Market, Policy Incentives, and Development of Forest Plantation Resources in the United States

A Report for FAO Asia-Pacific Forestry Commission

by

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1. Introduction

The United States of America has 2,263 million acres (916 million hectares) of land. About 33 percent of the U.S. land area or 747 million acres (302 million hectares) are forest land (Smith et al. 2001; Figure 1). Some 35 percent of the U.S. land area is classified as rangeland, 21 percent as cropland, and the rest as residential, commercial, and industrial lands (Cubbage et al. 1993). Some 40 percent of all lands in the U.S. are owned by federal and state governments, and the rest are owned by private entities (US Bureau of the Census 1991, p. 201).

As of 2000, the U.S. had 281 million of people, with a population density of 31 persons per square kilometer. In the last half century, the U.S. population grew at an annual rate of 1.25 percent on average. As of 1990, some 25 percent of the population lived in rural areas, declined from 60 percent in 1900, and the rest were urban residents (Table 1).

In 2000, the U.S. gross domestic product (GDP) was about $9,963 billion in current dollars, and per-capita income was $30,069 (US Bureau of Census 2001). The U.S. economy is diverse; its service sector (including trade, financial and other services) accounting for some 56 percent of its GDP; agriculture, construction, manufacturing, and transportation accounting for 31 percent; and the government sector accounting for the remaining 13 percent.

Forest land in the U.S. is further classified into timberland, reserved forest land, and other forest land. Timberland can produce 20 cubic feet of industrial wood per acre annually (or 1.41 cubic meters per hectare per year) and have not been withdrawn from timber production for legal and administrative reasons. Timberland covers 504 million acres (203 million hectares) or some 67 percent of the total forest land and is the primary source of timber production (Smith et al. 2001). Reserved forest land covers 52 million acres and is managed as parks and wildness areas for non-timber use. Other forest land (191 million acres) is land not capable of producing 20 cubic feet of industrial wood annually, but of major importance for watershed protection, wildlife habitat, and other uses (Figure 1). About half of "other forest land" is in Alaska.

The U.S. forest industry contributes about 2 percent to the U.S. GDP. The U.S. forest sector has four components: forestry, wood products, paper and allied industry, and wood furniture industry. While the forest products manufacturing facilities are exclusively owned by the private entities, the ownership of forest land in the country includes federal, state and municipal governments, forestry industry, and non-industrial private entities. Though private entities own 58 percent of the U.S. forest land, its share of U.S. timberland is 71 percent (forest industry owning about 13 percent and non-industrial private forest landowners owning 58 percent) in 1997 (Smith et al. 2001).

Timber production rose rapidly during the last half of the 19th century (from 76.8 million cubic meters in 1850 to 342 million cubic meter in 1900) and peaked at 368 million cubic meters at 1910 (Figure 2). Because of replacement of wood fuels by coal and oil, more efficient use of wood, and use of wood substitutes, production of timber began a slow decline that lasted until after the World War II (Clawson 1979; Powell et al. 1993). By the 1940s, U.S. wood production was about 20 percent less than the early 1900s. After the war, increased demand for housing and paper products caused timber production to rise; and by mid-1970s, timber production again

reached record levels. Production increased until 1990 when timber production reached a historical high of 530 million cubic meters.

The total consumption of industrial forest products has increased steadily since the Great Depression, and the U.S. has been a net importer of industrial forest products since 1915 (Figure 3). While the volume of net industrial forest products imports increased in the last half century, the share of net imports in total consumption varies widely. Historically little fuelwood is imported or exported.

The U.S. government encourages wood production to meet forest products demand as well as conservation of forest resources. As more emphasis on recreation and environmental services is put on public forests in recent years, the share of timber production from private forests has increased dramatically (Table 2; Figure 4). In 1997, timber production from public forests only accounted for 11 percent of total U.S. production, down from 25 percent in 1970. In the same period, timber production from non-industrial private forests increased from 48 percent to 60 percent while that from forest industry lands remained nearly constant at about 30 percent.

The current policies and regulations regarding timber production and conservation on public lands are primarily governed by the 1976 National Forest Management Act (which superseded the 1897 Organic Administration Act), the 1964 Multiple Use and Sustainable Yield Act, the 1969 National Environmental Management Act, and 1973 Endangered Species Act. The main polices regarding timber production and conservation on private lands are the 1980 reforestation tax incentive, capital gains tax treatment for timber income, various federal and state cost-share programs for tree planting, the 1973 Endangered Species Act, the Clean Water Act, and various state and local forest practice regulations.

As of 1997, the U.S. had about 54 million acres (22 million hectares) of plantation forests, which accounted for or 11 percent of timberland or 7.3 percent of forest land area in the country (Smith et al. 2001). Two earlier estimates show that the U.S. had some 13.5 million hectares of plantation forests in 1985 (Postel and Hiese 1988) and 18.4 million hectares in 1995 (Pandey 1997). The difference of 3.6 million hectares between 1995 and 1997 could partly be attributed to different assumption and estimation techniques used in the two studies. Monitoring of forest plantations in the U.S. was lacking prior to 1990, but is recently incorporated into national wide forest inventory survey, which is conducted every 5-10 years based on fixed plots.

2. Incentives and Plantation Development

Forest plantation development in the U.S. can be roughly divided into three phases: initiation, acceleration, and steady growth. The initiation phase corresponds to the period from colonial Americas to 1945. At the beginning of this period, tree planting was not economical and was rarely pursued by government policies. In the later part of this period, tree planting became a voluntary, private initiative, which was further promoted by government policies and programs.

The acceleration phase covers the period from 1946 to 1976. In this period, tree planting activities—fueled by strong market demand for and high prices of forest products, favorable tax policies, and various government cost-share programs—accelerated. Private tree planting areas

increased 90 fold from an annual acreage of 15,834 acres in 1946 to 1.43 million acres in 1976. This represents an annual rate of increase at 16 percent in this period.

The steady growth phase covers 1977 to 1999. Private tree planting kept expanding in this period, but at a much lower annual rate of 2.4 percent. In 1999, private tree planting acreage was about 2.42 million acres, 69 percent higher than in 1976. In this period, population and demand for forest products continued to grow, and changing public attitudes towards the environment resulted in concrete public policies. Several policies affecting tree plantations, such as the capital gains tax treatment for timber income and reforestation tax incentive, were initiated or modified in this period. In addition, earlier environmental and public forest policies had a major, although somewhat indirect, impact in private forest plantation development. For example, implementation and court rulings of the 1976 National Forest Management Act and the 1973 Endangered Species Act have gradually decreased timber supply from public lands and thus put pressure on private lands (see Box Four later).

2.1 Plantation Development from Colonial Americas to 1945: Initiation Phase

2.1.1 Overview

At the early part of modern American history, population was sparse, and territorial control and economic development were the primary concerns of government policy. In 1630, forests covered about 46 percent of the land area that eventually became U.S. territory, and timber harvesting and utilization of forest resources were the main forestry issues in the first four centuries after the European settlement (Clawson 1979). Although aimed at conservation (and possibly reproduction), the early forest regulations—such as the 1681 Governor (of Colonial Pennsylvania) William Penn's proclamation that every five acres of forestland cleared one acre should be kept—did not call for tree planting on either private or public lands. As population increased, land clearing for agriculture spread through out the county.

This lack of tree planting efforts was justified as the U.S. had abundant natural forest resources—despite a rapid increase in forest products consumption prior to 1900—and it was uneconomic for the private or public sector to invest in tree planting. When the U.S. experienced scarcity in some species (such as spruce and white pine for making newsprint in the late 19th century), it turned to Canada which had abundant natural forests for these species. In a nutshell, the production and consumption of forest products—whether from the U.S. or from Canada—were all from natural forests.

However, some areas of the country experienced rapid deforestation in the first half of 19th century, and shortage of trees and fuelwood in these areas concerned some influential individuals. For example, a writer, Henry David Thoreau, urged farmers to plant trees in 1840s. J. Sterling Morton, who moved to Nebraska from Detroit in 1854 and became a journalist, started to advocate tree planting in 1850s. In 1872, he first proposed a tree-planting holiday to be called "Arbor Day," which was officially proclaimed in the State of Nebraska in 1874. All other states followed and proclaimed their own Arbor Day in the next 30 years. In 1907, President Theodore Roosevelt called on the school children in the country to "give a day or part of a day to special

exercises and perhaps to actual tree planting, in recognition of the importance of trees to us as a Nation."

These efforts generated some results. It was estimated that a million trees were planted in the first Arbor Day in Nebraska. Other prairie states had successfully tree planting campaigns in the 1870s. For example, Minnesota planted some 26 million trees in 1876 (Hodge 1879 p.108). However, tree planting activities was confined at regional level (mostly in the Midwest). As a country, the areas planted with trees through afforestation and reforestation were relatively insignificant in size before 1900.

This tradition of little reforestation investment continued through the progressive era (1890-1930) despite the warning of timber famine and the call for regulating private timber harvesting by some prominent foresters and conservationists such as Gifford Pinchot. Nonetheless, the conservation movement that started in 1890s gave birth to the U.S. Forest Service. The 1897 Organic Administration Act established custodial management direction for the Division of Forestry (later the U.S. Forest Service) to harvest and establish forests within the boundary designated by the President.

It was not until early 1930s that some 13 states passed seed tree laws or state forest practice laws in order to ensure productivity of forestlands. These seed tree laws require trees to be left standing after a harvest. It was not until the early 1970s that several states started to pass comprehensive state forest practice laws to promote reforestation. Now 14 states have such reforestation regulations. Thus tree planting especially reforestation was relatively sporadic in the U.S. before 1920s.

The rapid increase in timber consumption finally caught up with the ability of the U.S. to produce timber, despite that the usage of wood substitutes made the per-capita industrial wood consumption decline somewhat in the first half of the 20th century. In 1915, the U.S. changed from a net industrial forest products exporter to a net importer (Figure 3). Large scale tree planting experiments started in 1919-1920; one of which successfully reforested 12,700 acres in Louisiana using 4 major southern pine species (USDA Forest Service 1980).

2.1.2 Incentives

Perhaps the most significant incentive for developing private tree plantations in the U.S.—not necessarily having an immediate impact in this period, but later—is the U.S. constitution. The U.S. constitution (1) requires that the U.S. respects and protects private property rights and adopts free-market capitalism and (2) limits the power of the government with respect to private property. The Fifth Amendment of U.S. Constitution states that private property shall not be taken for public use without just compensation. This amendment essentially eliminates or at least alleviates the worry and fear of private entities about government expropriation of their private property that bears the fruit of their investment. With relatively secure property rights (see Box One), landowners can afford to invest in long-term projects such as plantation as long as the market indicates such investment can generate a positive return and is made with careful planning and necessary technical support.

Box One
U.S. Constitution and Security of Property Rights

"…[No person] shall be deprived of life, liberty, or property, without the due process of law; nor shall private property be taken for public use, without just compensation." (The Fifth Amendment of U.S. Constitution)

"…No State shall make or enforce any law which shall abridge the privilege or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty, or property, without due process of law; no deny to any person within its jurisdiction the equal protection of the laws." (The Fourteenth Amendment of U.S. Constitution)

These two amendments of the U.S. Constitution have established a doctrine that when a private property is taken, it must be for public use and the owner of the property must be fairly compensated. This doctrine has been held in case of government physical taking of private property in the last two centuries in the U.S. Therefore the right to a private property is secure in the sense that it cannot be physically taken away by government without fair compensation.

However, when government regulates a private property and reduces the value of that property, whether or not government regulation constitutes a taking of that property so that the owner of the property is entitled to compensation is a different matter. The development of case laws in the last century in the U.S. have resulted in a full-or-nothing doctrine: compensation is due when all economic use of a property is destroyed by regulation; and no compensation is due when the property is partly devalued by regulation. The later scenario is a partial regulatory taking, which can be a source of property right insecurity in the U.S.

More importantly, property rights can bestow one, two or three powers to the holder of a property: to use or manage, to generate income, and to dispose of the property. Not only government regulations can alter these powers to the holder, taxation to property can also greatly influence these powers. Therefore, security of private property rights is a relative term. Comparing with most developing countries and some developed countries, property rights in the U.S. are relatively, but not (and cannot be) absolutely, secure.

The market incentive for developing private plantations is economic scarcity of timber, which is reflected in the rising real prices of timber and forest products. Real price means the price net of inflation, which is typically represented by the consumer price index. Prices may rise because of supply or demand factors, or both. Supply conditions leading to long-term price increases include reduced land base, declining resource quality, exceptionally rapid increase in the costs of labor or capital required for production. Supply conditions leading to price decline are primarily technological changes, discovery of new resources, and declines in unit input costs. Demand changes resulting in long-term price appreciation include consumption requirements that consistently expand faster than market supply can be increased. On the other hands, substitution keeps price at lower level than otherwise.

Developments of plantation resources are supply-side initiatives. In the U.S. the most significant factors influencing the supply of plantation resources are price of timber (i.e., market or market demand), government policy, and technology. These factors are discussed in details in each of the three phases of plantation resource development in the U.S.

Figure 5 shows the real lumber and stumpage price indices in the U.S. The lumber price index was from 1800 to 1999, while the stumpage price indices were from 1910 and on national forests only. The real lumber price increased from 1800 to 1945 at an annual rate of 2.2 percent; indicating that lumber had become more and more scarce relative to demand. The rise in the prices of lumber and other forest products has resulted in an increase in stumpage—the value of the standing trees. Douglas fir and southern pine stumpage on national forests were rising (Figure 5). Not surprisingly, some forest industry firms found that natural forests were dwindling, that costs of extracting natural forests were increasing (partly due to increased transportation costs), and that it is more economical to regenerate and extract timber from man-made forests. It was at this time when private landowners began to plant trees in response to market demand. For example, Weyerhaeuser Company, one of the largest forest products firm in the U.S., started reforestation on its lands around 1904.

The very first government incentive for promoting tree planting is the Timber-Culture Acts of 1873 and 1874 (amended in 1876 and 1877), entitled "An act to encourage the growth of timber on Western Prairies." Under this act, any person who planted trees on 40 acres in 10 years and kept the trees healthy was entitled to 160 acres of federal land at the end of the eighth years. As the objective of this act was to patent federal lands, its impact on tree planting was questionable primarily because many settlers at that time could not afford to do tree planting and cultivation (Hodges 1879 p. 159). This act was repealed by the1891 General Revision Act which also established national forest reserves (later became National Forests) (Libecap 1989).

The first modern government incentive for promoting plantation on private lands was spelled out in the 1924 Clarke-NcNary Reforestation Act. This Act authorized the Secretary of Agriculture to cooperate with land grant colleges and universities[1] and state agencies to aid farmers and small forest landowners in the production and distribution of seeds and seedlings for the creation, maintenance, and utilization of woodlots, shelterbelts, windbreaks, and other forest growth.

This act also initiated the federal and state cooperative efforts to control wild forest fires. The states have since assumed majority of funding and provided the personnel for fighting fires on private forest lands. Federal funds are now used to train and equip local fire departments for forest protection measures. Since 1920s, forest fires on private lands have largely been under control. This, in combination with wide usage of fence to control cattle grazing (Anderson and Hill 1975), provided assurance to private landowners as forest plantations could only survive without wildfire and animal damage.

[1] Land grant colleges and universities came with the Morrill Act of 1862, which provided federal funding, in the form of land granted to one public college or university in each state. These colleges and universities were then set up to train students in applied sciences such as agriculture and engineering. The colleges and universities which received the initial federal funding in the form of land are thus called land grant colleges and universities.

More significantly, the 1928 McSweeney-McNary Act authorized the secretary of Agriculture to establish forest experiment stations for cooperative research on reforestation and forest products development. This legislation paved the way for federal forest research agencies and programs that exist today. In addition, some forest schools established in this period conducted forestry research and development.

Finally, two federal programs encouraged tree-planting activities on private and public lands. Under President Franklin D. Roosevelt's New Deal implemented between 1933 and 1945, the Civilian Conservation Corps (CCC) put millions of young people to work building and protecting facilities in America's parks and forests, including tree planting. In total, some 2.3 million acres (930,000 hectares) of lands were planted with trees from the mid-1930s to mid-1940s, some of which still exist today (Moulton and Hernandez 2000). Most of these tree-planting activities took place on public lands. Although the CCC was a Great Depression program whose primary purpose was to provide employment to thousands of unemployed young people, it set a precedent for government intervention in tree planting and resulted in increased timber supply in the coming decades.

Another federal program was Agricultural Conservation Program (ACP), which was a cost-share program that encouraged farmers to address soil erosion problem. Authorized in 1936, this program provided assistance to agricultural producers for up to 75 percent of the cost of performing enduring conservation practices (mostly tree and grass planting) that would not have been carried out without assistance. This program was phased out in 1995.

2.1.3 Impact of Incentives

The first year that the U.S. officially estimated tree-planting activities was 1928. In that year the private landowners planted trees on 125,000 acres (43,000 hectares), accounting for 63 percent of the 200,000 acres (81,000 hectares) of land planted with trees in the country. The total area planted with trees increased to nearly 270,000 acres (110,000 hectares) in 1931 and 427,000 acres (173,000 hectares) in 1935 (Figure 6).

There were only 75,000 acres planted between 1941 and 1944, although it is not clear how these acreages were divided between public and private lands (Zillgitt 1958). The area planted increased to 519,000 acres (204,000 hectares) in 1940 (Figure 6). Between 1928 and 1945, the total area planted on record was 5.4 million acres (2.24 million hectares), half of which could be attributed to CCC. However, private forest landowners started to plant trees in response to market demand, even before CCC and Agricultural Conservation Program were implemented.

2.1.4. Summary and Lessons Learned

Forest resources were abundant, and tree plantations were not economical in most parts of the U.S. from colonial America period to around 1900. It was when timber price had risen substantially that tree planting became a voluntary economic activity under the free-market system with relative secure private property right arrangements. The conservation movement and the establishment of U.S. Forest Service raised the public awareness of forest issues such as

timber famine. Several legislative acts that promoted forest regeneration research and fire prevention and that provided subsidies to landowners encouraged tree planting on public and private lands between the 1920s and 1930s.

2.2 Plantation Development between 1946 to 1976: Acceleration Phase

2.2.1 Overview

The U.S. economy contracted for two years after World War II and then expanded for most part through 1976. The real GDP grew at about 3.1 percent annually on average in this period. The total U.S. GDP in 1976 was roughly 2.5 times of that in 1945. The U.S. population changed from 142 million in 1945 to 215 million in 1975; increasing at an annual average rate of 1.4 percent. The per-capita GDP nearly doubled in 31 years, increasing from $11,000 in 1945 to $19,000 in 1976 (both in 1996 dollars) (Table 1).

Increasing population and rising incomes had translated into high demand for industrial forest products such as paper and wood products as well as recreation and other non-timber values from forests (Figure 3). Demand for paper products increased faster than demand for other forest products, and prices for paper and lumber were rising (Clawson 1979). Increases in lumber prices had made some lumber users to switch to steel and plastic as well as plywood and other engineered wood products. Industrial forest product imports, which were primarily from Canada, had also increased, peaking at 14 percent in 1950 (Figure 3), and helped alleviate the shortage of domestic supply (see Box Two). Finally, electricity, oil and other energy materials had largely replaced fuelwood for energy until the 1973 energy crisis, and the annual per-capita consumption of industrial forest products averaged at 1.72 cubic meters in this period.

The investment climate for plantation was promising in this period. Scarcity of forest products had led private landowners—large and small—drastically increase tree planting in this period. Tree planting area totaled at 37 million acres (15 million hectares) in this period, with some 20 percent planted on public lands and the rest evenly divided between industrial private lands and non-industrial private lands.

It was in this period that additional forestry education programs were set up in land grant universities and that all forestry programs started to embark on forestry research, in addition to their traditional teaching responsibilities. Most schools also had steadily increasing budgets and numbers of scientists devoted to research (Cubbage et al. 1993). These schools were assisted by the 1962 federal McIntire-Stennis Act that authorized the Secretary of Agriculture to cooperate with state colleges and universities and provide technical assistance and financial support. In 1987, McIntire-Stennis funds were about $17 million. Other sources of funding such as state appropriations and external grants bring the total research budgets at least twice the size of the McIntire-Stennis funds.

Forest research conducted at universities, U.S. Forest Service, private forest industry firms, and collaboration among these institutions covered a wide range of topics and led to breakthroughs in genetics, tree-breeding, tree nursery, planting technique, herbaceous weed control, pest and

disease control, fertilization, and plantation management. Applying these results to forest plantations increased volume and economic returns to landowners.

Box Two
U.S.-Canada Forest Products Trade Disputes

Currently, more than half of all U.S. forest products imports are from Canada. More importantly, Canada's share of total U.S. imports in some products such as newsprint and softwood lumber, is more than 90 percent. Not surprisingly, these two countries have experienced various conflicts in forest products trade in the last 150 years, first in log and newsprint from 1880 to 1913, then shake and single in early 1980s, and softwood lumber which started in 1982 and is still going on (Zhang 1997).

A group of U.S. lumber producers charged that majority of Canadian softwood lumber producers is subsidized by their governments which own most forest lands in Canada and appealed to the U.S. Department of Commerce to impose a stiff tariff on Canadian softwood lumber imports in 1982. Since then, these two counties have gone through five rounds of accusation, investigation, litigation, negotiation, and settlement. The battles have been fought in U.S. Executive Branch, Judicial Branch, and Legislative Branch as well as multi-national organization such as North America Free Trade Agreement (NAFTA) and international organizations such as WTO. On May 2002, the U.S. imposed a 27 percent tariff on Canadian softwood lumber imports. Canadian governments have firmly denied the charge (of subsidizing lumber producers) and are challenging the U.S. tariff at NAFTA and WTO.

The tariff will raise softwood lumber price in the U.S., which in turn could increase stumpage price and promote forest plantation development in the U.S. However, the overall tariff has hurt U.S. softwood lumber consumers and the U.S. economy (Zhang 2001a).

For example, Pritchett and Comerford (1982) report that gains in pine volume due to fertilization averaging 50 cubic feet/acre/year (1.4 cubic meters/acre/year or 3.5 cubic meters/hectare/year) (for 15-20 years are common in southern coastal plains. Similarly, Allen (1987) finds that gains in pine volume could be as high as 80 cubic feet/acre/year (2.3 cubic meters/acre/year or 5.6 cubic meters/hectare/year) at newly planted stands or 100 cubic feet/acre/year (2.8 cubic meters/acre/year or 7 cubic meters/hectare/year) on established stands. Martin and Shiver (2002) document that improved genetics significantly reduced the percent of fusiform infection and increased pine volume by 11 to 19 percent and that herbaceous weed control contributed another 39 to 45 percent in volume growth in a 12 year pine plantation. Borders and Bailey (2001) show the real rate of return for loblolly pine plantation using intensive site preparation, complete control of vegetation, and annual fertilizer was 8 to 12 percent.

Federal and state governments have provided technical assistance to forest landowners since the 1937 Cooperative Farm Forestry Act. This act established a program of federal funding for technical assistance to farm woodland owners, employed by the states. The 1950 Cooperative Forest Management Act superseded the 1937 law and broadened the clientele served to include nonfarm private forest landowners, harvesters, and primary processors (Skok and Gregersen

1975). In 1978 the Cooperative Forestry Assistance Act consolidated all previous cooperative legislation. Many forest industry companies and consultants also independently provide forestry assistance to non-industrial private forest landowners. A few forest industry firms require landowners they have assisted to give them the first right of refusal to the landowners' timber, but the majority of industry firms merely ask landowners they have assisted to notify them when the landowners are ready to sell their timber (so that the industry firms can make an offer, before or along with other buyers).

Parallel to the public technical assistance program is the forestry extension program that provided forestry information and education services to landowners. In 1914 the U.S. Department of Agriculture and the state land grant universities set up agricultural and forestry cooperative extension services in all 50 states. A separate congressional authority for forestry extension services was granted in 1978. Funding for extension was provided by federal, state, and local communities. Extension foresters took a leading role in disseminating research findings to public and private foresters and timber prices and costs to landowners.

2.2.2 Incentives

The primary incentive for private landowners to plant trees in this period was the increase or expected increase in forest products prices. Forest industry companies, in response to demand for paper products, planted trees for pulpwood production. As stumpage prices rose (Figure 7), non-industrial private forest landowners planted trees with the expectation of generating high economic returns (relative to the risk of owning timberlands). Falling agricultural commodity prices helped some land conversion from agriculture to forest plantations (Alig et al. 1980).

Other than relatively secure property rights, stable macroeconomic policy, and relatively low income tax, the Soil Bank Program was a significant incentive provided by the government. The Soil Bank Act of 1956 was designated to withdraw land from agricultural production to conservation use. From 1957 to 1960, the U.S. Department of Agriculture paid landowners part of the establishment costs and annual cash payments (typically $10 to $12 per acre per year) for up to 10 years to maintain crop land in permanent cover (mostly trees or grass). The Soil Bank Program helped planting 2.2 million acres of private crop lands to trees (Moulton and Hernandez 2000; Figure 6); 95 percent of which were in the South.[2] Most of the Soil Bank Plantation remained in trees, even long after the cash payments were discontinued (Alig et al. 1980); indicating that landowners viewed their tree planting investment were worthwhile to them.

The Soil Bank Program was primarily prompted by economic crisis in agriculture and the need to take surplus crop land out of production to enhance farmers' incomes and to reduce federal government agricultural program costs. In 1974, the federal government implemented the Forest Incentives Program, which provided cost-share funding and was especially targeted for the development, management, and protection of timber and forest resources on private forest lands. Cost share agreements may be annual or multi-year (3-10 years) (see Box Three). But the Soil

[2] The U.S. South refers to the following 13 states: Alabama, Arkansas, Georgia, Florida, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

Bank Program had a bigger impact in terms of increasing the size of forest plantations in a short period of time.

Box Three
Forest Incentives Program

The Agricultural Conservation Program (ACP) funds for tree planting and timber stand improvement dwindled in the 1960s because of increasing competition for the available funds and the reluctance of county-level ACP administering board oriented to farm management to approve forestry practices. Perceiving needs for a better funding base, forestry interest groups successfully lobbied Congress for a separate cost-share program for forestry practices (Cubbage et al. 1993). In 1973 Congress enacted the Forestry Incentives Program as a rider to another large bill. Congress authorized a $25 million per year for FIP, starting in 1974. Actual appropriations have ranged from $10 to $15 million per years. An average of 160,000 acres is planted and another 80,000 acres timber stands are treated under FIP each year. The average cost-share rate under the Forestry Incentives Program for tree planting is about $56/acre between 1974 and 1992 (Table 3).

The federal cost-share rate is commonly 50 percent and has ranged up to 65 percent. Non-industrial private forest landowners who own less than 1,000 acres are eligible for FIP cost-share funds. The tract size must be 10 acres to qualify, and land must be capable of growing 50 cubic feet of wood per acre per year (1.4 cubic meters/acre/year or 3.5 cubic meters/hectare/year).

Mills and Cain (1978) and Risbrudt and Ellefson (1983) estimate that social (i.e., covering both private and public costs) internal rate of return ranges from 8.3 to 9.4 percent in real term and that the total benefit-cost ratio is 1.0 or greater for the Forestry Incentives Program.

The second, perhaps more significant, government program is the capital gains tax treatment for timber income. In 1944, a new legislation allowing timber to be treated as long-term capital gains for tax purposes went into effect. Prior to that time, only individuals who were not in the business of growing timber and who made infrequent sales could claim capital gains. This legislation extended this treatment to individuals and corporations engaged in the business of growing timber (Siegel 1978).

Capital gains treatment allowed timber income to be taxed at more favorable rates than ordinary income. For individuals, capital gains income was subject to a 60 percent exclusion. Thus only 40 percent of the gain was taxed. For example, individuals who were taxed at the maximum marginal rate of 50 percent on ordinary income would pay only (40 percent)×(50 percent) or 20 percent, on timber sale income and other capital gains. There were no exclusions for corporations, but there was a tax rate differential between ordinary income (46 percent marginal tax rate) and capital gains (28 percent marginal tax rate). This tax treatment was intended to and indeed benefited investors in long-term endeavors such as timber growing (Cubbage et al. 1993).

Government policies can indirectly provide incentives to forest plantations as well. In the height of the environmental movement in the 1960s and 1970s, various environmental laws were enacted in the U.S. Most notably are the National Environmental Policy Act of 1969, the Endangered Species Act of 1973, and the Federal Water Pollution Control Act (Clean Water Act) Amendment of 1972. The significance of these laws gradually appeared over time as they collectively reduced timber harvesting on public lands. For example, in 1978 the U.S. Supreme Court ruled that the intention of the 1973 Endangered Species Act was to put endangered species conservation on the highest of priorities and to halt and reverse the trend toward species extinction whatever the cost (*Tennessee Valley Authority* v *Hill* 437 U.S. 153, 174, 184 [1978]) (see Box Four). The Endangered Species Act has been successfully used by environmental groups to stop and delay timber harvesting activities on public and private lands.

Box Four
U.S. Court Rulings on Endangered Species Act

"It may seem curious to some that the survival of a relatively small number of three-inch fish among the countless millions of species extant would require the permanent halting of a virtually completed dam for which Congress has expended more than $100 million…We conclude, however, that the explicit provision of the Endangered Species Act requires precisely that result."

"Congress intended endangered species to be afforded the highest priorities…The plain intent of Congress in enacting this statute was to halt and reverse the trend towards species extinction, whatever the cost." (*Tennessee Valley Authority* v *Hill* 437 U.S. 153, 174, 184 [1978])

These are direct quotes from U.S. Supreme Court ruling on Endangered Species Act in 1978. Since then various court rulings have greatly impacted timber supply from public and private lands in the country. Perhaps the most famous case was the 1988 Jude Zilly's ruling that the government acted illegally by not listing the Northern Spotted Owls as an endangered species (*Northern Spotted Owl* v. *Hodel 716 F. Supp. 479 W.D. Wash* [1988]), which resulted the official listing of Northern Spotted Owls as a threatened species under the Endangered Species Act in 1990.

The Northern Spotted Owls live in the U.S. Pacific Northwest region, primarily in Washington and Oregon, but also in Northern California. Two characteristics of the Owls are important. First, they live only in "old growth" timberlands, roughly defined as being 100 or more years old. Secondly, each pair of Owls requires a very large acreage in order to breed successfully. Consequently, preservation of this species requires the cessation of logging over vast areas of virgin forests. It is, therefore, an ideal strategic issue for environmentalists who want to restrict logging in old growth forests.

The listing of Northern Spotted Owls in 1990 resulted in 80 percent reduction (4 billion board feet or 18 million cubic meters) of annual timber harvests from federal forests in the U.S. Pacific Northwest. In other words, the timber harvest from federal forests in the 1990s was only 20 percent of the average timber harvests for 1980s in the region (Brooks 1995).

On the forestry side, the environmental battle focused on clear-cut practices. The result was the National Forest Management Act of 1976. The major provisions of the act require (a) public participation in the planning process of national forests; (b) regulations for the preparation and revisions of the management plan; (c) resource management guidelines for controversial management activities such as clear-cutting, and (d) economic analysis of alternatives. This act, developed along the lines of the National Environmental Policy Act, gave citizens and interest groups the power to use administrative appeal processes to stop and delay U.S. Forest Service actions on national forests. It is this law and other environmental legislations created a near gridlock on and high costs of timber harvesting on national forests. Reduction in the timber volume from the national forests in turn increased the demand for and put pressure on private forests.

The lone negative incentive in this period was the rising planting costs. From 1951 to 1971, plantation costs in southern U.S. nearly quadrupled, and then declined somewhat in the next three decades (Figure 7). These costs are constructed as average cost per acre of mechanical site preparation, hand planting, machine planting, chemical removal, and prescribed burning, weighted by total area treated under each treatment. The increase in plantation costs before 1971 was due to increase in labor cost and equipment costs in mechanical site preparation and machine planting. Since 1971, all three components have been steady or declined. For example, substitution of less expensive one-pass mechanical site preparation for the more expensive two- and three-pass mechanical site preparation systems contributed to a moderation of overall mechanical site preparation costs. (One used to run the machine back and forth to do disking and bedding, now one single run will do both tasks.) Additionally, moderation of fuel and energy costs and substitution of chemical for mechanical treatments have reduced planting costs in the last 30 years.

2.2.3 Impact of Incentives

As mentioned earlier, tree planting areas in this (1946-1976) period totaled 37 million acres. Private forest landowners planted 29 million acres or 78 percent of the total planted acreage in the country. While government subsidies such as the Soil Bank Program had little impact on industrial landowners' tree planting decisions, they had significant influence on small landowners decisions to switch their land use from agriculture to forestry. The Soil Bank Program alone contributed 2.2 million acres, or 15 percent of the total plantation made by non-industrial private landowners in the 31 years.[3]

[3] Additionally the Soil Bank Program helped establish 18.4 million acres of vegetative (grass) cover, 14,000 acres of dams and ponds, and 310,000 acres of managed marshlands. The program paid a total of $162 million in cost-share funds to establish these practices. Furthermore, Soil Bank rental payments amounted to $2.4 billion. An economic analysis of tree planting under the Soil Bank Program in South Carolina shows that the real social internal rate of return for the project was 6.3 percent, which is satisfactory comparing with other investment made during the 1950s (Marsinko and Nodine 1981).

The impacts of all three federal incentives or cost-share programs (Soil Bank, ACP, and FIP) can be better illustrated at a regional level—the U.S. South. From 1951 to 1999, 12 southern states (Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia) accounted for 68 percent of all acreages of trees planted in the county. Private landowners in these 12 states accounted for 78 percent of all private planting acreages in the country in the same period. The cost-share tree planting acreage accounted for 5.3 million acres or 47 percent of all acreages planted by non-industrial private landowners and 23 percent of all acreages planted by private landowners in these 12 states from 1951 to 1976 (Figures 8 and 9). Obviously, federal cost share programs had a major impact on plantation development in the southern U.S. in this period (see Box Three).[4]

More importantly, the overall trend of plantation on private lands was increasing in this period. This confirms that the economics of plantation was working in private landowners' favor. The combination of tax incentives, cost-share, increased demand, higher biological growth due to technological advance, and macro-economic policy had a positive impact on the plantation development in the U.S. in the three decades after the World War II. With the exception of years under the Soil Bank Program, forest industry made more plantation than non-industrial private forest landowners in this period.

2.2.4 Summary and Lessons Learned

Forest resources became scarcer after World War II. After the war, tree plantations appeared to be more economic than exploring natural forests in the U.S. as all of the following factors point to a reasonable economic return for landowners who did tree planting

(a) Timber prices had risen substantially;
(b) Tree growth could be increased based on improved technology;
(d) Income tax on timber was subject to favorable capital gains tax treatment; and
(e) Government subsidies such as the Soil Bank Program shared some tree planting costs.

These positive factors had a larger impact than the lone negative factor—increasing costs of tree planting. Consequently, tree planting became a private and voluntary economic activity especially in the South and Pacific Northwest where tree grows fast due to favorable climate and soil conditions.

2.3 Plantation Development between 1977 and 1999: Steady Growth Phase

2.3.1 Overview

Despite experiencing a period of high inflation in the late 1970s and early 1980s, the U.S. economy continued to grow in the next two and half decades at an annual rate of 3.2 percent on

[4] The rest 53 percent of all acreages planted by non-industrial private landowners did not use cost-share. We hypothesize that these acreages are either not qualified for cost share programs (e.g., reforestation is not qualified under the Soil Bank Program) or the funds are not enough to cover all of these acreages. For example, annual funds for reforestation under ACP were only $1.5 to 3.9 million or 1 to 4 percent of the total ACP funds in the 1960s and early 1970s.

average. By 2000, its total GDP was more than doubled than that in 1976. In the same period, the U.S. population increased from 215 million in 1975 to 281 million in 2000, at an annual rate of 1.1 percent. The per capita GDP increased nearly 75 percent in the 25 years, from $19,000 in 1975 to $32.776 in 2000 (all in 1996 dollars) (Table 1).

Demand for forest products has continued to grow (Figure 3). At the same time, more and more public forest lands have been set side from logging or became roadless or protected areas since the 1964 when the Wildness Act was enacted (Smith et al. 2001). Consequently the share of timber harvesting from public forest lands in the total national timber harvesting started to decline in late 1970s (Table 2; Figure 4), and the volume of timber harvesting from public lands started to decline in absolute term in the later 1980s when the Northern Spotted Owls were listed as an endangered species. The states that are impacted the most by the listing of Northern Spotted Owls as a threatened species are Washington, Oregon, and California.

Industrial timber production and net forest products imports increased in most part of this period (Table 2). Both forest products production and imports were subject to economic fluctuation with net imports being the more sensitive of the two to the general economic conditions. For example, the share of net industrial forest products imports in total U.S. consumption declined dramatically in 1975, 1980, and 1990-1992, when the U.S. economy was in recession or experienced slowdown. Imports served as a reservoir to supply the shortfall of U.S. domestic production. Annual per-capita consumption of industrial forest products increased to 1.78 cubic meters in this (1977-1999) period from 1.72 cubic meters in the 1946-1976 period.

The trend of real lumber price was flat in this period. This was largely due to increased production efficiency, imports, and use of substitutes such as engineered wood products and non-wood products. The price of paper products showed a similar pattern, largely due to paper recycling, paper imports, and the wide usage of computers. Consequently, the real price of stumpage did not change much in this period, with the exception of later 1970s when timber was sought as an asset to hedge against double-digit inflation and of early 1990s when the listing of Northern Spotted Owls as a threatened species created a temporary shortage of timber in the country.

Research and development activities in the U.S. Forest Service, after several decades of increase, started to decline in the 1980s. National Research Council (2002) reported that the total number of U.S. Forest Service research scientists declined from 985 in 1985 to 537 in 1999, and the largest proportional loss of expertise had been in the forest products technologist classification while the largest increase in scientists was in the number of ecologists and social scientists. Forest research in colleges and universities had remained steady, but had little growth in the same period. Research conducted in the industry had been cut back due to merger, acquisition, and cost-cutting measures.

The investment climate for tree plantations was not as favorable in this period as in the period from 1946 to 1976 due to lack of price appreciation of forest products as well as government policies (see next sub-section 2.3.2). The total acreage planted with trees was 58 million acres in the country in this period. However, annual private tree plantation acreage only increased at a modest rate of 2.4 percent—far below the 16 percent annual rate of increase in the acceleration

phase. Some 9 million acres or 17 percent were on public lands, 28 million on forest industry lands, and 21 million on non-industrial private lands. Until 1987, forest industry had continued to plant trees on a larger acreage than non-industrial private forest landowners. Since 1988, forest industry firms and non-industrial private landowners were planting similar amount of acreage.

2.3.2 Incentives

Demand for forest products continued to grow in this (1977-1999) period. Although this had not necessarily translated into a high stumpage price, forest landowners could still rely on increased biological growth of timber stands due to technological improvements. At the same time the cost of establishing plantations declined (Figure 7), helping landowners generate an adequate return on plantation investment.[5]

Indeed a few publications (e.g., Washburn and Binkley 1990; Zinhkan et al. 1992; Sun and Zhang 2001) documented that timberland investment was a low risk investment and that generated a comparable or even higher returns (about 12-16 percent in nominal terms) than assets at the same risk level from late 1970s to middle 1990s. These results were due to price change, biological growth, and land appreciation in this period.

On the government incentive side, a 1980 reforestation tax incentive provision was enacted to allow landowners to receive a tax credit against their income tax for timberland investment. Under this provision, private landowners may receive both federal tax credits and deductions on their income tax for planting trees. For up to $10,000 per year of reforestation (could be afforestation as well) expenses, the legislation allows a 10 percent investment credit plus deduction of the expenses over an eight-year schedule, instead of waiting to deduct expenses at the time of harvest. The investment tax credit cannot exceed $1,000 annually. Their amortized deduction requires that one-fourteenth of the investment be deducted in the first and eighth years respectively and one-seventh in the second through the seventh years. If the owners do take the full 10 percent investment credit, they can deduct up to 95 percent (instead of 100 percent) of the reforestation expenses. This tax incentive remains in effect as of today.

Additionally, aimed at fighting government budget deficit, the Tax Reform Act of 1986 eliminated the preferential taxation rate for capital gains income, including timber, by reducing the amount of income excluded from taxation to zero. It also reduced the maximum marginal tax rate for individuals from 50 percent to 28 percent. The brackets for marginal tax rate have been changed several times since 1986. And in 1996, capital gains treatment was partially put back, which means gains from long-term investment such as timber will be taxed at a lower rate than ordinary income.

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[5] Based on Kline et al. (2002), we calculated the elasticity of non-industrial private tree-planting to plating cost as -1.00 to -1.26. Since tree planting costs declined 20 percent from $136 in 1976 to an average of $108 in from 1977 to 1997, we could infer that everything else being equal, some 4.2 to 5.3 million acres (or 20 to 25 percent) of total non-industrial private plantation was added due to the decline in planting costs alone in this period. In the same study, Kleine et al. (2002) find planting cost has a negative but insignificant impact on industrial tree planting.

Various federal cost-share programs also provided incentives to landowners. The Agricultural Conservation Program existed until 1995.[6] The aforementioned Forest Incentives Program was the only federal cost-share program specifically targeting on enhancing forestry productivity and increasing timber supply. In 1996 the Forest Incentives Program was rolled into a much larger and broader Stewardship Incentive Program that promotes stewardship of multiple forest resources. The Environmental Quality Program and Wetland Reserve Program had also had minor impacts on tree planting, which is not the primary focus of these programs. In addition, some 18 states have forestry cost-share programs (Mehmood and Zhang 2002).

Under the cost share programs, the federal or state governments provided some 50 to 75 percent of the site preparation and tree planting costs for qualified landowners. The Conservation Reserve Program (CRP), on the other hand, provided to qualified landowners a 50 percent cost share and an annual rental for lands they retired from agricultural use. Started in 1986, the CRP was similar to the Soil Bank Program and was intended to conserve soil, water, grazing land, wetland, and wildlife by reducing surplus crop land out of production. Some 2.3 million acres were planted with trees under the CRP, larger than any other cost-share programs in this period (Figure 4).

Finally, the federal government had a technical assistance program—Forest Stewardship Program in this period. Started in 1990, the Forest Stewardship Program was to encourage improved non-industrial private forest management. Public foresters, employed by state and federal governments, were asked to provide a broad array of technical assistance to non-industrial private landowners, including writing management plan, educating landowners about multiple use and best management practice. The program has enrolled some 25 million acres of non-industrial private forest lands.

Two disincentives became apparent in this period. The first is partial government regulatory taking of private property. Under the U.S. Constitution, private property owners shall receive compensation when their property is taken for public use. In 1922, the U.S. Supreme Court (*Pennsylvania Coal Co*. v. *Mahon* (260 US 393 [1922]) recognized that legitimate government regulations could expropriate private property by reducing its value to zero. In this case, private property is taken by regulations, and property owners are also entitled to full compensation. However, when property values are reduced but not to zero, property owners will receive no compensation at all. This traditional all-or-nothing compensation and increasing environmental regulations on private forestry practices have had a negative impact on private silvicultural investment because the property value and management activities are frequently restricted or regulated but the property value rarely go to zero (Zhang 2001b; Zhang and Flick 2001). With restriction, landowners are likely to reduce their expectation on future returns and thus decrease silvicultural investment. On the other hand, full compensation could lead landowners invest too much in tree planting.

The second disincentive is that some environmental groups are campaigning against forest plantations in the U.S. (e.g., Williams 2000). It is true that some plantations are less diverse in

[6] The Republican Party controlled Congress and the Clinton Administration repealed the ACP in 1995 to reduce government spending and subsidy to farmers.

wildlife populations than natural forests, but others are not much different than natural forests after certain years of growth. All plantation forests, with their increased productivity, help alleviate pressure on natural forests. Moreover, some radical groups such as the Earth Liberation Front, have even physically attacked genetic research facilities in the U.S. (Forestry Source 2001). So far, the negative sentiment against plantation forests have not had much impact on landowner behavior, but could hurt plantation development in the long-run.

2.3.3 Impact of Incentives

On average, some 2.2 million acres of private lands were planted trees annually in this period. In comparison, only 2.3 million acres were planted under the Conservation Reserve Program. This indicates that market forces, driven by demand and supply, have guided landowners to plant more trees than cost-share programs.

As a comparison, the cost-share tree planting acreage accounted for 6.8 million acres or 43 percent of all acreages planted by non-industrial private landowners and 17 percent of all acreages planted by private landowners in the12 southern states from 1977 to 1997 (compared with 47 and 23 percent respectively from 1951 to 1976) (Figures 8 and 9). There could be room for the federal and state governments to provide more funding to private landowners as some 64 percent of the land harvested in the South in early 1980s was left to reforest itself (Kaiser and Royer 1983). The primary reasons for land were left to reforest itself are misperception (79 percent of acres are owned by people who felt that the sites would reforest to pine naturally), high costs (51 percent of the acres); return from forestry occurring too far in the future (41 percent), and other use of harvesting revenues (40 percent).

On the other hand, tax incentive could have played a bigger role in enhancing returns to landowners who then invest more in tree planting. Guertin and Rideout (1987) indicate that the 1986 elimination of capital gains tax treatment of timber income reduced investment returns on all sites, resulting in some low-site lands becoming economically unproductive. Royer and Moulton (1987) report that 59 percent of landowners who planted trees claimed the reforestation tax incentive and only 48 percent of landowners used some type of federal or state cost-share programs, indicating that there was not enough cost-share funds to get to all landowners who wanted to use them.[7] Dennis (1983) shows that the reforestation tax incentives have favorable impacts on timber investment returns made by non-industrial private forest landowners. For landowners in the 40 percent tax bracket, average loblolly pine investment rates of return increased from 6.9 to 8.4 percent. Douglas fir investments increased from 7.3 to 8.2 percent.

While the acreage of trees planted by non-industrial private forest landowners increased, the acreage of trees planted by forest industry declined in the 1990s. Overall, private tree planting activities increased slightly if the Conservation Reserve Program is not considered. One of the factors that explains why forest industry firms did not planted trees on more acreage was that industrial timberland ownership declined 3.4 million acres or 5 percent from 1977 to 1997 (Table 2). The majority of these lands was sold to other corporations especially timberland investment

[7] Only 37 percent of applicants for Stewardship Incentives Program received funding from 1994 to 1999 (S. Stein. 2002. Personal Communication).

management organizations who manage timberlands for pension funds and insurance firms. A small portion of these lands was sold to developers.

2.3.4 Summary and Lessons Learned

Tree planting acreage grew at a smaller annual rate in this (1977-1999) period than in the 1946-1976 period. The area of tree planted in the U.S. reached a record level of 3.3 million acres in 1988 when tree planting under the Conservation Reserve Program was at its peak. The area planted by non-industrial private landowners was flat in the 1990s while that planted by forest industry declined. The latter was due to a lack of increase in forest products prices, forest industry merger, timberland disinvestment (selling timberlands to other corporations), and forest industrial firms' new emphasis on biological growth rather than size of timberland ownership.

Several factors worked in favor of tree plantation development in the U.S., including

(a) Continued growth in U.S. population and economy which translates into high demand for forest products and non-timber products;
(b) Decline in plantation costs;
(c) Advancement in technology;
(d) Federal reforestation tax incentive; and
(e) Various government cost-share programs.

Other factors worked against a more rapid development of forest plantation. They are

(f) The elimination of capital gains tax treatment for timber income in 1986;
(g) Increased imports of forest products which depressed timber prices;
(h) Increased partial government regulatory taking of private property rights; and
(i) Some environmental groups against tree plantation.

3. Conclusions and Future Directions

The U.S. Constitution protects private property rights and thus encourages landowners and other investors to invest in long-term projects such as tree planting. However, prior to 1900, forest resources were abundant, and human demand for forest products largely came from natural forests. It was only until after World War I when (a) timber price rose substantially and timber became economically scarce; (b) wild forest fire was largely prevented; and (c) open grazing was controlled due to the wide use of fence that tree planting became economical.

While the early sparks of tree planting were private endeavors driven by pursuit of economic returns, government policies and programs such as the Civilian Conservation Corps and Agricultural Conservation Program that provided incentive and funding helped many landowners plant trees on their lands. After World War II, federal and state governments have used various cost share programs to encourage tree planting. These programs were successful to the extent that they reduced the planting costs and enhanced the economic returns for landowners. However, these programs were subject to criticism that they were not efficient and equitable (see Box Five). While all these programs have undoubtedly raised the profitability and to increase wood production domestically, the primary purpose of these programs are environmental such as taking cropland out of production due to high erosion. The lone exception is the Forestry

Incentives Program, which is specifically focused on enhancing timber supply from non-industrial private forestlands.

Forestry related tax incentives, on the other hand, are directly aimed at enhancing the profitability of forestry business. Furthermore, they apply to all landowners and thus are more widely used and more equitable. Therefore, federal capital gains tax treatment for timber income and the reforestation tax incentive perhaps had a bigger impact in attracting landowners to plant trees than cost-share programs. The elimination of capital gains tax treatment, along with stagnation of forest products prices, contributed to the decline of tree planting by forest industry in the 1990s.

In addition, research conducted in public institution (public universities, U.S. Forest Service, and state forestry agencies) and private industrial firms have increased the biological growth and other traits of trees. The dissemination of technology through public technical assistance, forest extension, private consultants, and forest industry firms' landowner assistance programs has made technology being applied to the field quickly.

When considering investment in tree planting or any other long-term endeavors, landowners or other investors look for political stability, secure property rights, sound economic and trade policies, favorable tax policies, a competent labor force, and suitable infrastructure. In these respects, broadly referred to as the "investment climate," the U.S. is generally considered to offer an attractive environment for landowners and other investors.

However, when governments do not provide any compensation to landowners when their regulations have significant negative impacts on private land value and forest management activities, landowners have a pervasive incentive to avoid these regulations. Similarly, it is not clear that state reforestation regulations could have any impact on tree planting. On the other hand, some landowners may worry about the environmentalists' bashing against forest plantations.

All of these factors point to the risk and returns of private plantation development. In the future, if (1) the combination of timber price appreciation and biological growth increase is more than the establishment and management costs of plantations and (2) public policies enhance the economic returns of forest plantations, one would expect that tree plantation will continue to grow in the U.S. In fact, due to limited supply of natural forest and increased demand in forest products, forest plantations are perhaps the only way to strike a balance between protecting natural forests and satisfying our growing demand for timber. As Mills (2002) projects that the area of plantations in the South and Pacific Northwest will increase by 70 percent by 2050 and that softwood volume coming from plantations will increase from 16 percent in the 1990s to about 55 percent in 2050, the future of forest plantation development in the U.S. looks promising.

Box Five
Economics of Public Subsidy

Public subsidies are payments from governments designed to form a wedge between consumer's price and producer's cost so that the price is less than the marginal cost. Often subsidies are backed by arguments for the presence of market failure—market either will not produce at the desired level or is not equipped to internalize the externalities of production. Thus subsidies are instituted in order to achieve one or more of the following: (1) to transfer wealth from taxpayers to the producers or consumers of certain goods, (2) to influence producer or consumer behavior, and (3) to keep prices of certain goods low or stable (Pearce 1992).

All these three objectives have been used to justify cost share programs for forest landowners in the U.S. It has been argued that productivity of non-industrial private forestlands is low. These lands, however, are becoming increasingly important in meeting the nation's demand for wood products given the rising demand and diminishing supply from public lands (de Steiguer 1984). Hence, a transfer of wealth to the landowners may help in maintaining the supply of wood-fiber at a healthy level. Changing behavioral patterns has been raised as non-industrial private forest landowners need to be encouraged to invest in long-term timber production and that these programs help minimize the externalities of timber production and maintain a socially desirable environmental quality (de Steiguer 1984). Finally, it has been argued that rising demand may exceed supply in the future, causing real prices of wood products to increase. A subsidy, therefore, may help keep the prices of wood reasonably low and stable.

Cost share programs, however, have their controversy and considerable criticisms. Research in forestry has concentrated on the second objective—changes in landowner behavior due to cost-share funds. Except for Boyd and Hyde (1989), the price effects of cost-share programs have largely been ignored in the literature. Among the existing landowner behavior studies, Boyd (1984) and Boyd and Hyde (1989) find that landowners who would have invested on their land anyway use public funding instead. Bliss and Martin (1990) report that cost share does not change the level of management practiced by active forest managers, and Cohen (1983) concludes that the substitution effect of public for private funding in tree planting on NIPF lands is between 30 to 50 percent, while Zhang and Flick (2001) find a smaller (17 percent) impact. On the other hand, both de Steiguer (1984) and Lee et al. (1992) find no evidence of such substitution in plantation investment on non-industrial private lands. It is also possible that landowners may delay reforestation in the absence of cost-share funds (Bullard and Straka 1988), but no empirical evidence has been found to support this hypothesis.

Although views and justifications for such programs differ, these programs result in a transfer of wealth from the taxpayers to a certain targeted group of landowners. In addition to change in distribution of wealth, two obvious results from this transfer are deadweight loss and administrative cost (Cook 1994). (Deadweight loss is refers to economic losses due to either market imperfections or market intervention. For market interventions, deadweight loss is the social loss due to subsidy or taxation.) Economists have tried to measure the extent of the deadweight loss and quantify the efficiency of the redistribution of wealth in public subsidy programs. However, studies on the size of the deadweight loss created by forestry cost-share programs are virtually nonexistent, with the only notable exception of Boyd and Hyde (1989).

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Table 1. Population, Population Change, Gross Domestic Products, and Per Capita Gross Domestic Products in the United States: 1780-2000

Year	Total population	Annual population change (%)	Rural population	% (Rural in total population)	Population density (per km^2)	GDP (billion in 1996 $)	Per-capita GDP (in 1996 $)
1790	3,929,214		3,727,559	94.9	1.8		
1800	5,308,483	3.5	4,986,112	93.9	2.4		
1810	7,239,881	3.6	6,714,422	92.7	1.7		
1820	9,638,453	3.3	8,945,198	92.8	2.1		
1830	12,866,020	3.3	11,733,455	91.2	2.8		
1840	17,069,453	3.3	15,218,298	89.2	3.8		
1850	23,191,876	3.6	19,617,380	84.6	3.0		
1860	31,443,321	3.6	25,226,803	80.2	4.1		
1870	38,558,371	2.3	28,656,010	74.3	4.2		
1880	50,189,209	3.0	36,059,474	71.8	5.5		
1890	62,979,766	2.5	40,873,501	64.9	6.9		
1900	76,212,168	2.1	45,997,336	60.4	8.3		
1910	92,228,496	2.1	50,164,495	54.4	10.0		
1920	106,021,537	1.5	51,768,255	48.8	11.5		
1930	123,202,624	1.6	54,042,025	43.9	13.4	751.5	6,100
1940	132,164,569	0.7	57,459,231	43.5	14.4	980.7	7,420
1950	151,325,798	1.4	54,478,981	36.0	16.4	1,686.6	11,145
1960	179,323,175	1.9	54,045,425	30.1	19.6	2,376.7	13,254
1970	203,302,031	1.3	53,565,309	26.3	22.2	3,578.0	17,599
1980	226,542,199	1.1	59,494,813	26.3	24.7	4,900.9	21,633
1990	248,709,873	1.0	61,656,386	24.8	27.2	6,707.9	26,971
2000	281,421,906	1.3			30.7	9,224.0	32,776

Source: Population data are from U.S. Census Bureau webpage http://www.census.gov/population/censusdata/table-2.pdf and http://www.census.gov/population/censusdata/table-4.pdf. Gross Domestic Products (GDP) data are from U.S. Bureau of Economic Analysis web page: http://www.bea.doc.gov/bea/dn/gdplev.xls.

Table 2. Timber harvesting and Forest Landownership in the U.S.: 1952-1997

	Timber harvesting volume (million m^3)					%			
Year	National forests	Other public	Forest industry	NIPF	Total	National forests	Other public	Forest industry	NIPF
1953	30.0	14.9	91.1	172.2	308.2	9.7	4.8	29.6	55.9
1963	49.0	19.6	77.1	148.4	294.2	16.7	6.7	26.2	50.5
1970	57.8	24.7	95.8	164.3	342.6	16.9	7.2	28.0	48.0
1977	55.7	28.9	110.2	168.4	363.2	15.3	8.0	30.3	46.4
1987	65.7	30.9	148.6	253.7	498.7	13.2	6.2	29.8	50.9
1992	56.2	30.5	148.8	270.1	505.7	11.1	6.0	29.4	53.4
1997	26.3	28.9	132.9	279.0	467.1	5.6	6.2	28.4	59.7
	Forest Land Area (million acres)					%			
1953	94.7	50.7	59.0	304.4	508.8	18.6	10.0	11.6	59.8
1963	96.8	49.4	61.4	307.5	515.1	18.8	9.6	11.9	59.7
1977	88.7	49.5	68.9	285.2	492.3	18.0	10.1	14.0	57.9
1987	86.6	45.8	70.3	283.6	486.3	17.8	9.4	14.5	58.3
1997	96.4	49.6	66.9	290.8	503.7	19.1	9.8	13.3	57.7

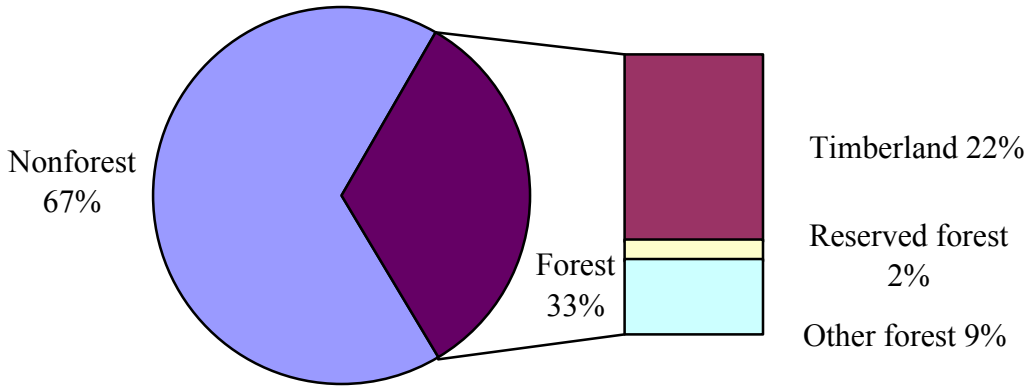
Source: Smith et al. (2001).

Table 3. Funding and Tree Planting Acreage under Various Cost-share Programs

Cost-share Program	Year(s)	Total nominal dollars used in tree planting (millions)	% of total program funding	Total acreages planted with trees (1,000)	Cost/ acre ($)	Data Source
Agricultural Incentives Programs	1960-1986	74.0	1.7	2,911	25.42	Cubbage et al. (1993)
	1986	5.4	4.2	98	55.10	Cubbage et al. (1993)
Forestry Incentive Program	1974-1992	166.8	82.0	2,953	56.49	Gaddis et al. (1995)
Stewardship Incentives Program	1992-1999	23.5	70.0	373	63.00	Stein (2002)
Conservation Reserve Program	1989-2001	n/a	n/a	1,345	n/a	McClure (2002)

Sources: Cubbage et al. (1993), Gaddis et al. (1995), Stein, Susan (2002, Personal Communication), and McClure, Donnie L. (2002, Personal Communication).

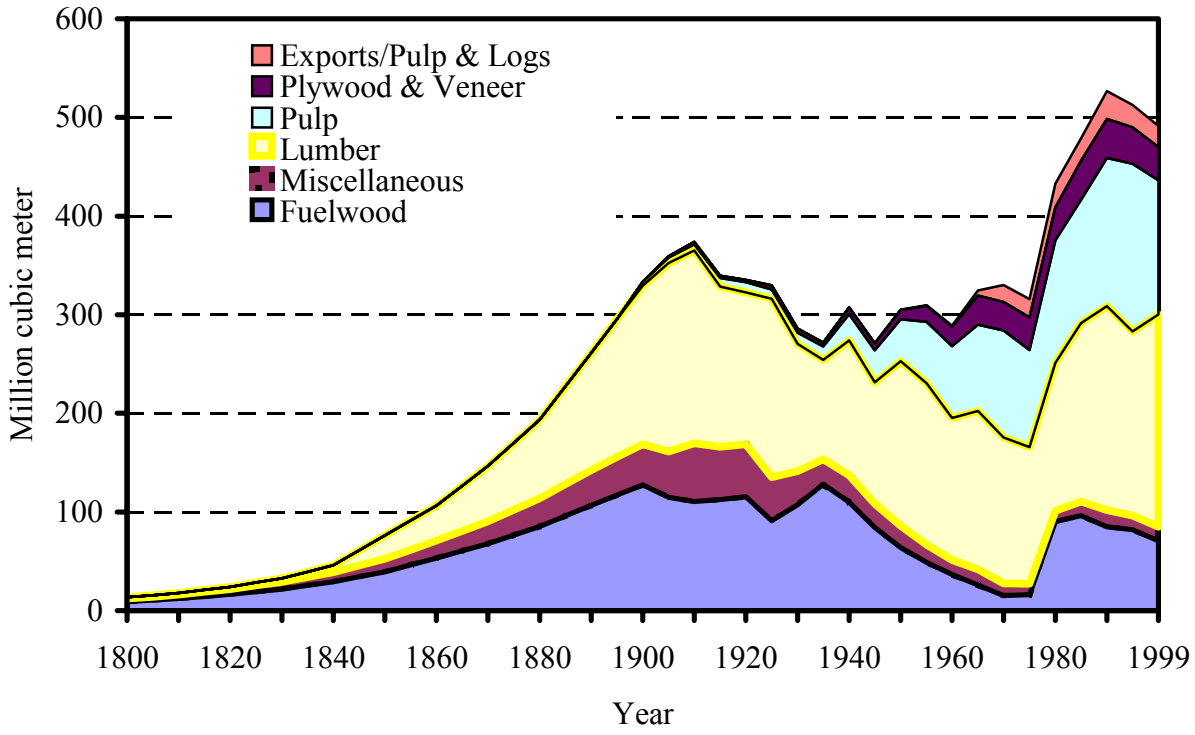
Figure 1. Land and Forest Area Distribution in the U.S.: 1997



Total land area of the United States: 2,263 million acres (916 million hectares)

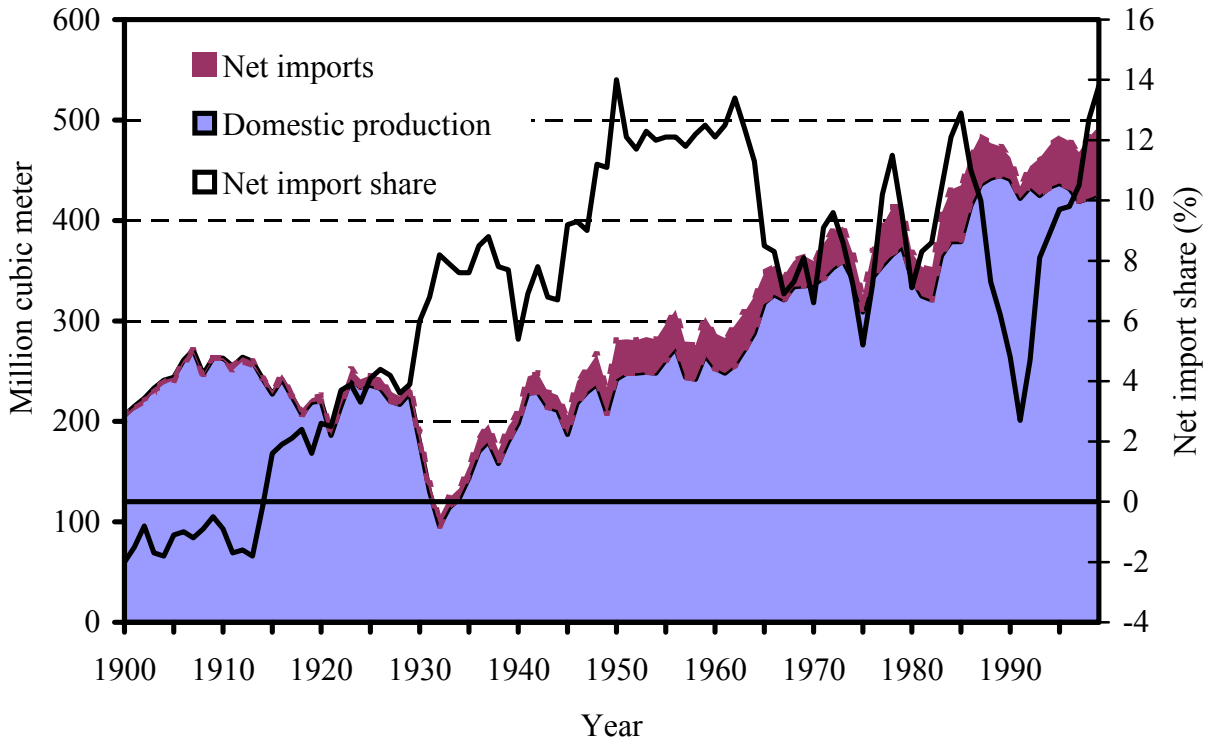
Sources: Smith et al. (2001)

Figure 2. Domestic Production of Forest Products in the U.S.: 1800-1999



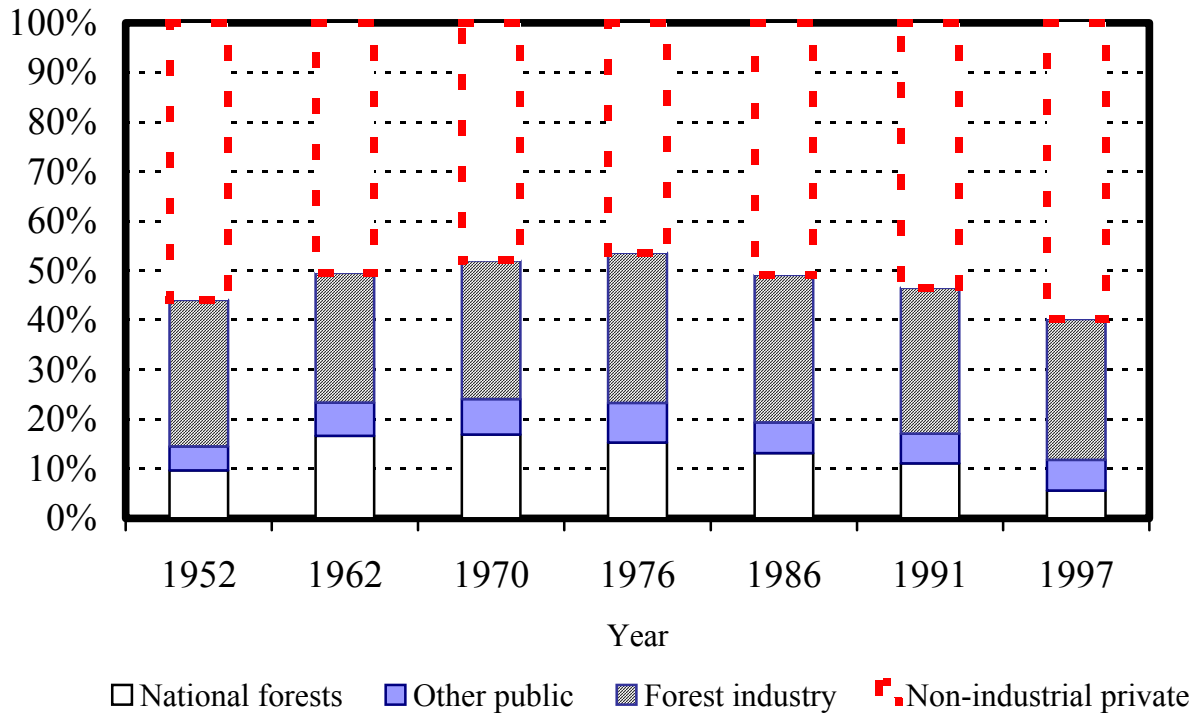
Sources: Clawson (1979), Sedjo (1991), and Howard (2001).

Figure 3. Domestic Production, Net Imports, and Consumption of Industrial Forest Products and Net Import Share of Industrial Forest Products in the U.S.: 1900-1999



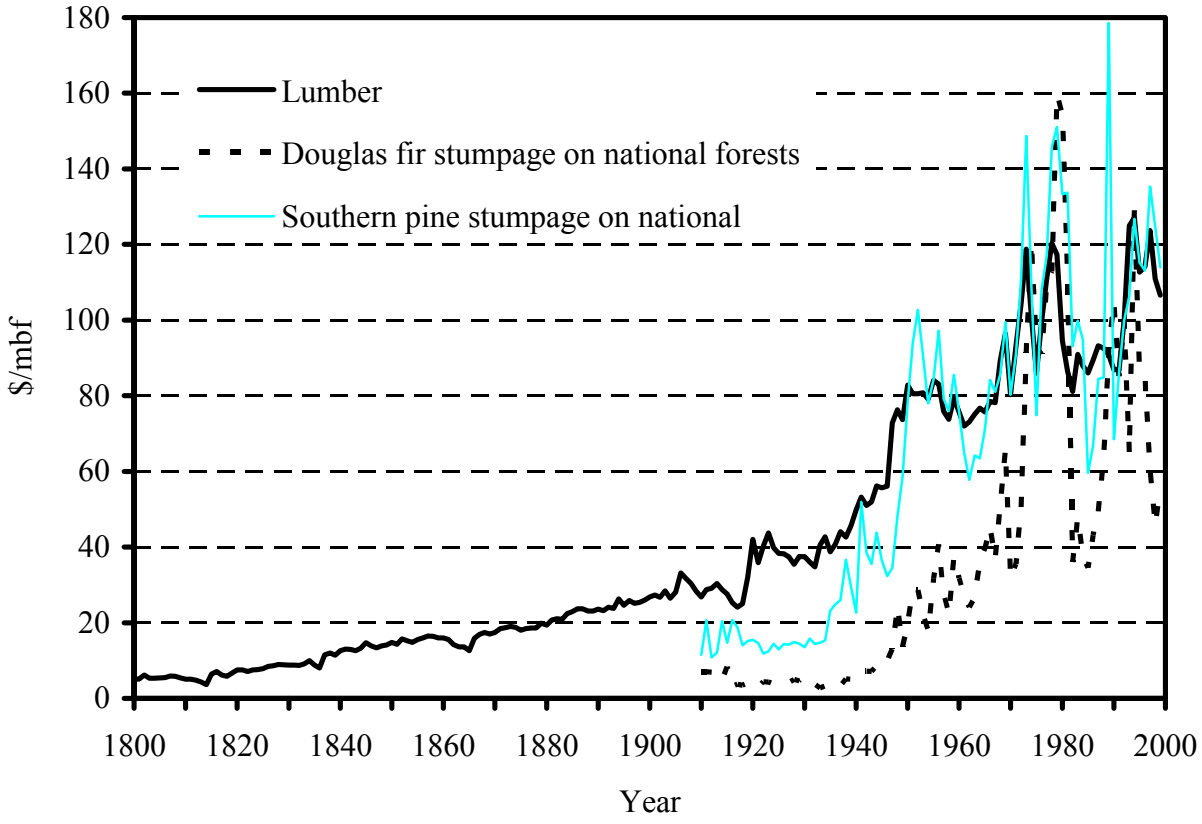
Sources: U.S. Department of Agriculture Forest Service (1964), Ulrich (1990), and Howard (2001).

Figure 4. Share of Timber Production by Ownership in the U.S.



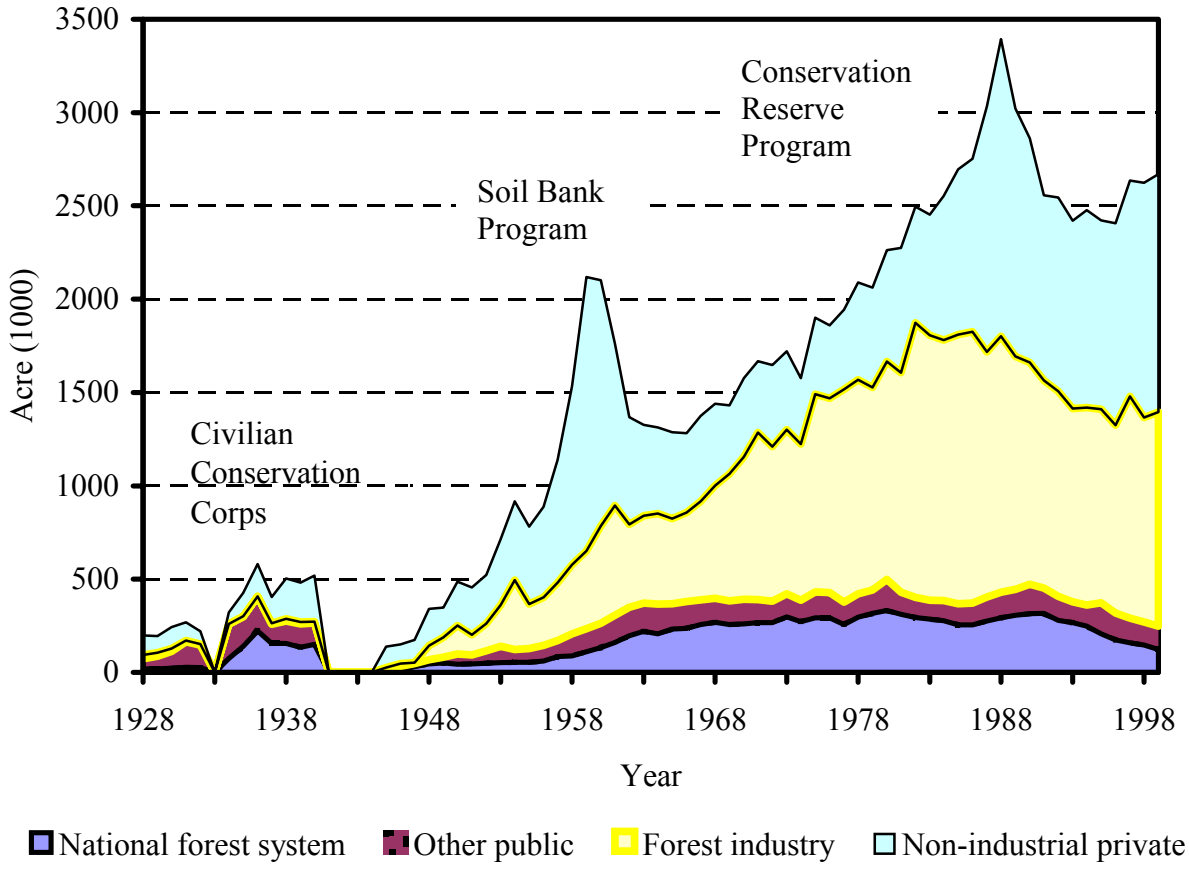
Source: USDA Forest Service RPA Timber Assessment homepage
http://www.fs.fed.us/pnw/sev/rpa/

Figure 5. Real Price Indices, in Terms of 1992 Prices (1992=100)



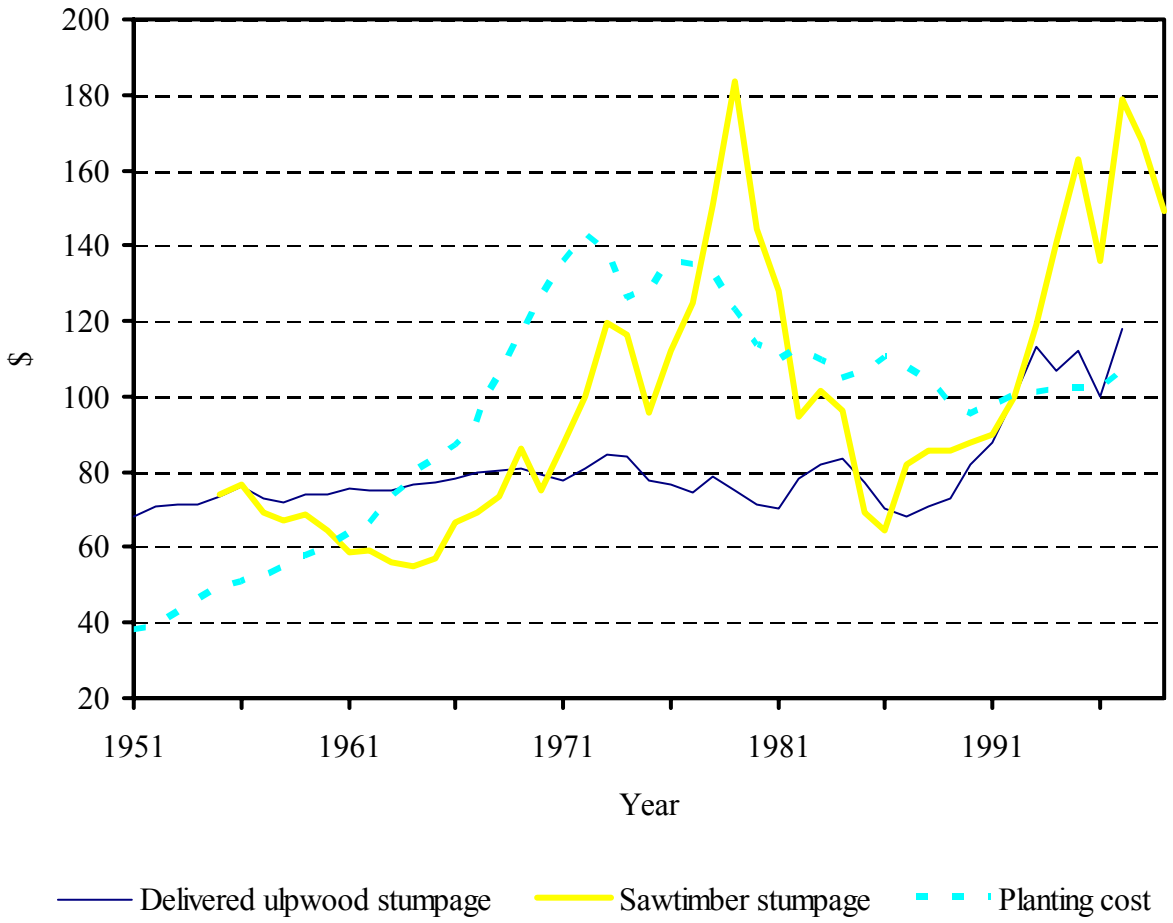
Sources: U.S. Department of Agriculture Forest Service (1964), Ulrich (1990), and Howard (2001).

Figure 6. Tree Planting in the United States: 1928-1999



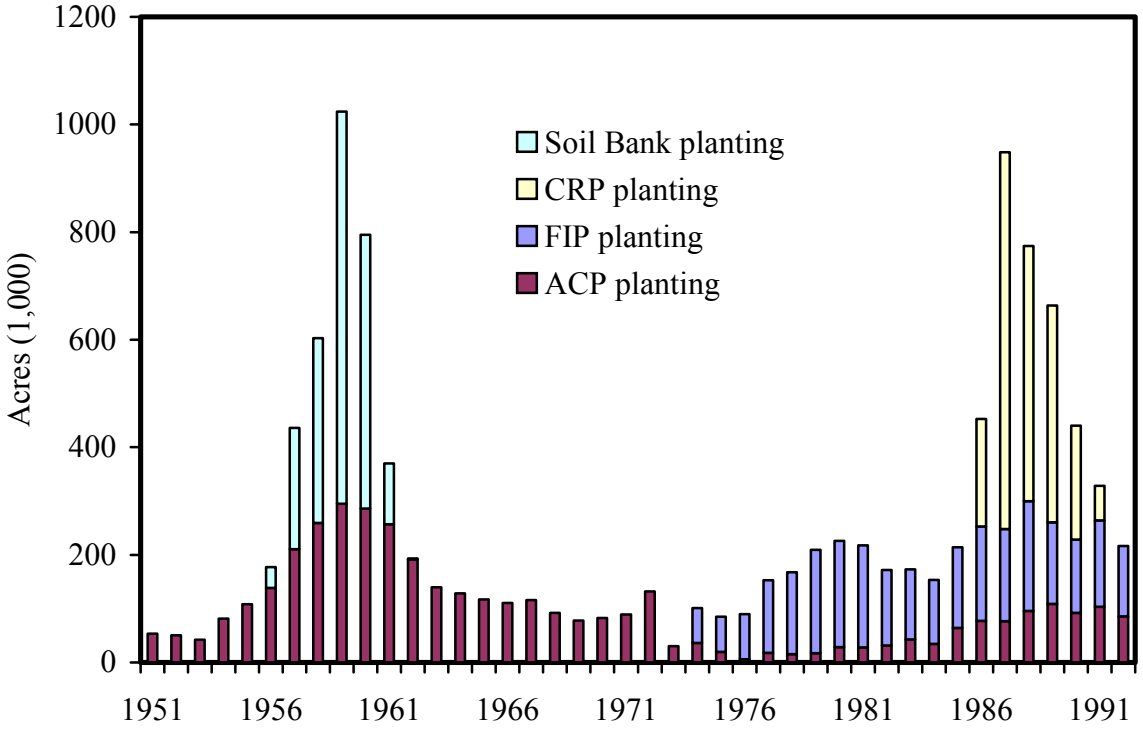
Source: Moulton and Hernandez (2000).

Figure 7. Private Stumpage Price and Plantation Cost Indices in the Southern U.S. in Terms of 1992 Prices (1992=100)



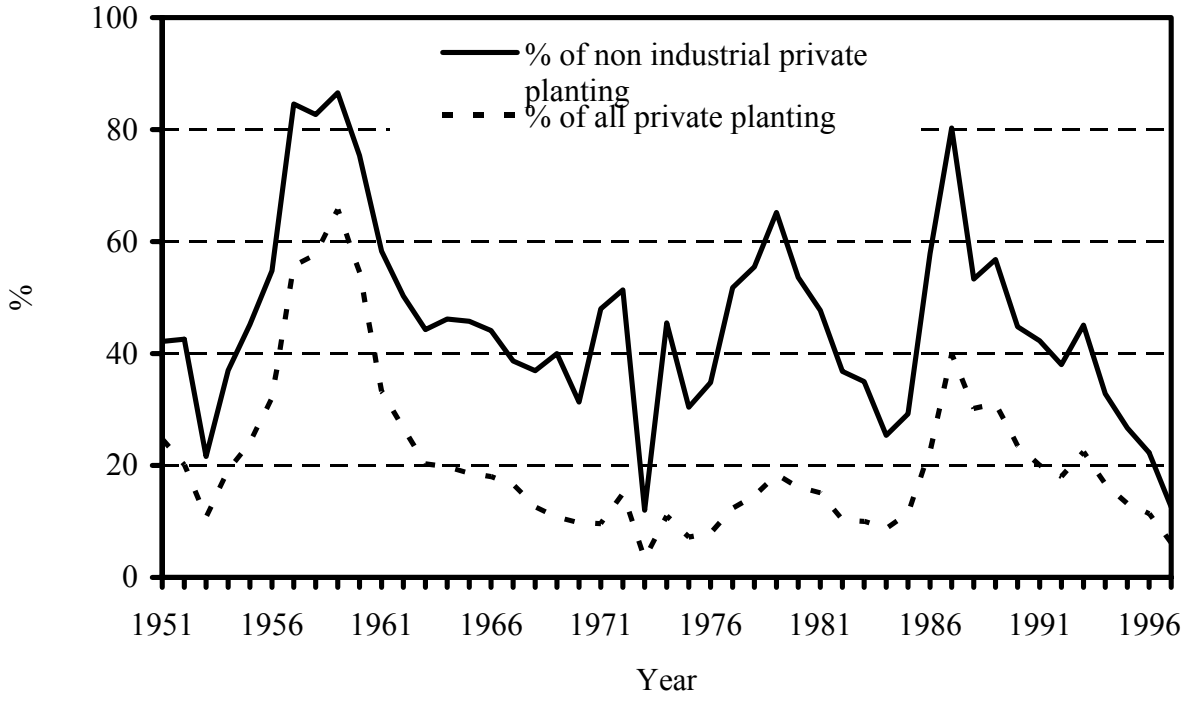
Sources: Data for delivered pulpwood price ($/cord) and planting cost ($/acre) (both are average for all 12 southern states) are from Kline et al. (2002); and Data for sawtimber stumpage ($/mbf) (Louisiana only) are from Howard (2001).

Figure 8. Cost-share Tree Planting Acreages by Programs in the Southern U.S.: 1951-1997



Sources: Kline et al. (2002).

Figure 9. Share of Tree Planted under Cost Share Programs in Nonindustrial Private Planting and All Private Planting in the Southern U.S.: 1951-1997



Sources: Derived from Kline et al. (2002).

Forest Policy and Economics is a leading scientific journal that publishes peer-reviewed policy and economics research relating to forests, forested landscapes, forest-related industries, and other forest-relevant land uses. It also welcomes contributions from other social sciences and humanities perspectives that make clear theoretical, conceptual and methodological contributions to the existing state-of-the-art literature on forests and related land use systems. These disciplines include, but are not limited to, sociology, anthropology, human geography, history, jurisprudence, planning, deve...

Incentive systems for tree plantations are an important instrument to create renewable resources through credible mechanisms to encourage private landowners to engage into the tree planting business. Experiences in Latin America provide some of the most promising examples on how to guide and promote land-use changes for tree-growing purposes. Convincing benefits such as job creation and tax incomes must be combined with budgetary and good governance commitments.Â Although the potential role of forest plantations in the sustainable supply of wood, non-wood forest products and environmental services has been recognized widely, the policy instruments that successfully encourage investments in plantations are not yet well understood. Deforestation, clearance, clearcutting or clearing is the removal of a forest or stand of trees from land which is then converted to a non-forest use. Deforestation can involve conversion of forest land to farms, ranches, or urban use. The most concentrated deforestation occurs in tropical rainforests. About 31% of Earth's land surface is covered by forests.