion of annual harvest levels over currently observed levels that would meet the growth in consumption associated with a larger population and higher incomes.

There will be environmental, social and economic tradeoffs should harvest levels in Oregon be constrained from increasing any further than today by environmental regulations or other societal priorities. These types of constraints lead to an increase in prices for forest products, beginning at the timber level, and eventually passed on to products and consumers that purchase them. As timber prices increase, other producers, including substitute products, augment production.

The US South is the major winner in gaining forest products market share that is given up by Oregon. Alternative producers like steel and concrete, and then Asian and Canadian producers of wood products follow in gaining share.

The constraints on Oregon harvest levels raise conservation concerns in the South particularly since there are already increased production pressures on the southern forest resources from previous timber shortages in the west and projected growth in US demand in general. Historically high producing central southern regions are constrained by their available inventories, which lead to greater harvest pressures in surrounding states. There exist concerns that ecosystem communities that are endangered and not under public management are declining. Investments in forest management are likely to take place if timber prices support them. These investments will increase aggregate output by using genetically improved species, more intensive use of mechanical and chemical means, greater use of fertilization and higher timber frequencies. Since greater acres are harvested and harvests occur more frequently, we suspect that there exists an environmental tradeoff by shifting the harvest volume to southern states. The magnitude of the tradeoff is unknown since adequate measures environmental services for biodiversity are lacking.

The international forest sector abounds with wood. Many of the emerging regions rank low in several biodiversity indexes. These regions may provide wood products that substitute for Oregonian products. As in the case of the southern states, we suspect that there exists an environmental tradeoff, but lack sufficient measures to quantitatively compare them.

Alternative products such as steel and concrete also have higher global warming gas emissions like carbon dioxide. Less wood available for the US market implies a greater number of steel and concrete houses that would be constructed. The carbon equivalent emissions associated with a larger number of alternative material homes are estimated to range from 0.6 million tons to 1.4 million tons of additional carbon dioxide equivalent emissions annually.

Finally, without a larger market for timber from Oregon, the incentive for forest management is reduced. Intensified management, which would characterize the southern forest resource management, would not take place unless forest returns were perceptible. The lower timber harvest volume implies fewer investments in processing capacity as well, indicating about 7 to 8 average sized mills that would not be built. Rather, mills will be constructed in those regions that substitute for Oregon simulated reduced harvest.

To date, the process that sets target levels for individual criterion within a region does not consider unintended consequences. Indicators are established to assist in attaining the goals such as maintaining biodiversity that is set within a region without consideration of the goals set by other regions. This study presents evidence that forest products markets are linked nationally and internationally through which these unintended consequences manifest themselves.

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Appendices

APPENDIX 1. STRUCTURE OF THE CGTM

The CGTM was initially developed in the 1980's by the International Institute of Applied Systems Analysis in Laxenburg, Austria and acquired by CINTRAFOR in 1987. Since then, CINTRAFOR has vastly improved the model by disaggregating world regions to emphasize forest products trade in Pacific Rim countries. The CGTM is a practical tool for assessing production, consumption, trade, competitiveness, and when linked to environmental multipliers, the model allows comparisons of environmental measures to be made.

The CGTM model structure is outlined below.

$$MAX\ [\Sigma_{rk} \int_0^{q_{rk}} \pi_{rk}(q)\mathrm{d}q - \Sigma_{rm} \int_0^{y_{rm}} \mathrm{C}_{rm}(z)\mathrm{d}z - \Sigma_{rsk} D_{rsk} e_{rsk}]$$

subject to:

$q_r - A_r y_r + \Sigma_s(e_{rs} - e_{sr}) = 0$ (materials balance constraint)

$q_r \in C_r$ (consumption possibilities)

$z_r \in Z_r$ (production possibilities)

$(e_{rS}, e_{Sr}) \in T_r$ (trade possibilities)

Product Demand

$Q_k = \alpha\pi^{\beta} I^{\mu}$

where:

Q_k is the production level (in million cubic meters of product *k*);

π is the product price (real local currency in m^3 of product *k*);

I is an indicator of market activity (for example GDP or housing starts);

α, β, μ are estimated parameters.

Product Supply

$\pi = C + \alpha U^{\beta}$

$C = (ST + HD)A_1 + MVMC - CHIPS*A_2$

$U = Q/K_{t-1}$.

where:

π is the product price (real value per m^3 of product);

C is the variable production cost (real value per m^3 of product);

U is capacity utilization;

α and β are estimated parameters;

ST is stumpage cost (real value per m^3 of log);

HD is log harvest and delivery cost (real value per m^3 of product);

A_1 is an input-output coefficient (m^3 of log used per m^3 of product);

$MVMC$ is minimum variable manufacturing cost (real value per m^3 of product);

$CHIPS$ is the price of wood chips (real value per m^3 of chips);

A_2	is an input-output coefficient (m^3 of chips generated per m^3 of product);
Q	is product output (million m^3 of product); and
K_{t-1}	is production capacity at the end of the previous year (million m^3 of product).

<u>Log Supply</u>

$\pi = \alpha(Q/I)^{\beta}$

where:

π	is the log price (real value per m^3 of wood)
Q	is the log quantity (million m^3 of wood)
I	is the growing stock volume (million m^3 of wood)
α, β	are estimated parameters.

<u>Equilibrium Condition</u>

$\pi_j = \pi_i + D_{ij} + C_{ij}$

where:

π	is the average product price;
D	is the transportation costs;
C	is a value adjustment or quality differential (premium or discount);
i	is the exporting region; and
j	is the importing region.

APPENDIX 2. CGTM REGIONS

WSV = Westside Oregon and Washington private

WSB = Westside " " public

ESV = Eastside Oregon and Washington private

ESB = Eastside " " public

INV = Interior US West private

INB = Interior US West public

ASK = Alaska

CAL = California

USS = US South

USN = US North

CBC = Coastal British Columbia

CIN = Interior British Columbia, Saskatchewan, Manitoba

CEA = Eastern Canadian provinces

CAM = Central America and Mexico

BRA = Brazil

SAN = Northern South America

CHI = Chile

SAS = Southern South America

FIN = Finland

SWE = Sweden

EUW = Western Europe

EUE = Eastern Europe

JPN = Japan

KOR = Korea

CHN = China

THK = Taiwan, Hong Kong

MAE = East Malaysia

MAW = West Malaysia

IDN = Indonesia

PHL = Philippines

PNG = Papua New Guinea

ICH = Indochina

IND = India

MDE = Middle East

SUW = Western Former Soviet Union

SUE = Eastern Former Soviet Union

AFE = Eastern Africa

AFN = Northern Africa

AFS = Southern Africa

AFW = Western Africa

AUS = Australia

NWZ = New Zealand

OCN = Oceania

APPENDIX 3. THE ENVIRONMENTAL MEASURES

The study originally attempted to follow the criteria and indicators established by the Montreal Process Working Group. They are also replicated in the Oregon Department of Forestry Core Indicator Data Matrix. Table 3.1 lists the various criteria and indicators that the study considers. The table also indicates whether they are included in the analysis and remarks about the indicator listed.

Table A.3.1. Oregon Department of Forestry Core Indicator Data Matrix

Criterion 1. Maintain Biological Diversity

Indicator	Included in Study	Remarks
1. Area of forest type	Included	Area of plantation is summarized for each region modeled using FAO publications.
2. Forest type by successional stage	Not included	No detail data exists for modeled regions.
3. Area by forest type in protected area categories	Included	We include two series. Extent of national parks summarized by CGTM regions and extent of protected areas also summarized by CGTM regions.
7. Status (rare, threatened, endangered)	Included	We include the number of extinct tree species and the number of threatened bird species.
9. Population levels of representative species	Included	We use the number of bird species per 10,000 sq km. and the number of plant species per 10,000 sq km.

Criterion 2. Maintain Productive Capacity

Indicator	Included in Study	Remarks
10. Forest land available for timber production	Included	Taken from FAO publications.
11. Growing stock of both merchantable and non-merchantable timber	Included	Taken from FAO publications.
13. Annual removal of wood products compared to the volume determined to be sustainable	Not included	We have data on annual removals but no data on sustainable harvests by CGTM region
14. Annual removal of nontimber	Not included	No data available

forest products compared to the level determined to be sustainable		

Criterion 3. Maintain Ecosystem Health		
Indicator	**Included in Study**	**Remarks**
15. Area and percent of forest affected by processes or agents beyond the range of historical variation	Included	We include management area as a percent of total area.

Criterion 4. Conservation of Soil and Water Resources		
Indicator	**Included in Study**	**Remarks**
18. Area and percent of forest land with significant soil erosion	Not included	No available data
23. Percent of water bodies in forest areas	Not included	No available data
24. Water bodies in forest areas with significant variation in pH, DO, chemical sedimentation or temperature change	Not included	No available data

Criterion 5. Maintain Global Carbon Cycles		
Indicator	**Included in Study**	**Remarks**
27. Contribution of forest ecosystems to the global carbon budget	Included	We estimate the carbon associated with the forest areas for each CGTM region and utilize CORRIM data.

Criterion 6. Maintain Socio-economic Benefits		
Indicator	**Included in Study**	**Remarks**
29. Value and volume of wood and wood products production, including value added	Included	Value and volume used to produce size of market shares using CGTM
33. Degree of recycling of forest	Not included	No data available

products		
35. Forest land managed for general recreation and tourism, in relation to the total area of forest land	Included	We include park data
37. Visitor days attributed to recreation and tourism	Not included	No available data
38. Value of investment in forest health	Not included	No available data
44. Direct and indirect employment in the forest sector	Not included	No available data

Criterion 7. Legal, Institutional Framework for Sustainable Management

Indicator	**Included in Study**	**Remarks**
54. Institutional capacity to undertake forest related planning and assessments	Not Included	No available data
60. Capacity to measure and monitor changes including the availability and extent of data measuring the indicators	Not Included	No available data

APPENDIX 4. PLANTING AREAS BY CGTM REGIONS

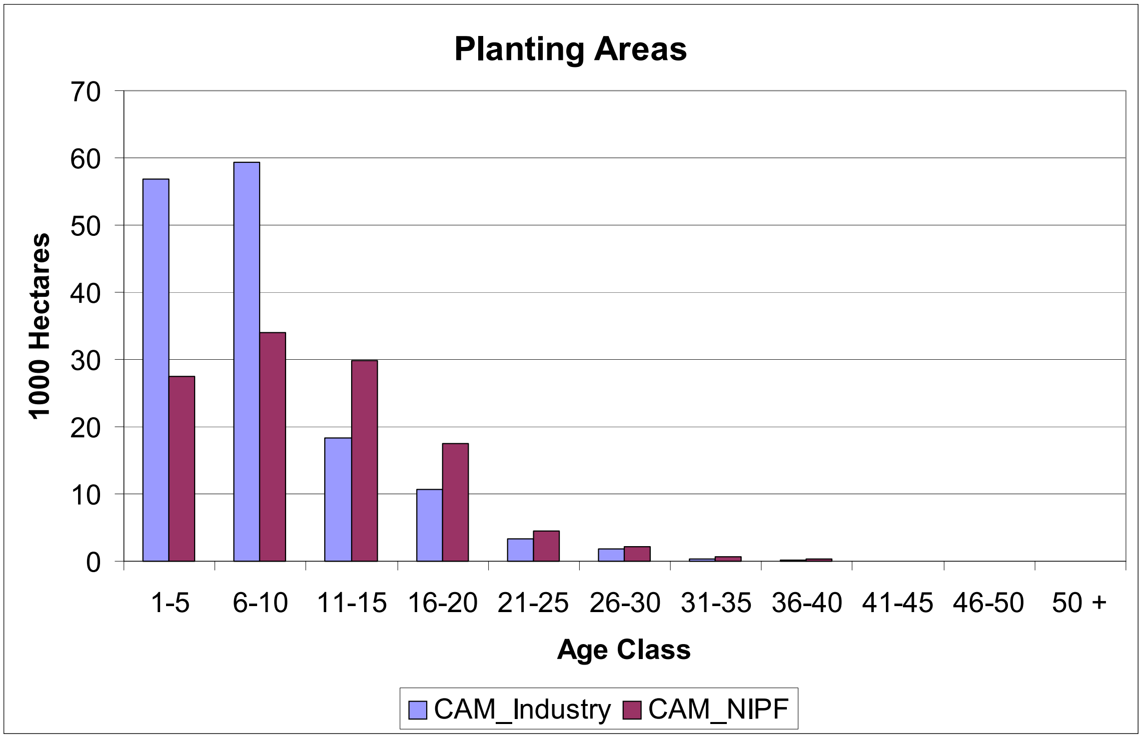
Plantings areas were summarized by CGTM region. The planting areas are taken from FAO statistics and are grouped by CGTM regions. Table 4.1 summarizes the graphs produced on subsequent pages.

Table A.4.1. The area planted by industry and Non-industrial Private Forest (NIPF) land category and their percentage that is less than 15 years.

Region	Industry 1000 ha	Percentage < 15 years	NIPF 1000 ha	Percentage < 15 years
Central America and Mexico (CAM)	151.0	0.89	116.5	0.78
Brazil (BRA)	2234.3	0.62	1945.7	0.67
Northern South America (SAN)	680.4	0.77	378.6	0.79
Chile (CHI)	1677.1	0.74	69.9	0.74
Southern South America (SAS)	793.5	0.50	361.0	0.54
Sweden (SWE)	572.5	0.66		
West Europe (EUW)	6620.9	0.34		
East Europe (EUE)	2735.8	0.63	220.8	0.77
Japan (JPN)	10670.0	0.11		
Korea (KOR)	1629.6	0.52	420.4	0.00
China (CHN, THK)	19120.2	0.96	4452.6	0.94
Malaysia (MAE, MAW)	86.2	0.85	37.8	1.00
Indonesia (IDN)	2623.7	0.77	399.3	0.36
Philippines (PHL)	79.2	0.96	72.8	0.85
Indochina (ICH)	1351.5	0.77	435.2	0.59
India (IND)	4224.9	0.84	8671.1	0.96
Middle East (MDE)	112.1	0.87	74.8	0.87
Former Soviet Union (SUW, SUE)	22199.3	0.24		
Africa East (AFE)	520.2	0.51	426.8	0.71
Africa North (AFN)	1033.5	0.61	887.8	0.58
Africa South (AFS)	1543.5	0.31	247.7	0.61
Africa West	132.2	0.50	193.8	0.95
Australia (AUS)	1042.6	0.47		
New Zealand (NWZ)	1540.1	0.62		
Oceania (OCN)	2846.2	0.56		
OREGON	2276.0	0.45	1176.0	0.33

Sources. FAO data bases. Some regions have no distinction between Industry and NIPF (NIPF column left blank). For OREGON, area taken from FIA data summary in Timber Resource Statistics for Eastern Oregon, 1999, and Timber Resource Statistics for Western Oregon, 1999 Percentage < 15 years is calculated as percentage area less than 20 years.

CAM: Central America and Mexico

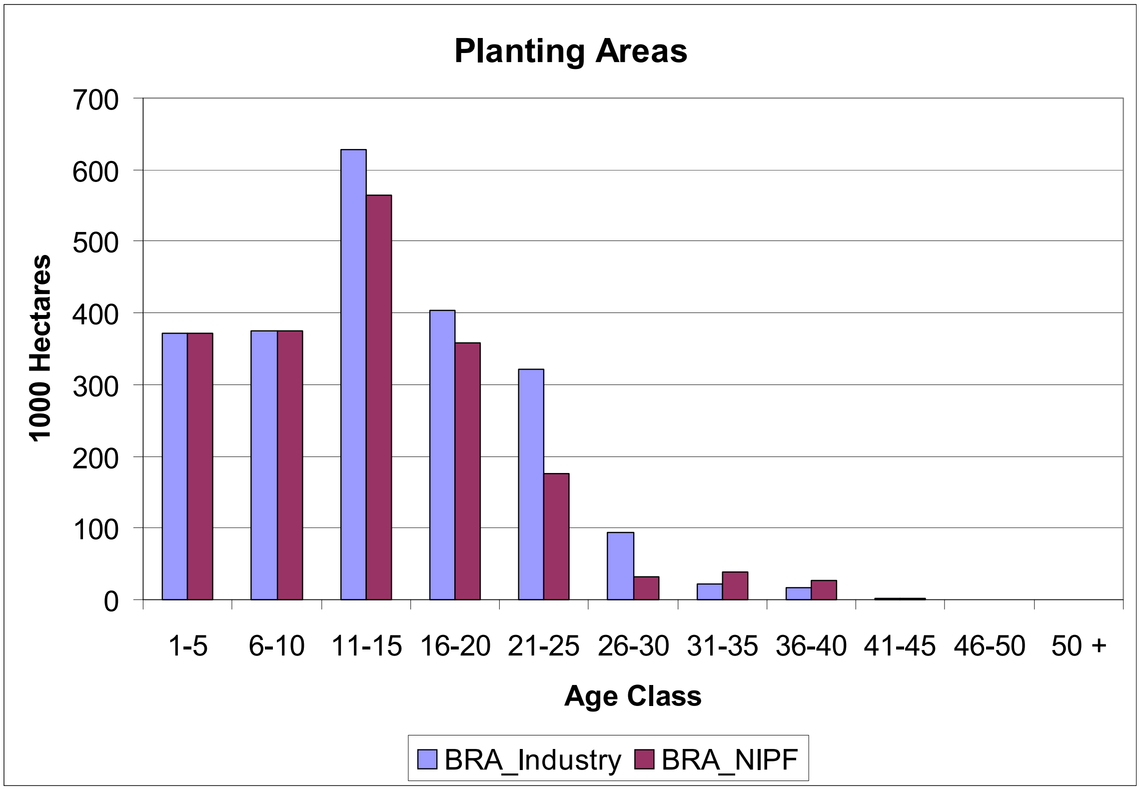


Source: FAO

Industry refers to industrial plantings; NIPF refers to non-industrial plantings.

	Total (1000 hectares)	Percentage < 15 years
CAM_Industry	151.0	0.89
CAM_NIPF	116.5	0.78

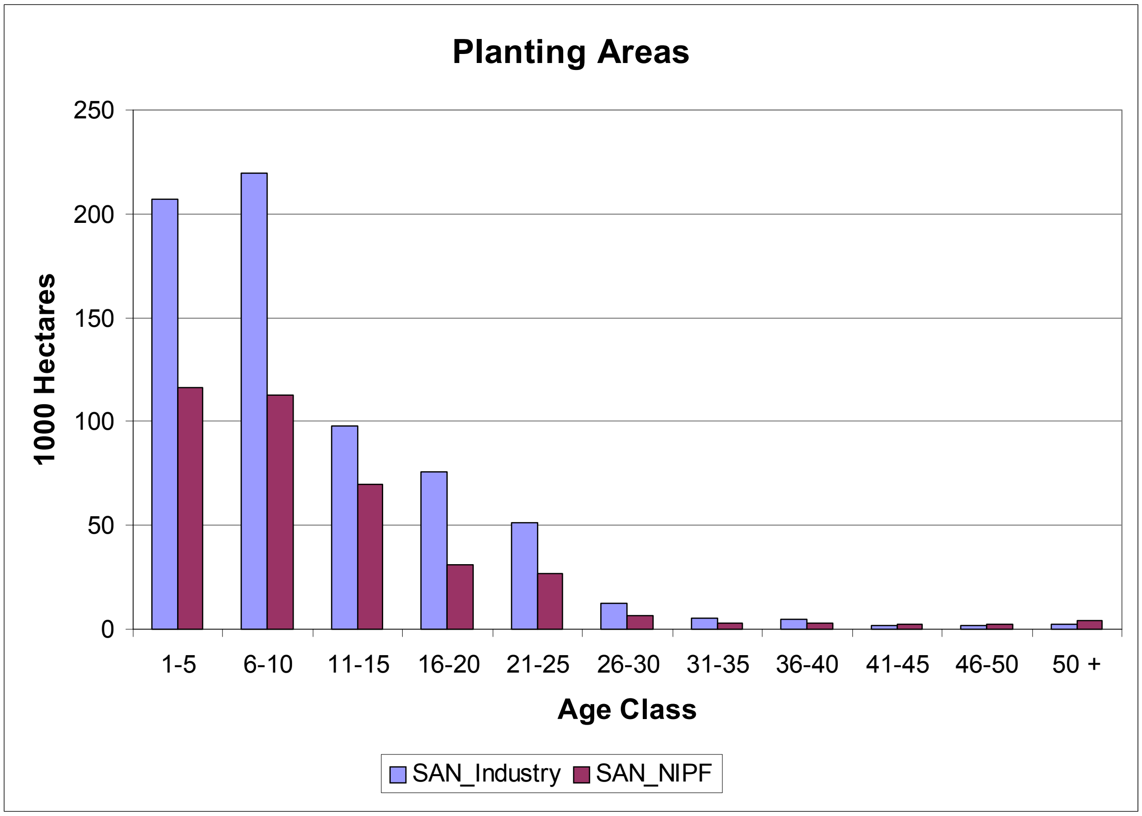
BRA: Brazil



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
BRA_Industry	2234.3	0.62
BRA_NIPF	1945.7	0.67

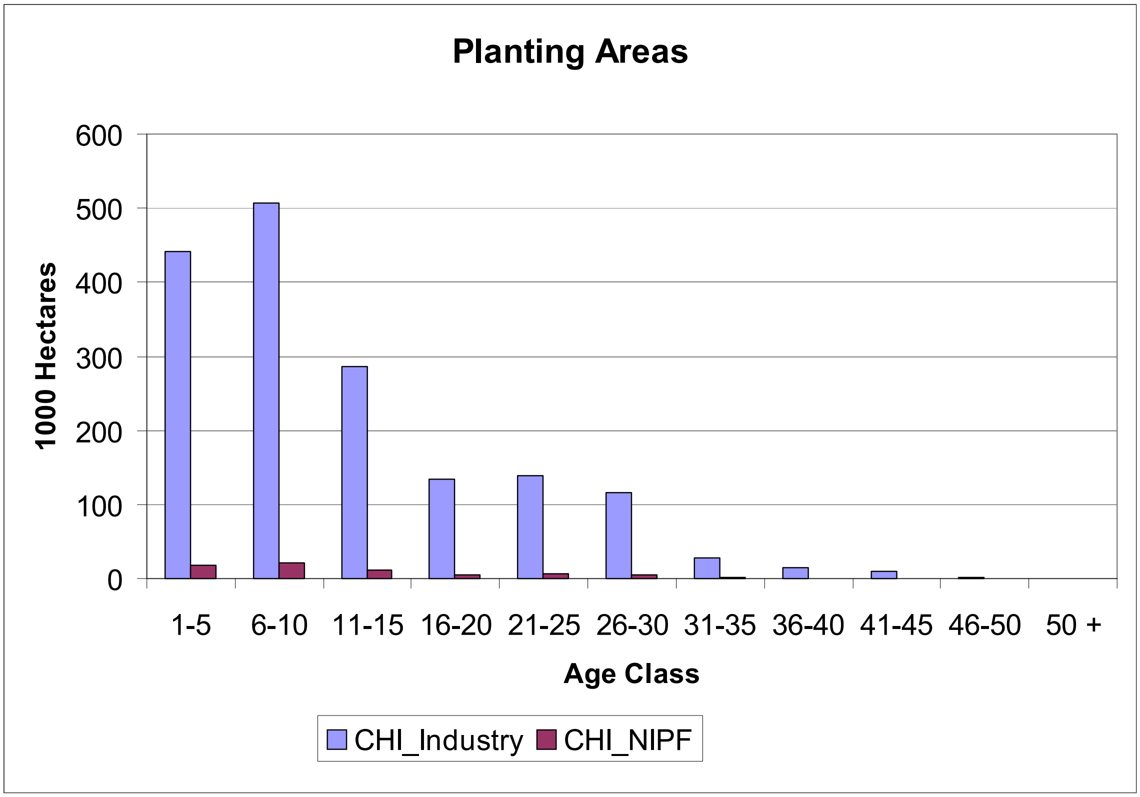
SAN: Northern South America



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
SAN_Industry	680.4	0.77
SAN_NIPF	378.6	0.79

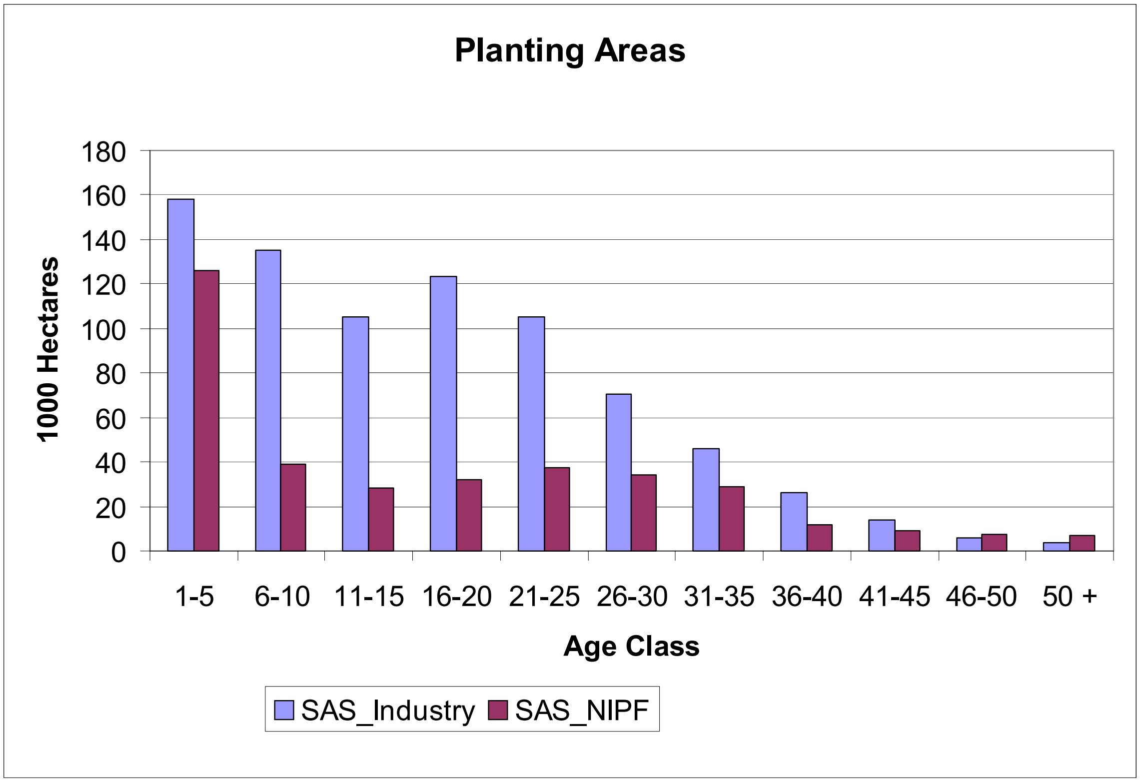
CHI: Chile



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
CHI_Industry	1677.1	0.74
CHI_NIPF	69.9	0.74

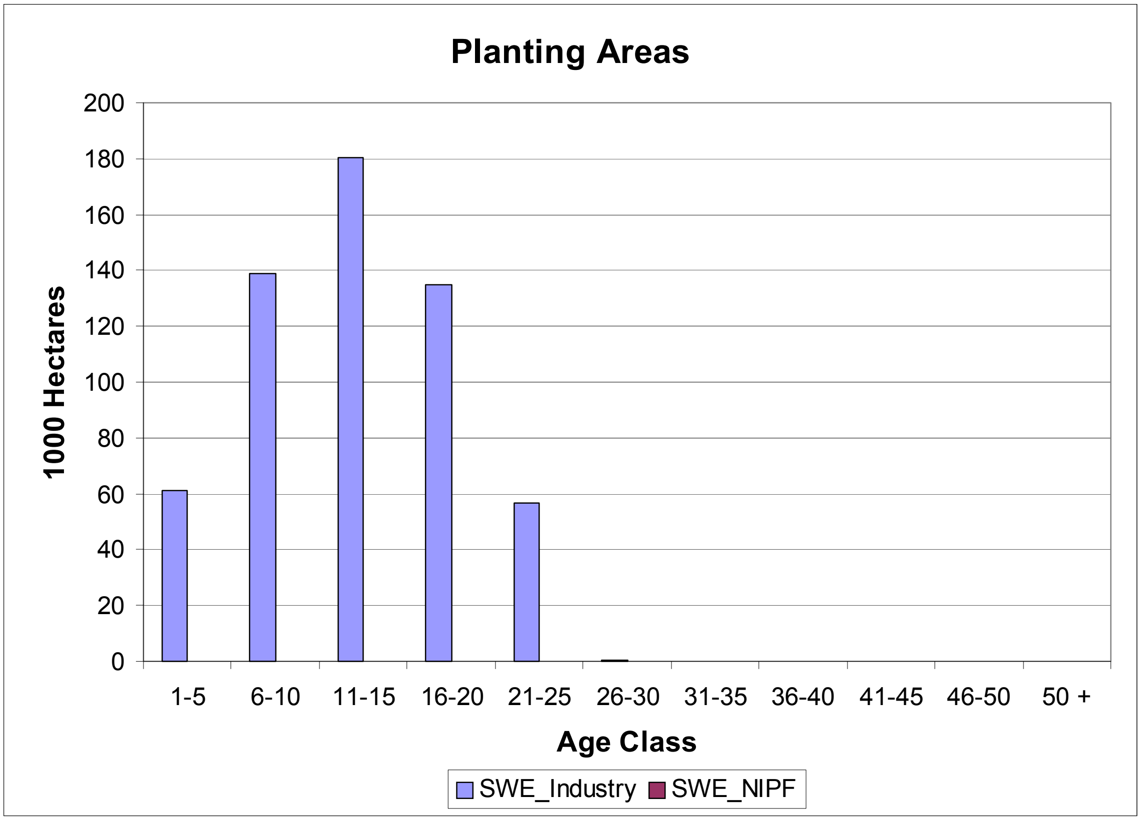
SAS: Southern South America



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
SAS_Industry	793.5	0.50
SAS_NIPF	361.0	0.54

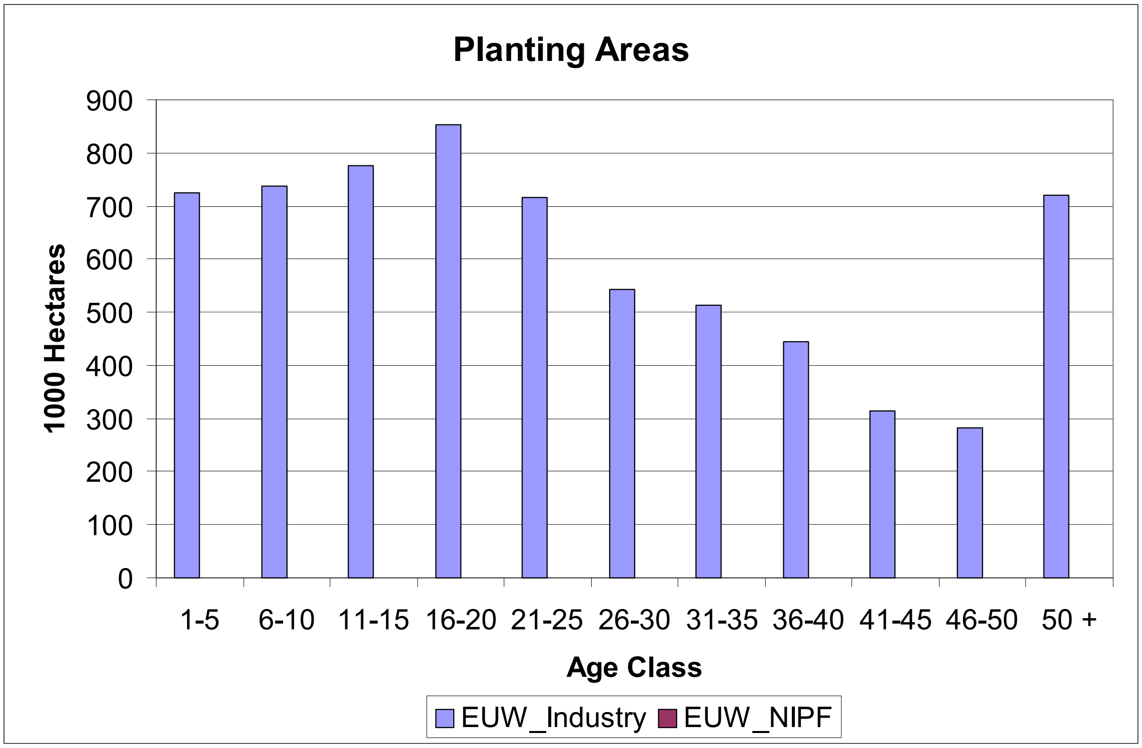
SWE: Sweden



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
SWE_Industry	572.5	0.66
SWE_NIPF	0.0	0.00

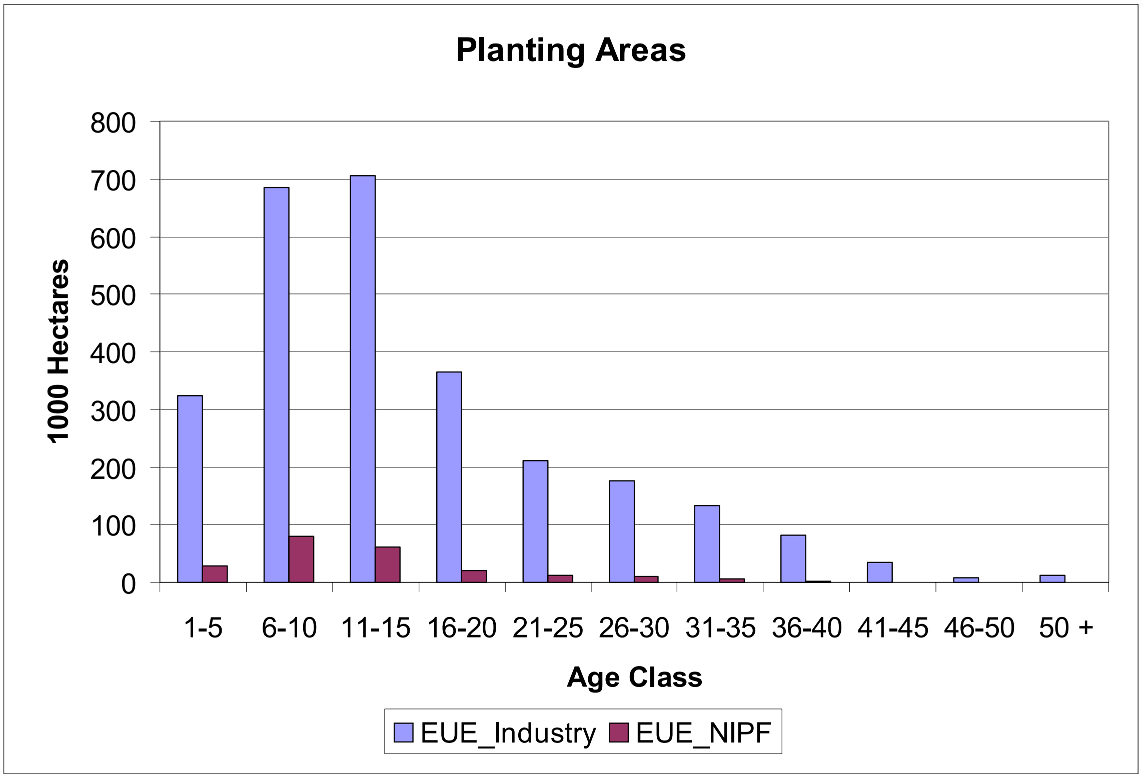
EUW: Western Europe



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
EUW_Industry	6620.9	0.34
EUW_NIPF	0.0	0.00

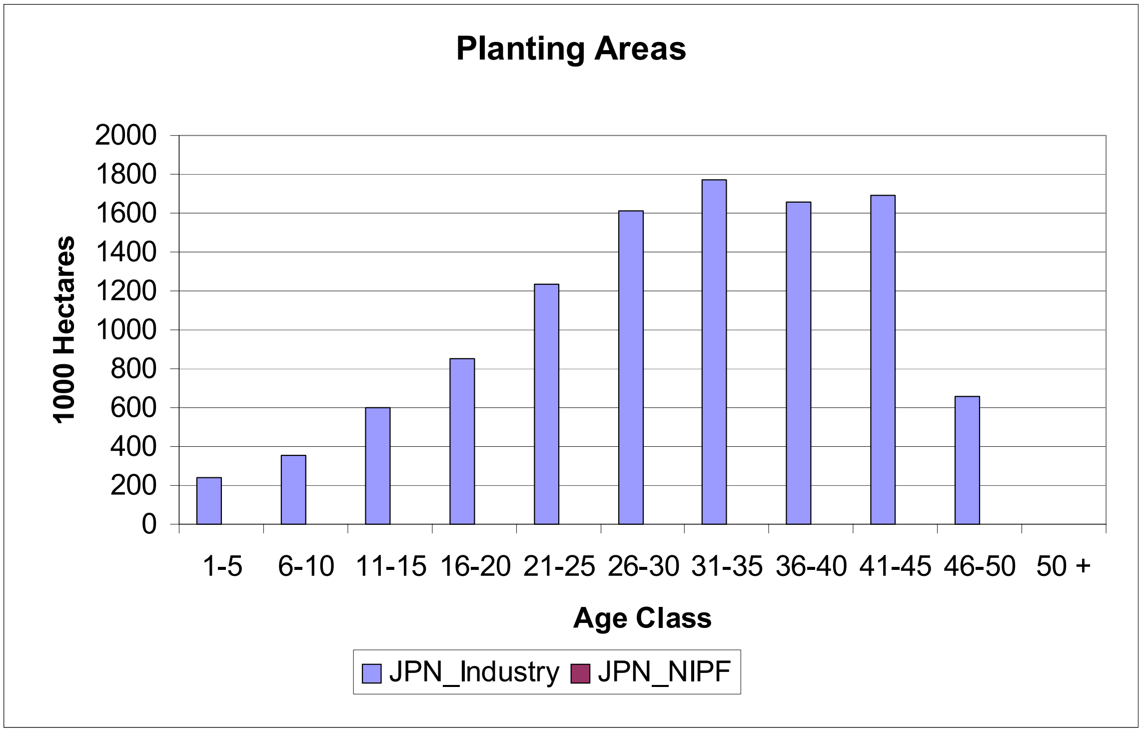
EUE: Eastern Europe



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
EUE_Industry	2735.8	0.63
EUE_NIPF	220.8	0.77

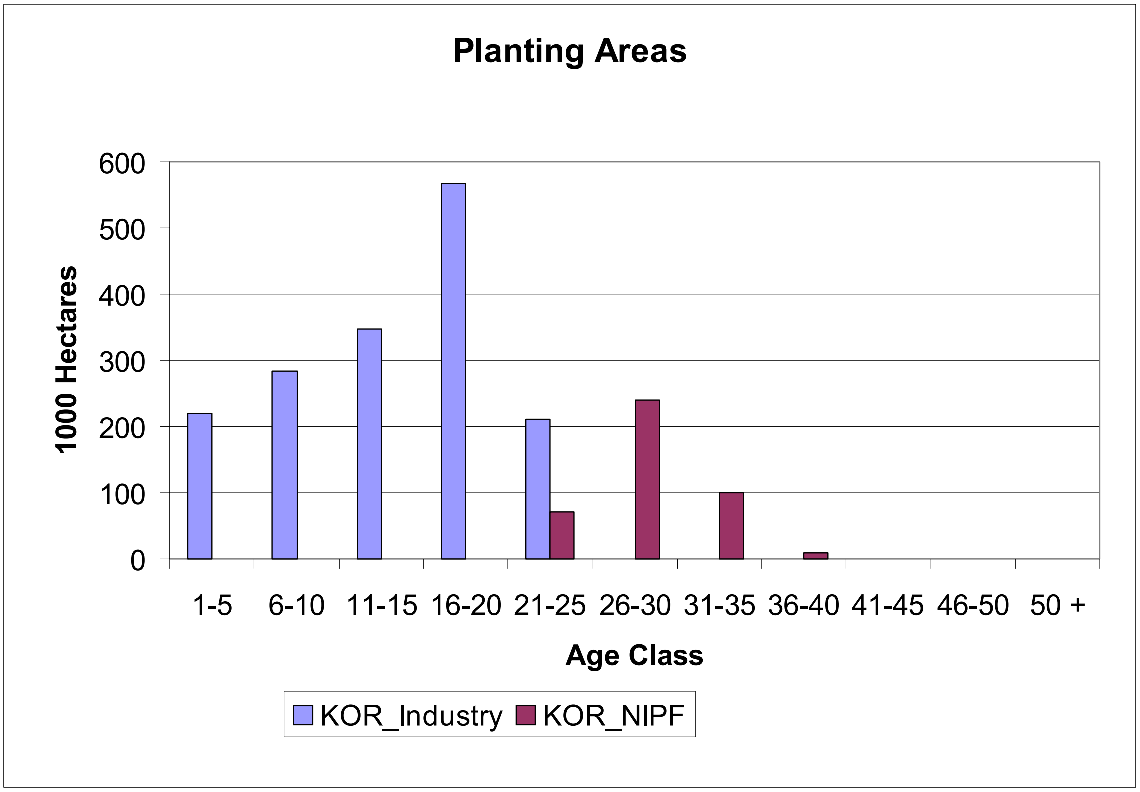
JPN: Japan



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
JPN_Industry	10670.0	0.11
JPN_NIPF	0.0	0.00

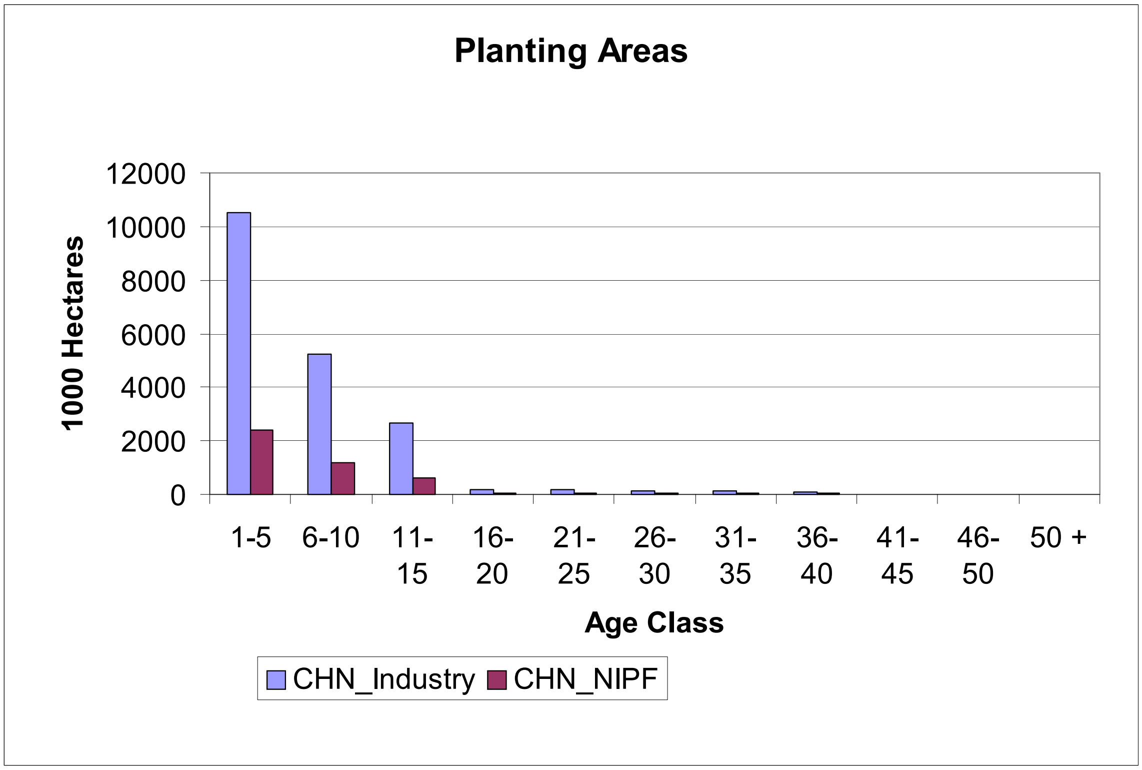
KOR: Korea



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
KOR_Industry	1629.6	0.52
KOR_NIPF	420.4	0.00

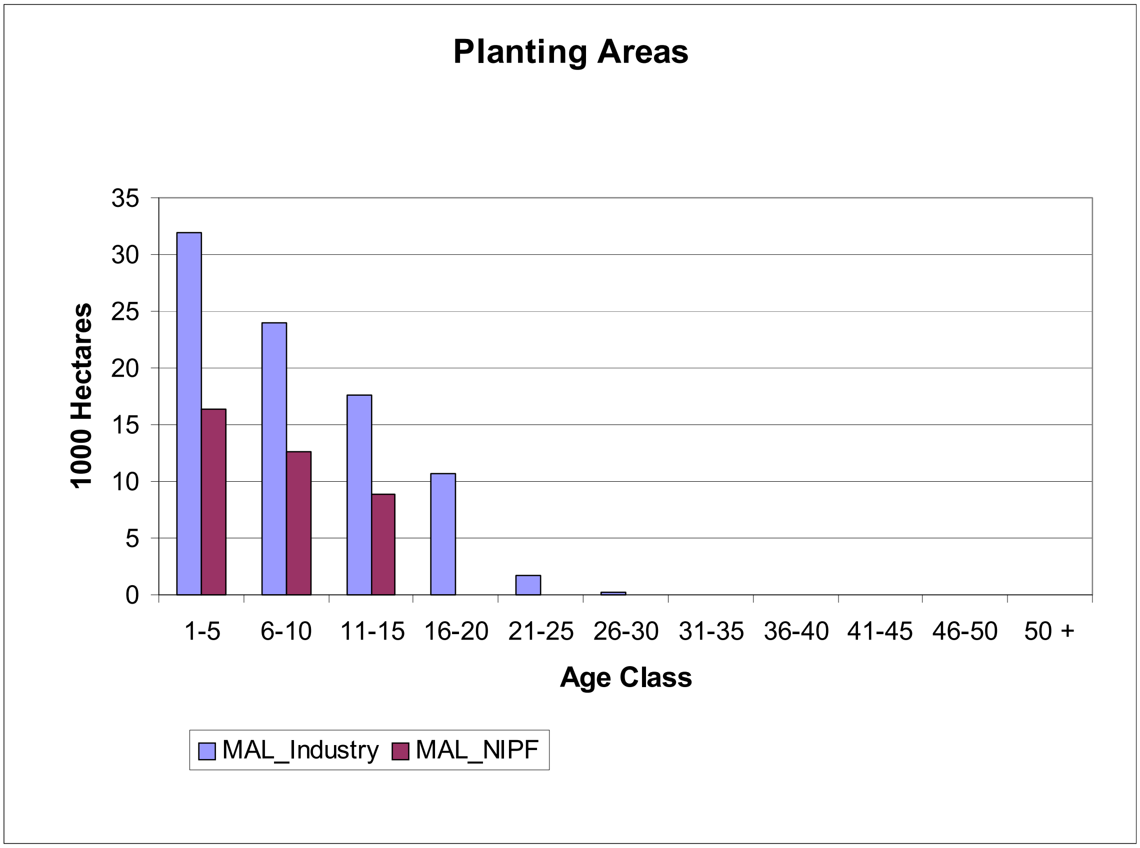
CHN: China



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
CHN_Industry	19120.2	0.96
CHN_NIPF	4452.6	0.94

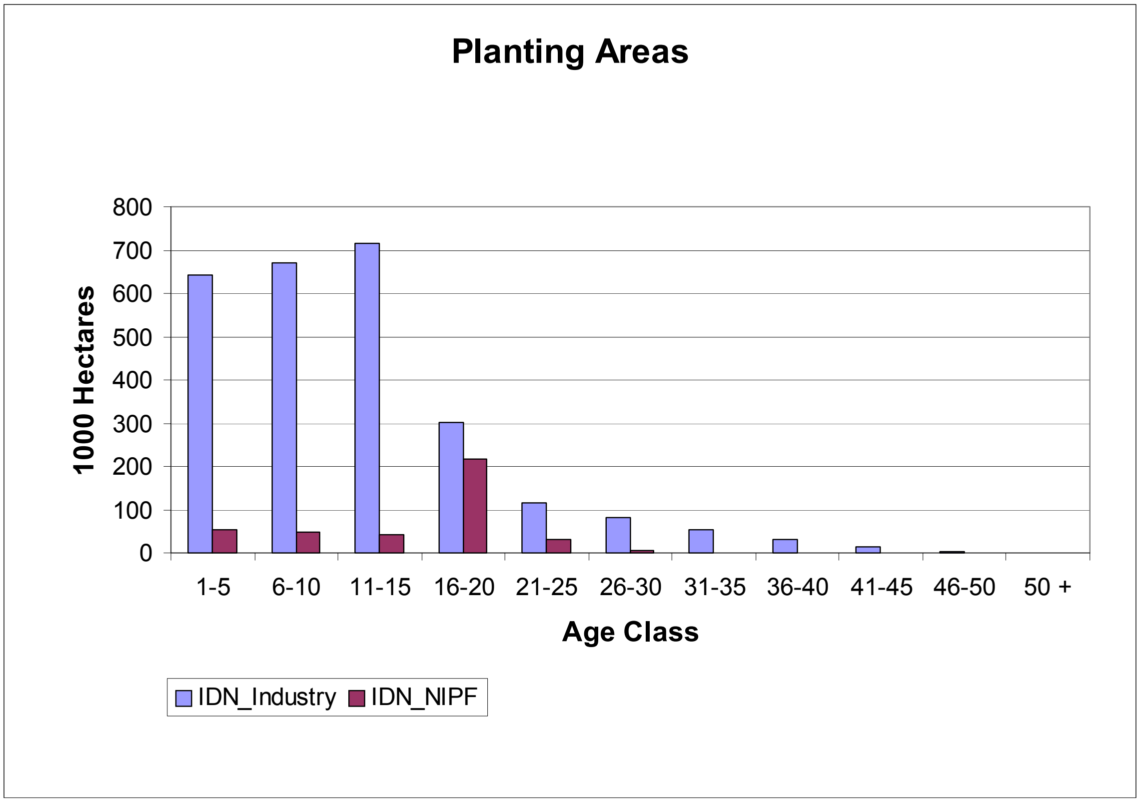
MAL: Malaysia



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
MAL_Industry	86.2	0.85
MAL_NIPF	37.8	1.00

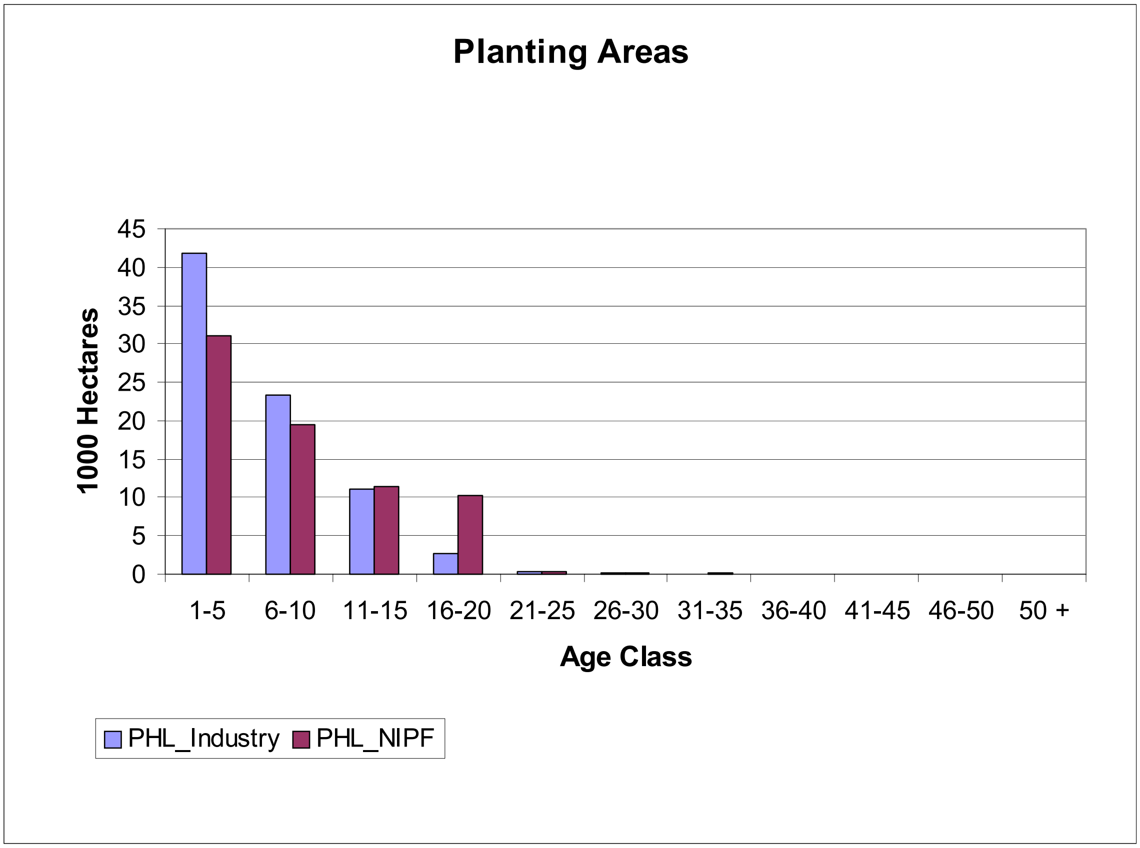
IDN: Indonesia



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
IDN_Industry	2623.7	0.77
IDN_NIPF	399.3	0.36

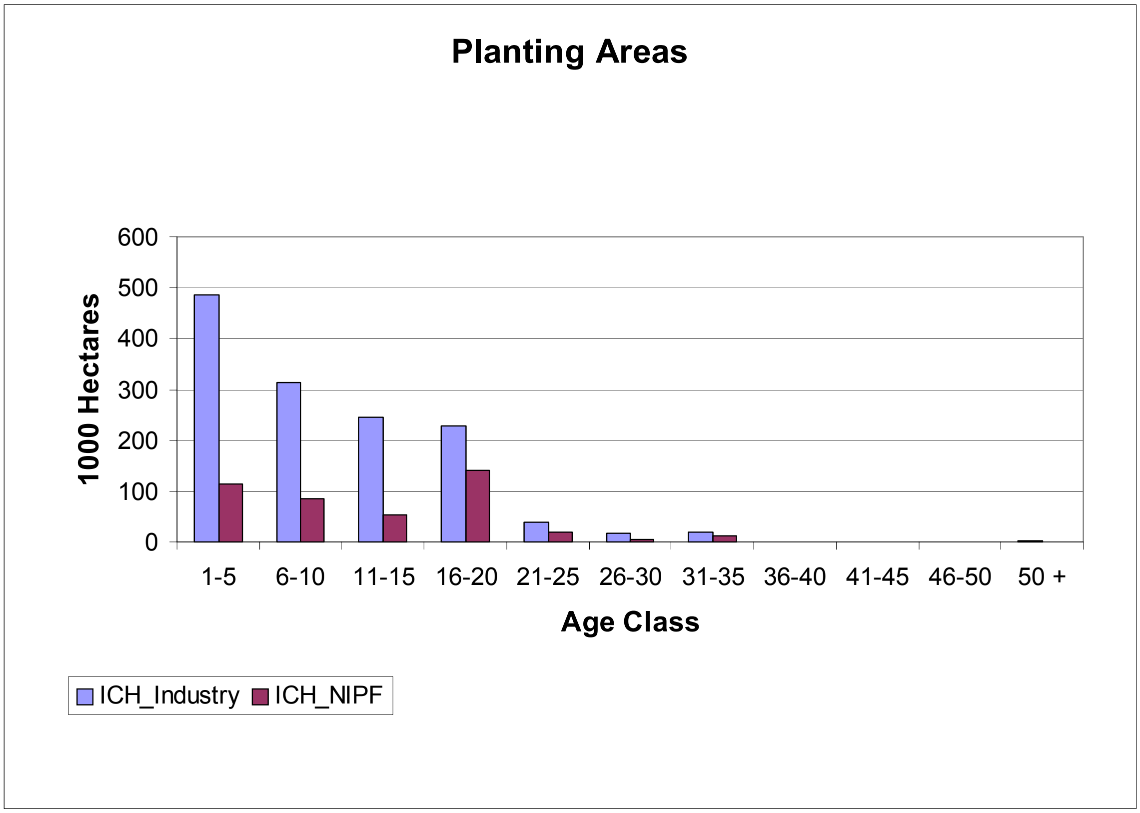
PHL: Philippines



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
PHL_Industry	79.2	0.96
PHL_NIPF	72.8	0.85

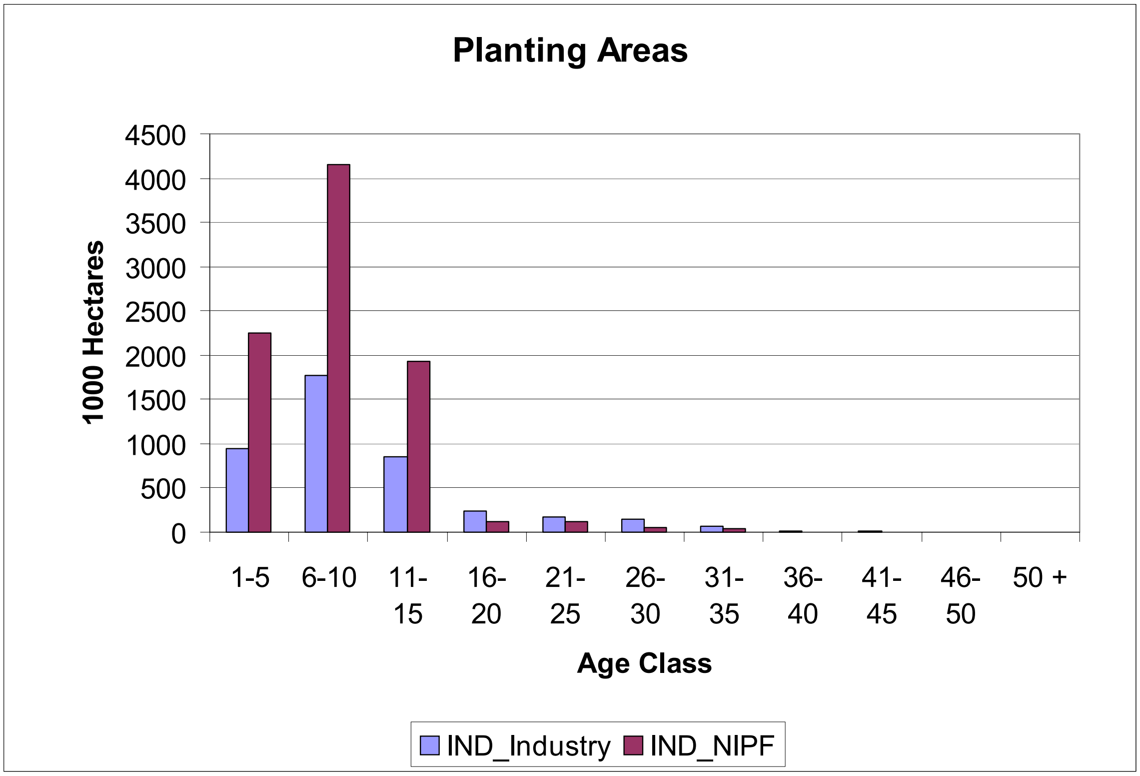
ICH: Indochina



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
ICH_Industry	1351.5	0.77
ICH_NIPF	435.2	0.59

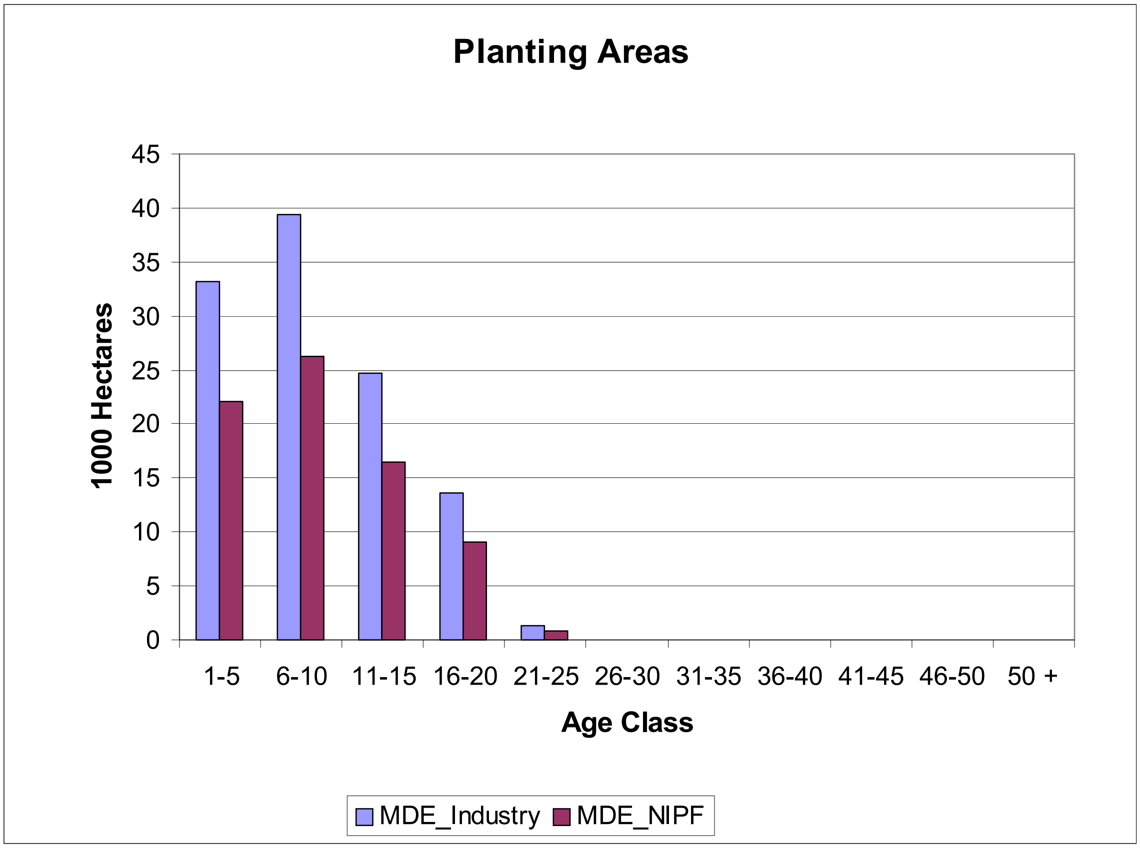
IND: India



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
IND_Industry	4224.9	0.84
IND_NIPF	8671.1	0.96

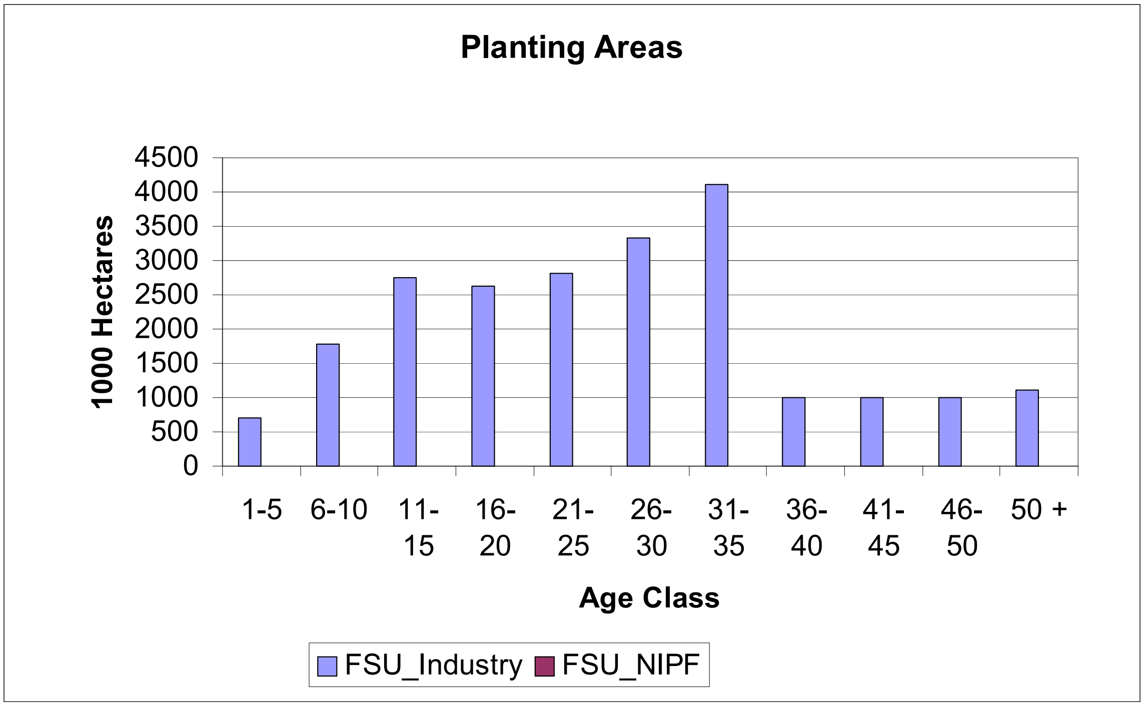
MDE: Middle East



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
MDE_Industry	112.1	0.87
MDE_NIPF	74.8	0.87

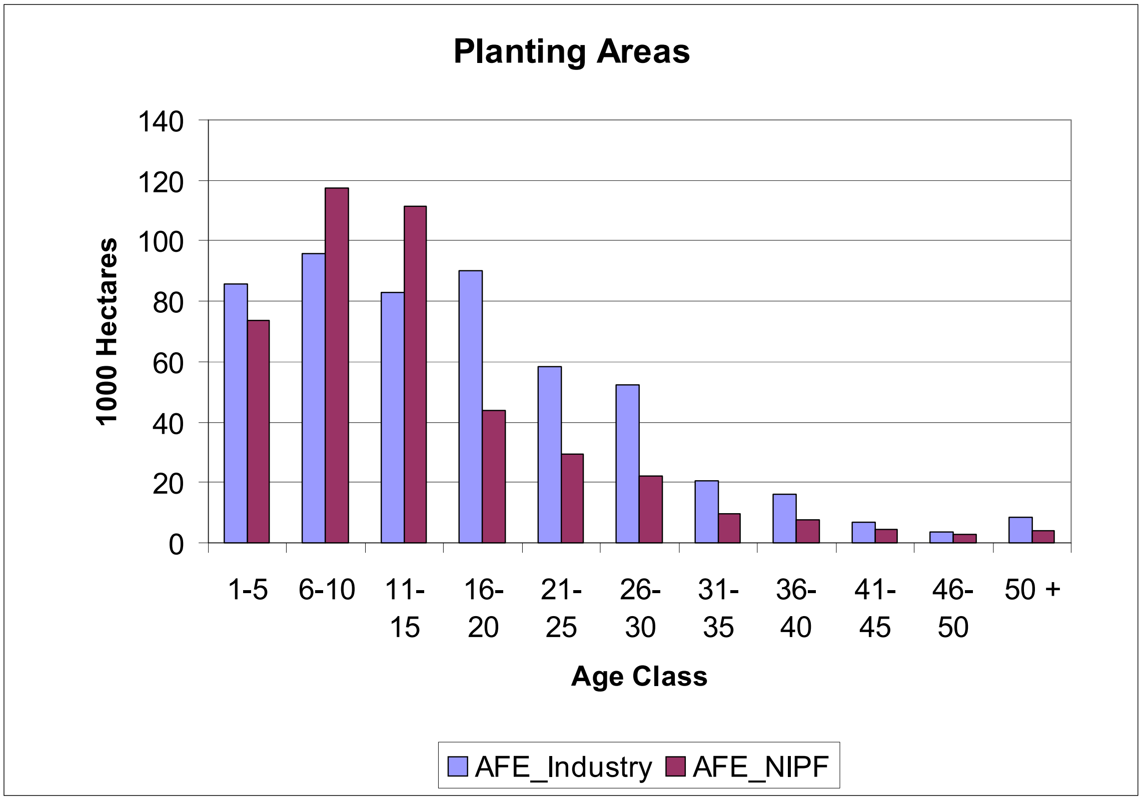
FSU: Former Soviet Union



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
FSU_Industry	22199.3	0.24
FSU_NIPF	0.0	0.00

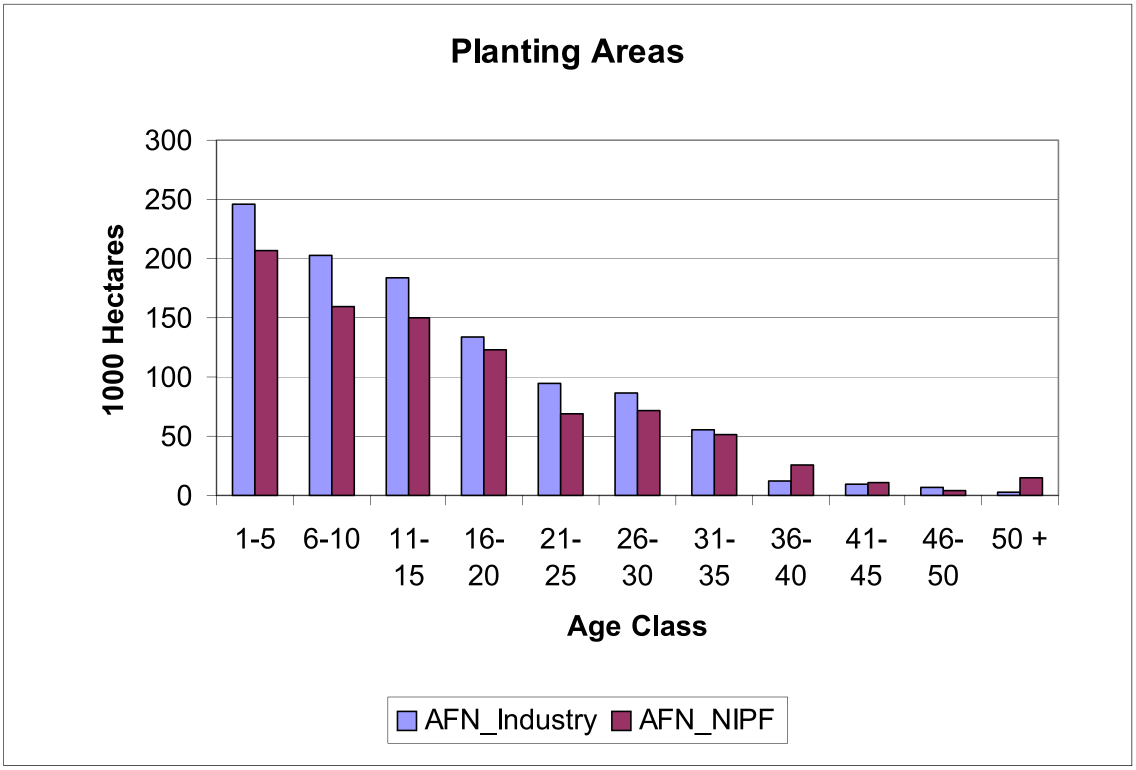
AFE: Eastern Africa



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
AFE_Industry	520.2	0.51
AFE_NIPF	426.8	0.71

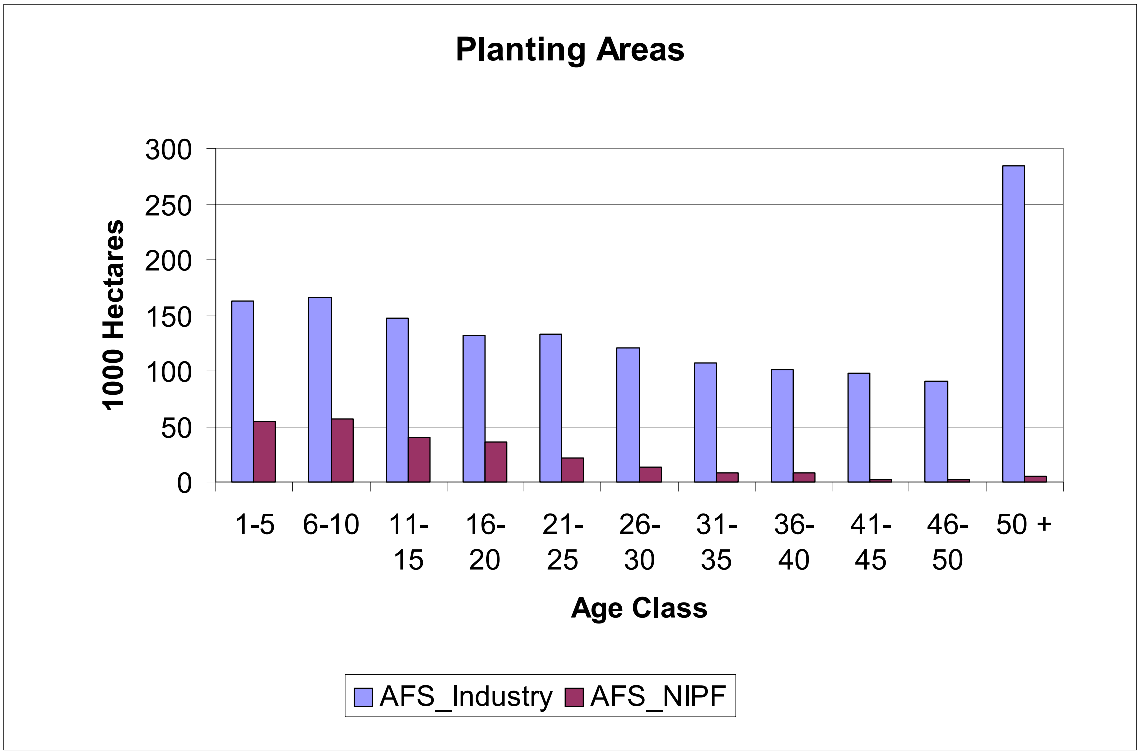
AFN: Northern Africa



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
AFN_Industry	1033.5	0.61
AFN_NIPF	887.8	0.58

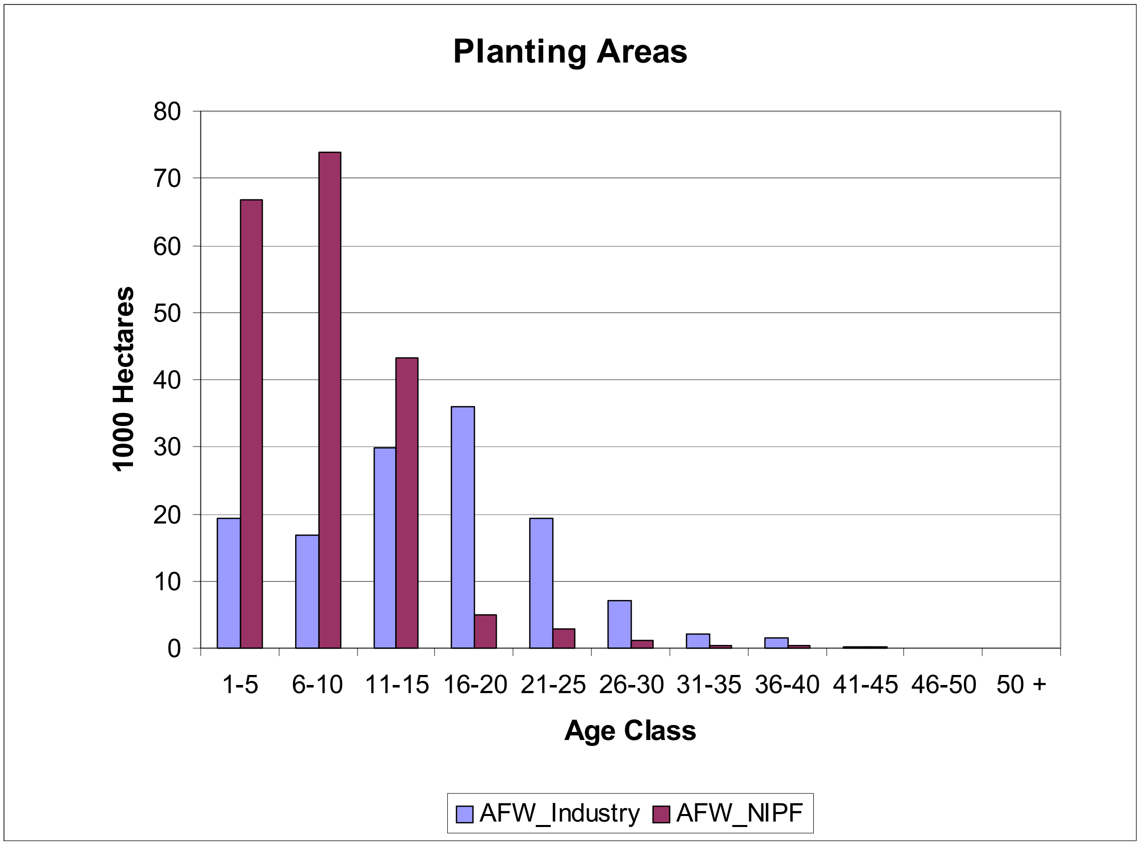
AFS: Southern Africa



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
AFS_Industry	1543.5	0.31
AFS_NIPF	247.7	0.61

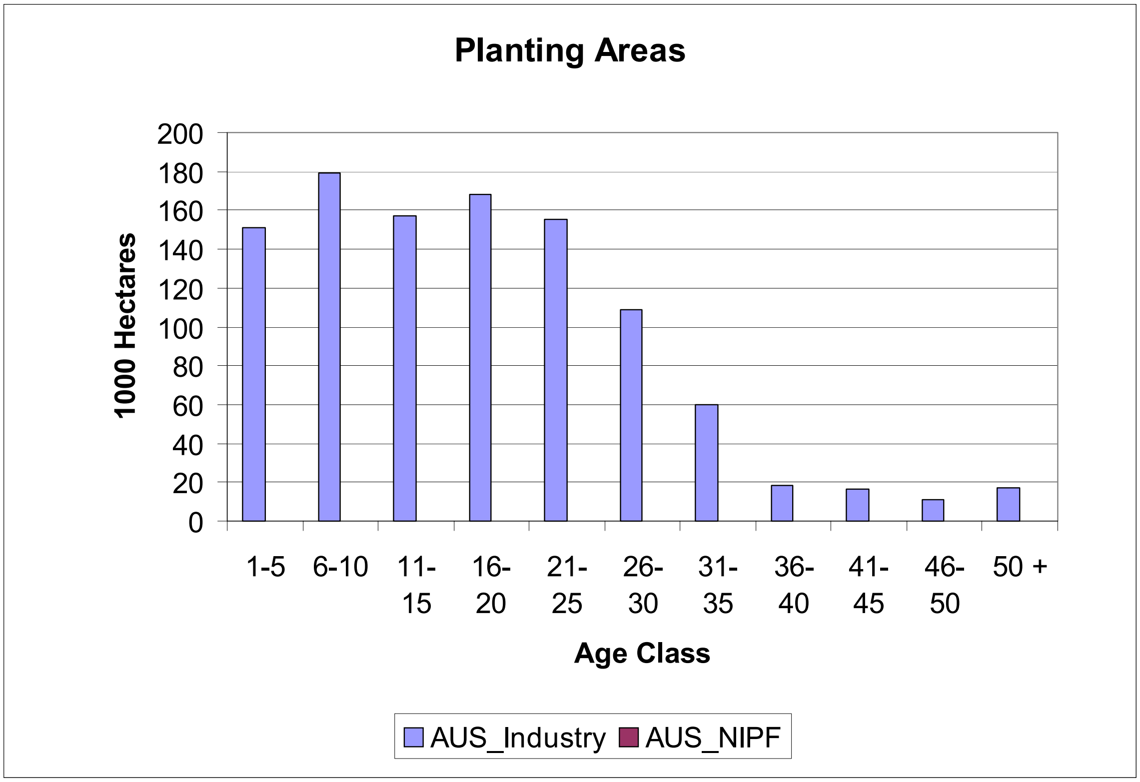
AFW: Western Africa



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
AFW_Industry	132.2	0.50
AFW_NIPF	193.8	0.95

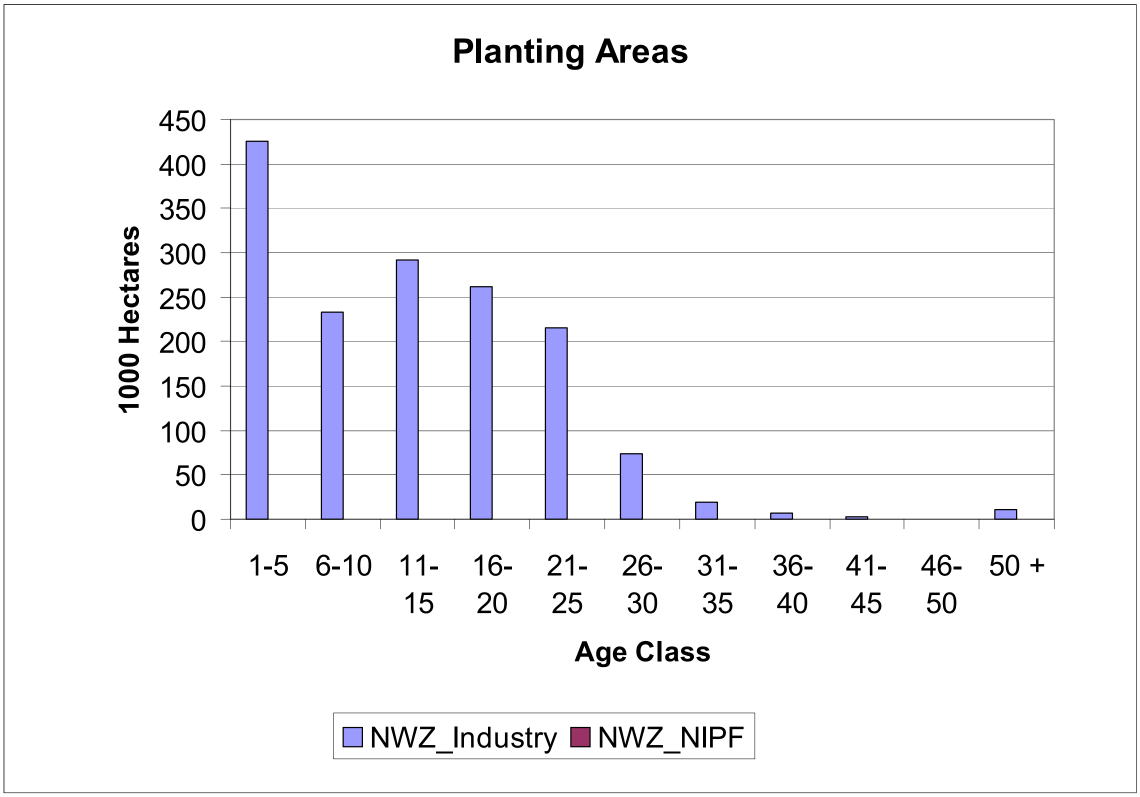
AUS: Australia



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
AUS_Industry	1042.6	0.47
AUS_NIPF	0.0	0.00

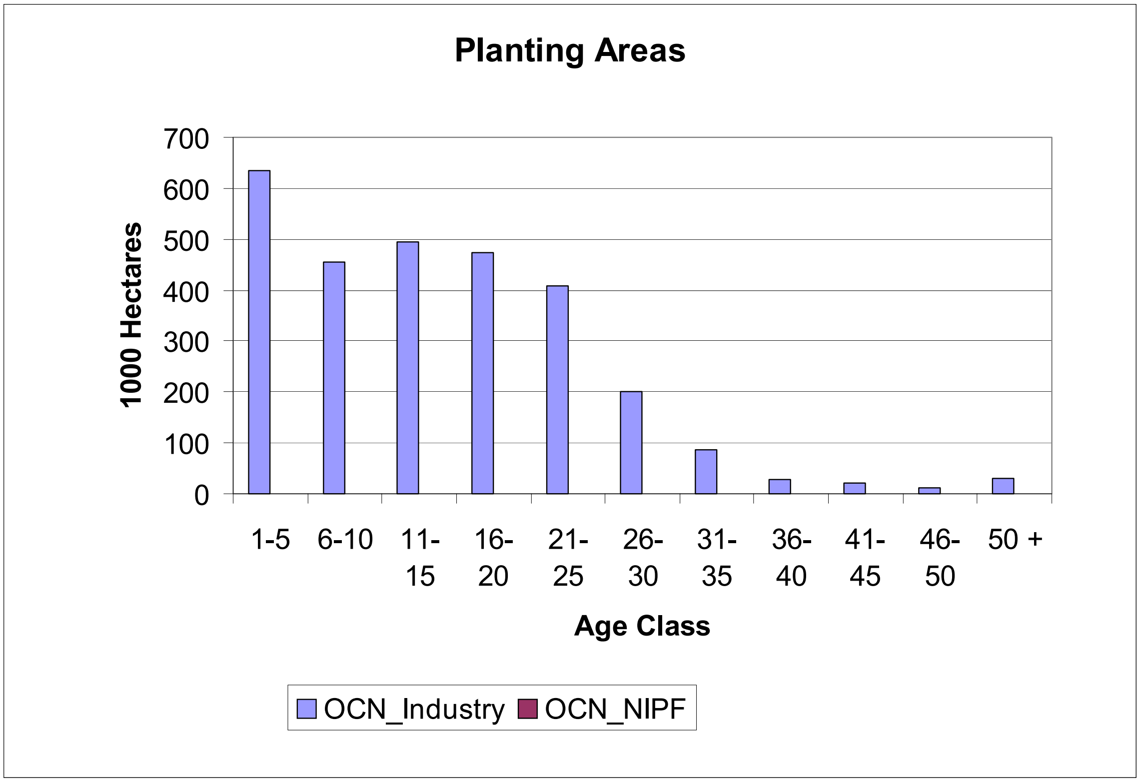
NWZ: New Zealand



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
NWZ_Industry	1540.1	0.62
NWZ_NIPF	0.0	0.00

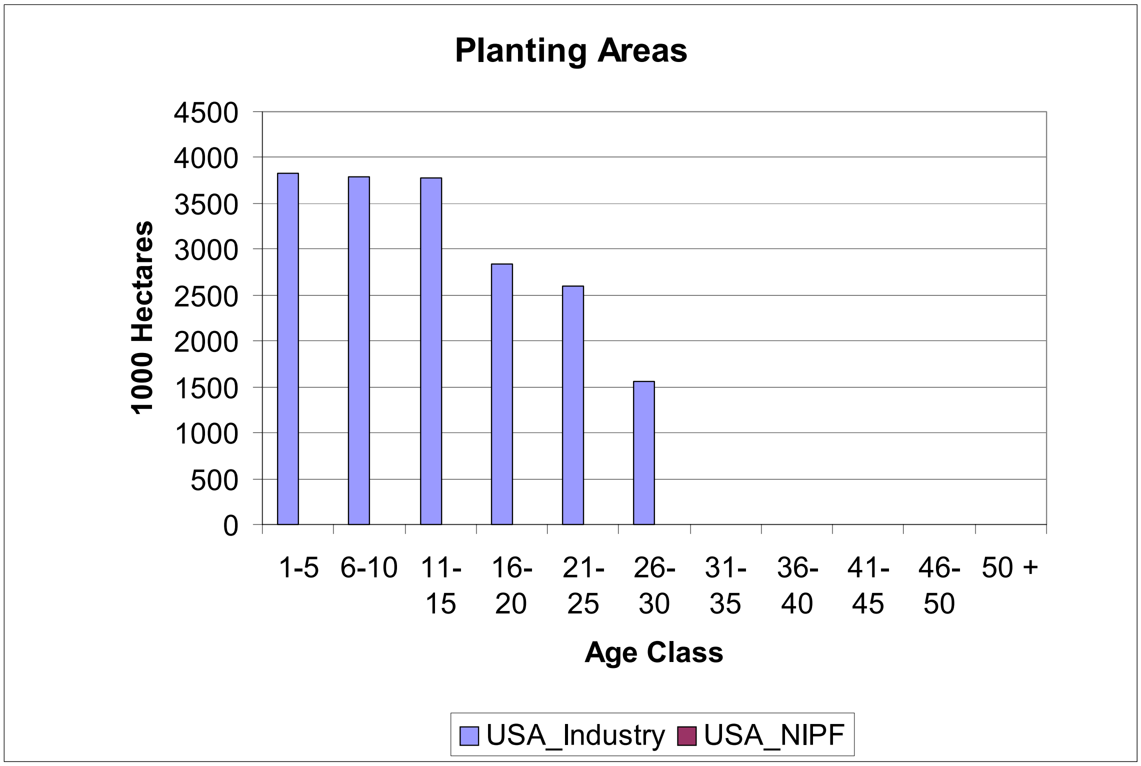
OCN: Oceanic Region



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
OCN_Industry	2846.2	0.56
OCN_NIPF	0.0	0.00

USA: United States of America



Source: FAO

	Total (1000 hectares)	Percentage < 15 years
USA_Industry	18387.5	0.62
USA_NIPF	0.0	0.00

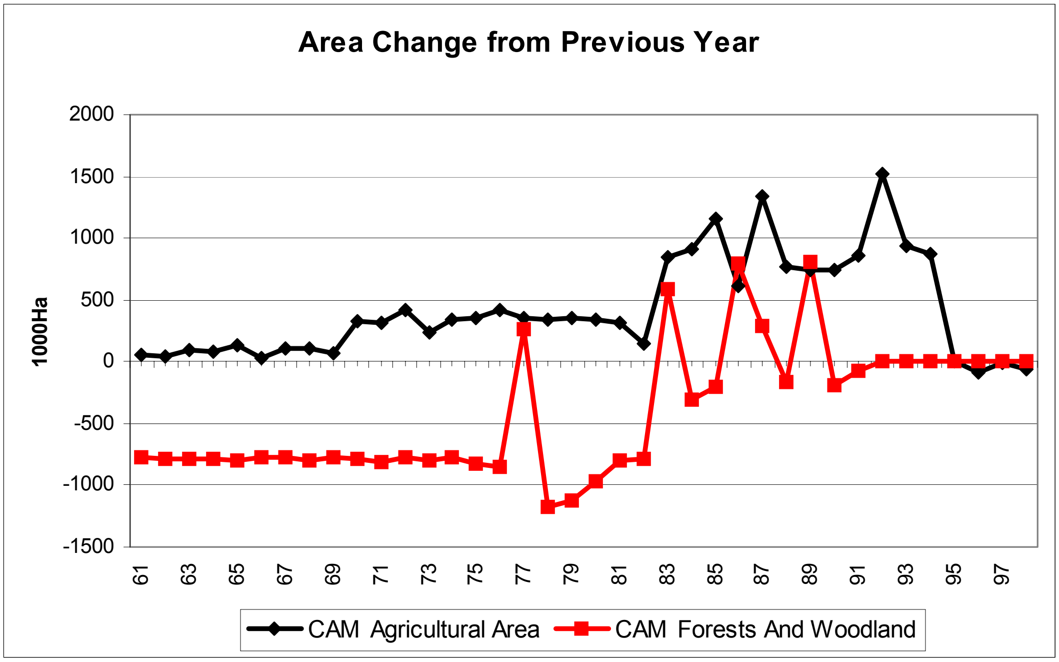
APPENDIX 5. LAND USE TRENDS

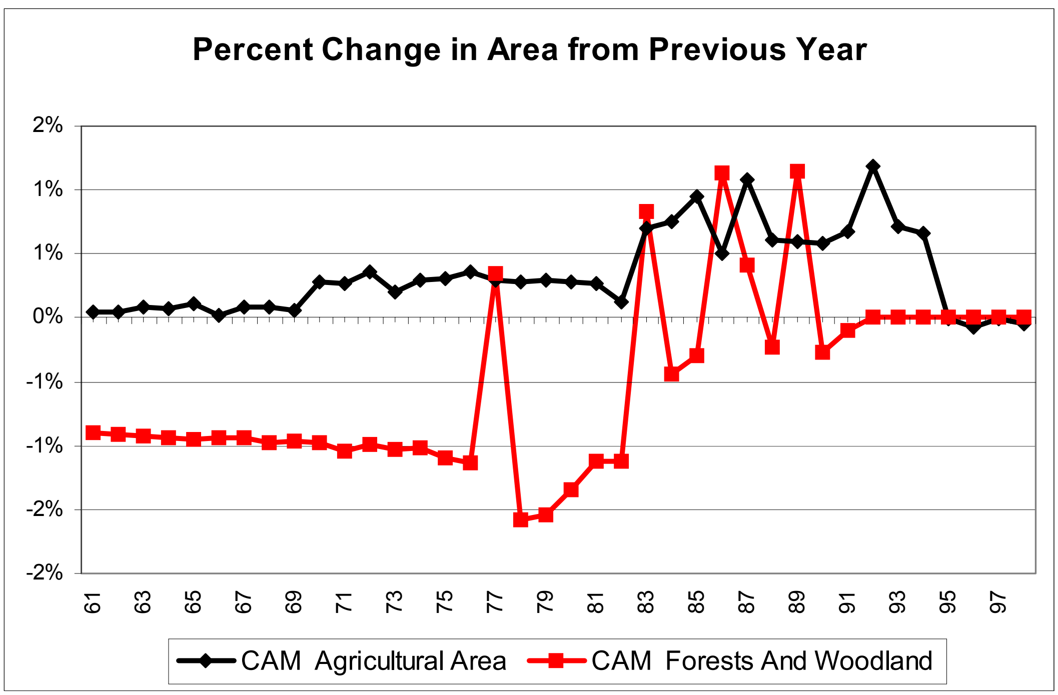
Land use trends are presented to represent the changes in forest area under Criteria 1. Area changes from previous years for CGTM regions are graphed on the following pages. Two series are presented: The change in agricultural area and the change in forests and woodland areas. We summarize these changes in the table below. The two series act as a check on each other. For example, we expect that an increase in agricultural land should accompany a decrease in forestland. For many regions this relationship does bear out, for others it does not. Notable are those regions that have experienced a loss of agricultural land, with a concomitant increase in forestlands, such as Finland and Western Europe.

CGTM Region	Total Forest Area 1000 ha (1995)	Ag Land	Forest Land
AFE	174,532	+	-
AFN	1,767	NA	NA
AFS	79,873	+	No change
AFW	447,322	+	No change
AUS	41,658	NA	NA
BRA	514,480	+	-
CAM	71,134	+	-
CAN	264,100	NA	NA
CHI	7,550	-	No change
CHN	129,462	+	-
EUE	24,905	NA	NA
EUW	67,210	-	+
FIN	19,885	-	+
FSU	791,600	NA	NA
ICH	77,180	NA	NA
IDN	116,895	+	-
IND	66,561	NA	NA
JPN	24,158	-	No change
KOR	4,800	NA	NA
MAL	20,996	+	No change
MDE	26,821	+	NA
NWZ	7,200	-	No change
PHL	9,510	+	-
PNG	38,175	+	-
SAN	271,395	+	-
SAS	64,700	+	No change
SWE	24,400	-	No change
USA	195,256	NA	NA
WRD	3,600,198	NA	NA

Source: FAO

CAM


Area Change from Previous Year
1000Ha
2000
1500
1000
500
0
-500
-1000
-1500
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
CAM Agricultural Area
CAM Forests And Woodland


Percent Change in Area from Previous Year
2%
1%
1%
0%
-1%
-1%
-2%
-2%
61
63
65
67
69
71
73
75
77
79
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83
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87
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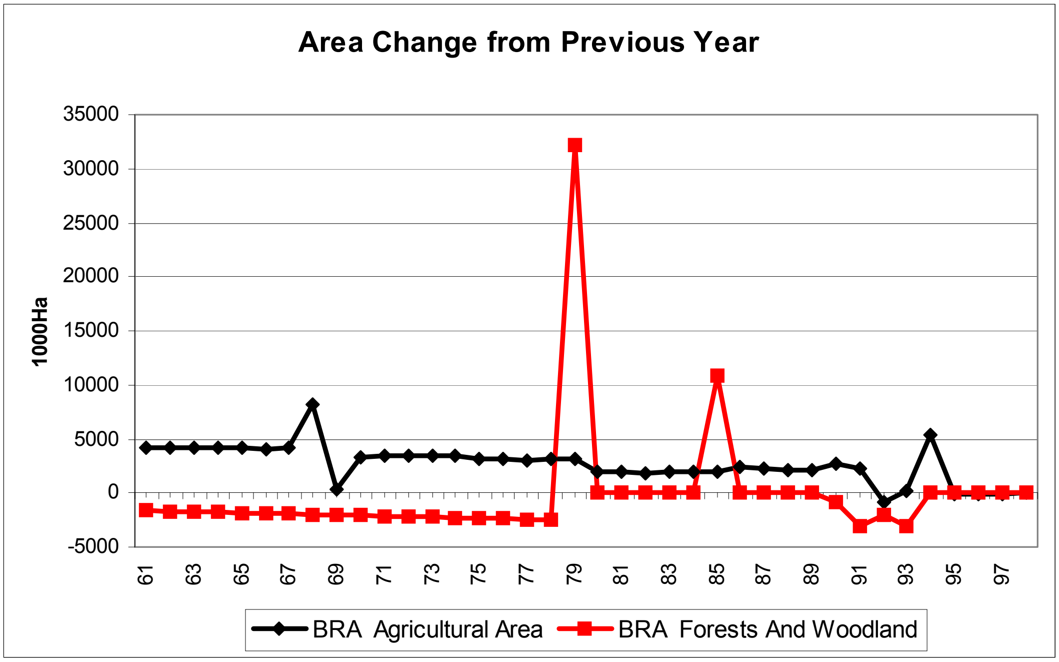
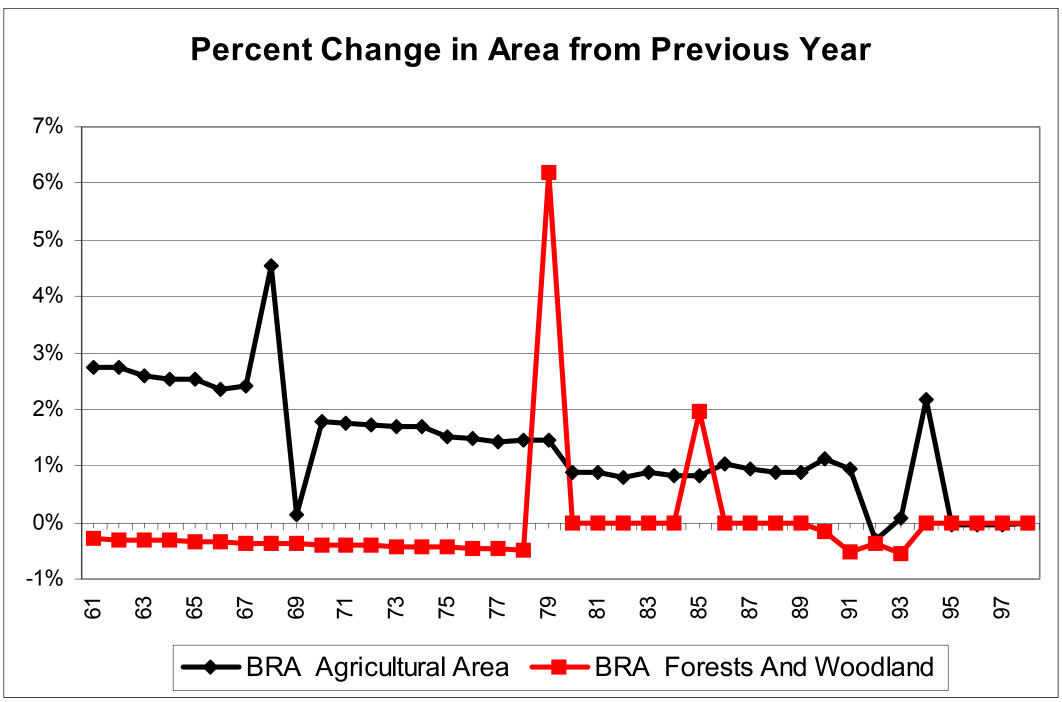
91
93
95
97
CAM Agricultural Area
CAM Forests And Woodland

BRA



Area Change from Previous Year
1000Ha
35000
30000
25000
20000
15000
10000
5000
0
-5000
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
BRA Agricultural Area
BRA Forests And Woodland



Percent Change in Area from Previous Year
7%
6%
5%
4%
3%
2%
1%
0%
-1%
61
63
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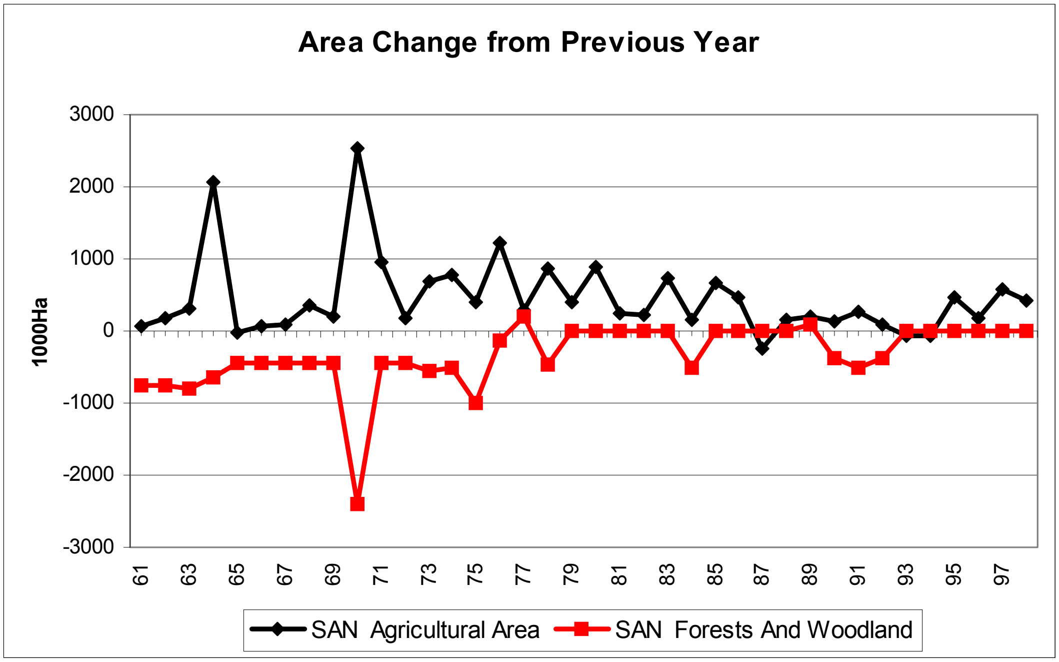
BRA Agricultural Area
BRA Forests And Woodland

SAN


Area Change from Previous Year
3000
2000
1000
0
-1000
-2000
-3000
1000Ha
61
63
65
67
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93
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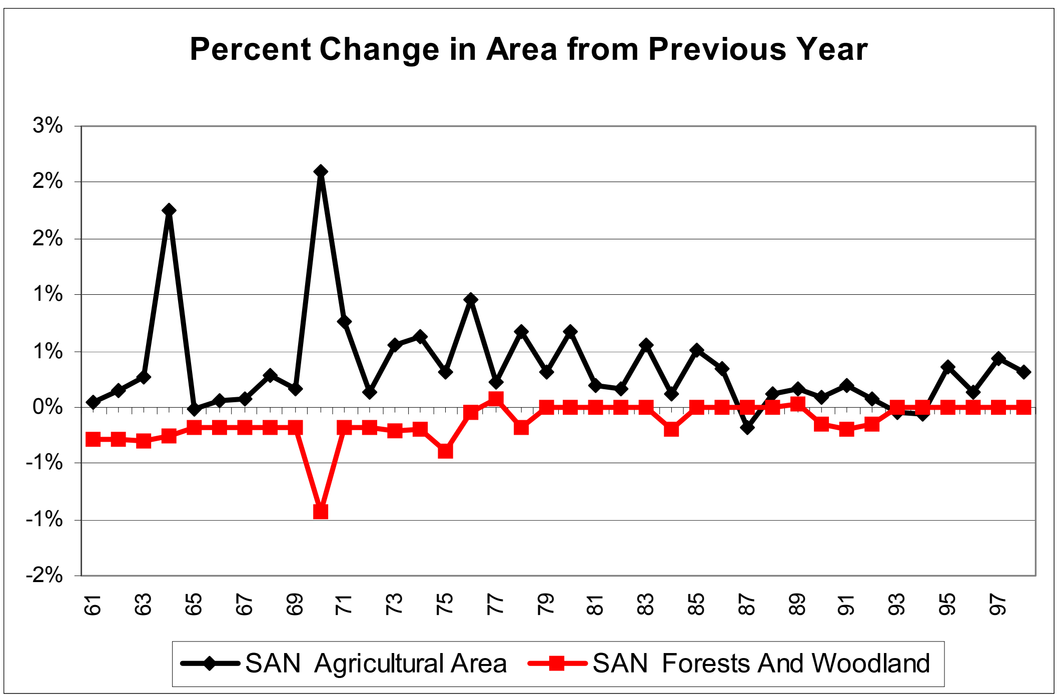
97
SAN Agricultural Area
SAN Forests And Woodland


Percent Change in Area from Previous Year
3%
2%
2%
1%
1%
0%
-1%
-1%
-2%
61
63
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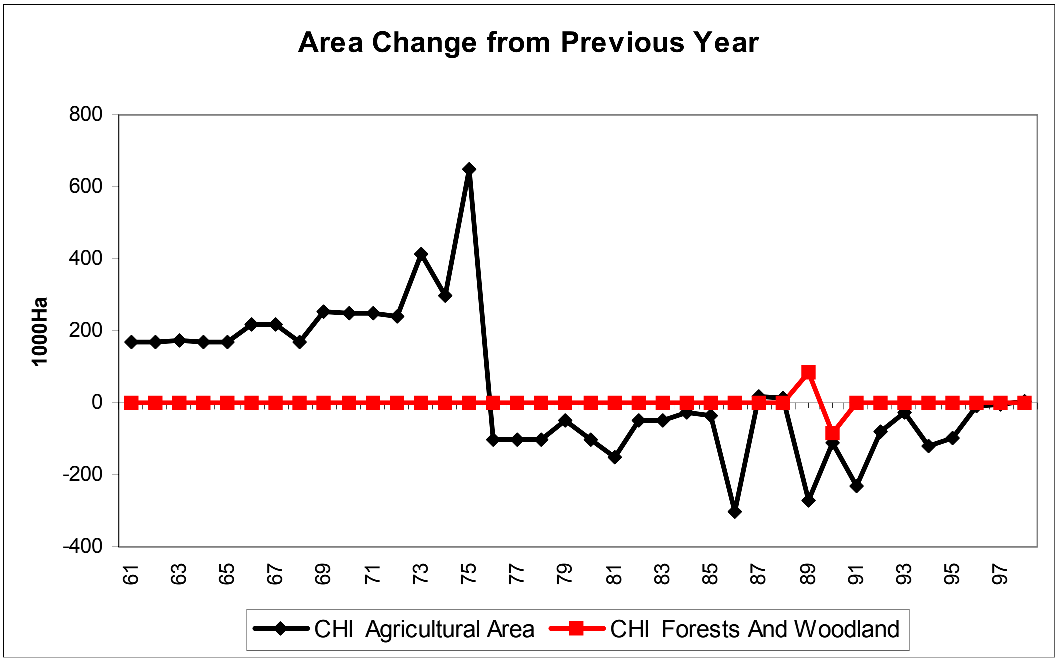
SAN Agricultural Area
SAN Forests And Woodland

CHI



Area Change from Previous Year
1000Ha
800
600
400
200
0
-200
-400
61
63
65
67
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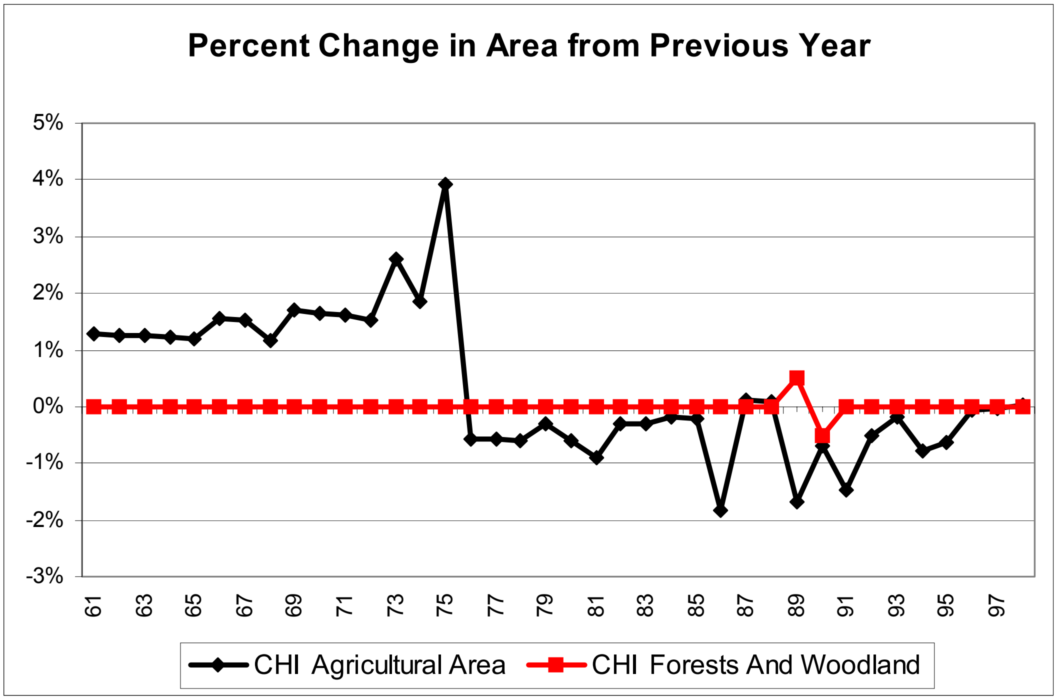
87
89
91
93
95
97
CHI Agricultural Area
CHI Forests And Woodland



Percent Change in Area from Previous Year
5%
4%
3%
2%
1%
0%
-1%
-2%
-3%
61
63
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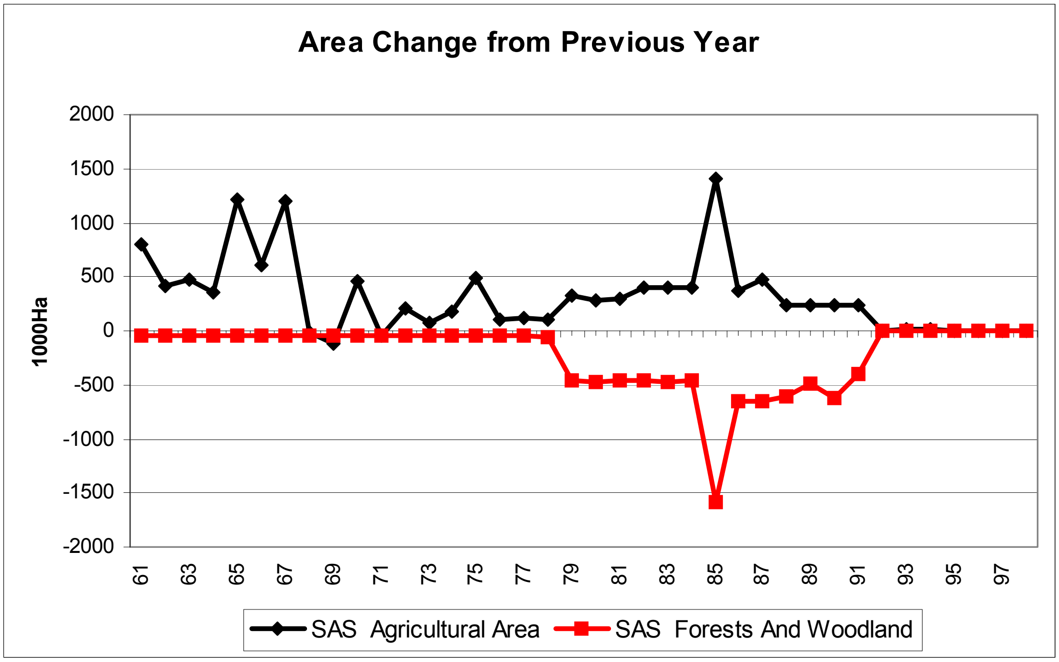
97
CHI Agricultural Area
CHI Forests And Woodland


Area Change from Previous Year
2000
1500
1000
500
0
-500
-1000
-1500
-2000
1000Ha
61
63
65
67
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75
77
79
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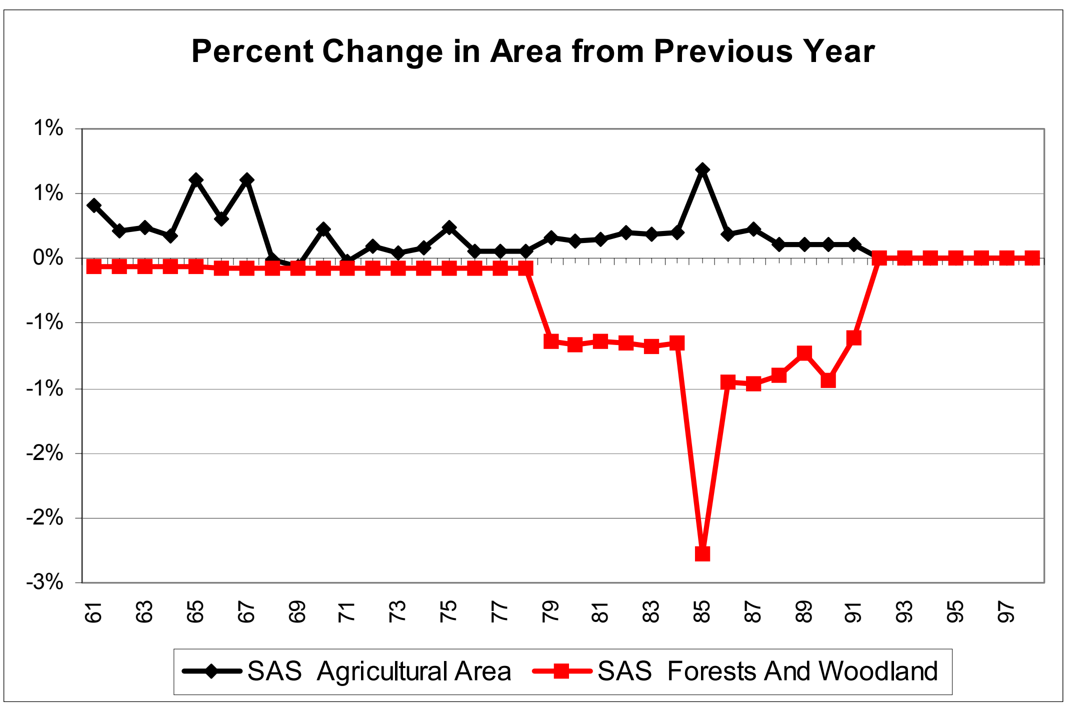
93
95
97
SAS Agricultural Area
SAS Forests And Woodland


Percent Change in Area from Previous Year
1%
1%
0%
-1%
-1%
-2%
-2%
-3%
61
63
65
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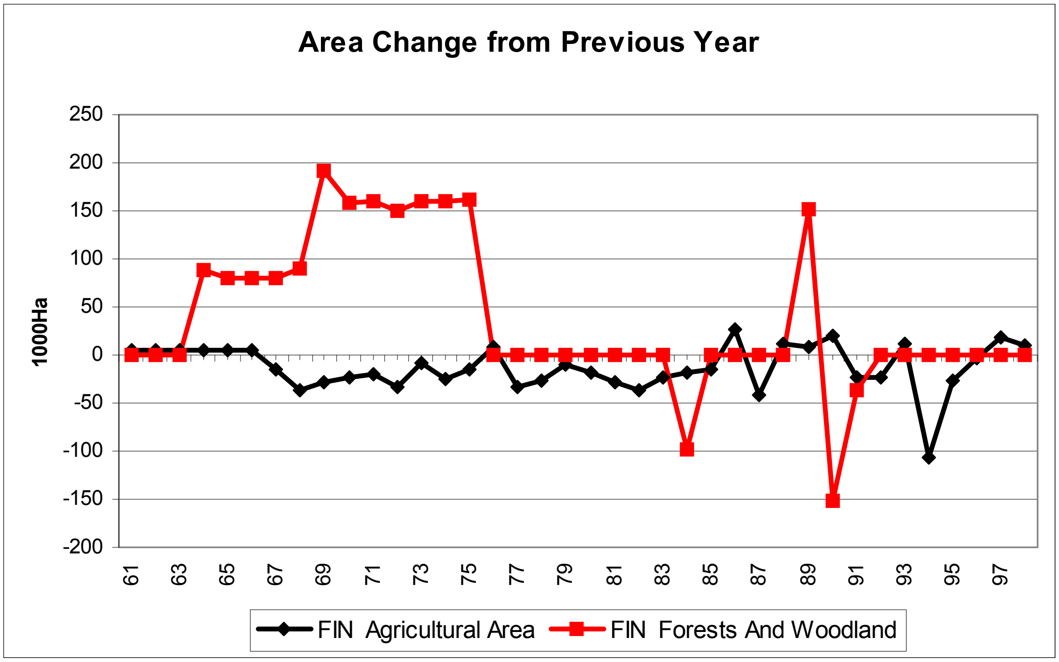
SAS Agricultural Area
SAS Forests And Woodland


Area Change from Previous Year
250
200
150
100
50
0
-50
-100
-150
-200
1000Ha
61
63
65
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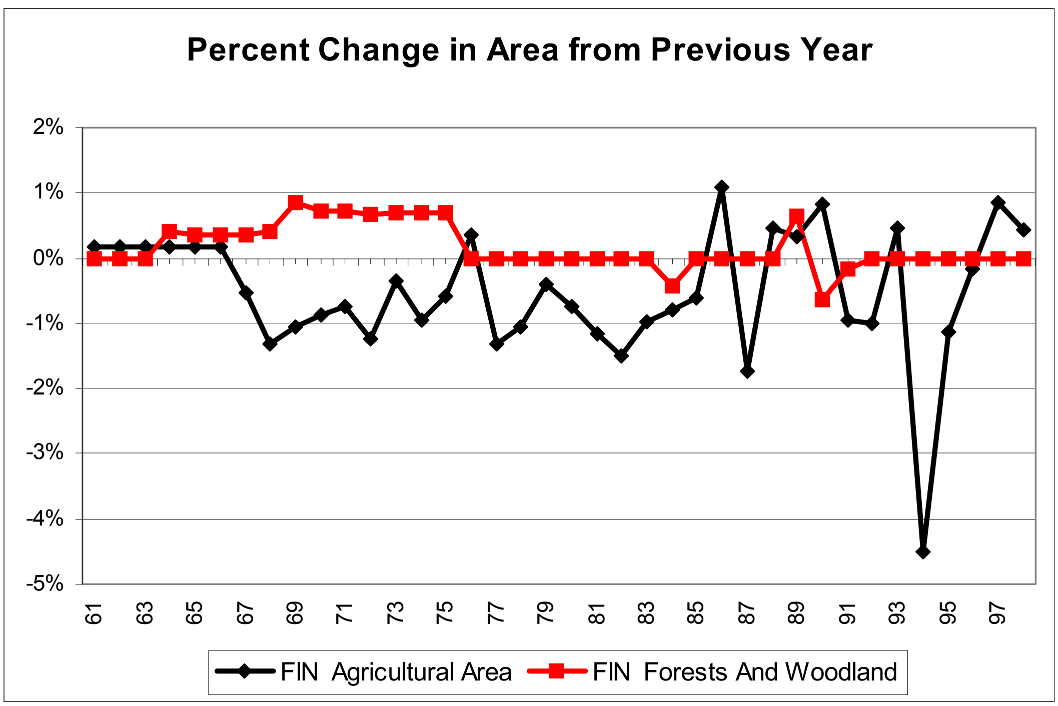
FIN Agricultural Area
FIN Forests And Woodland


Percent Change in Area from Previous Year
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
61
63
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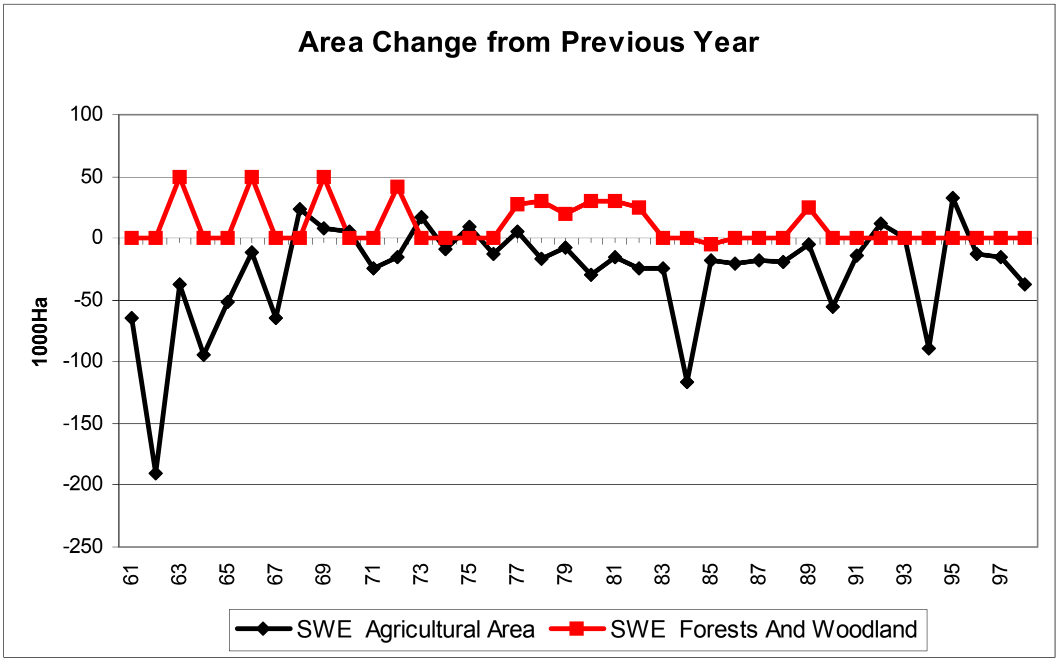
FIN Agricultural Area
FIN Forests And Woodland

SWE



Area Change from Previous Year
100
50
0
-50
-100
-150
-200
-250
1000Ha
61
63
65
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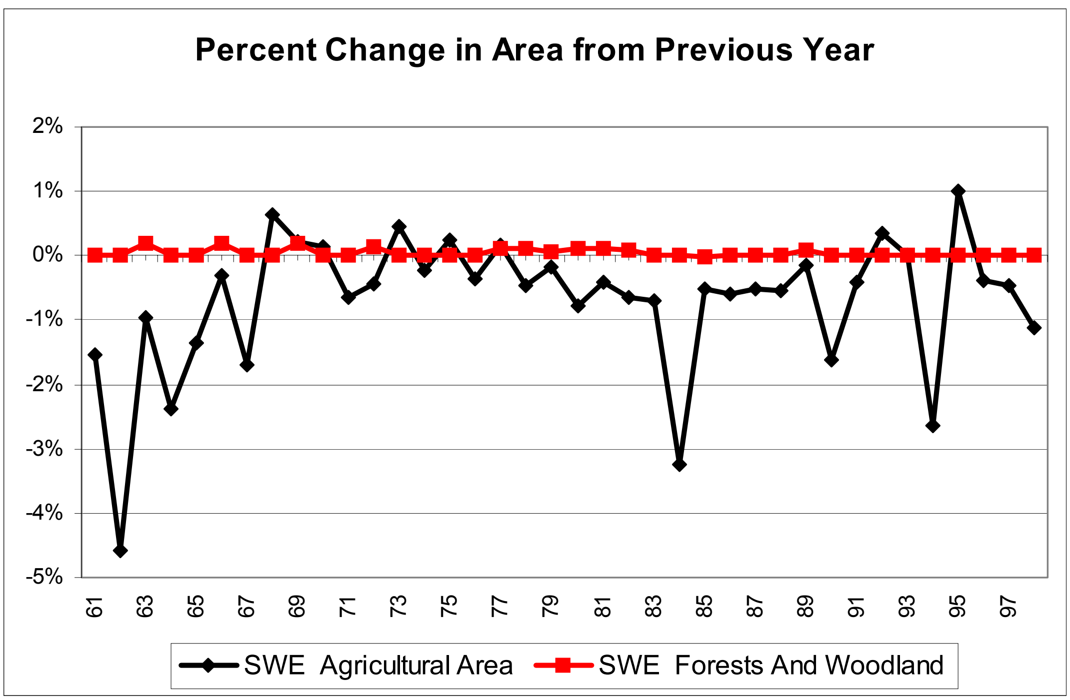
SWE Agricultural Area
SWE Forests And Woodland



Percent Change in Area from Previous Year
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
61
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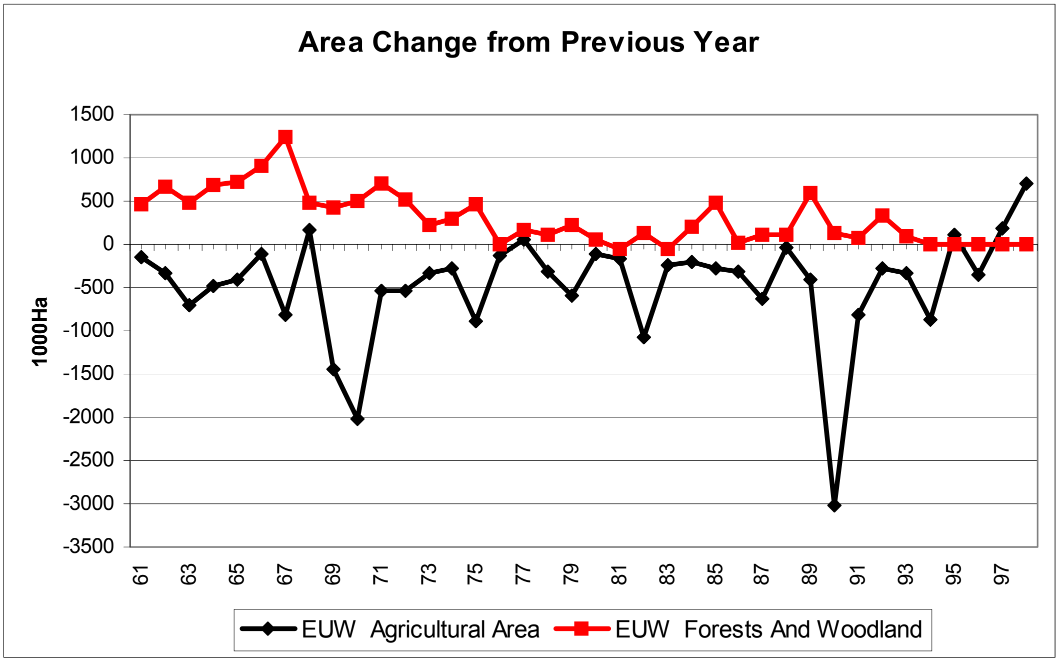
SWE Agricultural Area
SWE Forests And Woodland

EUW


Area Change from Previous Year
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
1000Ha
61
63
65
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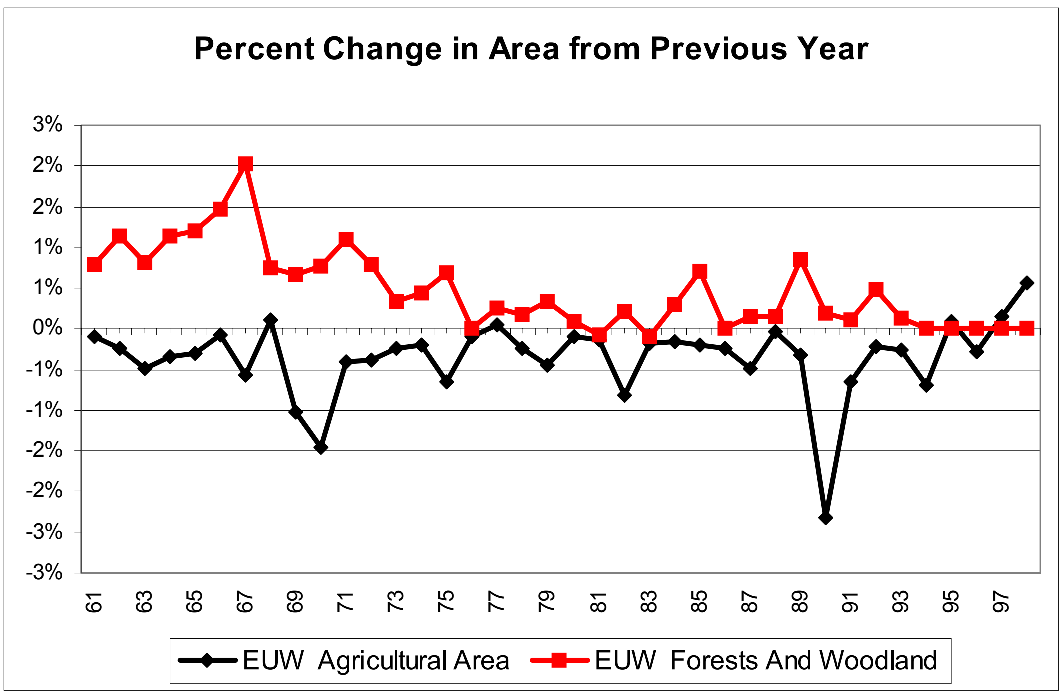
EUW Agricultural Area
EUW Forests And Woodland


Percent Change in Area from Previous Year
3%
2%
2%
1%
1%
0%
-1%
-1%
-2%
-2%
-3%
-3%
61
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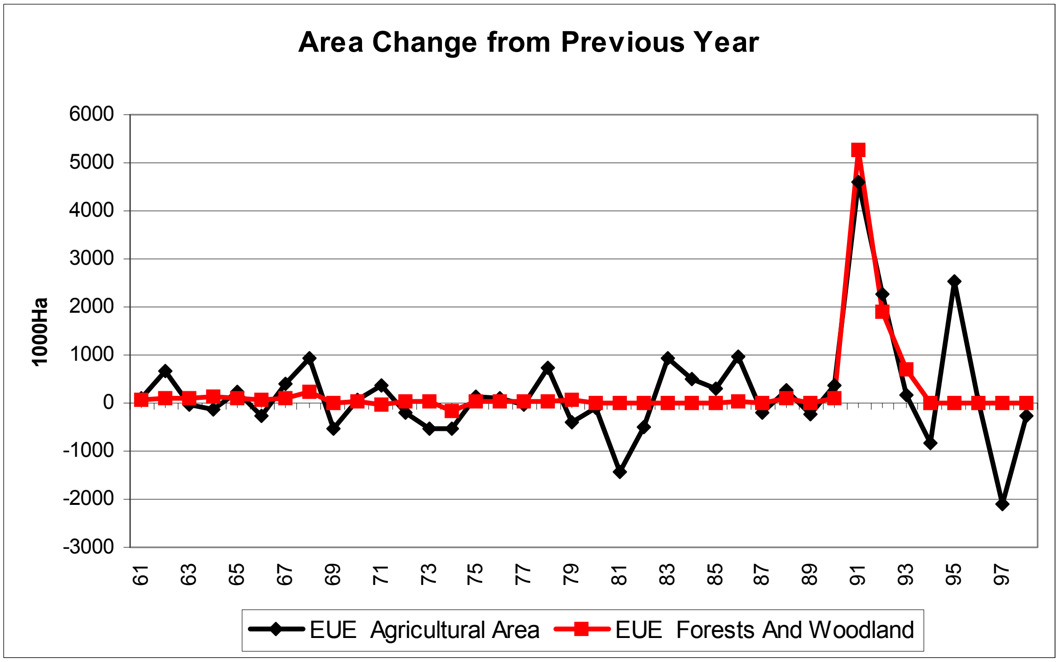
EUW Agricultural Area
EUW Forests And Woodland

EUE


Area Change from Previous Year
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
1000Ha
61
63
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95
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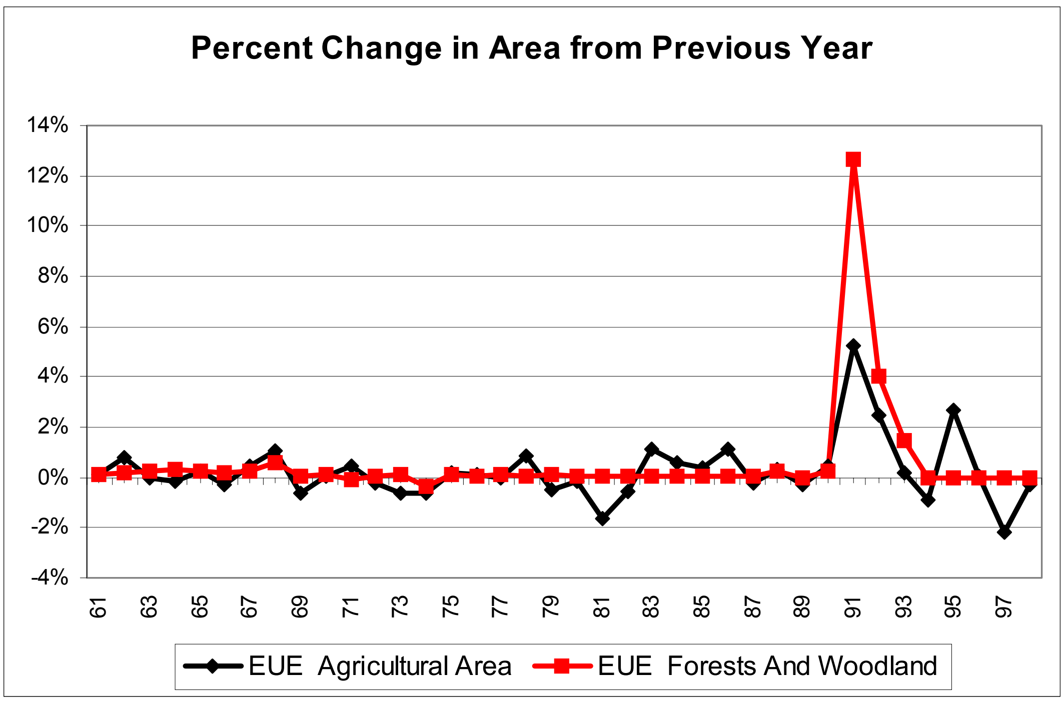
EUE Agricultural Area
EUE Forests And Woodland


Percent Change in Area from Previous Year
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
61
63
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69
71
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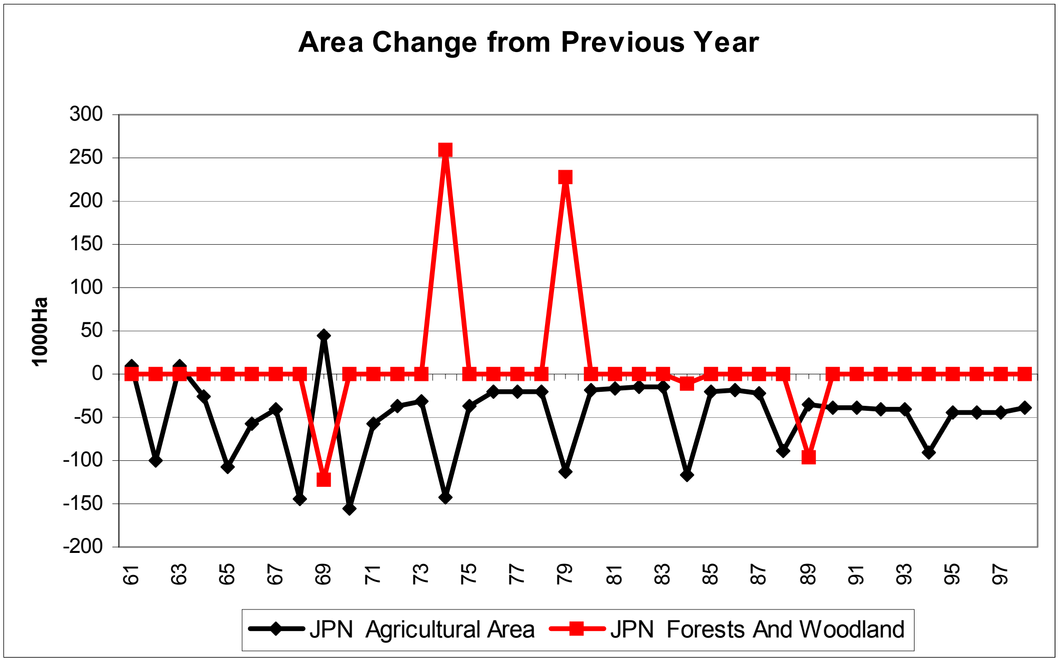
EUE Agricultural Area
EUE Forests And Woodland

JPN



Area Change from Previous Year
1000Ha
300
250
200
150
100
50
0
-50
-100
-150
-200
61
63
65
67
69
71
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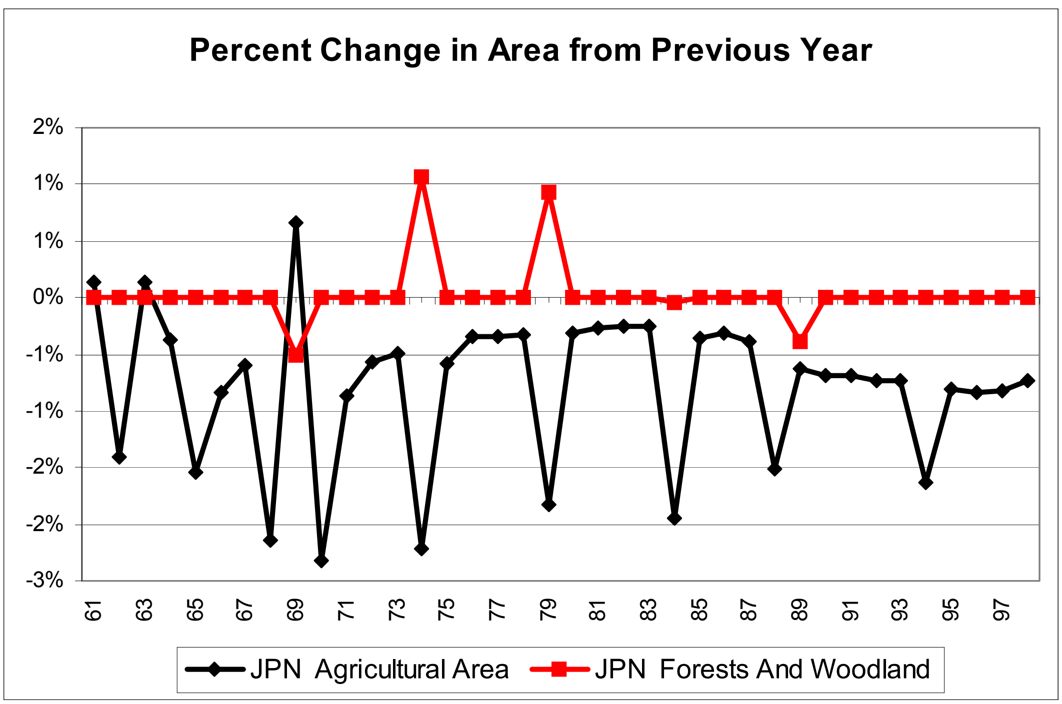
JPN Agricultural Area
JPN Forests And Woodland



Percent Change in Area from Previous Year
2%
1%
1%
0%
-1%
-1%
-2%
-2%
-3%
61
63
65
67
69
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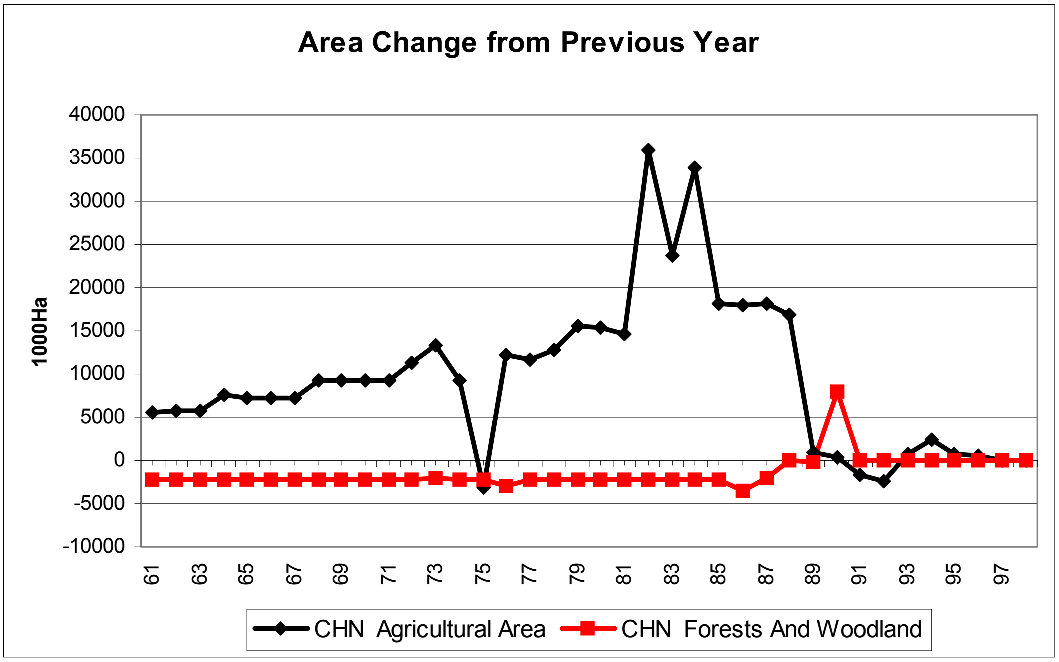
91
93
95
97
JPN Agricultural Area
JPN Forests And Woodland

CHN


Area Change from Previous Year
1000Ha
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
-10000
61
63
65
67
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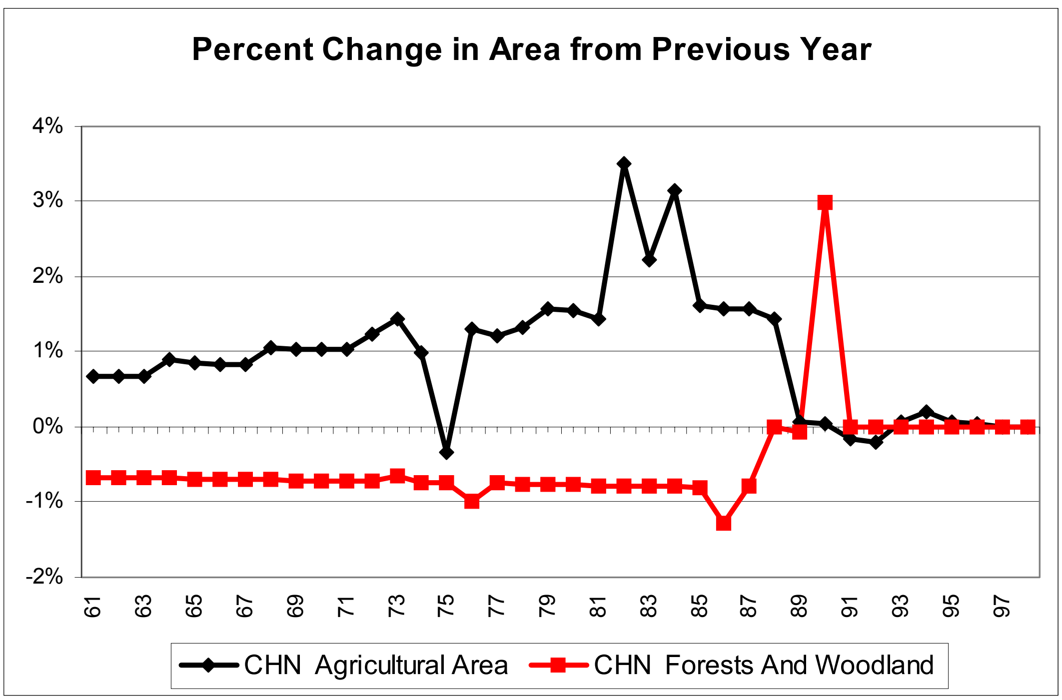
97
CHN Agricultural Area
CHN Forests And Woodland


Percent Change in Area from Previous Year
4%
3%
2%
1%
0%
-1%
-2%
61
63
65
67
69
71
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75
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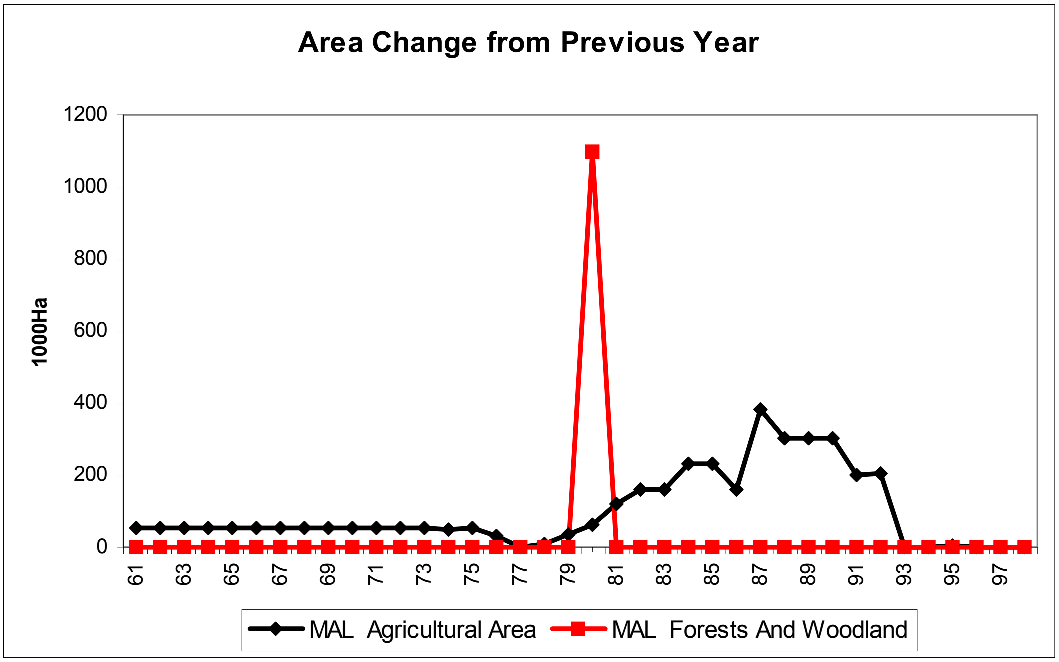
97
CHN Agricultural Area
CHN Forests And Woodland

MAL



Area Change from Previous Year
1000Ha
1200
1000
800
600
400
200
0
61
63
65
67
69
71
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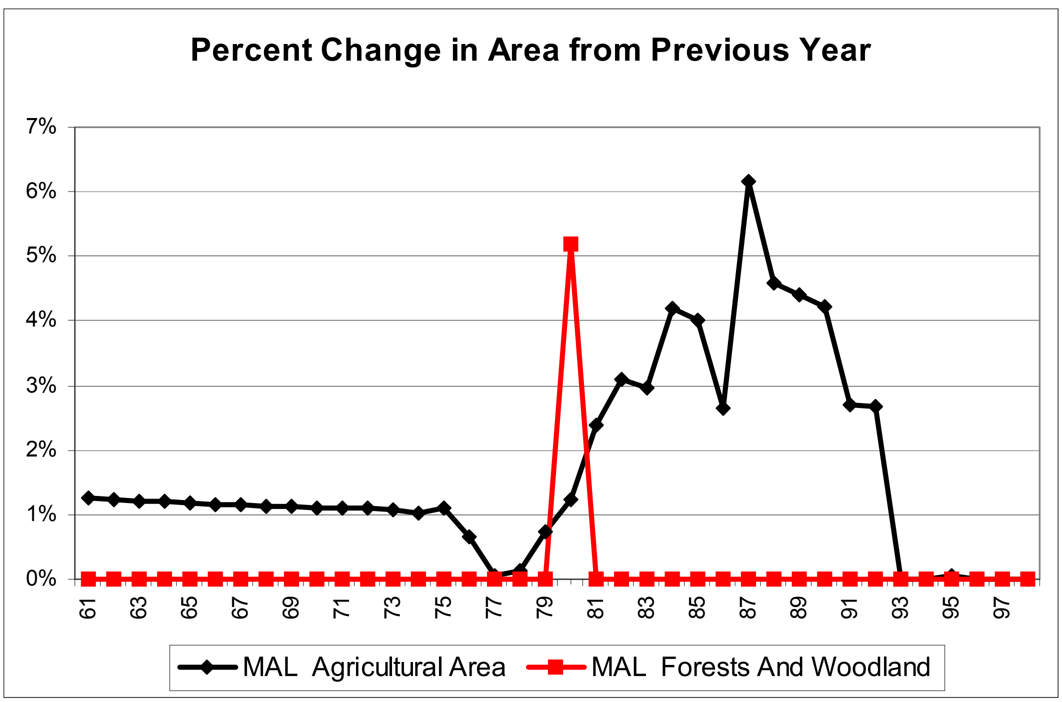
95
97
MAL Agricultural Area
MAL Forests And Woodland



Percent Change in Area from Previous Year
7%
6%
5%
4%
3%
2%
1%
0%
61
63
65
67
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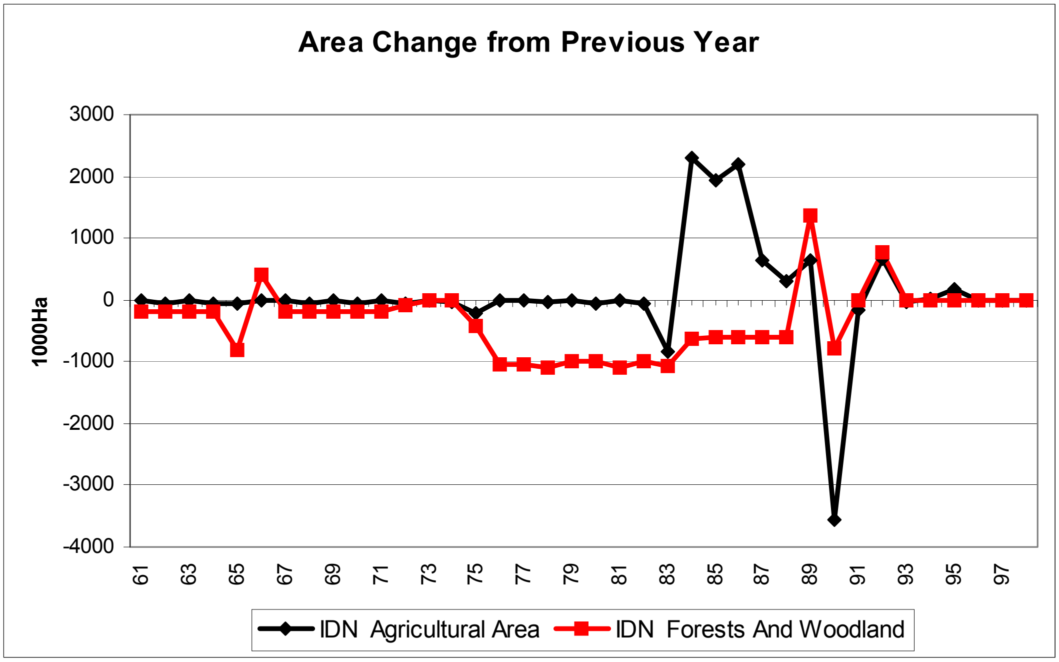
91
93
95
97
MAL Agricultural Area
MAL Forests And Woodland

IDN



Area Change from Previous Year
3000
2000
1000
0
-1000
-2000
-3000
-4000
1000Ha
61
63
65
67
69
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73
75
77
79
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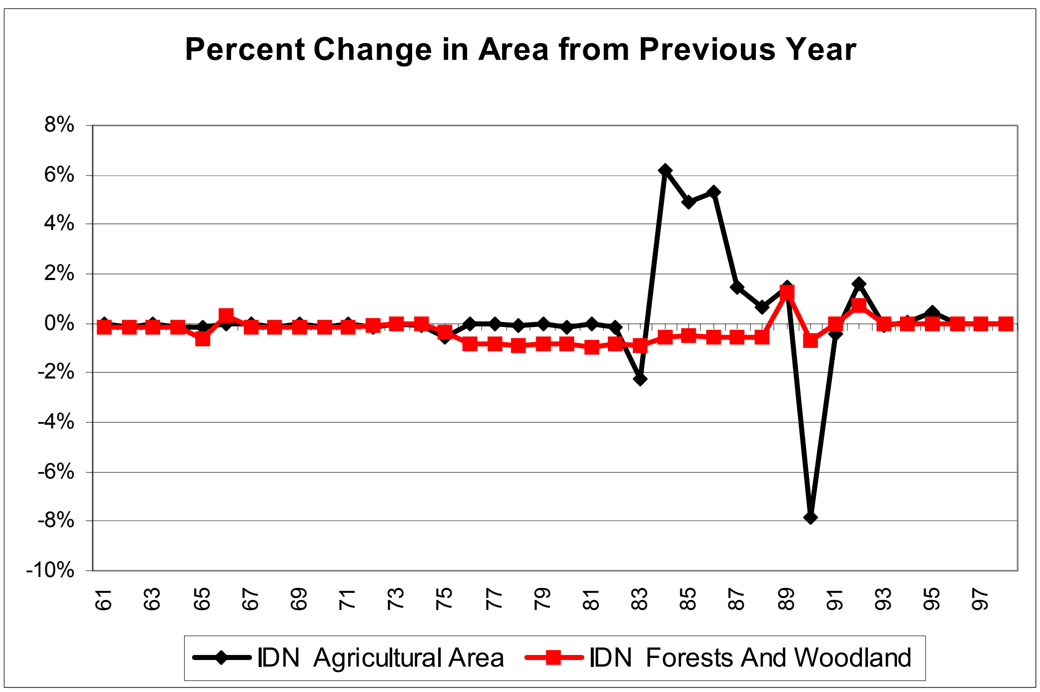
95
97
IDN Agricultural Area
IDN Forests And Woodland



Percent Change in Area from Previous Year
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
61
63
65
67
69
71
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75
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83
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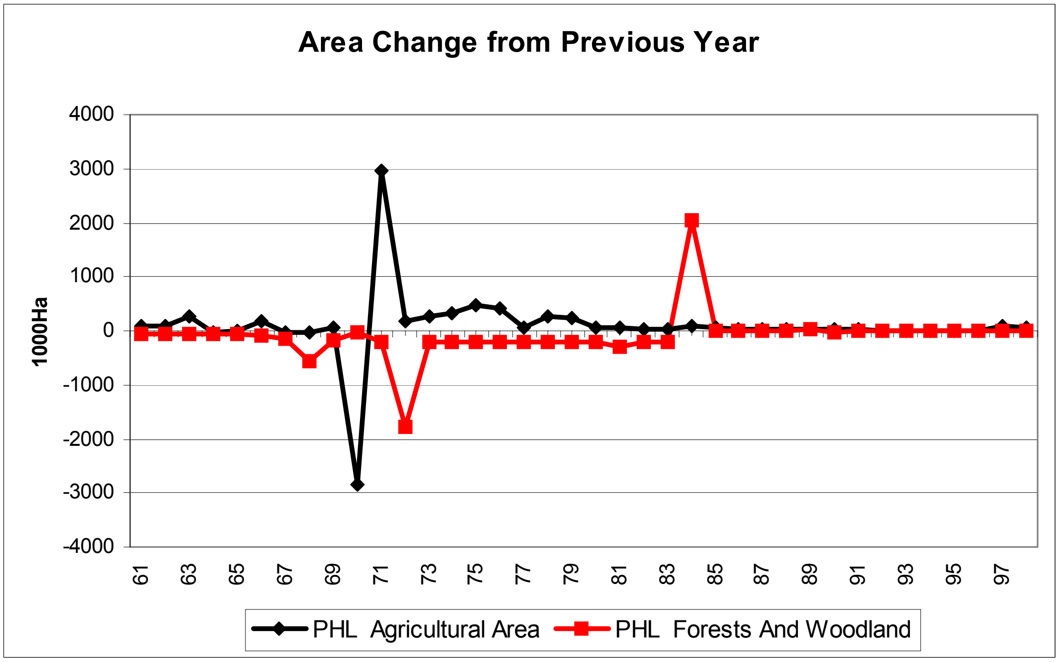
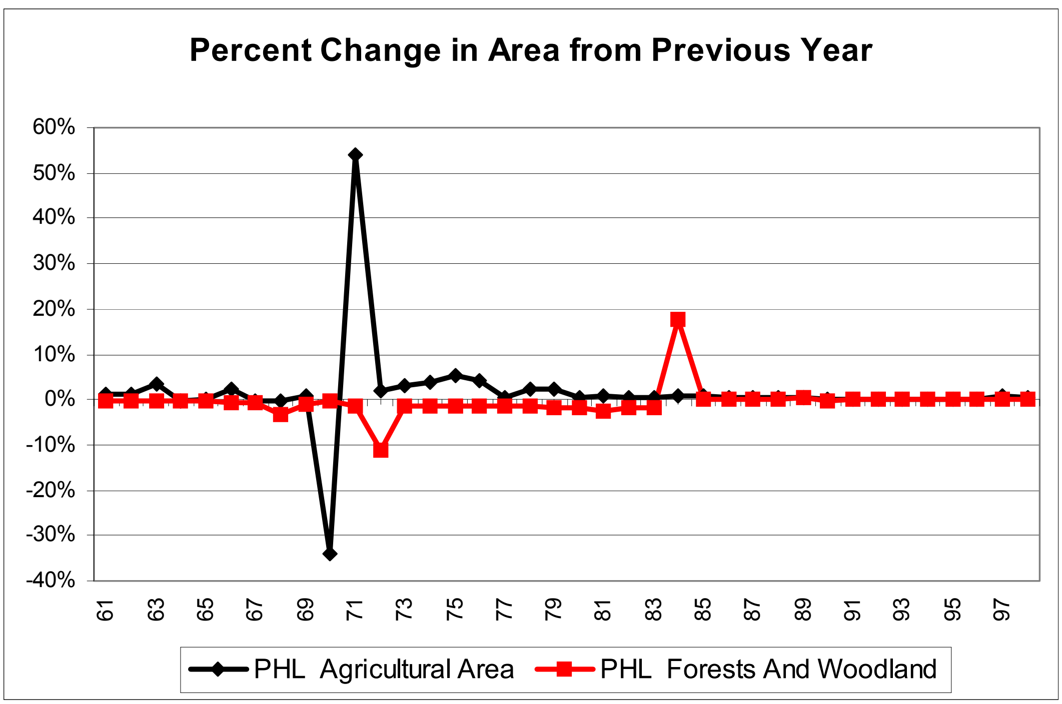
93
95
97
IDN Agricultural Area
IDN Forests And Woodland

PHL


Area Change from Previous Year
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
PHL Agricultural Area
PHL Forests And Woodland


Percent Change in Area from Previous Year
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
61
63
65
67
69
71
73
75
77
79
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83
85
87
89
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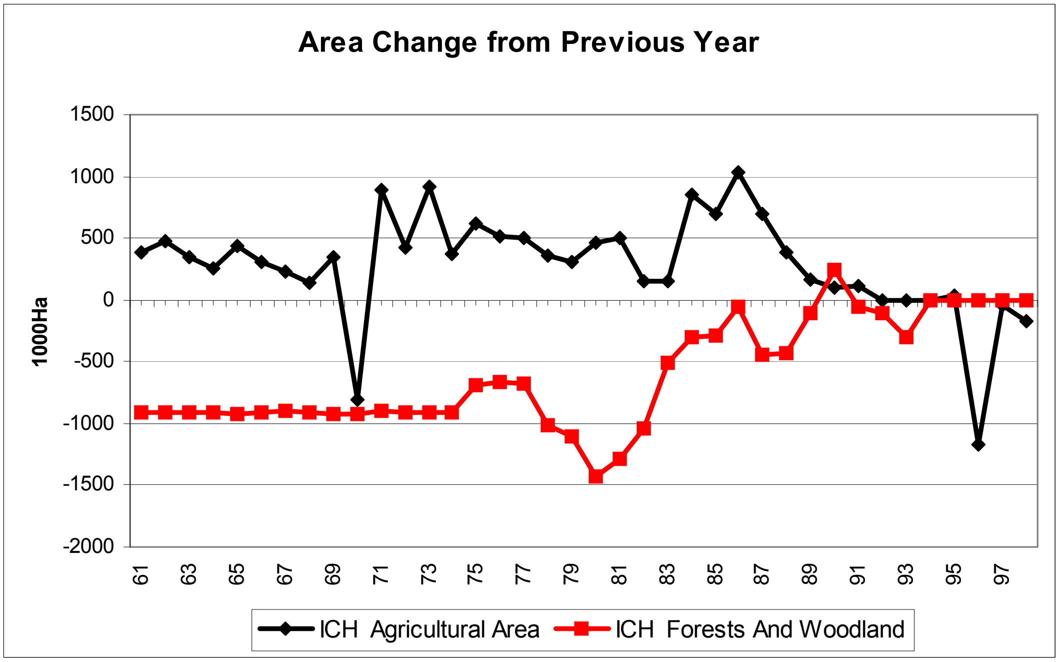
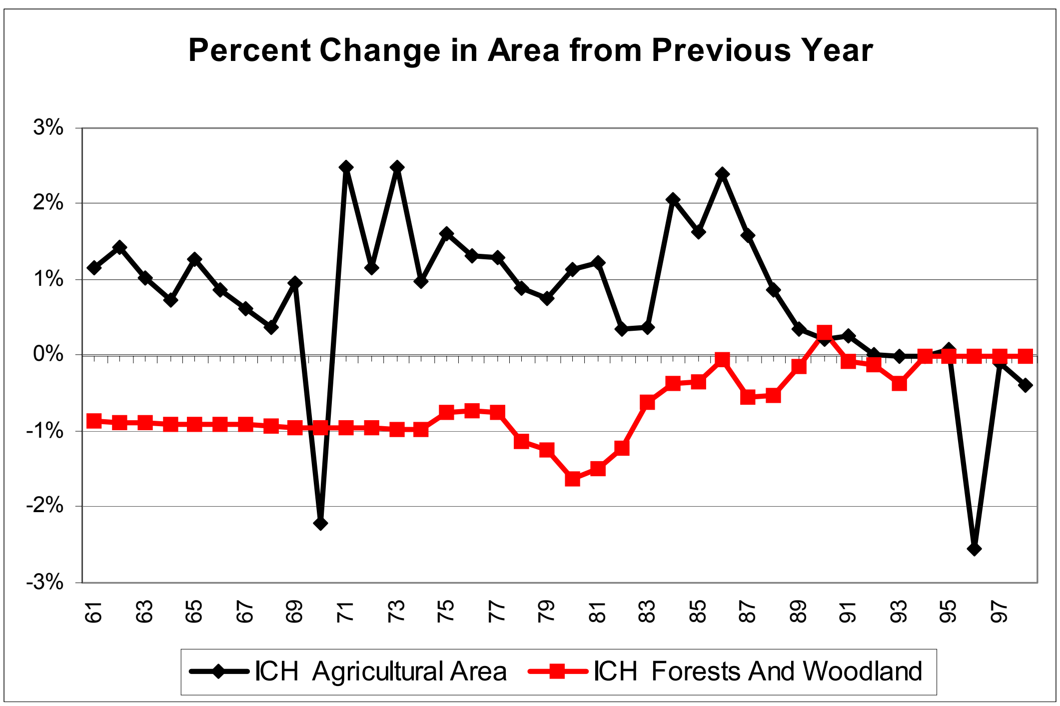
93
95
97
PHL Agricultural Area
PHL Forests And Woodland


Area Change from Previous Year
1500
1000
500
0
-500
-1000
-1500
-2000
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
ICH Agricultural Area
ICH Forests And Woodland


Percent Change in Area from Previous Year
3%
2%
1%
0%
-1%
-2%
-3%
61
63
65
67
69
71
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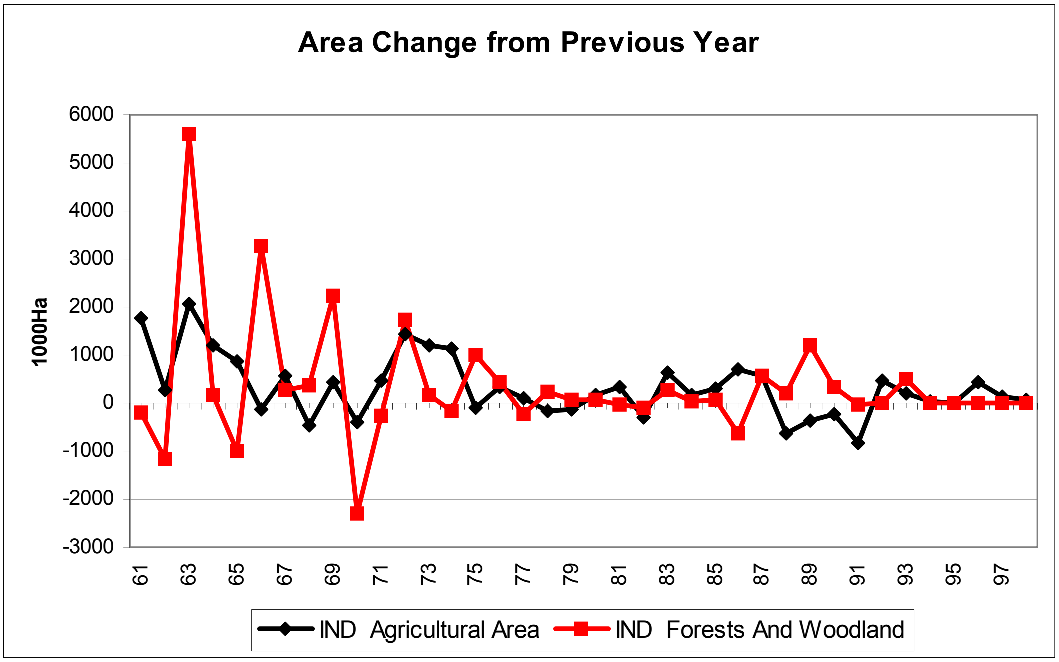
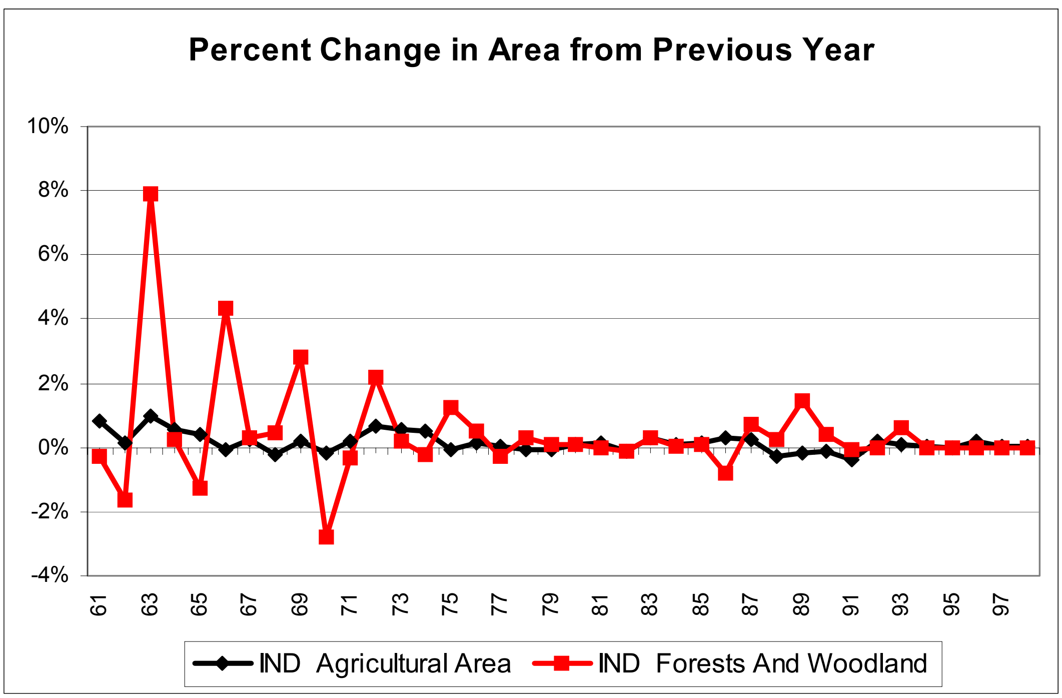
75
77
79
81
83
85
87
89
91
93
95
97
ICH Agricultural Area
ICH Forests And Woodland

IND



Area Change from Previous Year
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
IND Agricultural Area
IND Forests And Woodland



Percent Change in Area from Previous Year
10%
8%
6%
4%
2%
0%
-2%
-4%
61
63
65
67
69
71
73
75
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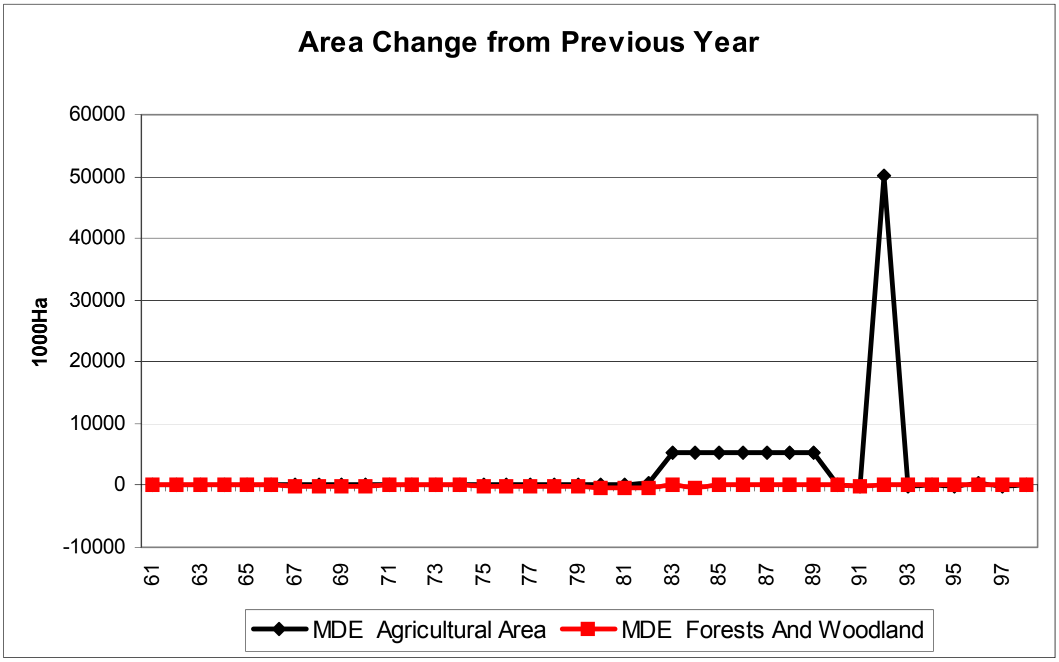
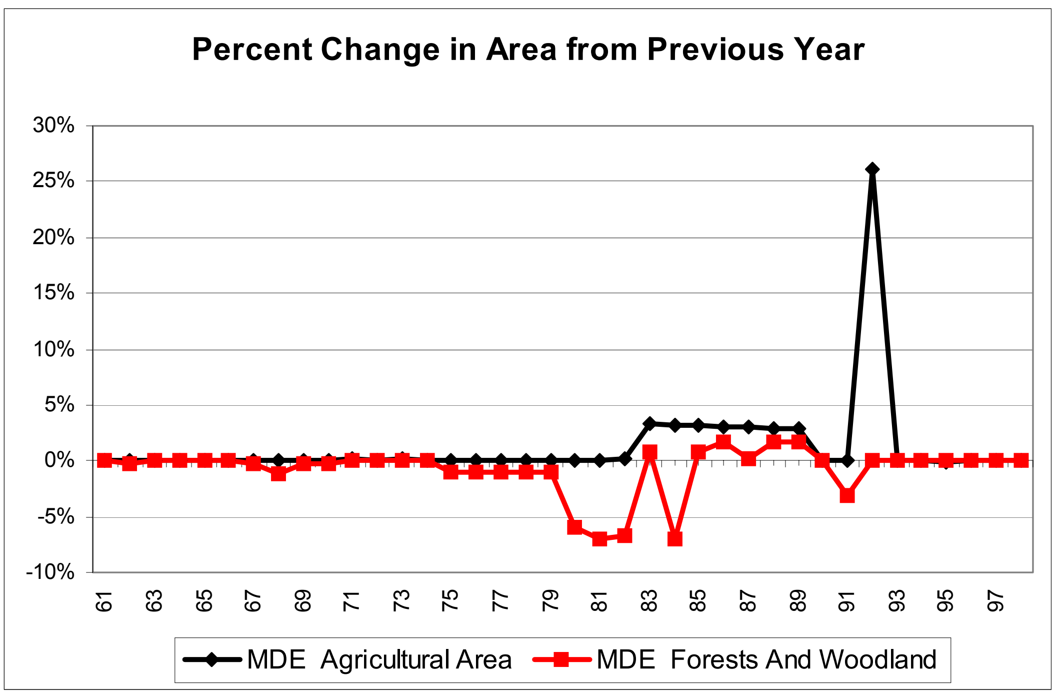
79
81
83
85
87
89
91
93
95
97
IND Agricultural Area
IND Forests And Woodland

MDE

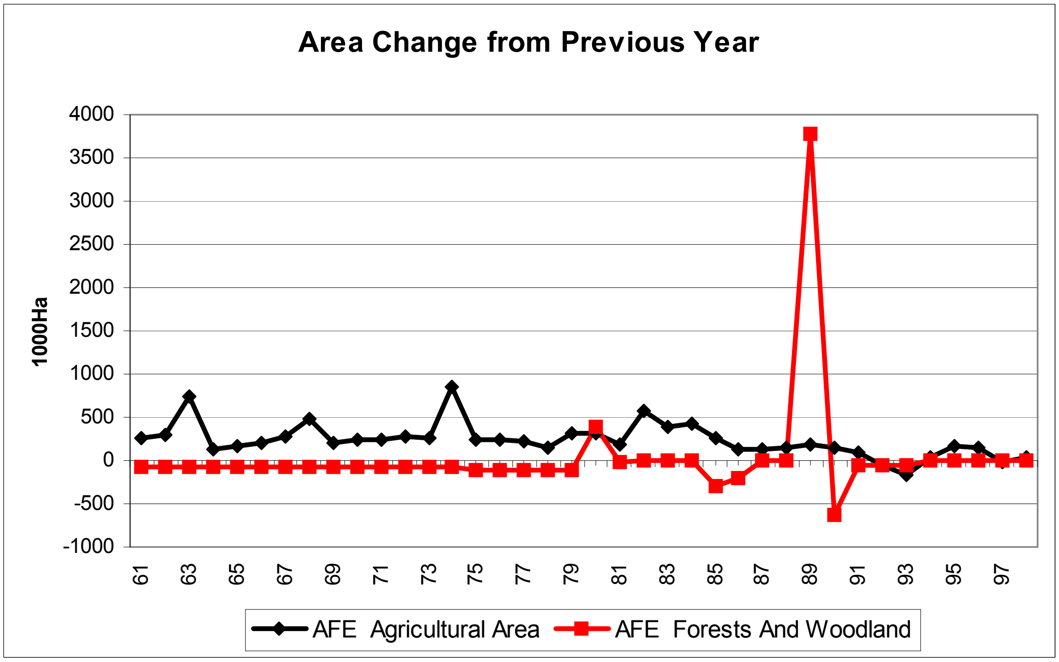


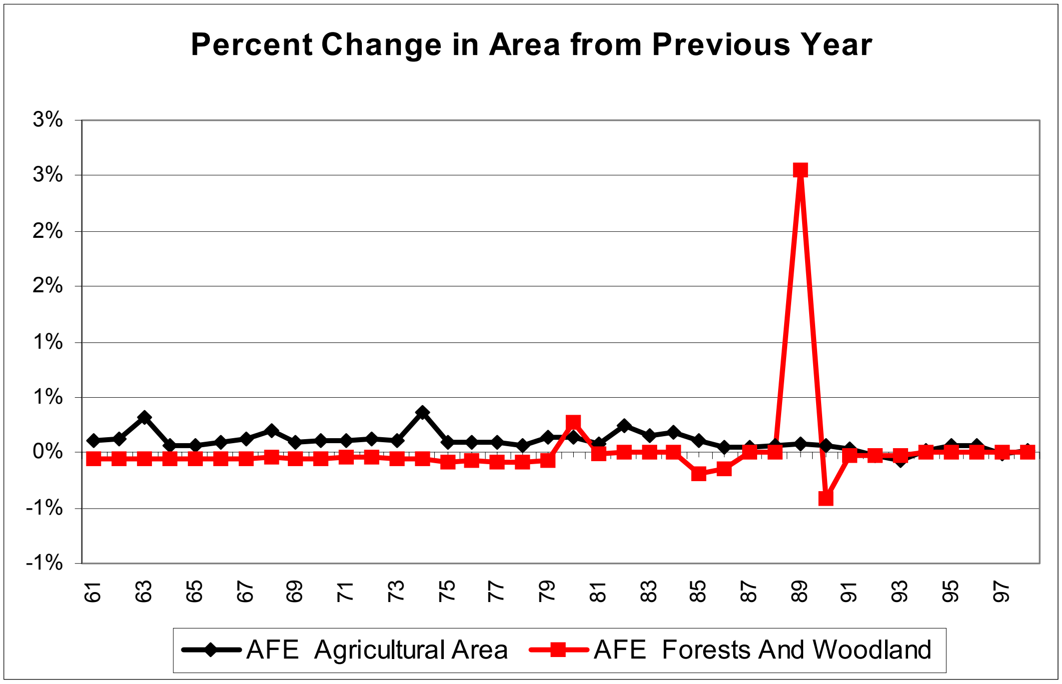
Area Change from Previous Year
60000
50000
40000
30000
20000
10000
0
-10000
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
MDE Agricultural Area
MDE Forests And Woodland

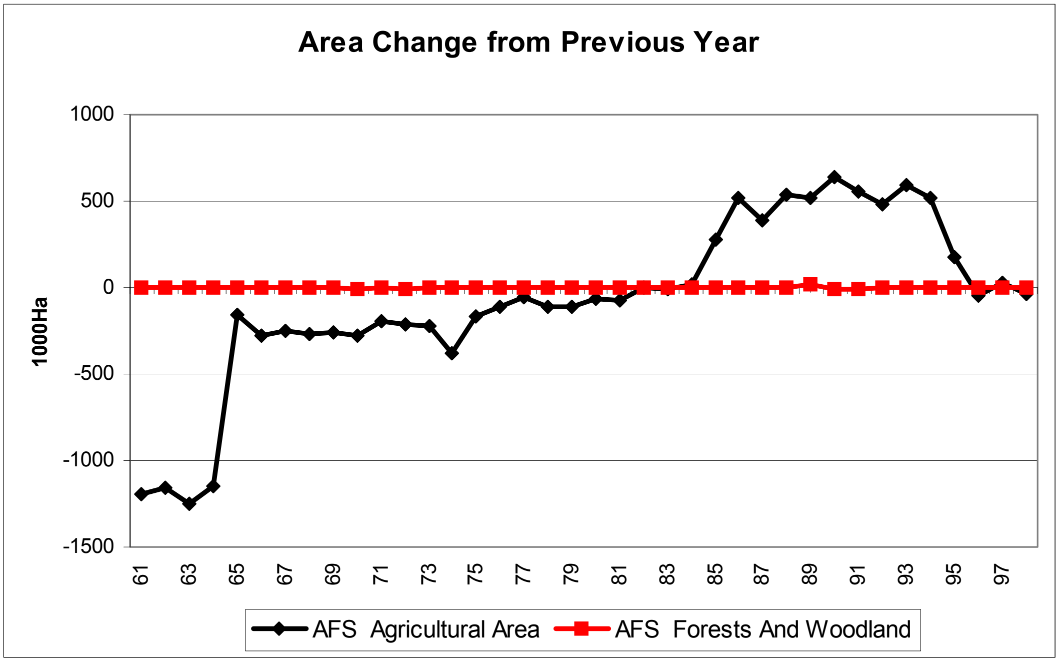


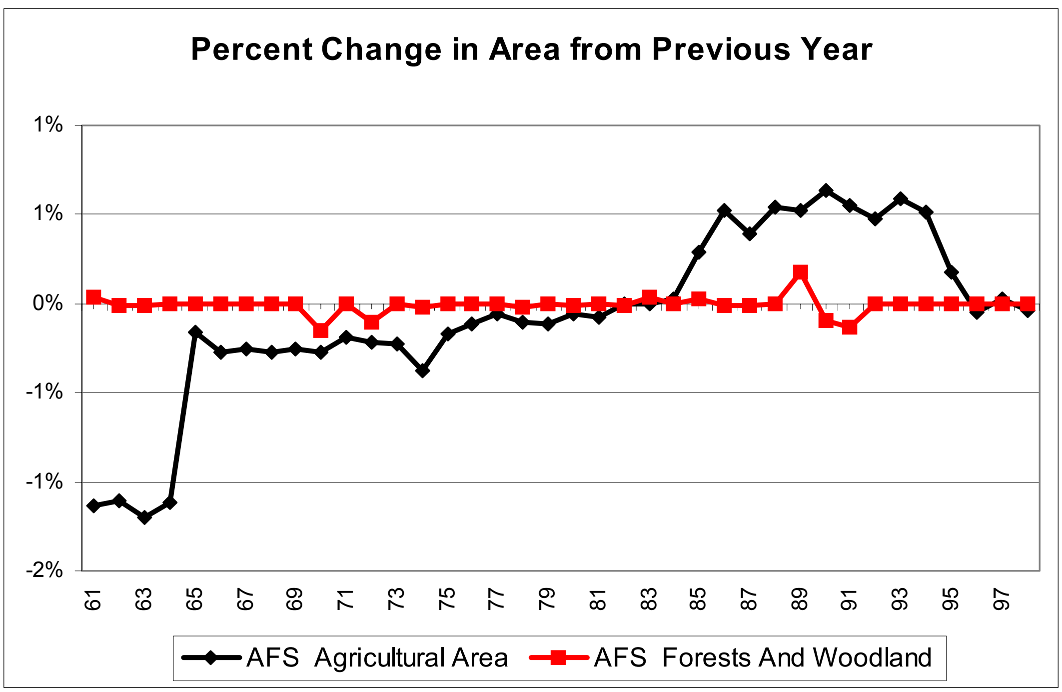
Percent Change in Area from Previous Year
30%
25%
20%
15%
10%
5%
0%
-5%
-10%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
MDE Agricultural Area
MDE Forests And Woodland

AFE

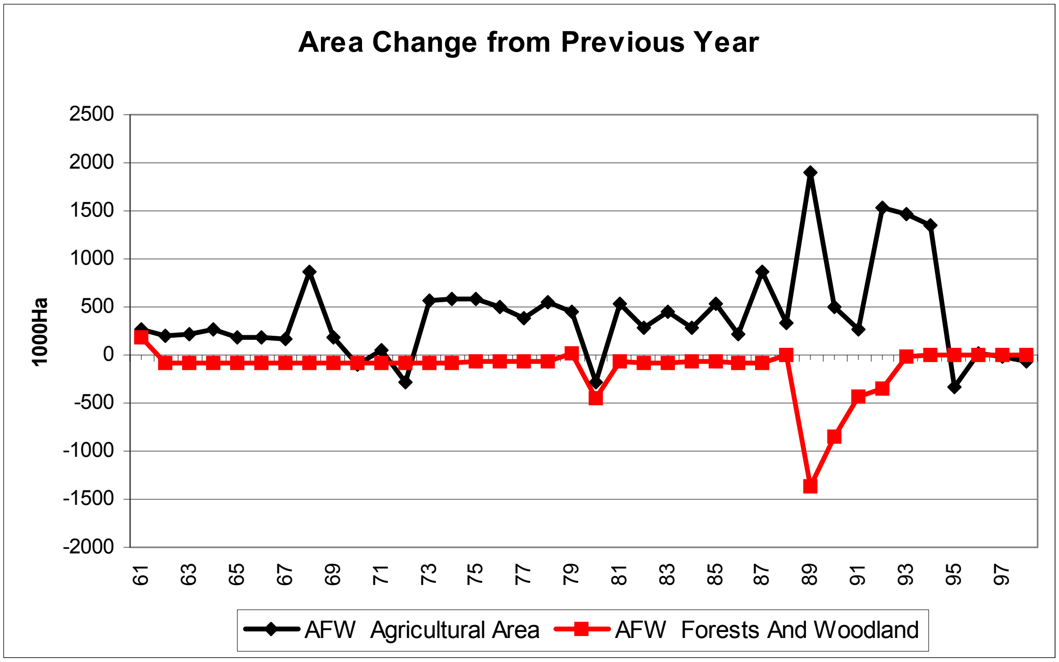

Area Change from Previous Year
1000Ha
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFE Agricultural Area
AFE Forests And Woodland

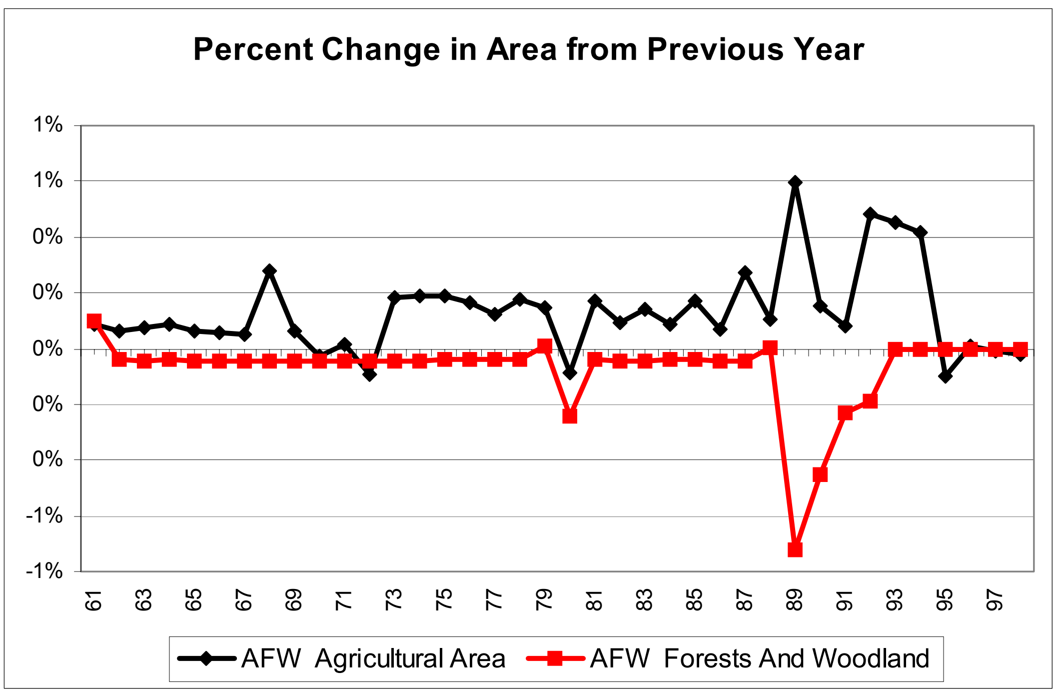

Percent Change in Area from Previous Year
3%
3%
2%
2%
1%
1%
0%
-1%
-1%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFE Agricultural Area
AFE Forests And Woodland


Area Change from Previous Year
1000
500
0
-500
-1000
-1500
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFS Agricultural Area
AFS Forests And Woodland

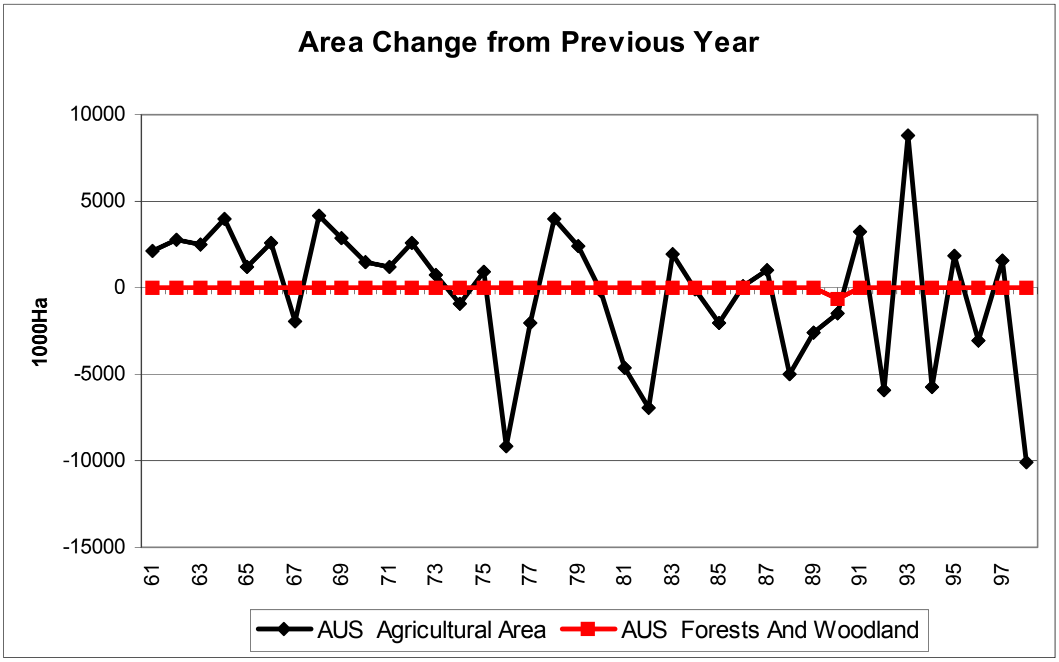

Percent Change in Area from Previous Year
1%
1%
0%
-1%
-1%
-2%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFS Agricultural Area
AFS Forests And Woodland

AFW

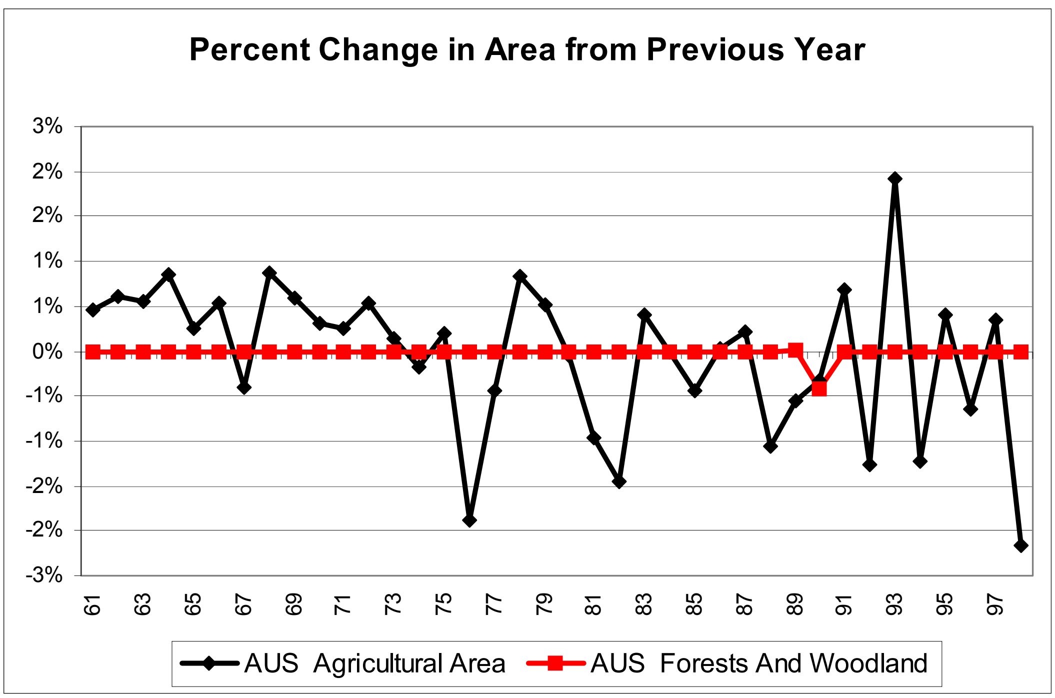

Area Change from Previous Year
1000Ha
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFW Agricultural Area
AFW Forests And Woodland


Percent Change in Area from Previous Year
1%
1%
0%
0%
0%
0%
0%
-1%
-1%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AFW Agricultural Area
AFW Forests And Woodland

AUS

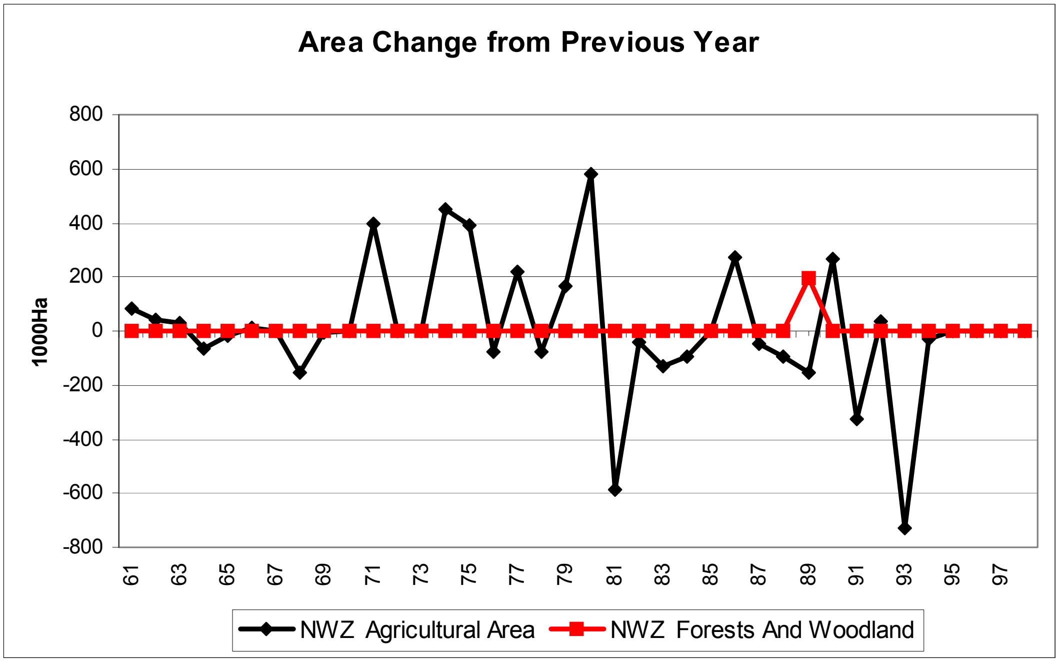


Area Change from Previous Year
10000
5000
0
-5000
-10000
-15000
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AUS Agricultural Area
AUS Forests And Woodland

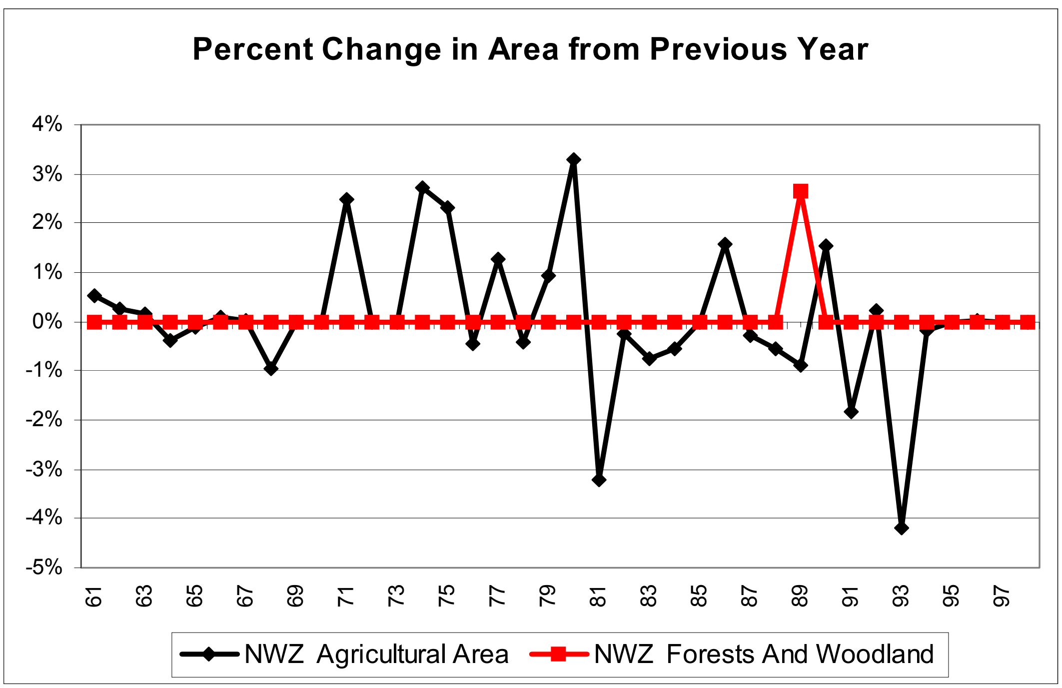


Percent Change in Area from Previous Year
3%
2%
2%
1%
1%
0%
-1%
-1%
-2%
-2%
-3%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
AUS Agricultural Area
AUS Forests And Woodland

NWZ

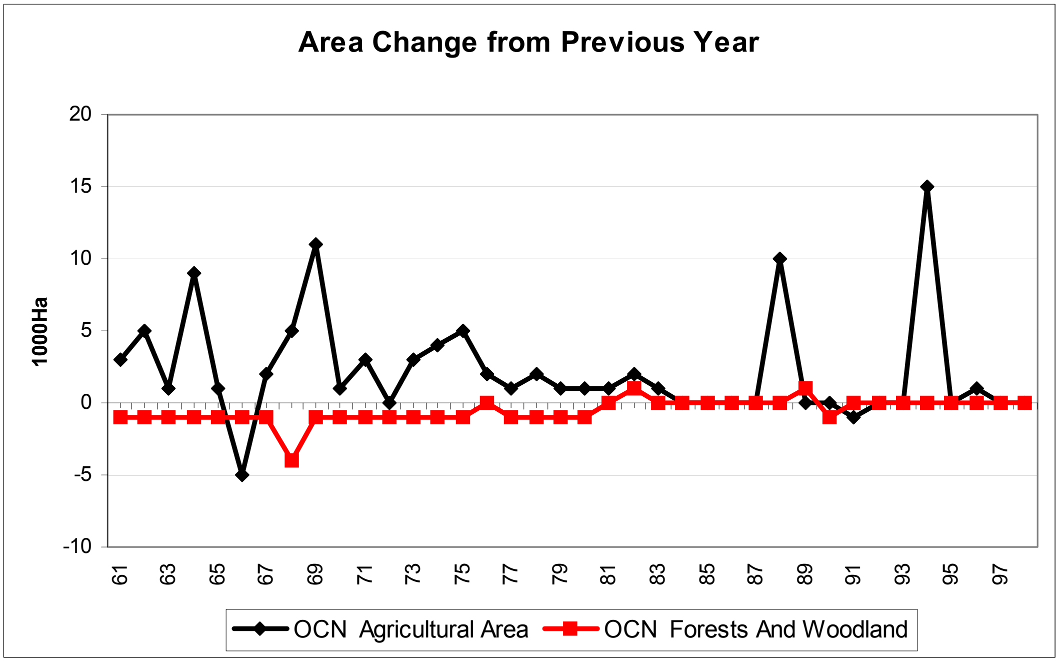


Area Change from Previous Year
800
600
400
200
0
-200
-400
-600
-800
1000Ha
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
NWZ Agricultural Area
NWZ Forests And Woodland

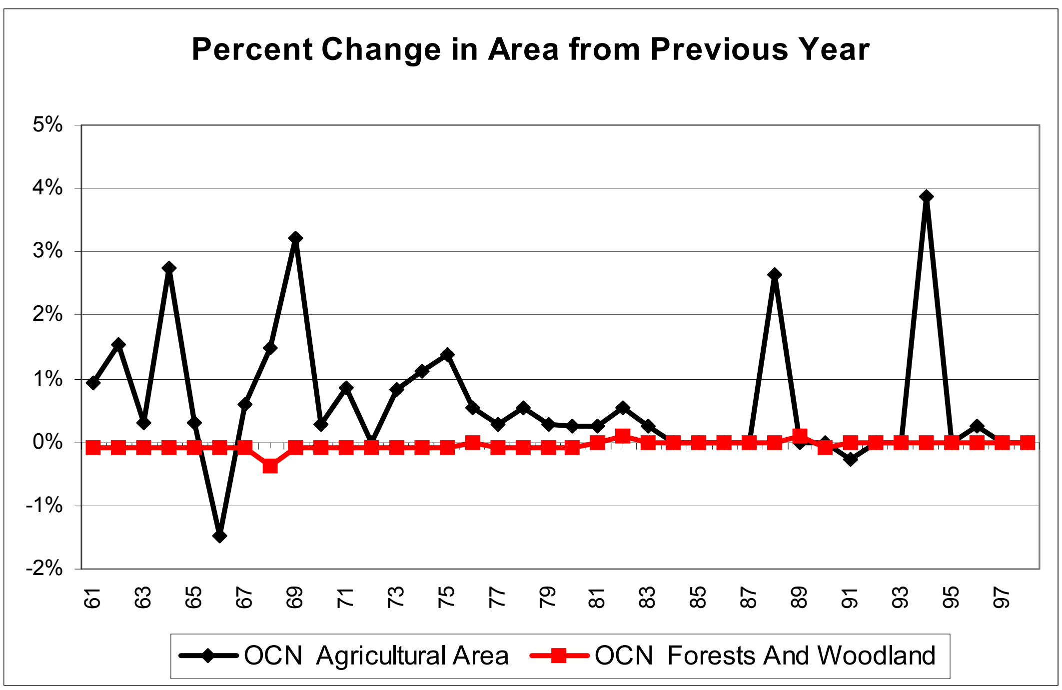


Percent Change in Area from Previous Year
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
NWZ Agricultural Area
NWZ Forests And Woodland

OCN



Area Change from Previous Year
1000Ha
20
15
10
5
0
-5
-10
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
OCN Agricultural Area
OCN Forests And Woodland



Percent Change in Area from Previous Year
5%
4%
3%
2%
1%
0%
-1%
-2%
61
63
65
67
69
71
73
75
77
79
81
83
85
87
89
91
93
95
97
OCN Agricultural Area
OCN Forests And Woodland

APPENDIX 6. BIODIVERSITY AND OTHER INDICATORS FOR CGTM REGIONS AND THEIR RANKINGS

Data is retrieved from World Resources Institute's site on biodiversity:

http://earthtrends.wri.org/searchable_db/

Biodiversity Indices Spreadsheet (ESIndex.wk3) is available on request from author.