United States
Department of
Agriculture

Forest Service

**Rocky Mountain
Forest and Range
Experiment Station**

Fort Collins,
Colorado 80526

**General Technical
Report RM-175**

The Evolving Use and Management of the Nation's Forests, Grasslands, Croplands, and Related Resources

A Technical Document Supporting the 1989 USDA Forest Service RPA Assessment

John Fedkiw

Preface

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), P.L. 93-378, 88 Stat. 475, as amended, directed the Secretary of Agriculture to prepare a Renewable Resources Assessment by December 31, 1975, with an update in 1979 and each 10th year thereafter. This Assessment is to include "an analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and an emphasis of pertinent supply, demand and price relationship trends" (Sec. 3.(a)).

The 1989 RPA Assessment is the third prepared in response to the RPA legislation. It is composed of 12 documents, including this one. The summary Assessment document presents an overview of analyses of the present situation and the outlook for the land base, outdoor recreation and wilderness, wildlife and fish, forest-range grazing, minerals, timber, and water. Complete analyses for each of these resources are contained in seven supporting technical documents. There are also technical documents presenting information on interactions among the various resources, the basic assumptions for the Assessment, a description of Forest Service programs, and the evolving use and management of the Nation's forests, grasslands, croplands, and related resources.

The Forest Service has been carrying out resource analyses in the United States for over a century. Congressional interest was first expressed in the Appropriations Act of August 15, 1876, which provided $2,000 for the employment of an expert to study and report on forest conditions. Between that time and 1974, Forest Service analysts prepared a number of assessments of the timber resource situation intermittently in response to emerging issues and perceived needs for better resource information. The 1974 RPA legislation established a periodic reporting requirement and broadened the resource coverage from timber to all renewable resources from forest and rangelands.

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INTRODUCTION

> ...The lessons of history teach us that no advanced civilization will long survive without due care and continuing stewardship of its renewable soil, water, and plant resources (Lowdermilk 1953).

At the time of European discovery and settlement (16th and 17th centuries) of the area to become the United States, the forests, grasslands, and croplands supported a sparse population of 1–2 million Native Americans (Hodge 1971, Ubelaker and Jantz 1986). The Native Americans used fire in various ways to manage natural resources. It was used universally to hunt wild animals; to encourage fresh, succulent grasses for hunted herbivores; to maintain savannahs such as the Shenandoah Valley; to provide an open forest understory for hunting and travelling; to reduce pest populations; and to develop clearings for farming and various other productive and defensive purposes (Pyne 1982).

Prior to the 16th century, Native Americans had been farming in a crude manner on limited areas for several centuries. They had only hand tools and lacked domesticated animals other than the dog. Cultivated lands were located on the more productive sites and farming included fertilizing with fish, intertillage between plants, irrigation, and land rotation—all familiar practices in the agricultural development of the United States. Partly due to the small number of Indians and their subsistence living style, the forests, grasslands, and cultivated areas were essentially a virgin natural heritage modified only by the widespread use of controlled fires by the Indians and by wildfires (Pyne 1982, Rasmussen 1974).

Today, the same resource area supports the food, fiber, and outdoor recreation and environmental needs for 240 million Americans. In addition, the United States in the past decade has exported 40% of the value of its cropland production, 5% of its livestock production, and 17% of the industrial wood harvest.[1]

Some 57% of the current U.S. crop production, based on farm-level values, consists of plants first domesticated by Indians of the western hemisphere. These crops include maize or corn, the white potato, tobacco, beans, squash, pumpkins, tomatoes, and many more (Rasmussen 1974).

This volume basically reviews the management and use of forests, grasslands, and croplands as our nation developed. It also addresses wildlife, recreation resources, minerals, and water resources. It provides a systematic account of the changing status of our natural renewable resources and minerals and their current status, and concludes with an outlook for the future. The approach is historical and analytical. The viewpoint is largely national. The focus is on land management and use, but policy, population, and technology as well as resource sensitivity, resilience, and productivity are other important dimensions of this review. The roles of economic circumstances, science, and research are addressed. Achievements and problems are discussed as they emerge and an outlook for the future is provided as the review closes.

The reader should note the systematic focus of the methodology of this review is on the resources, their use, and management—who used the resources, what for, and why. The methodology also describes what happened to the resources as well as to the users and the nation. The objective is to provide an integrated view of the use and management of all the renewable resources and minerals. The intent is to present a graphic understanding of the whole development of our resources while describing the parts—the individual resources—in relation to each other and the whole (i.e., the nation).

Forests are lands at least 10% stocked by forest trees of any size, including land that formerly had such tree cover and will be regenerated. Grasslands include pasture and range. Pasture is land used primarily to produce domesticated forage plants for livestock. It includes cropland pasture in rotation, but excludes cropland under winter crops which is grazed and later harvested. Range is land on which the natural plant cover is mainly native grasses, grasslike plants, herbs, and shrubs. Cropland is that land used primarily to produce cultivated crops.

Our present forests, grassland, and croplands constitute 1.63 billion acres or 86% of the contiguous 48 states (U.S. Department of Agriculture 1984a). This compares with an estimate of 1.75 billion acres in 1880 (U.S. Department of Commerce 1975) that suggests a somewhat larger area of forests, grassland, and croplands at the time of colonial settlement. Today's distribution of forests, grassland, and croplands, however, is somewhat different. It includes much former desert that is now irrigated. There is much more cropland and less forest and grassland. Large areas now inundated by reservoirs are excluded as well as areas converted to urban and community use, parks, and wildlife areas, transportation routes, airports, and commercial, industrial, and similar developments. These developed areas, nevertheless, usually have much land that is in tree, grass, or garden cover that is not counted in the forest, grassland, or cropland inventory.

[1] *Sources: U.S. Department of Agriculture, Economic Research Service and Forest Service.*

The ways most of the nation's land is used, the management practices that accompany land uses, and the quality of the related environment are inextricably linked. This narrative account describes how the nation's land and its resources have come to be used as they now are; it also describes the development of their use and management for wilderness and wildlife protection, for recreation, and for parks. This integrated historical perspective is intended to provide a better understanding of the relationships, resilience and renewability, and responsiveness of natural resources to management. It is also intended as a basis for molding a more informed approach to decisions about use and management of natural resources as the nation responds to the future demands of its people and the rest of the world's needs.

CONVERSION OF THE ORIGINAL HERITAGE TO THE NEEDS OF A GROWING POPULATION 1500–1920

COLONIAL SETTLEMENT TO THE REVOLUTION AND INDEPENDENCE, 1500–1783

The European colonists of Eastern North America found an undeveloped, largely virgin land rich with forest, fish, wildlife, grasslands, minerals, and water resources and a vast area available for settlement. It was a land of challenge and opportunity. It contrasted strongly with the situation in England—the home of most of the early colonists.

There land was relatively scarce and increasingly expensive and becoming short of timber. Game and fish belonged largely to the feudal lords. The movement to enclose open-field farms and convert arable land to pasture was underway to capture profits to be gained from sheep and a growing wool trade. Enclosure meant more profitable farming for landlords and freeholders. Common rights of villagers to use certain meadows, woods, and other lands in common were being withdrawn. Small land holders and laborers were facing a declining demand for their services. Land scarcity and rising values were leading to efforts to convert forests, fens, heaths, and marshes to agricultural uses in the 17th century (Rasmussen 1974).

In contrast, the virgin American forests and their wildlife populations, including white-tailed deer, wild turkey, bobcats and cougars, ruffled grouse, black bear, and wolves, extended almost continuously from the East Coast to the prairies of the Midwest. Salmon and shad migrated up the major Atlantic coastal rivers to spawn. The grassland prairies and plains stretched to the foothills of the Rocky Mountains. They were populated with bison and pronghorned antelope, prairie birds, elk, mule deer, wolves, and grizzly bears. The lands beyond the Rockies to the Pacific coast were occupied by the crests of bare mountains at the highest elevations and arid deserts at the lowest. Bighorn sheep were common. The lands between the deserts and mountain tops were covered with evergreen forests and relatively dry grasslands. The great valley of central California was a vast plain and marshland harboring elk, pronghorns, salmon, and grizzly bears. America was a land of natural beauty as well as abundant natural resources (Trefethen 1975).

The American Southwest from central California to Texas and Louisiana was settled by the Spanish from Mexico. They introduced the horse and domesticated cattle to areas that were mostly grasslands, desert, and mountains with some forests. The English and other Europeans who colonized most of the East Coast provided the main thrust of development from the East to the Rocky Mountains and the Pacific Coast.

For the early English colonists, farming under the climatic and geographic conditions of the East Coast was a new experience and challenge. Agriculture developed slowly and served mainly the subsistence needs of the settlers. They often took advantage of lands originally cleared by Indians. As their numbers grew they were compelled to clear forestland by girdling and burning deadened trees, and to farm among the stumps until the latter rotted away. Their farm practices were only a step above those of the Middle Ages, and their tools were not much better. Domesticated animals were initially scarce and expensive to import (Rasmussen 1974). Wild game and fish were a common early source of fresh meat until excessive harvesting decimated their populations (Trefethen 1975). Logs, hewn timbers, and some lumber were the early building materials. Lumber mills were largely water powered and first appeared in Virginia in 1611. By 1700, probably more than 100 mills were sawing lumber. Wood was the universal building material and provided most of the fuel for heating and other purposes (Davis 1983).

The most important minerals in colonial America, aside from stone, clay, and adobe construction materials, were iron and lead. Bog iron was discovered in Virginia and an ironworks operated near Jamestown from 1619 to 1622. The first permanent ironworks was set up in 1643 in Massachusetts. By 1750, iron ore was being mined and furnaces and forages, using charcoal for fuel, were making iron and iron products in all colonies but Georgia. They provided goods for farming and small cottage industries. Lead was used mostly for bullets. Small lead mines were operating in New England and Virginia by 1750, but production was relatively small. Colonial exports of pig and bar iron to England rose in the 18th Century as English production declined to low levels for lack of charcoal (Dorr n.d.).

Water for domestic use was essential and generally received first priority by all concerned. Colonists usually obtained their domestic water needs from a spring, a dug well with a bucket and rope hoist, or a bucket carried from the nearest stream. Location and development of water were seen as the responsibility of each individual, family, or local group or community. Some larger towns used cast iron or wooden pipe systems to distribute water within their communities. Natural lakes, rivers, and wells were used to satisfy the need for water. Waste from domestic water use was usually disposed of in ways that did not jeopardize its continued availability to the users, but not necessarily with regard for its effects on others (Linsley 1979, Schad 1979, Weber 1979).

In addition to sawmills, there were many grist mills with dams and mill races to provide water power. Water wheels also powered machinery in forges and other small industries. Maximum use was made of rivers and harbors for transportation. Their use for transportation during the colonial period required little modification or maintenance. Several canals were built for shipping bulky and heavy commodities. Public interest in improving water resources for transportation emerged about the time of Independence. Meetings, for example, are reported to have been held in 1784 between Maryland and Virginia representatives to consider opening and improving navigation of the Potomac River (Linsley 1979, Schad 1979, Weber 1979).

The settlers gradually improved their tools and farming practices. Subsistence farming remained typical in New England. The middle colonies produced some wheat and other commodities for export. In the South, tobacco became a main export crop reaching 100 million pounds a year by the Revolution. It became a mainstay for the southern plantation system of farming. Rice and indigo, first developed in South Carolina, also became important plantation crops with good export markets by the end of 18th century. Cattle raising and small farms characterized the frontier. It included the back country of New England, the Mohawk Valley, the Great Valley of Pennsylvania, the Shenandoah Valley, and the Southern Piedmont. Settlement west of the Allegheny Mountains was severely restricted when the British Government established the Proclamation Line in 1763, to keep peace with western Indians and protect a prosperous fur trade. No land could be purchased from the Indians, and no settlements established west of the line without permission from the crown. Settlers living beyond the line were directed to leave (Clawson 1964, Rasmussen 1974). There were similar treaties between England and the Indian tribes in the southern Appalachians that also restricted westward migration.

Despite the difficulty of clearing land and farming, colonial farmers were soon producing a surplus for which there was no market in America. The growing population, which exceeded 3 million by the time of the Revolution, placed great pressures on the land. Farming was the main way of making a living and more than 90% of the people lived on farms. The Proclamation Line concentrated that pressure east of the mountains (fig. 1). Restrictions upon land settlement and private conveyance, and trade disputes with England became sources of discontent that helped bring about the Revolution (Rasmussen 1974). By 1776, a 100-mile-wide strip of the East Coast from southern Maine to Georgia had been settled; one-half to three-quarters had been cleared. In the North, 5% to 15% of the land was tilled each year. In the South, 40% to 50% was tilled. Continuous tilling reduced the natural soil fertility. On sloping fields, where plowing up and down the slopes was common, erosion increased and accelerated the loss. Crop yields declined. After several years, some fields lost so much productivity they were abandoned. Abandoned areas sometimes became pastures and, in other cases, reverted to brush and new forests. Land rotation became a regular experience and continues to this day as the economic margins between crop, grassland, and forest use change with demands and technological progress (U.S. Department of Agriculture 1981b). The effects of development were noticed early by George Washington, "Our lands were originally very good, but use and abuse have made them quite otherwise."

During the Revolution the farmers fed the Americans, French and many of the British forces and made money doing so. The farming population also provided most of the revolutionary soldiers. The farmers were a vital key in winning independence and establishing the new nation.

GROWTH AND DISTRIBUTION OF THE PUBLIC DOMAIN, 1783–1920

At the end of the Revolution, the new United States owned all lands as far west as the Mississippi River, except for Florida. The lands west of the original 13 states became the nucleus of the public domain, except for Kentucky, Tennessee and some limited reservations. Although seven of the states had colonial claims to these lands, they were ceded to the new national government with the general understanding that they were won by a common effort of the 13 states and should be common property. Those cessions assured some equity of size and population among the original states. They also comprised a public domain of 268 million acres, about one-half of the area of the national territory of that period. The states also agreed that as the public domain was settled, it would be divided into states that would be admitted to the Union as equals (Hibbard 1924).

The public domain expanded rapidly in the first half of the 19th century. By 1853, the nation's territories included the entire 1.9 billion acres of the contiguous 48 states. More than one-half of this national territory was added to the public domain following the cessions by the original states after the Revolution (fig. 2).

Distribution of the Public Domain

Almost as soon as the new Congress received its first cession of western lands, pressures emerged from numerous interests to fix procedures for disposal of the public domain. "The spirit of immigration is great," Washington wrote in 1784. "People have got impatient and though you cannot stop the road it is yet in your power to mark the way" (Hibbard 1924). The most urgent reasons for early action were:

- to redeem the government promise of land grants to soldiers;
- to secure much needed national revenues from land sales;
- to provide for defense of the Northwest from Indian attacks;
- to link the commercial interest of the western settlements in Kentucky and Tennessee with the eastern states;

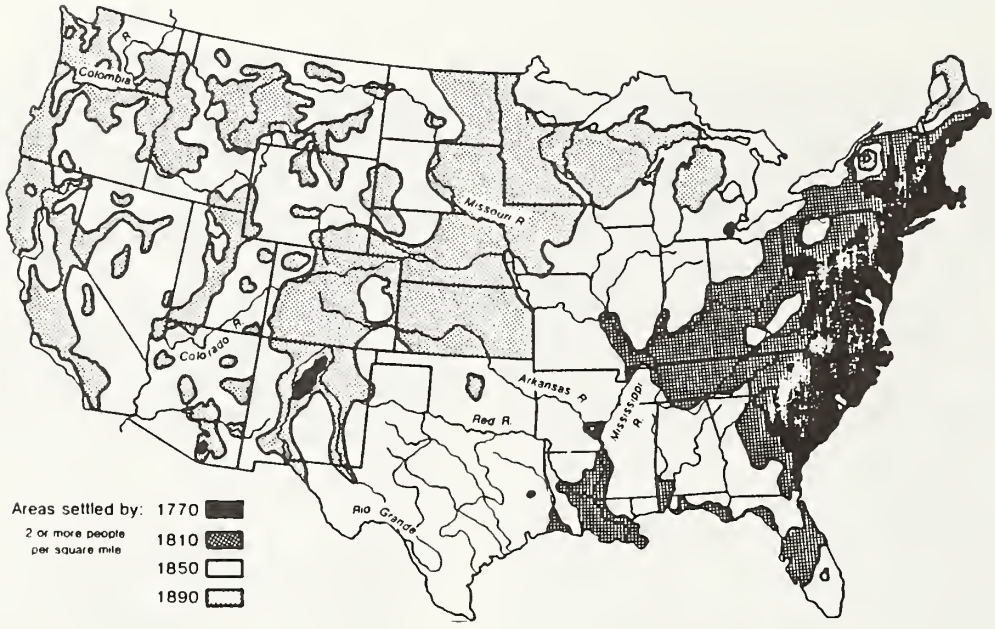

Figure 1.—The progress of settlement in the United States from 1770 to 1890.

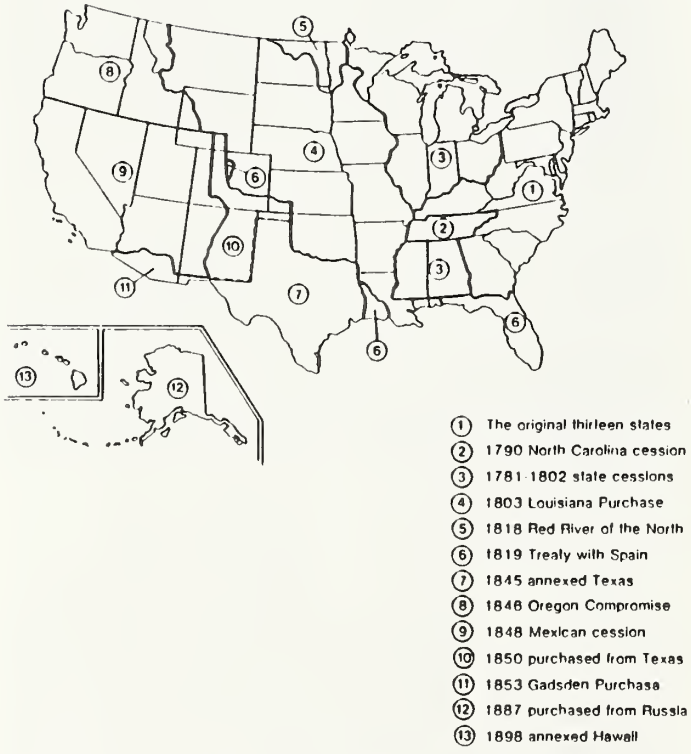

Figure 2.—Acquisition of the territories of the United States.

- to decide upon a form of government for the public domain, including the establishment of new states;
- to dispose of the public domain as property for the public benefit; and
- to respond to the population and economic pressures for immigration to the western lands.

The Northwest Ordinance of 1785 set the basic directions for settlement and development of the public domain (Hibbard 1924). The lands were to be auctioned and sold for cash at a minimum price of $1 per acre. The western lands were to be surveyed into townships made up of 36 sections of 1 square mile, or 640 acres. One-half of the townships were to be sold wholesale. Alternate townships were to be sold by sections. Surveys had to precede sales, but settlement could precede surveys. That became the general practice. One section in each township was reserved for schools and four others for disposition by Congress. One-third of all subsurface gold, silver, lead, and copper deposits were reserved to be sold or otherwise disposed of as directed by Congress (Hibbard 1924, Wilkinson and Anderson 1985). The Secretary of War also was authorized to withdraw one-seventh of the ceded lands for the Continental Army, after which sales could proceed (Hibbard 1924).

The Northwest Ordinance of 1787 provided for the government of the lands as they were settled. It established territories whose settlers would be controlled by officials appointed by Congress. When adult male residents numbered 5,000, a territory could elect a legislature to share power with a council appointed by the governor and Congress. When residents totalled 60,000, the territory could frame a constitution and apply for admission to the Union on equal terms with the original states. A Bill of Rights also guaranteed territorial settlers basic freedoms similar to the Constitution. In this way, the western territories and the states to be formed from the public domain were bound to the nation by the strongest of possible ties—that of equal rights (Hibbard 1924).

There were many debates throughout the 19th century and into the 20th concerning the disposal, management, and use of the public domain, and many laws were passed. However, the main policy thrust into the early 20th century was to transfer land from federal ownership to private individuals, developers, and selected

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Despite the difficulty of clearing land and farming, colonial farmers were soon producing a surplus for which there was no market in America. The growing population, which exceeded 3 million by the time of the Revolution, placed great pressures on the land. Farming was the main way of making a living and more than 90% of the people lived on farms. The Proclamation Line concentrated that pressure east of the mountains (fig. 1). Restrictions upon land settlement and private conveyance, and trade disputes with England became sources of discontent that helped bring about the Revolution (Rasmussen 1974). By 1776, a 100-mile-wide strip of the East Coast from southern Maine to Georgia had been settled; one-half to three-quarters had been cleared. In the North, 5% to 15% of the land was tilled each year. In the South, 40% to 50% was tilled. Continuous tilling reduced the natural soil fertility. On sloping fields, where plowing up and down the slopes was common, erosion increased and accelerated the loss. Crop yields declined. After several years, some fields lost so much productivity they were abandoned. Abandoned areas sometimes became pastures and, in other cases, reverted to brush and new forests. Land rotation became a regular experience and continues to this day as the economic margins between crop, grassland, and forest use change with demands and technological progress (U.S. Department of Agriculture 1981b). The effects of development were noticed early by George Washington, "Our lands were originally very good, but use and abuse have made them quite otherwise."

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GROWTH AND DISTRIBUTION OF THE PUBLIC DOMAIN, 1783–1920

At the end of the Revolution, the new United States owned all lands as far west as the Mississippi River, except for Florida. The lands west of the original 13 states became the nucleus of the public domain, except for Kentucky, Tennessee and some limited reservations. Although seven of the states had colonial claims to these lands, they were ceded to the new national government with the general understanding that they were won by a common effort of the 13 states and should be common property. Those cessions assured some equity of size and population among the original states. They also comprised a public domain of 268 million acres, about one-half of the area of the national territory of that period. The states also agreed that as the public domain was settled, it would be divided into states that would be admitted to the Union as equals (Hibbard 1924).

The public domain expanded rapidly in the first half of the 19th century. By 1853, the nation's territories included the entire 1.9 billion acres of the contiguous 48 states. More than one-half of this national territory was added to the public domain following the cessions by the original states after the Revolution (fig. 2).

Distribution of the Public Domain

Almost as soon as the new Congress received its first cession of western lands, pressures emerged from numerous interests to fix procedures for disposal of the public domain. "The spirit of immigration is great," Washington wrote in 1784. "People have got impatient and though you cannot stop the road it is yet in your power to mark the way" (Hibbard 1924). The most urgent reasons for early action were:

- to redeem the government promise of land grants to soldiers;
- to secure much needed national revenues from land sales;
- to provide for defense of the Northwest from Indian attacks;
- to link the commercial interest of the western settlements in Kentucky and Tennessee with the eastern states;

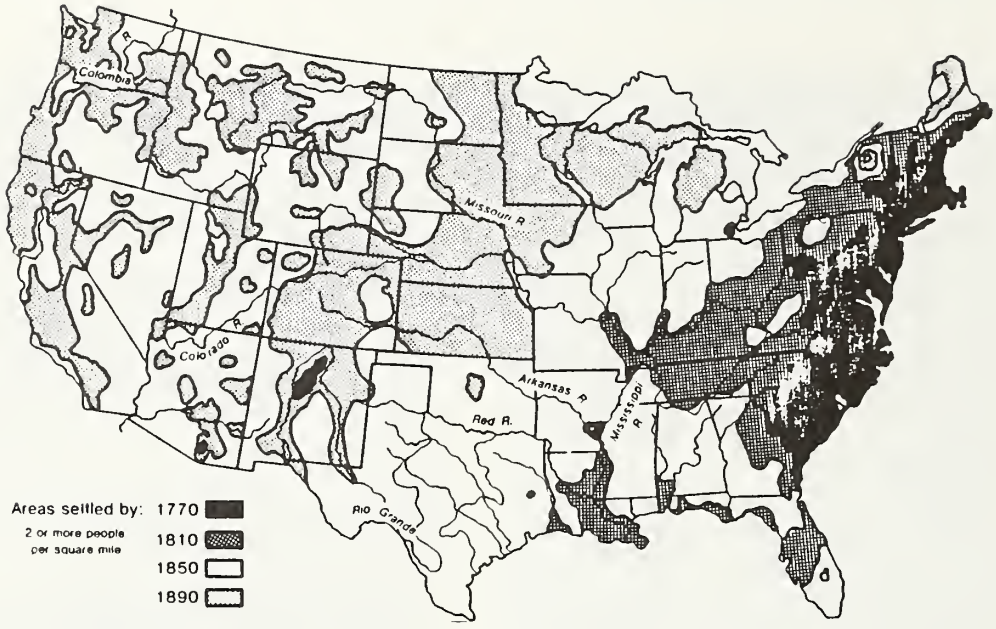

Figure 1.—The progress of settlement in the United States from 1770 to 1890.

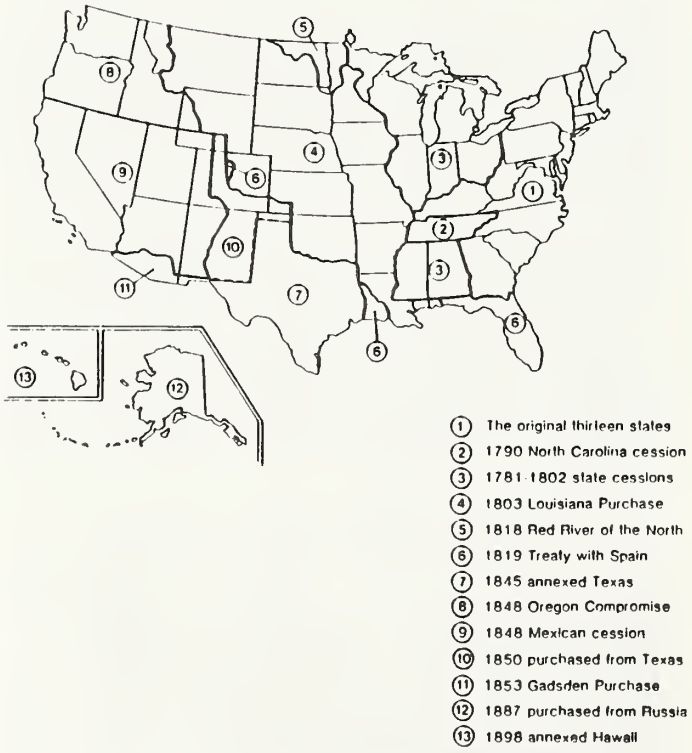

Figure 2.—Acquisition of the territories of the United States.

- to decide upon a form of government for the public domain, including the establishment of new states;
- to dispose of the public domain as property for the public benefit; and
- to respond to the population and economic pressures for immigration to the western lands.

The Northwest Ordinance of 1785 set the basic directions for settlement and development of the public domain (Hibbard 1924). The lands were to be auctioned and sold for cash at a minimum price of $1 per acre. The western lands were to be surveyed into townships made up of 36 sections of 1 square mile, or 640 acres. One-half of the townships were to be sold wholesale. Alternate townships were to be sold by sections. Surveys had to precede sales, but settlement could precede surveys. That became the general practice. One section in each township was reserved for schools and four others for disposition by Congress. One-third of all subsurface gold, silver, lead, and copper deposits were reserved to be sold or otherwise disposed of as directed by Congress (Hibbard 1924, Wilkinson and Anderson 1985). The Secretary of War also was authorized to withdraw one-seventh of the ceded lands for the Continental Army, after which sales could proceed (Hibbard 1924).

The Northwest Ordinance of 1787 provided for the government of the lands as they were settled. It established territories whose settlers would be controlled by officials appointed by Congress. When adult male residents numbered 5,000, a territory could elect a legislature to share power with a council appointed by the governor and Congress. When residents totalled 60,000, the territory could frame a constitution and apply for admission to the Union on equal terms with the original states. A Bill of Rights also guaranteed territorial settlers basic freedoms similar to the Constitution. In this way, the western territories and the states to be formed from the public domain were bound to the nation by the strongest of possible ties—that of equal rights (Hibbard 1924).

There were many debates throughout the 19th century and into the 20th concerning the disposal, management, and use of the public domain, and many laws were passed. However, the main policy thrust into the early 20th century was to transfer land from federal ownership to private individuals, developers, and selected

industries, such as railroads. Some grants were made to states, largely for educational purposes, but they were limited. Agricultural and timber production to meet national food and fiber needs were never expressed as explicit goals for land transfers. That was largely left to the new owners and developers, and the free marketplace.

Early changes in the terms, procedures, and policy for disposal of the public domain facilitated land transfers to individual settlers and frontiersmen. The size of parcels and prices were reduced and payment conditions eased. Land squatters' rights were recognized. Land offices were established in the developing areas for easy transfer of titles. Revenues from land sales became less important to the growing nation and gave way to a goal of economic development through rapid settlement.

There was sectional resistance to reforms that accelerated western settlement. Until the 1850's, industrial and other interests in the North feared that westward migration would reduce their labor supplies and lead to dissolution of the Union. Eastern speculators looking after their land investments opposed homesteading reforms. However, a growing industrial capacity and immigrant population led northern leaders in the 1850's to see western development as an expanding market for their manufactures. Influential leaders, such as Horace Greeley, strongly supported reforms that offered free homesteads to settlers (Roth n.d.).

The South feared the growth of federal power, development of new states, and the threat of western development to its economic interests and way of life. Its delegations consistently opposed reforms that facilitated western settlement prior to the Civil War (Rasmussen 1974). Westerners were sensitive to federal restrictions on their development. They wanted development above all else. They supported liberal reforms for settlement and expansion of grants for education and internal developments (Roth n.d.).

The drive for liberalized settlement policies came to a climax in 1862, when southern opposition was absent, and President Lincoln signed the Homestead Act. It gave eligible settlers free title to 160 acres of public land after 5 years of residence and homestead improvements, or after 6 months residence with suitable improvements and payment of $1.25 per acre.

By the end of 1862, the federal government had sold or granted to individuals and states 320 million acres of the 1.31-billion-acre public domain, about 25%. Land sales were the largest segment—156 million acres for which the government received an average of $1.19 per acre. Grants to states totalled 109 million acres. About one-third were for internal development: railroads (86%), canals and river improvements (13%), and wagon roads (1%). The remaining two-thirds of state grants were almost entirely for schools and educational purposes (Gates 1968, Hibbard 1924, U.S. Department of Commerce 1975). All the states east of the Mississippi, including Minnesota and Louisiana, had been formed and admitted to the Union by 1862, as well as five states west of the Mississippi—Iowa, Missouri, Kansas, California, and Oregon.

The total number of farms in 1862 exceeded 2 million. Their land area constituted more than 400 million acres. The national population was just over 32 million. Farm families and workers made up about half the population and half the labor force. The states and territories carved from the public domain accounted for over 45% of the population and about half of the nation's farms (U.S. Department of Commerce 1975).

The Period 1862–1920

From 1860 to 1920, the United States population grew to 106 million—an increase of more than 70 million in 60 years. The demand for food and timber accelerated accordingly and strengthened incentives for settlement and development. Although the transfer of public lands to individuals had slowed sharply after 1860, it escalated strongly in the 1880's, averaging more than 7 million acres a year until 1920. Public land transfers to private ownership in this period, including sales and homestead entries, totalled almost 325 million acres, about one-third of the public domain that remained in 1862.

Most of these land transfers occurred in the arid and semiarid regions between the 100th meridian and the Sierra and Cascade Mountains of the Pacific Coast. The region was characterized by low rainfall, a wide diversity of land forms and conditions, uncertainty about climate and crop yields, and a predominance of cattle grazing on the dry grasslands (Roth n.d.). The 160 acres of free land provided by the Homestead Act of 1862 was too much for irrigation and too little for dry farming or grazing cattle or sheep. As Congress became aware of the limitations of these arid lands, it passed a wide variety of legislation to fit homesteading to the diversity of conditions and the aridity of these lands. Under the new laws, the homestead grants were increased to 320 and 640 acres. The objectives of these laws were directed to specific land uses—irrigation, timber, grazing, and dry land farming. Land classification was authorized, but weakly applied.

Direct federal land grants to railroad corporations to link the Pacific coast with the Eastern United States, and open new areas to settlement and growth, were authorized by Congress in 1862, after many years of debate. The first transcontinental linkage was completed in 1869, and others soon followed.

Direct federal land grants to railroads totalled 131 million acres. They opened new areas to settlement and provided more rapid access to markets and manufactured goods. The main role of the grants was to attract private investment in railroad securities needed to build the railroads. Some were built well in advance of their real need. The grants and new lines induced strong promotion campaigns among the land grant railroads to attract settlers from all parts of Europe and the settled states. Settlement accelerated in the 1880's and continued to 1920. Between 1862 and 1912, 13 new western

states in this arid region were admitted to the Union, thereby completing the contiguous 48 states. By 1920, the people residing in states formed from the public domain made up 58% of the U.S. population (Carstensen 1968, Gates 1968, Hibbard 1924, U.S. Department of Commerce 1975).

Including state grants, a total of 518 million acres of public land were transferred to private or state ownership between 1862 and 1920. They constituted 52% of the unoccupied public domain in 1862. An additional 272 million acres were set aside as federal reserves for national forests, parks, and other purposes. The remaining unoccupied public land in 1920 was only 200 million acres. Transfer of the public lands to private and state ownership was virtually completed. Today, the remaining unreserved public domain is only about 170 million acres in the contiguous 48 states, and is administered by the USDI Bureau of Land Management.

The number of farms in the United States had grown to 6.4 million by 1920, and 4.2 million (66%) were in the public domain states. In the same period, the farm population rose to more than 31 million, nearly equal to the total U.S. population in 1862 and 30% of the U.S. population in 1920. America was growing fast in all its dimensions during this period (U.S. Department of Commerce 1975).

Historians and later generations have questioned the wisdom and criticized the way the public domain was distributed. Congress clearly believed the vast public domain would be more valuable to the growing nation if it were transferred to the hands of those who could develop it. There was no detailed federal plan for its development prepared by economists, scientists, or anyone else. There was no schedule for the rate of development. The question of food supplies barely entered into the debate, although agriculture was generally seen as the best and dominant use. Food was abundant and cheap, and so were the public lands. The transfer of ownership of the public lands was, and remains, a subject of controversy.

There was much fraud and speculation, which often frustrated the intent of the public land legislation. There were many mistakes in land distribution and use. The General Land Office often asked for more funds and staff but remained taxed just to handle the entry and patenting of the public lands. It never received any real authority to manage any of the public lands in the years leading up to 1920. Public land policy and the distribution of the public domain that went with it were largely the work of Congress. The main guidelines appear to have been that the lands should be settled rapidly, at little or no cost to settlers, and that the new ownership should be predominantly private and widely distributed (Carstensen 1968, Hibbard 1924).

Allen Bogue wrote in 1968 that historians still have good reasons to weigh the consequences of the American land system. "The place of land policy in the broader picture of American economic development is still incompletely understood" (Carstensen 1968). In 1915, Eugene Davenport, then Dean of the College of Agriculture of Illinois, recognized there had been abundant waste and abuse in the distribution and use of public lands, but said, "We have these farms, these cities, these railroads, and this civilization to show for it, and they are worth what they cost" (Carstensen 1968).

PRIVATE DEVELOPMENT AND USE OF PUBLIC LANDS, 1783–1920

Agricultural Expansion to the West

Agriculture expansion to the West responded primarily to rapid population growth. The demands for domestic food supplies, feed for draft animals and domestic livestock, and the opportunity for exports expanded throughout the 19th and the early 20th centuries. Agricultural production was a main source of employment and way of life throughout this period. Agricultural productivity per acre was low and increased only slowly during this period. Therefore, large acreages of farmland were required to meet the nation's growing food, feed, and fiber demands. Declining productivity of the eastern seaboard croplands and the availability of low cost or free public lands for settlement also encouraged expansion to the West. Periods of economic distress and low prices only slowed the expansion periodically. Periods of high demand and prices often accelerated it. Climatic factors frequently brought distress to farmers but did not deter the steady expansion, as long as public lands remained available for easy acquisition and settlement.

1783 to 1860

Agriculture was still very primitive at the end of the 18th century. Probably less than 20 million acres per year were used for cropland.[2] In 1800, this was only 6% of the area of the 17 states of the Union, where essentially all of the population was concentrated at that time (fig. 1). The area cultivated per farm worker probably averaged no more than 10 acres.[3] The harvesting equipment, largely hand tools, determined the number of acres a farmer could cultivate. As the population grew, acres required for food production increased proportionately. By 1860, the total cropland had grown to 109 million acres (table 1). Most of this expansion took place on public lands. Thus, farming entailed continuous clearing of forests, draining of swamplands and valley lowlands, and breaking of prairie sod. The loss of natural fertility and erosion on slopes led to continuous abandonment of some cropland. Abandoned land reverted to

[2]*Based on extrapolation from 1850 and later data on cropland used (table 1) and 1820 and later data on workers (table 2).*

[3]*See note 2.*

Table 1.—Major uses of land, contiguous 48 states, 1850-1982.

Year	Cropland[1]	Grassland pasture and range[2]	Forest land[3]	Other land[4]	Total
	Million acres				
1850	76	([5])	([5])	([5])	1,884
1860	109	([5])	([5])	([5])	1,904
1870	126	([5])	([5])	([5])	1,904
1880	188	935	628	153	1,904
1890	248	892	604	160	1,904
1900	319	831	578	176	1,904
1920	402	750	567	185	1,904
1930	413	708	607	176	1,904
1940	399	723	602	180	1,904
1950	409	700	606	189	1,904
1959	392	696	614	200	1,902[6]
1969	384	689	603	221	1,897[6]
1978	394	661	583	259	1,897[6]
1982	404	659	567	266	1,896[6]

[1]*Excludes cropland used only for pasture.*
[2]*Grassland and other nonforested pasture and range including cropland used only for pasture.*
[3]*Excludes forest land in parks and other special uses.*
[4]*Includes urban areas; rural transportation systems; parks and wildlife areas; defense and industrial uses; miscellaneous uses not inventoried; and area of little surface use such as swamps, bare rock areas, desert, and tundra.*
[5]*Not available.*
[6]*Changes in total area are due to changes in methods and measures used in remeasurement and in surface area of reservoirs.*
Sources: Wooten (1953).

pasture, brush, and regenerating forest. The total lands cleared east of the Mississippi River by 1860 probably totalled between 150 million and 200 million acres. Although there are no reliable estimates for this period, this would have been 30% to 40% of the territory of the United States at the beginning of the 19th century.

The cropland required for domestic food, fiber, and tobacco needs in both 1850 and 1860 averaged about 3 acres per person.[4] There was little improvement in cropland productivity in this period. Rasmussen (1982) also reports there was virtually no improvement in productivity per farm worker. Persons supplied with farm commodities per farm worker, a partial measure for farm worker productivity, remained about the same from 1820 to 1850, and increased 11% from the average of this period to 1860 (table 2). Farm workers made up about 85% of the persons gainfully employed in 1800. This proportion declined to 70% by 1840, and 60% by 1860. The U.S. population remained dominantly agrarian, even though nonagricultural employment was growing much more rapidly (Rasmussen 1974, Taylor et al. 1949).

A breakthrough in farm mechanization took place in the 1830's, when both Cyrus H. McCormick and Obed Hussey invented horse-powered grain reapers. They solved the major problem in wheat production—timely harvesting. However, farmers were slow to adopt the new machines and did so on a widespread scale only during and after the Civil War, when high prices made it profitable.

Plows at the turn of the 19th century were mainly made of wood, and used a minimum of the relatively scarce and expensive iron or steel. Improvements were being made incrementally but slowly. Neither the wooden nor early cast-iron plows would turn the sticky soil of the prairie. More effective one-piece plows made of wrought iron with a steel cutting edge on the share became available after 1837 when John Deere began to produce such plows. Few were sold at first, only 1,000 in 1846 and 10,000 in 1857. Other makers produced similar plows. Sales accelerated as cheaper steel became available in the 1850's. Steel plows effectively cut the prairie sod and worked well at the speed of a working horse. By 1860, some gang plows pulled by horse teams were in use (Schlebecker 1975).

The invention of the cotton gin in 1793 provided an effective way to sort lint from seeds. Cotton culture spread rapidly to the interior of the South and established plantation agriculture throughout the region. Cotton output rose steadily from 10,500 bales in 1793 to 1 million by 1835, and then to 4.5 million by 1861. It strongly commercialized farming in the South, with strong markets

[4]*Based on table 2, total population data and cropland use data from table 1 reduced for exports by 5% in 1850 and 11% in 1860.*

Table 2.—Persons supplied farm products by one farmworker, 1820-1984.

Year	Persons supplied per farm worker			Total farm employment[1]	Total U.S. population
	Total	At home	Abroad		
	Millions				
1790	—	—	—	—	—
1800	—	—	—	—	—
1810	—	—	—	—	—
1820	4.1	3.8	0.3	2.4	9.6
1830	4.0	3.8	0.2	3.3	12.9
1840	3.9	3.7	0.2	4.4	17.1
1850	4.2	4.0	0.2	5.7	23.3
1860	4.5	4.0	0.5	7.3	31.5
1870	5.1	4.6	0.5	8.0	39.9
1880	5.6	4.5	1.1	10.1	50.3
1890	5.8	4.7	1.1	11.7	63.3
1900	6.9	5.2	1.7	12.8	76.1
1910	7.1	6.1	1.0	13.6	92.4
1920	8.3	6.9	1.4	13.4	106.5
1930	9.8	8.8	1.0	12.5	123.1
1940	10.7	10.3	0.4	11.0	132.1
1950	15.5	13.8	1.7	9.9	151.7
1960	25.8	22.3	3.5	7.1	180.8
1970	47.9	40.6	7.3	4.5	205.1
1980	75.7	52.3	23.4	3.7	227.7
1984	77.3	57.3	20.0	3.5	236.7

[1]*Includes farm operators, unpaid family workers and hired workers.*
Source: Economic Indicators of the Farm Sector: Production and Efficiency Statistics, Statistical Bulletin No. 65, 1979 and Statistical Bulletin No. ECIFS 4-4, 1984, U.S. Department of Agriculture, Economics Research Service.

in New England and England. In Virginia, Maryland, and Kentucky, where cotton did not become established, tobacco remained the staple crop (Hibbard 1924; Rasmussen 1974, 1982).

Farming in the North was characterized by small landowners engaged in general farming. Specialized production such as dairying was growing in New England and the mid-Atlantic states. The Mormons had settled in Utah in 1847 and immediately began irrigated farming. Lowlands and swamplands were being drained largely through the construction of levees by the states enabled by general drainage laws. New machinery had been invented for more farming operations. The use of lime had been demonstrated and commercial fertilizers were available. As westward settlement accelerated in the 1850's, public land sales averaged more than 5 million acres a year. The total population was growing faster than 3% a year (Hibbard 1924). The farm labor force was growing about 2.5% a year (table 2).

1860 to 1920

The Civil War brought on labor shortages. Strong wartime and foreign demands for farm commodities produced high prices. Farmers in the North and West turned to machinery to replace the men joining the armed forces. Strong demands and economic incentives accelerated adoption of new machines and methods during the war, and became the catalyst for the first agricultural revolution in the North and West. In the South, farmers changed little, even though farm workers became scarce. The adoption of new machinery did not accelerate simply because the machines were not available.

By 1880, the area used for cropland totalled 188 million acres. The total persons supplied per farm worker rose to 5.6, almost 25% more than in 1860. The area of cropland cultivated per farm worker rose to 19 acres. The cropland used for domestic consumption remained about 3 acres per person, indicating that average crop yields were not rising significantly. But farm labor productivity was increasing with the growing use of new farm machinery and horsepower. The rate of increase in farm workers from 1860 to 1880 was 1.7% a year. Total population grew 2.4% a year while farm exports rose from 10% of farm production in 1860 to 20% in 1880.

In the South, cotton again dominated the economy. Production, which had dropped to less than 500,000 bales during the Civil War, rose to 6.6 million bales in 1880. Cotton was largely produced by tenants working small acreages under fixed contracts. Cotton was harvested on 16 million acres in 1880.

Nationwide, corn was the largest crop. It made up one-third of the cropland in 1880, when more than 62 million acres were harvested. Wheat was the second largest crop, with 38 million acres harvested in 1880. Hay and oats used another 43 million acres. These crops, including cotton, accounted for 85% of the cropland used in 1880. Close to 40% of all cropland was in row crops. Feed for draft animals and livestock was the dominant use of cropland.

Beginning in the 1880's, dryland farming development was strongly encouraged for the semiarid West. It required half the land to lay fallow each year to gather moisture, so that more acres were needed to achieve efficient production levels. The Northern Pacific Railroad was a strong supporter of dryland farming, and largely through railroad efforts, a Bureau of Dry Land Agriculture was set up in the Department of Agriculture in 1906. Congress tried in various ways to modify the public land legislation to adapt homesteading provisions to the semiarid West. Homestead acreages were increased to encourage irrigation by landowners. Then grants were made to states for resale to raise revenues to develop irrigation. Neither of these irrigation initiatives were effective. By 1920, less than 10 million acres were added to the area that had been irrigated largely by the Mormons in earlier years.

Dry farming did not achieve its expectation. As Schlebecker (1975) expressed it, "the desert never 'blossomed like a rose.'" The early stages of settling in the semiarid lands, conflicts with cattlemen accustomed to an open range, periodic droughts, and low prices in the 1880's and 1890's proved difficult for many farmers and busted some (Rasmussen 1974, Schlebecker 1975).

After 1900, however, dry farming combined with technological advances and economic improvement brought prosperity to the plains and prairies (Rasmussen 1974, Schlebecker 1975). Cultivated cropland continued to expand rapidly after 1880 and more than doubled by 1920 to 402 million acres. In these 40 years more acres were added to the annual cropland used than in the entire 250 years since settlement. Most of these additions occurred west of the Mississippi with large amounts in the dryland areas of the West.

Agricultural expansion from 1880 to 1900 came despite a decline in commodity prices and a generally depressed agricultural economy. The rapid rate of this expansion no doubt contributed to the lower prices. Cropland expansion peaked in the Northeast in the 1880's and net land abandonment was underway. Cropland expansion slowed and peaked in 1920 in the Lake States and Corn Belt, except for Illinois, Iowa, and Wisconsin. Cropland also peaked in 1920 in the South, except for North Carolina, Florida, and the Delta States.

Total farm output almost doubled between 1860 and 1920. The abundance of production and low prices in the 1880's and 1890's attracted European buyers who easily absorbed 20% or more of the annual crop production. After 1900, farm prices rose again and reached very high levels as World War I reduced European production and increased demands on U.S. cropland. Crop exports averaged more than 25% of U.S. production in the years 1900 to 1920 (U.S. Department of Commerce 1975). Farm income and prices after 1900 held steady in comparison to the rest of the economy, until the early 1920's (Rasmussen 1974). It was a prosperous time for farmers.

Agricultural productivity, measured as the ratio of total outputs to total inputs, increased about 50% between 1860 and 1920 (U.S. Department of Agriculture 1980b). Farm population reached its historic peak of 32 million

in 1910, as did the number of farm workers at 13.6 million. The average cropland cultivated per farm worker rose to 30 acres, 60% more than 1880; persons supplied per farm worker rose to 8.3, 48% greater than 1880. Cropland used to supply domestic food and fiber needs remained at 3 acres per capita, indicating little general improvement in average crop yield and livestock productivity. The productivity gains came largely from reduced farm labor and costs of production associated with new and improved farm machinery and equipment. Even these improvements were limited by almost complete dependence on horsepower. Tractors numbered fewer than 250,000 and there were even fewer trucks. Horses on farms in 1920 totalled 20 million, just a million less than the World War I peak of 21 million. Farm workers actually declined 1.5% from 1910 to 1920, releasing farm labor resources for the first time for use in the rest of the national economy as total population and total demands continued to grow.

The Conversion and Use of the Forests, 1800–1920

At the time of settlement, the original forests of the contiguous 48 states covered about 850 million acres. By 1920, they had been reduced to 567 million acres, about the same as today (table 1). Thus, a net area of 250 million acres was cleared for farming and other uses or allocated to national parks, wildlife refuges, or other purposes. The most rapid clearing occurred between 1800 and 1920. Because some farmland was abandoned and left to revert to forest during this 120-year period, the gross area cleared was somewhat more than the net change in forest area. Most of the clearing as well as the forest regrowth occurred east of the Mississippi.

The standing commercial sawtimber in 1800 is estimated to have been 7.5 trillion board feet. Most of it was old growth timber up to several hundred years old. (Today's managed forests seldom have rotations as old as 100 years.) By 1920, this virgin inventory was reduced by almost 75% to about 2.0 trillion board feet and was still declining. About half the conversion occurred on lands cleared for farms and other purposes, usually but not always on the more productive soils. The other half was harvested from lands that remained in forest use and were left to regenerate as young growing forests.

The net growth of forest growing stock, which includes commercial tree species down to 5 inches in diameter, is considered to have increased from zero in 1800 to about 5 billion cubic feet by 1920 (Davis 1983). The zero growth for 1800 is based on the assumption that annual mortality equals or exceeds annual growth in old growth, biologically mature, and overmature forests. (For comparison, the growing stock net growth in 1976 was estimated to be nearly 22 billion cubic feet, about 50% more than the actual 1976 harvest.)

The net clearing of forests for farms continued at a declining rate in most of the Northeastern States until 1880, and until the 1920's for the rest of the states east of the Appalachians. On public lands west of the Appalachians, clearing accelerated after 1800 with the expanding westward migration, and did not peak until after the 1920's.

Farm Woodlands

Most farms east of the prairies and plains retained woodlands on their poorer lands. In 1860, farm woodlands totalled 244 million acres, about 120 acres per farm. The typical farm woodland in the more developed areas, however, was closer to 50 acres. At the frontiers, it commonly exceeded 100 acres. In 1920, the total farm woodland area was reduced to 168 million acres—about 25 acres per farm, including many farms on the plains and prairies with much less or none (Lane 1959, U.S. Department of Commerce 1975). Woodland provided farmers the materials needed for housing, farm buildings, fences, fuel, forage, and many other needs. In 1853, for example, there were more than 3 million miles of farm fences built with wood and they had to be replaced about every 25 years (Davis 1983).

Firewood

The common use of wood was for heating, cooking, and energy for steam engines, steamboats, railroads, and growing industrial purposes. Fuelwood was initially abundant and cheap in the forested areas east of the prairies. It became increasingly scarce and costly in the more populated areas, as lands were progressively cleared for farming and for sale of fuelwood supplies to urban dwellers. By 1840, farmers were selling 5 million cords of firewood annually (Davis 1983). In 1853, a 76-mile New York Central rail line had 18 wood storage stations along its tracks to supply its needs. Firewood provided 95% of the BTU's produced in 1850. The fireplace was the main heating facility in 1800 and required 10 to 20 acres of woodland to supply its wood needs. Wood stoves, introduced in the late 18th century, gradually replaced fireplaces because they were more efficient; improving wood stoves became the main means for increasing fuel efficiency. From 1793 to 1840, the U.S. Patent Office issued more than 800 stove patents, more than for any other object (Davis 1983).

Firewood use peaked in the 1870's. The wood share of BTU's dropped to 73% as the use of coal increased. By 1920, wood provided less than 10% of the BTU's. Most of the wood users were farm families.

Lumbering

Throughout the 19th century lumber was the universal building material. The demand seemed virtually insatiable even though lumber prices in real terms rose steadily and continuously. Enormous wood supplies were needed to construct homes and all types of private and public buildings in the expanding cities of the East and the growing towns and farms on the prairies and plains. The supply was considered unlimited. There always were new virgin areas of timber to which to turn.

Up to 1845, it is probable that most of the saw logs used for lumber and larger timbers came from farm-owned

woodlands that were being progressively cleared for farming (Lane 1959). Expansion of cotton plantations in Georgia, for example, had pushed back the forests to the mountains in the extreme northwest of the State by the 1840's (Davis 1983).

Logs were heavy and difficult to transport. Sawmill productivity was low, only 3,000 to 5,000 board feet a day. As a result, there were many sawmills in every state. New York had 7,000 mills in its 74 counties. Vermont, with one-fifth the land area, had 1,000-plus mills (Lane 1959). Distribution and marketing were largely limited to local watersheds. Commercial shipments across regions were limited mainly to white pine. Southern states were exporting some southern pine. Georgia with the largest lumber industry, exported about 25 million board feet a year in the 1840's; about half of it went to the West Indies (Davis 1983). Reported lumber production increased from an estimated 300 million board feet in 1799 to 1.6 billion by 1839. The real price of lumber rose 2.5 times or 2.3% a year (Steer 1948, Ulrich 1985), indicating that user demands were growing faster than supplies.

Improvements in saws and power sources between 1840 and 1860 made it possible to build mills to produce 40,000 board feet a day. As larger mills were built, the number of small sawmills declined sharply, even though total lumber production expanded rapidly (Lane 1959). The development of the crosscut saw for tree felling also increased labor productivity. Previously, all felling had been done with hand axes. The extension of the rail system, often through areas passed by or still unsettled, and the development of railroads as an alternate to dependence on streams for log-rafting, allowed lumbermen to open up vast new areas and timber stands that had been inaccessible earlier. These developments, together with rising lumber demands and prices, led to continued growth and migration of the lumber industry. By 1920, it had expanded to all the major timber regions of the nation.

Lumber production accelerated in each successive decade after 1839 to 1889, except for the Civil War decade (table 3). The expansion continued until 1906 and 1907 when the output of the lumber industry reached its historic peak of 46 billion board feet. Per capita lumber consumption rose from 250 board feet in the 1840's and 1850's to a peak of 530 board feet in 1906 and 1907, despite steadily rising real prices (table 3). To meet these needs, vast areas of virgin softwood and hardwood timber were harvested in all parts of the East, and major logging initiatives were underway in the West.

New York succeeded Maine as the leading lumbering state in 1839. In 1860, Pennsylvania became the lead producer. In 1870, Michigan took the lead, and by 1879, Lake states production exceeded that of the Northeast. A decade later Lake states lumber output reached its peak at 10 billion board feet, 37% of the estimated national supply. The white pine of the North remained the dominant softwood construction species throughout the 19th century. In 1899, lumber output in the South rose above 11 billion board feet as Lake states output declined.

By 1910, the southern production was 20 billion board feet, 44% of the national supply. Thereafter, it declined and was again at 11 billion feet in 1920. As Lake states production declined after 1900, Midwest lumbermen increasingly shifted their operations to the West Coast. They competed strongly with the southern producers for the markets of the Midwest, and by 1920 were producing about 10 billion board feet. Rocky Mountain production remained below 2 billion feet (Davis 1983).

The successive declines in state and regional lumber outputs meant that the virgin volumes of white pine timber and then southern pine were being exhausted. Little or no provision, other than unassisted natural regeneration, was made for the regrowth of harvested stands. There were no foresters in America until the late 19th century. Even so, the regrowth would have taken 60 or more years to mature and become competitive with the virgin old growth. Bernard Fernow, a German forester employed as the chief forester with the U.S. Department of Agriculture, reported in 1892 that forest owners failed to practice forest conservation because it did not pay. The costs of management showed that the profitable harvest of timber and conservation "are at present more or less incompatible" (Robbins 1985). A veteran editor of the American Lumberman, J.E. Defebaugh, expressed a similar view to the American Forestry Association in 1893: "...little can be expected from the lumberman or timber owner who depends on that business for his livelihood in...conserving the forests, simply because it does not pay him" (Robbins 1985). Gifford Pinchot on a later occasion told a lumberman's meeting that it would be fruitless to discuss forestry unless it was profitable: "We must show first that forestry will pay" (Robbins 1985). In general, the fixed costs of interest on loans and bonds for standing timber as well as annual taxes on the timber and land offered little incentive to lumbermen to hold old growth or mature timber for many decades. The risks of loss from fire and

Table 3.—Total lumber production and the relative producer price index[1] for lumber, 1799–1983 (1967 = 100).

Year	Lumber production[2] bill. bd·ft	Price index	Year	Lumber production[3] bill. bd·ft	Price index
1799	0.3	NA	1910	44.5	34.4
1800	NA	6.4	1920	35.0	53.8
1809	0.4	7.0	1930	29.4	48.2
1819	0.6	8.6	1940	31.2	63.7
1829	0.9	11.4	1950	38.0	105.9
1839	1.6	14.6	1960	32.9	97.0
1849	5.4	18.1	1970	34.7	103.0
1859	8.0	20.5	1972	37.7	133.8
1869	12.8	21.8	1974	34.6	129.4
1879	18.1	25.5	1976	37.0	127.3
1889	27.0	29.6	1978	40.5	154.0
1899	35.1	33.3	1980	35.4	121.2
			1982	30.0	103.8
			1984	36.9	112.7

[1]*Actual price index divided by all commodities price index.*
[2]*Source: Steer (1948), Ulrich (1985).*
[3]*Source: Ulrich (1985).*

the annual costs of taxes and protection of young stands for long periods discouraged investment in forest management. Thus, the old growth heritage remained the only physical and economical source of softwood construction lumber throughout the period of rapid settlement and development of the new nation, and wood remained the primary building material.

Cutover Lands, Forest Fire, and Land Use

The term "cutover lands" came into use in the 1880's and 1890's, particularly in the Lake states where lumbermen harvested the pine first and later returned to cut the commercial hemlock and hardwoods. Similar cutovers occurred in parts of the Northeast and the South as lumbering cleared extensive timber stands in largely unsettled areas. Although efforts were made to settle these lands, they remained unattractive to most farmers. The pine stumps did not rot and had to be grubbed or blasted out.

The soils in the pine cutovers of the Lake States and South were usually sandy and had low productivity for farming. There were few other resources of value. Mill towns that grew up with the lumber industry declined rapidly and often disappeared as the timber ran out. The prairies offered more productive alternatives for most settlers and had no stumps. Settlement of the cutover areas for farming never really became successful or thrived. Those who tried it usually faced a dismal future in later years. By the 1920's, 156 million acres had been logged in the South. In the Lake states and Northeast, the acreage was less—perhaps about one-half as much (Davis 1983).

Farm Woodland Grazing

Farm woodlands and the frontier forests were used for grazing from the time of first settlement. Competition from domestic animals forced game animals away from the settlements. Acorns and beechnuts in the hardwood forests supported hog raising and helped make pork the leading domestic meat staple for American families by the time settlement reached the Mississippi River. "Cow pens" on the cutovers of the South became an early base for a cattle raising empire. Sheep herding followed crop farming in New England as farmers migrated to the more productive, very cheap or free lands of the public domain (Davis 1983). Browsing by dairy cattle also expanded in the North as dairy production grew (U.S. Department of Agriculture 1958).

Census data show that 80 to 90 million acres, or about one-half of the farm woodlands were being grazed between 1900 and 1920. That relationship suggests that woodland grazing may have been somewhat greater in the early 19th century, before land clearing had reached its peak level.

Livestock in some areas of the North injured and destroyed young trees by browsing and trampling. Excessive use often accelerated erosion on woodland slopes and sometimes compacted soils, reducing soil quality and forest productivity. In the South, hogs rooted pine seedlings to feed on their roots and prevented thousands of acres from regenerating (U.S. Department of Agriculture 1958). Regular woodland burning became common practice—an effective way to reduce the rough; encourage the growth of palatable grasses, legumes, and other herbaceous vegetation for livestock; keep down the snakes, ticks, and chiggers; and aid the movement of cattle. It was an art learned from the Indians and sustained by the settlers throughout the 19th century. Older southern pine trees were resistant to light fires, but the reproduction was usually destroyed. Burning cutovers for grazing and the rooting of hogs delayed their regeneration.

Forest Fires and Other Catastrophic Timber Destruction

Forest fires were common and often burned unchecked. They repeatedly burned over the residual brush and second growth forests. Ely and Wehrwein (1940) reported "the cutover fires were regarded lightly because they were considered a help to the land-clearing settler. However, they destroyed the humus of the soil and the seeds of young trees which might have yielded a second harvest even without the care of man."

Forest fires were the most conspicuous catastrophic events that damaged the forests in the 19th and early 20th centuries, particularly in the North and West. In the South the rural sentiment was "unqualifiedly in favor of the annual burning over of the pineries" (Pyne 1982). Regular burning precluded the buildup of forest fuels that encouraged episodic fires elsewhere. Thus, southern forests, unlike those of the North and West, remained free of catastrophic fires until the 1930's (Pyne 1982).

The first holocausts of record were the Miramichi and Piscataquis fires of 1825 which burned 3 million acres in Maine and New Brunswick, Canada, the centers of lumbering at that time. In 1871, the Peshtigo fire burned 1.3 million acres in Wisconsin and took 1,400 lives. At the same time Chicago was burned with a much lower loss of life. Other fires burned 2.5 million acres in Michigan. In 1881 and 1894, fires again burned several million acres in the Lake states. Large fires also recurred in 1908, 1911, and 1918. In the Northeast, fires burned more than 1 million acres in an arc from Maine to upstate New York in 1903 and recurred in 1908. In the West in 1902, more than 110 large fires, sometimes referred to as the Yacolt fire, burned more than 1 million acres and took 38 lives in western Oregon and Washington. These fires led to the formation of private fire protection organizations which merged under the Western Forestry and Conservation Association in 1909. The catastrophic 1910 fire in northern Idaho and northwestern Montana had the greatest effect on the development of federal policy for forest protection from wildfires (Davis 1983, U.S. Department of Agriculture 1958).

These and many other episodic fires elevated concerns about timber famine and damage to watersheds. Industries organized their own fire protection associations where they owned valuable timber. There also were systematic public efforts, particularly at state and regional

levels, to establish fire protection systems. Total timber losses from catastrophic fires were reported to be 20 billion board feet from 1900 to 1920, a small fraction of the consumption in this period (U.S. Department of Agriculture 1958).

Catastrophic losses from insects and disease were greater. They approached 30 billion board feet and included the losses from the spruce bud worm in New England and the Lake states, the mountain pine beetle in the West, and chestnut blight in the Northern States. Total catastrophic losses from 1900 to 1920 were about 50 billion board feet. About 15% of the losses were salvaged (U.S. Department of Agriculture 1958). Except for the local cost of fire fighting, loss of life, and damage to developed properties, these losses probably were not felt by the general economy. The threat of these destructive forces to the future, however, was real.

Grasslands and Grazing

Cattle and sheep were introduced in the colonial period and were raised on the frontier woodlands and developed pastures. Cattle raising became important early on the Southern Piedmont. But it was transitory, giving way to cotton plantations and crop production as farm settlement moved westward (Rasmussen 1974).

In the early 19th century, European visitors described the cattle as generally red in color and indifferent in size and quality. Longhorns and a variety of Shorthorns were being imported from England to Virginia and Maryland in 1783. In 1817, they were being introduced into Kentucky together with Herefords. Improved Shorthorns were also being imported to Pennsylvania in 1822, and Ohio herders were importing Durham cattle in 1833 (Rasmussen 1974).

Cattle raising and hogs were largely a frontier industry. Drovers trailed herds of both from the Ohio country to the East from 1818 to 1845. Dairy cows became important in New England and the mid-Atlantic states. Some farmers in the latter states were fattening cattle for the city markets. In the Old South, as cattle gave way to cotton, its livestock declined from 22% of the national total in 1840 to 13% in 1860 (Rasmussen 1974).

The Census reports that all cattle numbered 58.6 million in 1867. Dairy cows made up 30% of that number. Pasture land appears to have been equal to about 60% of the cropland, 40 to 60 million acres. Pastured woodlands seem to have been in the 80 to 100 million acre range. Pastures were probably utilized mainly for dairy cows and draft animals, and some beef cattle and sheep.[5]

By 1865, the cattle industry had moved to Illinois, Iowa, and Missouri and then to the West Coast (Rasmussen 1974). Cattle herds were introduced by Spanish herdsmen in both Texas and California. American settlers continued the industry and improved the stock by breeding. Herds roamed freely on the Plains with little tending. Herding was the predominant way of raising beef cattle. Markets were remote, and cattlemen had little incentive to produce quality beef. Some cattle were sold in Texas, but more in New Orleans. In 1846, Texas herders even drove 1,000 head to the Ohio Valley. During the Civil War, the Texas herds were largely neglected but multiplied anyway, and by 1865, 5 million head grazed the Texas rangelands. Various entrepreneurs rounded up these herds (they had no owners) and, in 1866, began the first drive to northern markets in Missouri. In 1867, cattle were herded to the Abilene, Kansas, rail head (Schlebecker 1963).

Cattle herding was permitted on the public lands throughout the 19th century without constraint. The open and free range provided a strong economic incentive for cattlemen to use the abundant grasslands of the Western Plains. The acquisition and purchase of large ranch holdings did not get underway on a significant scale until the late 19th and early 20th centuries.

In the 1870's and 1880's, cattle herding expanded throughout the Northern Plains. However, as barbed wire became cheap, cattlemen began to substitute fences for cowboys on lands they were accustomed to graze with herdsmen. Some companies fenced as much as 1 million acres each and ranches of 100,000 fenced acres were common. Settlers entering the Plains in the early 1880's complained of hundreds of miles of fencing on public lands suitable for farming. In 1885, Congress passed a law making fencing a punishable offense. By 1890, the fencing was removed and grazing returned to free use and open range herding. Most of the range was in full use by domestic livestock. As homesteading rapidly progressed, cattlemen were pressed to forcefully resist homesteaders who fenced off the better parts of the public lands (Hibbard 1924, Schlebecker 1963).

There was no systematic or orderly control of the use of the open range. No agency had any management responsibility to avoid overgrazing and the damage to the forage that followed. The vacant public range lands were free to all users until they were homesteaded or sold. Total stock cattle numbers rose from 21 million in 1870 to 45 million in 1890. Stock sheep in the nation rose from 36 million in 1870 to 50 million in 1884 and 1885. Their numbers remained between 40 and 47 million to 1910 (U.S. Department of Commerce 1975).

Cattlemen tried to control the range by forming their own user associations and by purchasing limited base areas of meadow land and sources of water. The coming of sheepmen intensified competition for the free range. Sheepmen also sought out the key watering places and purchased parts of railroad grants as base property. Various grazing interests parcelled out large parts of the open range through informal agreements and compacts. The agreements, however, did not control access. Notorious sheep and cattle wars emerged (Davis 1983, Schlebecker 1963).

Herding on the open range often suffered from severe winters. The ultimate blizzards came in the winters of 1886 and 1887. Cattlemen lost 30% to 80% of their cattle on the Northern Plains. Many turned to ranching and acquired base properties to provide for winter feeding.

[5] *Estimates extrapolated from data reported for 1867 and later years from U.S. Department of Commerce (1975).*

The adjustment was needed to meet the periodic catastrophic conditions imposed by an unpredictable climate, to work out a dependable system of meat production, and to contend with the homesteading of the public lands by farmers. Settlement by farmers remained the basic objective of the nation and Congress, despite the great uncertainties of farming in the semiarid areas of the West (Schlebecker 1963).

The changing organization of grazing did not alter the free use of the open range. The Public Land Commission in 1904 reported overgrazing and ruin of millions of acres of valuable grazing lands because of lack of control. Range vegetation was so seriously reduced in some areas that it induced soil erosion. Stockmen knew and understood the problem. But they had no economic incentive to improve or invest in managing the free range to protect or restore productivity without an assured means of profit. A Public Land Commission had suggested in 1880 that range land be disposed of in huge blocks of 2,560 acres. In 1905, the Commission proposed grazing districts and leasing. Both initiatives failed (Davis 1983, Hibbard 1924).

Several special homestead acts were passed between 1904 and 1916 to encourage transfer of the grazing lands to private ownership. Although the most knowledgeable persons believed the acreages should be at least 2,560 acres or more than 1,000 acres, the largest homestead grants for stock raising were limited to 640 acres. About 100 million acres were transferred to private ownership in this period. Most likely, they were the better lands of the declining area of the public lands which remained available for grazing as open range (Cartensen 1968, Hibbard 1924, U.S. Department of Commerce 1975).

On the forest reserves, created by Presidential Proclamation in 1891, grazing was allowed under a permit system. The area was only 17 million acres in 1891; an additional 21 million acres were proclaimed in 1897. At first, however, it was believed the reserves precluded grazing. That became the initial policy though it was ineffective. Protests of stockmen who did not feel grazing damaged the forests led to the permit system. The Forest Management Act of June 4, 1897 (Stat. 30, 34–36) authorized the management of the reserves to improve and protect the forest, secure favorable conditions of water flow, and furnish a continuous supply of timber. The General Land Office, in 1900, published rules and regulations for issuing permits based on the number of animals the forested range could support consistent with the welfare of both the forest and the cattle. The stockmen accepted the permit system, and in 1905, when the reserves were transferred to the Forest Service for management, grazing fees were introduced. The stockmen objected to the fees for a while. However, the stock fared better under the government restrictions and the permittees soon recognized this advantage as well as the assurance of the grazing privilege (Hibbard 1924, Roth n.d.).

The forest reserves were renamed national forests, and by 1920 their total net area exceeded 150 million acres. In 1915, the Secretary of Agriculture, reporting on the grazing of the forests, stated, "When the regulated system was established the forest ranges, like the open public lands today, rapidly were being impaired. The productivity of the land for forage in most places has been restored and everywhere is increasing; the industry has been made more stable; stock come from the forest in better condition...that the forests have promoted the development of the stock industry...is appreciated by the stockmen and they are urging that a similar system of range regulation be extended to the unreserved public lands" (Hibbard 1924, Roth n.d.). The forested range lands were at the higher elevations, where the climate was generally cooler and moister. For this reason, these lands were probably less damaged than the open range grasslands at the lower elevations with much dryer conditions. They probably responded more effectively to good management for the same reason.

During World War I, beef demand and prices rose sharply. Total stock cattle rose more than 25%, from 40 million to 52 million between 1910 and 1918. The ranges and pastures became more crowded. Stocking levels were increased on all lands. Cattle and sheep numbers on the public ranges—the national forests and the unoccupied public lands—increased sharply, despite the fact that they were still suffering from the impacts of long-term overgrazing. Droughts aggravated the impacts of higher stocking levels. The end of the war drove livestock prices and profits down, and the livestock industry into hard times. As a result, federal land managers were forced to slow down their efforts to reduce range stocking, and thus, the effects of continued overgrazing were extended into the next several decades.

Wildlife and Fisheries in the 1800's

The original fauna of the country included salmon running up the major coastal rivers, elk, and bison in Pennsylvania and Kentucky and across the undisturbed Plains, enormous flocks of passenger pigeons in the old growth hardwood forests of the East and Midwest, wolves and mountain lions in virtually every state, and grizzly bears throughout the Plains and West. Wild turkeys were abundant in the South. Deer were common but probably not abundant. Native Americans used these wildlife and fish for food, fiber, and religious purposes but had only minor local impacts on their populations. Agricultural development, logging, domestic livestock grazing, industrial and urban pollution of waters, heavy harvest of game, and the spatial requirements of the growing population of new settlers and their settlements progressively changed the more or less stable, natural situation for wildlife and fish.

Wildlife and fish populations are inextricably linked to their habitats and change as their habitats change. Severe winters, prolonged drought, diseases, and heavy predator control also influence the location and size of populations.

The conversion of the original eastern forests together with subsistence hunting and efforts to eliminate predators of domestic livestock exterminated wolves and lions from much of the East and Midwest and eliminated

deer, elk, turkeys, and passenger pigeons from many eastern areas. Many nongame birds of the eastern forests also declined. These losses were offset by a boom in farm wildlife. The new habitats that replaced the old growth forests were excellent for rabbits and quail.

Growing industries and urban communities increasingly dumped their wastes into rivers and bays causing declines in salmon runs and resident fisheries. Market hunting decimated many wildlife populations and accelerated the effects of habitat changes that brought the passenger pigeon to extinction. Venison, wild fowl, and other game were staple foods in most American homes throughout the 1800's. Deer haunches and quarters of beef hung together in butcher shops. Prices for braces of ducks, snipe, woodcock, and passenger pigeons were regularly quoted on the financial pages of New York, Boston, and Chicago newspapers (Trefethen 1975).

Settlement across the prairies and plains to the West pushed the bison, elk, wolf, grizzly bear, bighorn sheep, and pronghorn antelope from their original haunts and to critically low population levels. Professional hunters reduced the millions of bison to a few scattered remnant herds by the end of the 1880's. The accelerated slaughter began largely after the Civil War with arrival of the railroads on the prairies and plains, and the need to feed construction workers. The railroads also provided reliable and rapid means to ship bison meat products to the eastern markets. Although there was some public sentiment for preserving some sample bison herds, it was overwhelmed by strategic considerations for the assured orderly settlement of the West and reduction of Plains Indian resistance which depended upon the bison herds. The enormous pressures for settlement, farming, and domestic livestock grazing also left no place for the bison. To save one herd in its natural state would have taken a contiguous area the size of Montana; but no such area remained after 1880 (Trefethen 1975).

Five factors contributed to the steady reduction of the wildlife populations throughout the country in the 19th century: the axe, the cow, the plow, the gun, and hard winters. The deeper, underlying influences were the rapid growth of the American population and its food, fiber, and timber demands, the demand for the cheap or free public lands, the dominant agrarian way of life, good markets for game and wild fowl for food, and the lack of generally effective state or federal constraints on the control of predators or on hunting and taking of wildlife and fish (Trefethen 1975).

Mining Laws for Public and Private Lands

In the 19th Century, the mining of private lands and those owned by state and local governments, including more than 1 billion acres alienated from the public domain, were governed then as today by state laws. They had their origins in the mining laws of the original 13 colonies and England. Mineral rights in general go with the land together with surface rights, water rights, and timber rights. Owners may lease their lands for mining in return for a royalty or other payment form, or sell the land or just the mineral rights separately. This system of state mining law applied to Texas, which joined the Union in 1845 and retained its public lands, to individual land grants made by the Spanish territorial governments in the Southwestern States, and to 44 million acres of public domain assigned to native corporations in Alaska by act of Congress in 1971 (Wilkinson and Anderson 1985).

Congress revised and consolidated the federal mining statutes of 1866 and 1870 under the General Mining Law of 1872. It remains the basic law, as amended, for hard rock mining on public domain lands today.

The 1872 Act provided that public land be open to prospecting unless withdrawn by the President or Congress. Any U.S. citizen or corporation or an individual with declared citizenship intentions could enter public lands and stake a claim upon discovery of a valuable lode or placer deposit covering up to about 20 acres of overlying lands. Any number of claims could be staked as long as each included a "discovery." The unpatented right gave miners "the exclusive right of possession and enjoyment of all the surface" within the claim bounds. Claims could be held indefinitely, as long as some minimum assessment work was done on each claim each year. Miners also had the right to remove minerals without payments to the government and the option of buying the land for a nominal price and receiving a patent in fee upon validation of a valuable mineral discovery.

This liberal law was consistent with the federal policy for opening the West and encouraging settlement as well as with miners' determination that prospecting and mining be left to local rather than federal control. The law was clearly designed for the individual prospector to assure him the rewards of his discoveries. For decades, it became the Interior Department's position that it had no authority to regulate mining or miners and that the Department could do little but issue patents (Cameron 1986, Dorr n.d., Wilkinson and Anderson 1985).

Under the 1872 Act, claims did not have to be recorded with any federal agency. For many years there were no government records of the number or status of claims on public lands. Claims eventually numbered in the millions. Many were staked and sometimes patented to acquire the land for various nonmining purposes such as grazing or recreation. Enforcement of claim requirements were often lax. Assessment work, for example, was never done on many claims. Unless patented, claim boundaries often were not accurately surveyed and locations not tied in exactly with official land surveys. Other frequent difficulties were vague claim notices, overlapping claims, and lost corner stakes. Litigation was the result in many cases (Cameron 1986).

Minerals Development, 1800–1870

From the Revolutionary Period through the Civil War, the principal metals used in the United States were iron, lead, copper, gold, and silver. Westward exploration and settlement led to the discovery of new ore deposits.

Congress provided that the reserved lead-bearing lands should be leased. But administration proved difficult. Beginning in 1829, lead lands and then copper lands were gradually sold. Iron and coal lands were ruled as non-mineral lands. Prices for mineral lands were generally higher than for farmlands. But many such lands were not classified, and fraudulent acquisition was not uncommon.

The Lake Superior iron ores, from which most of the domestic iron production has come, were discovered in 1845. Improved transportation, especially the canals, facilitated shipment of iron ore from the Lake Superior area to the coal-producing regions of Pennsylvania and midwestern states. The development of the steam engine and railroads after 1830 brought an increase in demand for iron. Large scale iron production gradually replaced local ironworks. Pig iron output from anthracite blast furnaces rose from 22,000 tons in 1842 to 393,000 tons in 1856 (Dorr n.d.).

Lead deposits were found in a number of places—southern Missouri, the tri-state area in Missouri, Oklahoma, and Kansas; eastern Tennessee; and the Wisconsin-Illinois area. Copper was discovered in Upper Michigan in the 1840's. The petroleum industry began in Pennsylvania in the late 1850's (Dorr n.d.).

During the first three-quarters of the 19th Century, most of the extensive mineral resources in the eastern United States passed into private ownership under the various laws providing for agricultural settlement and development. That included lead and zinc land in Missouri and Wisconsin, copper mines in Michigan, extensive coal lands in the western slopes of the Appalachian Mountains, and a large share of the iron deposits in Alabama, Michigan, Wisconsin, and Minnesota (Hibbard 1924).

The discovery of gold in California in 1848 led to the location and development of one major mining district after another in the Western States. Silver-ore mining began in Nevada in 1859. As the Gold Rush emerged in California, the need for order in the mining districts became critical. The miners made their own rudimentary mining laws. Their system, based initially on custom, became sanctioned by judicial decisions and eventually was incorporated into state laws. Early federal policy was one of benign neglect. Congress designated mineral lands policy during the 1850's and 1860's. In 1866 and 1870, Congress validated the miners' lode and placer claims, respectively, on public lands. The public domain lands were declared "free and open to exploration...by all citizens of the United States" (Wilkinson and Anderson 1985).

Mineral Production and Use, 1870 to 1920

Mineral use expanded rapidly as agriculture and industrialization continued to grow. The first Bessemer furnace for making steel by blasting air through the metal to remove carbon and other elements began operation in 1865. The open-hearth method which produced higher quality steel was introduced in the late 1860's. Its production surpassed the Bessemer process by 1908. As late as 1886 more than half the U.S. pig iron and steel output was used by the expanding railroad system. Technology to vary steel composition to provide different properties for special uses raised the demand for many mineral commodities which previously were sparsely used, including chromium, nickel, molybdenum, tungsten, fluorspar, and many others (Dorr n.d.).

The opening of the first commercial electric power station in 1880 and rapid electrification by industry and domestic uses after 1900 accelerated the demand for copper. U.S. copper production rose from 30,000 tons in 1880 to 591,000 tons in 1920. The use of lead for storage batteries and cable sheathing accompanied the growth of electricity (Dorr n.d.).

Industrialization, urbanization, and building an infrastructure for the country required enormous amounts of construction materials. Demands for the common nonmetallic minerals rose rapidly—sand, gravel, crushed stone, cutstone, cement, lime, clay, gypsum, and asbestos. Steel and many other metals were also required, especially as steel revolutionized the construction of multistoried buildings and bridge construction (Dorr n.d.).

The production of fossil fuels in terms of physical volume expanded by a factor of 11 between 1870 and 1920. Production in terms of British thermal units (BTU's) went from 1 quadrillion BTU's in 1870 to more than 20 quadrillion in 1920. Coal provided practically all the energy from fossil fuel resources in 1870. Crude oil constituted less than 0.5%. In 1920, coal, mainly bituminous, made up 83% of the fossil fuel energy. Crude oil and natural gas made up only 17%, even though the number of oil and gas wells rose from 15,000 in 1870 to 258,000 in 1920. The use of water power for electricity, which began at the end of the 19th century, added only 3% to the BTU production from fossil fuel resources in 1920 (U.S. Department of Commerce 1975). Fossil fuels not only expanded energy production and use, they also replaced most of the fuelwood use that dominated energy sources in the first half of the 19th Century.

The physical volume of ferrous metal output expanded by a factor of 8 between 1880 and 1920. For all metals the growth factor was 5. Nonmetal minerals output expanded by a factor of 4.5 (U.S. Department of Commerce 1975). Clearly iron and steel and fossil fuels were great technological forces in the industrialization, urbanization, and transportation development in the United States during this period of national growth. Their development added greatly to the wealth of the nation. Their production involved relatively few acres of land. Their contribution to America's productivity in various ways, both direct and indirect, reduced the pressures of a growing population on the land and its renewable resources, especially the timber resource.

Water Resources Planning and Development, 1784–1920

The Period 1784–1870

Early water resources planning focused on inland and coastwise transportation. In 1784, for example, George Washington helped establish the Potowmack Canal

Company to build a canal with several locks so barges could bypass the Great Falls of the Potomac River above Washington. The canal provided a water route from the coast to the farms and settlements in the hinterlands. It was used from 1802 to 1830, when the Chesapeake and Ohio Canal was opened on the Maryland side of the river. Similar canals were planned for the James, Susquehanna, Delaware, Mohawk, and other rivers. Private companies were favored to build them. Private capital, however, was too limited to complete many of the planned facilities and led to efforts to get federal assistance for river improvement works (American Public Works Association 1976, Linsley 1979, Schad 1979, Weber 1979).

The issue of federal funding for canals was debated often in early Congress. Federal funds were approved in 1806 to build a National Pike to link the undeveloped areas of the Northwest Territories beyond the Appalachians with turnpikes being built from Washington to Baltimore. Federal assistance for canals, however, foundered on a continuing constitutional dispute between "national" proponents and strict constructionists. This deadlock was resolved by the Supreme Court in 1824 in the famous Gibbons vs. Ogden case. Chief Justice John Marshall, who decided the case, ruled that Congress's constitutional power to regulate interstate commerce included power over navigation "within the limits of every state in the Union so far as that navigation may be in any manner connected with commerce..." (Linsley 1979, Schad 1979, U.S. Department of Agriculture 1972, Weber 1979).

The dispute about federal funds for waterways improvement did not preclude planning for canals. The Secretary of Treasury, Albert Gallatin, was directed by Congress to prepare a Report on Roads and Canals which was delivered in 1808. It can be viewed as the first comprehensive water resource development plan in the United States. It covered canals to facilitate inland navigation along the Atlantic coast from Massachusetts to North Carolina; canal systems for four rivers draining into the Atlantic, including turnpikes from their headwaters and across the Appalachians to four western rivers; and canals linking the Hudson River to Lake Champlain and Lake Ontario and around the Niagara's falls and rapids to open a water route from the Great Lakes to the Atlantic Seaboard. John C. Calhoun drew up similar plans after the War of 1812. By 1816, however, there were only 100 miles of canals despite their advantages of cheaper and faster transportation (Burges 1979, Linsley 1979, Schad 1979, Weber 1979).

The famous Erie Canal was started in 1817 and completed in 1825. The 363-mile system cost $17 million and earned $500,000 in its first year of operation. Its success accelerated canal building in other states. By 1830, there were 1,300 miles of canals, and by 1840, there were 3,300 miles in use. Few had the economic potential of the Erie Canal. By 1850, most canals that could have been built with private and state funds had been constructed (Burges 1979). Public and private spending for canal construction from 1815 to 1860 totalled almost $200 million; 62% was expended on purely public projects, including major state construction in New York, Ohio, and Pennsylvania; an additional 8% made up the public share of cooperative efforts; and the remaining 30% was privately financed (American Public Works Association 1976).

The passage of the General Survey Act in 1824 (repealed in 1838) marked the beginning of the Army Corps of Engineers' systematic role as the engineering arm of the federal government in water resources planning and development, mainly because it was the only agency in the United States with the required capabilities. The Survey Act authorized the Corps to make survey plans and estimates for roads and canals of national importance. Corps planning and improvement for rivers and harbors was initiated by separate legislation in 1814 for the improvement of the Ohio and Mississippi Rivers, and subsequently extended by periodic omnibus Rivers and Harbors Acts authorizing specific ad hoc improvements and surveys, the first of which was passed in 1826 (U.S. Department of Agriculture 1972).

Flood control remained largely a state and local concern through the first half of the 19th century. National interest emerged as settlement and development grew in the flood-prone lower Mississippi River. In 1849 and 1850, Congress sought to encourage state efforts for flood control through the Swamp Land Acts. The acts granted federal lands subject to flooding in Arkansas, Louisiana, Mississippi, and Missouri to those states with the condition that funds from their sale would be used for flood protection and to reclaim floodlands for cultivation. The acts generally failed in this purpose, but they may have helped establish many of the levee districts and flood control districts which later facilitated joint federal and state/local efforts to control flooding on the Mississippi. In the 1850's and 1860's, the Corps of Engineers surveyed the flood problem of the Mississippi in response to congressional direction. The Corps reported on a need for extensive levees, but their costs exceeded the financial means of the states and local communities. Proposals for federal financing failed in part because of post-Civil War sectionalism (U.S. Department of Agriculture 1972, Weber 1979).

The 1870–1920 Period

The expansion of railroads after 1840 greatly reduced the cost and increased the speed of overland transport for people and goods. Most canals lost their profitability and many were abandoned (Weber 1979).

Congressionally-directed river and harbor improvement projects increased greatly after the Civil War. State and local demands became the source of many of these projects. The authority for deciding whether a project was worth improving was the sole responsibility of Congress, although after 1884, Congress required a Corps district engineer's preliminary assessment, as to whether "said harbor or river is worthy of improvement." In 1902, a national Board of Engineers for Rivers and Harbors was established to review preliminary examinations, surveys, projects or project changes, and evaluate the commercial potential of the proposed improvements

in relation to their cost of construction and maintenance. The Board provided the Corps of Engineers a means for culling infeasible projects and reducing congressional endorsement of unsound proposals (U.S. Department of Agriculture 1972).

Toll charges for watercraft passing through navigational improvement projects were prohibited by federal policy. This policy had its roots in the Northwest Ordinance and the acts admitting new states to the Union. Shippers could not be charged for passage through navigable waters; they were "common highways and forever free" (U.S. Department of Agriculture 1972).

A clear federal role in flood control did not begin to develop until 1874, when Congress, after a disastrous flood, appointed a commission to prepare a permanent plan to reclaim those parts of the Mississippi Valley subject to flooding. The commission's report presented alternative methods of control and a severe critique of the uncoordinated and ineffective local levee systems. In 1879, those findings led a Mississippi River Commission, including three Corps members, three civilians, and a U.S. Geological Survey representative, to survey the river and prepare a plan to improve navigation and prevent floods. Funding, however, remained limited to channel improvement for navigation and prohibited spending for levees. A similar group led by the Corps was set up in 1893 to develop plans to prevent flooding and protect navigability for the Sacremento and San Joaquin Rivers. After major floods in 1915 and 1916, these initiatives were reinforced by the Flood Control Act of 1917 giving the Corps authority for both planning and constructing flood control works on the Mississippi and Sacremento Rivers. The Act also extended the Rivers and Harbors Board review authority over plans and expenditures to flood control works. It also provided that at least one-half of the costs of levee construction be covered by benefitting states and localities (U.S. Department of Agriculture 1972).

States continued to have a primary role in flood control. Their efforts had varied results. The best were exemplified in Ohio by the establishment of the Miami Conservancy District, after catastrophic flooding that took hundreds of lives and caused damage totaling millions of dollars in 1913, to obtain overall flood protection for the entire Miami Valley. The citizens' charge was expressed this way, "The valley has suffered a calamity that must not be allowed to occur again. Find a way out." A comprehensive unprecedented systems approach was taken covering the entire valley basin. The design went beyond the conventional wisdom of the day in which flood control was based on levee construction and channel improvements. It also included dams and retarding basins. The results were exemplary and so effective that flooding never again became a problem after the system was implemented (Burges 1979, U.S. Department of Agriculture 1972).

Federal interest in water power development and irrigation also emerged in the late 19th century. In 1879 and thereafter, Congress passed special laws authorizing either the leasing of water power or "surplus water" to private companies by the Secretary of War, or the construction of private power dams. The Carey Act in 1894 provided for grants to states with public domain lands for reclamation purposes. An appreciation of the role of forest cover for flood prevention and the protection of water supplies and stream flow (watersheds) also emerged toward the end of the 19th century. It was epitomized in the 1891 legislation authorizing the President to establish forest reserves. That legislation was partly motivated by flood control concerns as reflected among its stated objectives "for the protection of water flows." The main objective, however, was timber conservation (U.S. Department of Agriculture 1972).

Multipurpose water resource planning after 1900 became a widely supported new expectation and goal for a sound and rational approach to water resources development. It was an expression and aspiration of the conservation movement of that time. It was also linked to an apparent need for more widespread and successful settlement of the West, the dispersal and growth of the American population, economic development of the western resources, and integration of the regional economics of the Nation (American Public Works Association 1976).

The 1908 report of the Inland Waterway Commission, appointed by President Theodore Roosevelt, defined the multipurpose concept clearly. It recommended that federal rivers and harbors improvement reports reflect all the water uses that could benefit from proposed projects including flood control, water power, irrigation, and even pollution control as it affected navigation. The commission also proposed that both local and national benefits be taken into account "with a view to equitable distribution of costs and benefits." It also called for a National Waterways Commission to coordinate the efforts of the Corps of Engineers, Reclamation Service, U.S. Department of Agriculture, Bureau of Corporations, and other federal agencies making multipurpose plans for waterways, in cooperation with state and local governments. The National Conservation Commission, appointed by President Roosevelt, urged similar multipurpose planning for waterway improvements in 1909, as did the joint Congressional National Waterways Commission Report in 1912.

Legislation for a multipurpose water resource planning agency, a waterways commission, originally proposed in 1907, was passed in 1917. Its members, however, were never appointed, and in 1920, the law providing for the commission was repealed by the Federal Water Power Act (U.S. Department of Agriculture 1972). This act provided for federal power development and authorized the Federal Power Commission to engage in comprehensive broad water resources planning.

THE RISE OF CONSERVATION AND LAND MANAGEMENT BY THE FEDERAL GOVERNMENT

Early Awareness of Resource and Conservation Problems and Needs

Starting in the colonial days, there emerged a recognition and concern that farming often produced conditions that led to soil erosion, loss of productivity, and offsite

damages to streams. Those perceptions and concerns, however, were limited to a relatively few educated farmers and leaders all through colonial times and until after the Civil War. The early leaders—Jared Eliot (1685–1763), Samuel Deane (1733–1814), Solomon Drown (1753–1834), John Taylor (1753–1824), John Lorain (1764–1819), Isaac Hill (1789–1851), Nicholas Sorsby (mid 19th Century), Edmund Ruffin (1794–1865), and others—recognized that soil erosion was a basic problem in farm production; it reduced productivity and led to impoverishment of the soil and the farm family who tried to remain on the same land (McDonald 1941). National leaders such as Thomas Jefferson and George Washington shared the interests and concerns of this group (Rasmussen 1974, 1981).

These leaders appeared in all the original colonies and states. They experimented with soil cultivation and erosion, published their findings and recommendations and shared their views with neighbors and many interested groups. Their efforts to prevent soil depletion were successful on their own farms. They explained erosion and its causes including wind erosion and gullying, the use of drainage and ditches, the effects of plowing, and the advantages of contour plowing. They knew the importance of organic materials, manuring, soil-building crops, and crop rotations in preventing erosion and maintaining fertility. They advocated the liberal use of lime, or marl as it was known then. They understood the agronomic and economic consequences of erosion and its effects on stream sedimentation and flooding (McDonald 1941).

To raise interest in soil erosion and agriculture, many of the leaders advocated and supported the establishment of agricultural societies and organizations and wider distribution of books, pamphlets, and farm journals on agriculture. The scientific societies, such as the American Philosophical Society and the American Academy of Arts and Science, were organized early. The agricultural societies followed. The first, the Philadelphia Society for Promoting Agriculture, was established in 1785. The South Carolina Society for Promoting and Improving Agriculture and Other Rural Concerns came later in the same year. More followed in other states. Their members were professional men who could afford to experiment and to use and adapt innovations from abroad. The agricultural societies focused on the best solutions for problems of broad importance and awarded premiums. Although they were real pioneers in advancing agricultural knowledge, they appear to have had little direct influence on the mass of small farmers (Rasmussen 1974).

Farm journals were developed for regular distribution to practicing farmers. County level organizations sponsored fairs for the mass of farm people. States supported these organizations with grants. The fairs focused on premiums for exhibits of better looking crops and fatter animals, particularly in New England (Rasmussen 1974).

Some progress was made before the Civil War in improving farming methods and erosion control. Ruffin's efforts eventually popularized the use of marl and other improvements. However, the outbreak of the Civil War, westward expansion and the economic pressures of commercial agricultural after the war diverted attention from soil erosion and its control for almost 75 years. The early leaders for improved farm practices were too few, the incentives for the huge mass of farmers too weak, and the alternative opportunities to settle new lands too strong to form any strong consensus for soil conservation in the farming community or the growing urban population. The great pressure after 1860 was to settle the public domain and encourage economic development through agricultural expansion on the western lands (Rasmussen 1981, Roth n.d.).

The federal interest in agriculture beyond the settlement policy was first reflected in the U.S. Census in 1840. It was the first census to collect agricultural information. One year earlier, Congress appropriated $1,000 for the Patent Office to establish a program to collect and distribute seeds and plants. The interest within the States in advancing agriculture appears to have been somewhat stronger. Michigan and Pennsylvania established state agricultural colleges in 1855, Maryland in 1856, and Iowa in 1858. A movement for federal aid to do more had been underway for 20 years (Rasmussen 1974).

Before 1860, the concern for the forest resources was limited to early federal action to reserve live oak trees for naval construction, sporadic efforts at tree planting, and fears of a fuelwood supply crisis, particularly in towns and cities of the Northeast, as firewood became more expensive. Among rural residents and farmers who made up most of the population and usually had woodlots of their own, there appears to have been little concern. For the settlers, the dense forests were an obstacle to farming and a difficult task to clear. Lumber supplies were abundant. The timber resource still seemed virtually endless. The center of the commercial lumber industry remained in the Northeast with New York still the leading producer in the 1850's. Lumber production was largely a local activity dependent upon thousands of small mills with small outputs (Davis 1983).

The grasslands of the West were still unimportant in 1860, except in Texas. Grazing livestock was largely a frontier activity permitted freely on the public domain. Cattle raising interests appeared to focus largely on improving their stock.

Formation of the Department of Agriculture and Land Grant College System

The year 1862 marked the beginning of the U.S. Department of Agriculture and the Land Grant College System. They were to play an increasing role in improving the management and productivity of agriculture and forestry. The Department was established in 1862 with a commissioner responsible to the President. Its objectives were to collect and distribute useful agricultural information; introduce valuable plants and animals; respond to farmers' inquiries; test farm implements; do research on soils, grains, fruits, plants, vegetables, and manure; provide instruction in botany and entomology; and establish a library (Baker et al. 1963). In the same

year, Congress authorized land grants to states and the use of revenues from the sale of grant lands to establish and support a college in each state to teach subjects related to agriculture and the mechanical arts. Although both institutions were criticized in their developmental phases, their capability and services became increasingly recognized.

Some of the early work of the Department improved control methods for animal diseases and led to the establishment of a Bureau of Animal Industry with regulatory powers for animal disease control by 1884. In 1887, Congress passed the Hatch Act which provided grants to the State Land Grant Colleges through the Department to establish agricultural experiment stations. This linked the Department closely with the stations and colleges, expanded the research capability, and brought system and direction to the colleges for their future development (Baker et al. 1963). The experiment stations earned the support of farmers because their research provided useful, practicable results that added to productivity and farm earnings. That included soils analysis, fertilizer recommendations, ways to control plant and animal diseases, and marketing aids. In 1889, after a long period of debate, Congress elevated the Department to Cabinet status.

Both the Department and Land Grant Colleges sought ways to accelerate the transfer and adoption of their research results. The college faculties and researchers emphasized farmer institutes, lecture tours, short courses, instruction at fairs, and publications. The Department emphasized ways to reach the farmers by working more directly through their local organizations and offering on-farm demonstrations. Both were concerned that the results of research were not reaching all farmers and making their maximum contribution to productivity. Not all results were always practicable. But many were successful and contributed to the control of animal pests such as the cattle ticks, reduction of boll weevil damages, some new crops, improved seeds, and better soil cultivation practices. Overall increases in crop and livestock yields, however, remained relatively small (Jenkins 1980).

Concern for more effective transfer of research findings and a more productive agriculture led to the passage of the Smith-Lever Act in 1914 for the organization of the Cooperative Federal-State Extension System at each of the Land Grant Colleges. This linked agricultural research with education of the local farmers in each county. The system was supported by federal matching grant funds to the states. Although the colleges thought differently at first, they agreed to design the system based on the Department's local project and local resident agent approach to the transfer of research findings and technology to local farmers.

The period of 1914 to 1920 was one of organizational development of the Extension System at the county and state level throughout the rural United States. It was also a period of growth in public awareness and acceptance of the system and its structure. Because of the timing, a large part of the early extension effort was devoted to the narrow aim of drastically increasing food and fiber production to meet the demands of the war. Agents also found time to teach vaccination of hogs against cholera and to find ways to offset labor shortages, preserve foods, cull livestock, and locate good quality horses and mules. They also assisted liberty loan programs, draft boards, and Red Cross drives. By the end of 1920, the Cooperative Extension Service had a visible national organization. U.S. agriculture had a highly coordinated research, education, and extension system to develop new technology to raise output per farmer and per acre and a way to transfer it quickly and effectively to local farmers in all parts of the nation (Jenkins 1980).

Forestry also was getting a start in the Department of Agriculture. In 1876, the American Association for the Advancement of Science and the American Forestry Association proposed, and Congress authorized, the position of federal forest agent within the Department. Franklin Hough, who, as superintendent of the 1870 Census, had developed a growing concern for timber supplies, became the first appointee. His assignment was to study timber needs and supplies, ways to preserve and renew forests, and their influence on climate. His work led to the formation of a Division of Forestry in 1886 and then a Bureau in 1887. Bernard Fernow, a well-trained German forester, succeeded Nathaniel Eggleston who held the position briefly after Hough. Fernow lectured and published a wealth of material about the problems, needs, and objectives of professional forestry as well as appropriate procedures for harvesting timber. He also encouraged constructive management of the forest reserves established in 1891. His efforts, and those of a few other trained foresters, helped to expand appreciation for European approaches to forest management among the late 19th century conservation movement leaders, who were focussing attention on the public forest lands (Davis 1983, Gates 1968).

Gifford Pinchot, who was to become the renowned leader of the conservation movement, succeeded Fernow as Chief of the Bureau of Forestry in 1898. A skilled administrator, well-trained in forestry, he expanded the forestry staff severalfold and developed cooperative forest management and reforestation programs with many timber companies. He also extended the research program from timber physics to the study of the forest itself. At the same time, he campaigned strongly for the conservation movement and encouraged the transfer of the forest reserves to the Department of Agriculture. That transfer came in 1905, and the Bureau, in the same year, became the Forest Service, emphasizing a service commitment to the public. In 1907, the forest reserves were renamed national forests to signal that their resources were to be managed for the use of all the American people (Davis 1983).

The Emergence of Forestry at the State Level

The first efforts for professional forestry education began with forestry lectures in the 1870's at Cornell University, the University of Michigan, and other colleges, usually in departments of botany or horticulture.

The courses emphasized tree planting and the agricultural aspects of forestry. The first 4-year curriculum in forestry was established by the State of New York, in 1898, at Cornell University. Yale University founded a professional forestry curriculum in 1900, the same year that the Society of American Foresters was formed. Other schools soon followed (Davis 1983).

The first efforts to apply forestry on a large property, as practiced in Europe, began in 1892, when George Vanderbilt hired Gifford Pinchot to manage the extensive forests on his 100,000-acre Biltmore Estate in the mountains of North Carolina. Although this effort to apply silviculture proved unprofitable, it marked the beginning of professional forestry practice in the United States. Now a part of the national forests in North Carolina, the Biltmore forests are commemorated as "The Cradle of American Forestry" (Davis 1983).

In 1885, California and New York were among the first four states to establish state forestry programs. They responded to farmer concerns about water supply, lumbermen concerns about losses of valuable timber from fire, politicians wanting to safeguard their states' economic base, and private citizens concerns for conserving forest resources. Ohio and Colorado also formed forestry agencies in 1885. These and other early state forestry agencies remained small. Only New York, among the first four, had uninterrupted development. The young state forestry agencies received a welcome boost from the Weeks Act of 1911, which provided federal grants up to $10,000 for qualified state forest protection programs (Davis 1983).

The Conservation Movement

The conservation movement of the late 19th and early 20th centuries emerged from growing national concerns about the condition and trend of natural resources and particularly, the disposition of the remaining public lands. The resources and interests included the forests, their waters and watersheds, wildlife and fisheries, aesthetic values, recreation opportunities, the rangelands, and soil. Each of these interests had their own supporters and often the support of the users—irrigators, graziers, lumbermen, and sportsmen. These groups frequently found mutual or complementary objectives and often combined their support for selected public initiatives at both federal and state levels. Their goals ranged from resource preservation to wise use over time and the maintenance of economic opportunity. Although the wise use theme came to dominate the movement, it did not suppress the interests in preservation or economic opportunity.

The efforts of the various interests in the conservation movement were epitomized in the reservation of public lands, legislation and programs for resource protection and management, regulation of hunting, and preservation of parklands, natural monuments, and historic sites. These actions slowed the conversion and utilization of resources of public domain lands and helped to reverse downward trends in resource conditions and productivity. The results came slowly, but perceptively, even though they did not bring ideal use and management to all resources on all lands.

Establishment of Federal Reserves

The movement to reserve public lands from private development and retain them under federal ownership and management emerged from first sporadic, then converging and sometimes conflicting interests in aesthetic preservation and conservation of resources in the utilitarian sense of wise use. Congress had been reserving areas of the public domain since the Ordinance of 1785. However, there was no general policy objective for reserves. Thus, the origin of federal reserves did not have a sharp resource-oriented policy beginning or path (Clawson 1964).

National Parks

Reserves for park purposes were among the notable early actions. Congressional interests in lands of extraordinary beauty and uniqueness led to setting aside four sections of the Hot Springs of Arkansas in 1832 which later became the Hot Springs National Park. In 1864, Congress granted the State of California lands that eventually became the Yosemite National Park for "public use, resort and recreation." Then, in 1872, the Yellowstone Park Reserve of 2.2 million acres was established "as a park or pleasuring ground for the benefit and enjoyment of the people." The act creating the park also gave the Secretary of the Interior the authority to manage the park reserves. This was long before those lands could be accessed and widely used by the American people. Three more parks were established by 1900, bringing park area to more than 4 million acres. In 1916, the National Park Service was established and the concept of a system of national parks defined. That system included the national monuments, which were authorized in 1906 to preserve prehistoric and historic sites and relics, geologic spectacles, botanical reserves, and wild animal reservations. By 1920, the parks and monuments with bird and game reserves totalled almost 9 million acres (Davis 1983, Gates 1968, Hibbard 1924).

State Parks

The concept of state parks did not emerge formally until the end of the 19th century. States had reserved forests and other areas for various purposes; but, the best claim to the first full-fledged state park is attributed to the Niagara State Reservation at the falls of the Niagara River established in 1885. In that same year, New York State also established the Adirondack and Catskill State Parks encompassing 2.25 million acres of state and private lands. The state lands were declared a wilderness preserve to remain "forever wild." Congress had authorized and California had accepted the grant of Yosemite Valley and the nearby Mariposa Grove of giant sequoias in 1866 as a state park; but, those lands were

receded to the federal government in 1906 and became the Yosemite National Park.

About 1900, more states began to set aside historic, scenic, and recreational areas for park purposes. Mount Greylock was established in Massachusetts in 1898. Minnesota acquired two parks in 1893, Birch Coulee, a Sioux battleground, and Itasca at the headwaters of the Mississippi. The Palisades Interstate Park was established along the lower Hudson River in 1895. California initiated Big Basin Redwoods State Park in 1900.

Such initiatives, the formation of the National Park System and activities of nature advocates and outdoor interests, gave momentum to efforts on behalf of state and local parks. A nationwide campaign slowly emerged under the general leadership of Stephen T. Mather, the first director of the National Park Service. With the support of the Secretary of the Interior and the Governor of Iowa, he was able to convene a National Conference on State Parks in Des Moines in 1921. Two hundred representatives—mostly private citizens—participated from 25 states. The success of the Conference established it as a permanent organization. The area of state parks at that time was just a few million acres in a few states with the bulk of the acreage concentrated in New York State.

Water Power and Reservoir Sites

Authority was provided as early as 1879 to reserve land for access to potential water power. However, there were relatively few reservations, most of which were being developed by private companies. In 1910, because of complications with reservoir sites, new legislation was passed that accelerated the rate of federal reservation of both power and reservoir sites. By 1920, about 5 million acres had been reserved. They retained a vast capacity for power and water storage in the hands of the federal government. However, no comprehensive plans had been made for development of these sites (Hibbard 1924).

Reclamation Reserves

By 1900, the slow progress in irrigation and desert land reclamation made it clear that private initiatives and land grants to states for reclamation through large impoundments and water diversion projects were not working well. Basically, the costs were too great for homesteaders to repay fully. Irrigation interests had opposed creation of federal reserves for reclaimable lands. In 1902, however, they supported the Newlands Act, which authorized the Secretary of the Interior to locate, construct, operate, and maintain projects to store, divert, and develop water for reclamation. The Department of the Interior established the Reclamation Service for these purposes. It was a new departure in public land policy. The act authorized the federal government to make land useable where and when it was not profitable for the private sector to do so. In the next 20 years, 26 projects were undertaken at a cost of $135 million. Only about 1 million acres were irrigated and patented for crop production by 1920. Much speculation was involved in the lands to be irrigated. Settlers who homesteaded lands to be reclaimed found irrigation came more slowly than expected; they suffered from droughts and were largely unable to pay for the lands on the anticipated short schedule. Reclamation was a new and expensive experience for the federal government. Progress was slow, troubled, and difficult. There were 16 million acres in reclamation reserves but the reclamation program in 1920 fell far short of its hope and promise for both government and the settlers (Gates 1968, Hibbard 1924).

Forest Reserves

The forest reserves were first proclaimed in 1891 and expanded very rapidly, reaching 161 million acres by 1920. They were the single largest segment of the public lands withdrawn for federal ownership and management, making up almost 60% of all federal reserves in 1920. They were the outcome of a campaign to assure long-term timber supplies from public lands (Hibbard 1924).

Concern for timber supplies was being expressed publicly as early as 1849 when the Commissioner of Patents addressed "the waste of valuable timber in the United States" in his 1849 annual report. Similar views and articles followed in the 1850's and 1860's (Davis 1983). There were efforts to encourage tree planting such as Arbor Day, first observed in Nebraska in 1872. In 1873, the Timber Culture Act offered 160 acres to homesteaders who would plant 40 acres of trees. The act failed in its purpose and was repealed in 1891. In the 1870's there was a growing fear that the depletion of white pine in the Northeast and Lake States would lead to use of inferior southern or West Coast species. This was evidenced by rising prices and the expectation of even higher prices because of costs of shipment from other regions. The American Forestry Association was organized in 1875 and sponsored national forestry conferences. Some state forestry societies, commissions, and boards of forestry were organized, and many accounts were written of wasteful and destructive timber harvesting on public lands (Gates 1968).

Before 1878, there were no specific authorities for private acquisition of public domain timber. Nevertheless, much timberland was moving into private hands through the Preemption Act of 1841, the Homestead Act, Presidential proclamations offering timberland for sale to the highest bidder, and some theft. In the 1870's and 1880's, the Department of the Interior sought legislation to manage public timberlands. But, in 1878, Congress in several ways actually liberalized private access and timber cutting on public domain lands not suitable for homesteading in the far western states (Gates 1968, Hibbard 1924).

The Report of the Forests of North America, a part of the Census of 1880, advised that the remaining white pine in the Lakes States would be exhausted in 11 to 12 years at the existing rates of harvest. Although discredited by trade journals, the report influenced prices and helped amplify the growing concern about timber supplies (Gates 1968).

As a result of the growing concern about timber supplies and the initiative of a few leaders concerned about the use of public forests, Congress, in a late-night conference, inserted an amendment to an 1891 land bill authorizing the President to reserve forest lands, but did not include any provisions for their management. Although this authorization had not been previously discussed, Congress passed the land bill the next and last day before adjournment based only on a reading of that amendment. President Harrison soon reserved 11 million acres, and in 1897 President Cleveland, at the end of his term, set aside additional lands which more than doubled the forest reserve area.

There was a strong outcry, particularly from western interests and western Congressmen. Mining, grazing, and other uses were not permitted on the reserves. This prohibition was reversed when a new Congress, responding to this western issue, passed the 1897 Organic Act providing for the use and management of the reserves. The act removed the prohibition and permitted grazing, mining, and other uses. It also granted miners free access to the timber and stone needed for their operations.

In 1905, when the administration of the reserves was transferred from the Department of the Interior to the Department of Agriculture under the Forest Service, Congress provided that minerals management remain with Interior. The Forest Service, however, instituted regulations to restrict the use and occupancy of remaining claims to those activities necessary for working the claim. These regulations responded to widespread abuses of the mining laws for nonmining purposes. It did not try to regulate valid prospecting or mining activity (Wilkinson and Anderson 1985).

Support for expanding the forest reserves remained tenuous. Congress, concerned about further additions, passed a law in 1907 requiring Congressional review and approval of reserve proclamations. However, President Theodore Roosevelt, a strong supporter of the conservation movement, who shared the interests of Gifford Pinchot and other leaders of the movement, reserved even more areas before signing this bill into law in that year.

President Roosevelt issued 17 proclamations at that time, affecting national forests in Arizona, California, New Mexico, Nevada, and Utah. The papers and maps describing the affected areas, as well as draft proclamations, had been developed by the Forest Service earlier in the year. To obtain the Chief Forester's approval and acceptance for the proposed proclamations before he left for an extended absence, the Forest Service Chief of Boundaries, Arthur C. Ringland, travelled to Lansing, Michigan at the end of May 1897 to meet with Gifford Pinchot. Pinchot was there to receive an honorary degree from Michigan State College. Ringland recalls this dramatic meeting with Pinchot in this way:

> ...I carried these papers, maps and descriptions in a golf bag that I kept with me even in my pullman berth during the trip. Upon arrival at the Hotel Downey, Mr. Pinchot's sitting room was cleared of furniture and the maps spread on the floor. We took off our shoes, rolled up our trousers, and in stocking feet crawled all over the maps with Mr. Pinchot carrying a heavy blue pencil in his hand. With this pencil, he indicated the areas to be included in the proclamation.
>
> When Mr. Pinchot had made his final determinations, I immediately carried the papers back to Washington where the Boundaries staff prepared them for signature and proclamation by President Roosevelt.[6]

In 1911, Congress expanded the authority to add to the reserves, or national forests as they were renamed in 1907. The Weeks Act of 1911 authorized the Forest Service to acquire and manage forests on the head waters of navigable streams. The same act gave consent to states to form interstate compacts to conserve forests and water supplies and authorized annual incentive grants to states with qualifying programs to protect forested watersheds from wildfires. The act was addressed essentially to the eastern states, where forestlands were almost entirely in private ownership. It responded to a growing concern in the East about the influence of deforested lands on periodic flooding of cities and towns, the loss of scenic areas to the recreation industry, and the general reduction of the original forest inventory. By 1923, 1.6 million acres had been purchased in three or four eastern states. Many more million acres were being identified and studied for acquisition in other states (Davis 1983, Gates 1968, Hibbard 1924).

Mineral Reserves

Efforts were made during the 1800's to control the development of mineral resources on public lands, but little progress occurred before 1905. Most of the earlier focus was on coal lands. They were not subject to the General Mineral Law of 1872, and demand for coal was rising rapidly in the latter part of the 19th and early 20th Centuries. Congress first provided for disposal of coal lands in 1864 by authorizing a minimum sale price of $25 per acre. In 1873, the price was reduced to $10 per acre for coal lands farther than 15 miles from a railroad, and to $15 an acre for those that were closer. A total of 603,006 acres were sold between 1873 and 1923 at a total price of $11.9 million (Hibbard 1924).

In the latter part of the 19th Century, recognition of the importance and value of coal lands increased. Issues arose about withdrawing them from entry and excluding them from agricultural entry. When the Geological Survey, established in 1879, found after 1900 that large areas of valuable coal lands in the West had been acquired through agricultural entries, the President undertook decisive action. He directed the Secretary of Interior to withdraw all such valuable coal lands from entry for proper examination and classification. In 1906 and 1907, 66 million acres which were presumed to hold coal deposits were withdrawn by proclamation. Millions

[6]*Interview of Arthur C. Ringland conducted by Amelia Fry, University of California Oral History Office on November 25, 1953. In: National Forest Additions by Presidential Proclamation. Berkeley, CA: Harris Collingwood Library of Congress. Appendix.*

of these acres, however, were soon determined to have no coal and were returned for agricultural entry. Others were appraised for their coal deposits and some were sold for $75 to $100 an acre between 1906 and 1909 without any change in the existing law. It was interpreted that the legislated "not less than" price did not define a ceiling price. But the issue remained as to what to do with the surface rights of the retained coal land withdrawals which were also valuable for farming.

Congress resolved this issue in 1910 with legislation permitting entry of coal lands for farming while reserving the government right to dispose of the coal separately. Settlers holding surface rights were protected against losses from the discovery and removal of coal by reimbursement for their loss. They were also permitted to dig coal for their own use.

The Withdrawal Act of 1910 provided for the withdrawal of other minerals, such as oil, gas, nitrate, phosphate, potash, and asphaltic minerals, as well as coal (many acres of which had previously been withdrawn from entry by proclamation). At the end of the Taft Administration in 1913, most of the mineral resources on the public domain were completely locked up. Leasing of mineral withdrawals was first authorized for the development of coal lands in Alaska in 1914 and for potassium deposits in 1917. Federal leasing became the general policy for fuel and fertilizer minerals on withdrawn public lands under the Minerals Leasing Act of 1920. Awards for mineral leases were based on competitive bidding or as the Secretary of Interior directed. The Secretary of the Interior also was authorized to attach conditions to the leases to protect public resources and the public interest. This provision essentially restricted the miners' previously unqualified access to fuel and fertilizer minerals on the federal lands.

Between 1920 and 1923, 26,036 lease applications were filed in 22 states under the Mining Leasing Act. At that time, there were almost 2.5 million acres of phosphate land and 6.4 million acres of oil land withdrawals in addition to the 34 million acres of coal land withdrawals (Hibbard 1924, Robbins 1956, Wilkinson and Anderson 1985).

Wildlife Management Development in the Late 19th and Early 20th Centuries

Before the Civil War, efforts of organized sportsmen from larger towns and cities, a few scientists, and fewer nature enthusiasts produced laws in most states for closed seasons for various game species. They were generally ineffective. Rural counties and towns where the game was found exempted themselves from the state laws. Effective local or state enforcement was lacking.

The concept for central authority for management of fish and wildlife only emerged after the Civil War when Congress, in 1871, set up the U.S. Fisheries Commission and charged it with rehabilitating depleted fisheries. By 1880, almost all states had followed suit and in 1910, nearly every state had some type of agency responsible for protecting its wildlife and replenishing fisheries. Most were poorly funded and their performance varied widely. Nevertheless, raising game fish in hatcheries and stocking ponds, lakes, and streams was widely successful even though it was limited. That success encouraged experimentation in stocking game birds. The greatest early success was with the Chinese ringnecked pheasant, first introduced in Oregon in 1881. By 1900, that success was repeated throughout the Northern United States from coast to coast (Trefethen 1975).

In the late 1800's and early 1900's, state wildlife agencies focused management efforts on small game birds and mammals. There was little big game to manage, except mule deer in the Rockies. Only the bison, protected on national parks and federal refuges, appeared to have an assured survival with the help of an intensive federal management program. The appearance of a sudden and large improvement in the white-tailed deer population in the Northeast provided much hope for wildlife managers. The return of the deer was associated with the net abandonment of pastures and croplands in the 1880's and their reversion to young forest cover. Wildlife managers took advantage of the returning habitat to restore deer throughout the Northeast (Trefethen 1975).

In 1896, Congress created the Division of Biological Survey in the Department of Agriculture by reorganizing and expanding the Division of Economic Ornithology and Mammalogy. Its work included the study of bird distribution and food habitats as they related to agriculture and biological surveys of mammals. The Division gained Bureau status in 1905 and remained with Agriculture until it was transferred to the Department of Interior in 1939 (Davis 1983, Trefethen 1975).

The control of hunting, licensing of hunters, and laws relating to wildlife conservation began to improve notably after 1900. Congress brought the federal government into the wildlife conservation picture with the passage of the Lacey Game and Wild Birds Preservation and Disposition Act in 1900. It made interstate shipment of wild birds and animals and their products taken in violation of state laws a federal offense. In 1913, the passage of the Migratory Bird Act and legislation authorizing the President to enter into international agreements to protect migratory birds brought federal protection and management to migratory fowl. It authorized the Secretary of Agriculture to fix closed seasons when it would be illegal to kill or capture migratory birds. The Treaty between the United States and Great Britain for the Protection of Migratory Birds in the United States and Canada was signed in 1916 (Trefethen 1975).

In these ways the impacts of market hunting and unregulated hunting for food and wildlife products were reduced. It was the result of the wildlife conservation efforts that paralleled the conservation movement which had centered largely on the forests. The influence of a number of early leaders including George Perkins Marsh, an early leader and writer on scientific principles for wildlife resource use and management; George Bird Grinnell, longtime editor of Forest and Stream magazine; Theodore Roosevelt as conservationist, Governor, and

President; and Senator John F. Lacey successfully brought protection to many wildlife species and populations. State efforts to enforce game laws also became more effective.

THE TRANSFORMED HERITAGE AND NEW DIRECTIONS IN 1920

In 1920, more than a billion acres of the public domain, over half the area of the contiguous 48 states, had been transferred to largely private ownership, development, and management. Much acreage east of the prairies had been harvested and cleared of its virgin timber to provide for cropland and pasture, lumber for homes and other purposes, and fuelwood for cooking, heating, and energy. The old growth timber lands of the West were largely unaccessed although some timbering had begun. Over 400 million acres were being plowed for cropland, 750 million were being used for pasture and range, and 567 million remained in forests (table 1). Another 185 million acres had been devoted to other uses including cities and communities, transportation systems, defense and industrial uses, parks, some wildlife areas, and residual unused swamp, desert, and barren rock areas. The settlement of the nation from coast to coast and north to south was largely completed and linked with rail transportation. Minerals development and technology were also making important contributions to national industrialization, urbanization, employment, and wealth.

Much of the original fertility of the soils, timber of the forests, and forage of the prairies and plains had been consumed. Although the process of the transformation has been repeatedly described as wasteful, exploitive, depletive, and fraudulent, much of the wealth of resources was largely transformed to viable homesteads and farm enterprises. Some of the virgin wealth was used to establish and support public schools, colleges, and universities. Some of the private savings from that wealth educated new generations of scientists, professionals, farmers, and business people, and expanded the intellectual resource of the nation. In these ways, much of the regional wealth of a new land became converted to working capital that helped build a new nation, raise the welfare of its people, expand its population, and provide for its defense. At the same time, the process sustained the basic traditions of freedom and democracy in both the political and market arenas.

Settlers and graziers had experienced frequent years of drought and some extended periods of depressed prices and markets. But 1900 to 1920 was a period of record prosperity for farmers and graziers alike. It was also a boom time for the lumber industry in meeting the very strong demands of a growing population for building materials. Economic incentives and professional knowledge and capability for forestry were lacking during most of the 19th and early 20th Centuries. Thus, abundant timber remained the least cost source for basic building materials. Its lumber has provided decades of service, and still does in most of the homes of America to this day.

There were reasons and evidence for concern, however. Would the resilience of the soils, the grasslands, and the forests be sufficient to meet the needs of future generations? Many citizens were unhappy with some of the existing resource conditions. The dimensions of emerging resource problems were difficult to assess. Consensus for change and improvement came very slowly and unevenly. The pressures for public land settlement and economic development through resource use remained strong, both in the private and public sectors. Even the movement for conservation became dominated by the utilitarian concept of wise use.

Soil erosion, which had received the early attention of many agricultural and conservation leaders, became more prevalent. But, awareness of the problem seemed to fade. One of the first farmers' bulletins published by the Department of Agriculture in 1894, "Washed Soils: How to Prevent and Reclaim Them," reported that thousands of acres of fine cropland were eroding and being abandoned annually. It urged farmers to reclaim and use those lands again. Congress approved the first annual appropriation for soil survey work in the same year, $3,000 to investigate different typical soils and determine their chemical character, physical properties, and the nature of the nitrifying organizisms they contained. Soil surveys usually follow county boundaries. They delineate the areal extent of specific soil types, define their chemical and physical characteristics, and provide interpretive information on feasible uses and management requirements for sustained use. The first soil survey was printed in 1899. Five years later, Congress, recognizing the value of soil survey information to the pubic, passed a resolution for the regular publication of completed surveys (Miller et al. 1985).

In 1910, the Department published additional bulletins on soil conservation and corn cultivation advising farmers that erosion had to be stopped to maintain production and productivity. The response was apparently minimal.

Soil erosion was not forgotten during the conservation movement of 1890–1920. Gifford Pinchot, a chief leader of the movement, was aware of it. But the focus of the movement on timber supplies, public forests, forest management, and generally the resource problems of the arid West appeared to eclipse attention for the soil erosion problem in that period (Miller et al. 1985).

Gifford Pinchot, the leading reformer for conservation, had attempted to coalesce the separate elements of the movement into a unified association and effort. The separate elements often shared common interests and worked together. However, they never actually fused into a single unified organization and movement with common goals and priorities. Forestry, reclamation, water power, flood control, waterway improvement, and mineral leasing interests were making progress in their own way. The advocates of these separate interests were wary that a managerial approach would dilute their specific objectives. Other groups not a part of the Pinchot program, such as wildlife and natural beauty, were similarly advancing their own interests. Each had its own but overlapping followers (Davis 1983).

The nation entered the 1920's and 1930's with 272 million acres of public land reserves, a federal commitment for their productive management, and 200 million acres of unoccupied public lands with open range grazing. The Department of Agriculture and the Land Grant Colleges had a strong commitment and system to reach local farmers more effectively with improved farming methods, materials, and technology through a cooperative extension education program. State efforts for protecting the nation's private forest resources were gaining momentum as the Forest Service was improving the protection of national forests.

A PERIOD OF INSTABILITY AND TRANSITION, 1920–1945

The end of World War I and the rehabilitation of European agriculture brought a collapse in foreign demand for farm production and commodity prices plummeted in 1920 and 1921. A prolonged period of agrarian distress began, from which agriculture did not fully recover until World War II sharply revived farm export demands after 1940.

The collapse of commodity prices and a rigidity in nonagricultural prices and wages, and therefore farm costs, squeezed farm incomes. Average income per capita for the farm population in the 1920's was less than half that of nonfarmers. Farmers were not sharing in the general prosperity of the rest of the nation. When the Great Depression affected the rest of the economy in the 1930's, general farm welfare fell to new lows as both domestic and foreign demands and commodity prices fell (Breimeyer 1983, Paarlberg 1964, Rasmussen 1974).

EXPANSION OF THE FEDERAL ROLE IN LAND USE AND RESOURCE MANAGEMENT

Farm Production Adjustment and Supply Management

During the 1920's, farm groups sought direct federal assistance that would raise commodity prices through export subsidies. These efforts failed (Halcrow 1984). Authority granted to farmers in 1922 to set up cooperatives to market large volumes of commodities, and thus increase their market influence, proved ineffective (Rasmussen 1974).

There were different diagnoses of the problem of farm prices and incomes. One saw agricultural distress as part of a more general problem associated with the collapse of money and credit supply. A changed monetary policy was seen as the remedy. Another viewpoint attributed the agricultural problem to excess production. The remedy in this case was production control. The latter viewpoint prevailed. The nation turned toward federal farm production control that would raise United States commodity prices above the world price structure.

The concept became national policy through the Agricultural Adjustment Act of 1933 (Paarlberg 1983). This act was declared unconstitutional in 1936, but subsequent legislation in 1936 and 1938 retained the federal role in production management. The law was administered by the Department of Agriculture as the federal government became a partner with the farmer in adjusting production and managing supply—a role that has continued to the present. Implementation of the policy reduced crop acreages, provided payments to farmers for participation, and helped support farm commodity prices. It brought financial relief to the farm sector. Full recovery, however, came with the expansion of European demands for farm commodities during World War II (Paarlberg 1964).

During this period, agriculture emerged as a separate economic sector subject to annual national planning as epitomized in production adjustment, supply management, and price support policies. Thus, national agricultural planning was added to the traditional Department of Agriculture roles of research, education, and regulation. Policy objectives now explicitly included maintenance of farm income and welfare, and improving production efficiency (Breimeyer 1983, Paarlberg 1983, Rasmussen 1983).

Other federal programs designed to contribute to the farm income stability and welfare objectives included federal crop insurance, disaster relief payments, resettling farmers from poor land, aiding tenants to purchase their own farms, soil conservation, rural electrification, farm credit, and distribution of surplus commodities to the needy. These programs were all a part of the New Deal of the Roosevelt Administration and constituted what historians have labelled as agricultural reform. In this way, agrarian distress found both relief and reform. And with the help of World War II demands, it also found economic recovery.

Land Use Adjustment and Public Acquisition

During the 1930's, when the Depression intensified the economic distress of farmers, it became evident that many farmers were cultivating lands that were poorly suited for farm crops, low in productivity, and earning below the margin for profitable farming. These lands were labeled submarginal areas. In those areas, farm foreclosures were multiplying, tax delinquency increasing, and farm income dwindling. Frequently, these lands were abandoned after their saleable resources had been liquidated. The land resources often were damaged by drought, floods, erosion, poor farming practices, and neglect.

The New Deal response to these seriously distressed areas was to provide funds to buy the land, retire it from crop use, and redevelop it for pasture, forest, range, park, recreation, wildlife refuge, and other uses. A study and evaluation by the National Resources Board in 1934 recommended that the Government buy and develop 75 million acres of this submarginal farmland in various regions to relieve the distress of its farmers (Ubelaker and Jantz 1986). The Copeland Report on American Forestry, prepared by the Forest Service for the U.S. Senate in 1933 found that "more than 50 million acres

of agricultural land, originally timbered, have been abandoned because they were never suited for agriculture or because they have reached the submarginal class from erosion or other causes. The land is now idle and available for forestry. The area may become still larger in the future" (U.S. Department of Agriculture 1933).

Under Executive Order, some 250 land utilization projects, totalling 11.3 million acres in 45 states were acquired between 1933 and 1946. About 25,000 farm families sold their lands under this program. Over 8,000 received federal help to relocate. More than 9.5 million acres of this area were eventually redeveloped for range, forest, and related multiple uses such as wildlife protection, watersheds, and recreation. Another 1.8 million acres were transformed into wildlife refuges and parks (Wooten 1965).

The bulk of the acquired lands were managed by the Soil Conservation Service of the Department of Agriculture. Ultimately, 5.4 million acres were transferred to the Forest Service; 3.8 million were used to form the national grasslands and the balance were assigned to forest use. Another 5.8 million acres were transferred to other federal agencies, granted or sold to states and local governments, and, in a few cases, sold to private parties. The program did adjust ownership and use to the capabilities of the land. It fell far short, however, of the 75 million acre target proposed by the National Resources Board (Wooten 1965).

Multipurpose Water Basin Planning and Development Expands Rapidly

The western pressure for multipurpose river basin planning and development with federal leadership, financing, and assistance continued to build in the 1920's. Industrial opposition to federal power development delayed its strong emergence until the 1930's. At that time, it virtually exploded with the reinforcement of New Deal programs for public planning, financing, and construction of public works to create jobs and employment during the Depression. Federally-installed hydropower generating capacity in 1920 was no more than 10 thousand kilowatts while privately-owned generating capacity was almost 13 million kilowatts and municipal capacity only some 500,000. By 1945, federal capacity for hydropower generation exceeded 5 million kilowatts, about 10% of the total hydropower supply at that time (U.S. Department of Commerce 1975).

The Federal Power Commission authority for comprehensive water resource development planning provided by the Federal Water Power Act of 1920 was not funded. The Commission devoted its efforts in the 1920's mainly to licensing nonfederal power projects. Licensees, however, were required to show that their plans were adapted to comprehensive development. In the meantime, the Bureau of Reclamation, under the aegis of the Kincaid Act of 1920, investigated the potential for irrigating the Imperial Valley of California by diversion of the lower Colorado River waters. In 1922, the Bureau recommended building a diversion canal and a huge storage reservoir for multipurposes on the Colorado River. It also proposed that all future developments on the Colorado be undertaken by the federal government, reflecting the potential for further multipurpose projects in six other Colorado River Basin states.

The Bureau recommendation was implemented by the Boulder Canyon Project Act of 1928. Its purposes included flood control, navigation, water storage for irrigation, the generation of power as a way to make the project financially self-supporting, and other beneficial uses, particularly municipal water supplies for several cities in southern California. The main structure, the Hoover Dam, was completed in 1935. The first power flowed in 1936. The first irrigation water was delivered in 1940 and eventually served 600,000 acres.

The Hoover Dam became a precedent and symbol for American public works water resource projects in the early 20th century (U.S. Department of Agriculture 1972). It transformed the economy of the Southwest by increasing the supply of both power and water and contributed particularly to rapid economic growth in southern California. It set the stage for similar power and reclamation projects such as the Grand Coulee and Bonneville Dams on the Columbia River, Fort Peck on the Missouri River and Shasta in California (American Public Works Association 1976, Rasmussen 1974).

In 1925, Congress set the path for river basin development projects for the rest of the United States. In that year, it directed the Corps and the Federal Power Commission jointly to prepare a list of the nation's navigable streams and their tributaries (excluding the Colorado River) having power development potentials. Cost estimates were to be made for making stream examinations and surveys with a view to the improvement of such streams for navigation and development for power, flood control, and irrigation. That list was printed in 1927 in House Document 308. Thereafter, Congress authorized the Corps alone to conduct the surveys which became known as the "308 reports." These 308 reports took the Corps over 20 years to complete and provided much of the basis for water resources development during the New Deal and post-World War II periods, including the Tennessee Valley Authority and the Columbia River power system development, both of which were authorized in 1933. The Bureau of Reclamation retained its multipurpose project authority for the Colorado River Basin and continued its investigating role for irrigation improvements in the 17 Western States (U.S. Department of Agriculture 1972).

The emergency programs of the New Deal period provided enormous sums of funding for public works projects and federal work relief efforts which supported many federal water resource development projects as well as state and local government efforts at improvement of water resources. The Public Works Administration provided loans and grants to states and local governments for municipal waterworks, sewage disposal plants, irrigation, flood control, and water power projects. Federal agencies also received grants for irrigation, navigation, power, and flood control projects. The Works Progress Administration similarly financed staffing,

planning assistance, and construction of smaller water resource projects sponsored by state and local governments. Federal financial aid in this period made important contributions to water pollution control and many other water resource improvement projects. During the 1932–1937 period, for example, the total population served by sewage treatment works increased 73% and the number of treatment plants increased by one-third (U.S. Department of Agriculture 1972).

Levees and other water control works were built in the 1920's and into the 1930's by several federal agencies for specific areas under individual project authorities as well as by states, levee boards, cities, counties, districts, and railroads. A consistent public policy and coordination for flood control were a continuing challenge. There were proponents for a national flood control approach. The constitutional issue over the federal role had been settled. It was increasingly accepted that the broad benefits of flood control extended to the entire population. Specific beneficiaries as in the case of power or irrigation were difficult to segregate. Thus, the Flood Control Act of 1936 emerged as a new area of general national planning in the middle of the New Deal era.

The 1936 Act inaugurated a national flood control program. The Corps was given jurisdiction over flood control studies and improvements on waterways. Together with the 1936 congressional direction for the Corps to update 308 reports for important economic changes, new stream flow, and other resource data, this gave the Corps continuing authority for nationwide river basin planning for navigation and flood control. The 1936 Act also gave the Department of Agriculture responsibility for investigating watersheds and measures for runoff, water flow retardation, and prevention of soil erosion (American Public Works Association 1976).

The new flood control legislation also authorized investigations and surveys for many reservoir projects for navigation, flood control, and other purposes. Many basin-wide flood control plans were prepared and in 1938, following a series of catastrophic floods, construction projects were authorized for the Connecticut, Merrimack, Ohio, Upper Missouri, White, Arkansas, and Willamette Rivers (U.S. Department of Agriculture 1972).

Federal water resources planning continued through the war years, stimulated in part by an expected need for major public works to avert an economic slowdown after the war. State and local participation tended to fall by the wayside and eventually raised fears among western states of federal aggrandizement in water resources development. These tendencies and fears were allayed in Section 1 of the 1944 Flood Control Act. Section 1 established the principle of federal/state cooperation in planning for navigation, flood control, irrigation, and related federal water resource projects of the Corps and Bureau of Reclamation. All reports of these agencies henceforth would include state comments when submitted to Congress (Weber 1979).

The 1944 act also authorized a large number of new projects for many river basins "with a view to providing a reservoir of...public works for the postwar construction program." It also provided for integration of the Corps of Engineers Missouri River Basin plan for flood control and navigation ("Pick Plan") with Bureau of Reclamation planning for the basin which emphasized irrigation and hydroelectric power ("Sloan Plan"). The authorization for construction of the Pick-Sloan Missouri River Basin Project furthered full river basin development as a federally led activity.

Other provisions of the 1944 Act gave the Corps its first authorization to include municipal water objectives in multipurpose reservoir projects to supplement domestic and industrial water supplies. The Corps was also granted authority to build, maintain, and operate public park and recreation facilities, or to permit such construction and operations at reservoir sites, further broadening the multipurposes and benefits of water resource projects.

The 1944 Act gave Department of Agriculture responsibility to provide land treatments to reduce flooding for 11 watersheds covering 30 million acres. Disagreement between the House Agriculture and Public Works Committees kept these watersheds to a low number and excluded structural works. Implementation was divided between the Soil Conservation Service and the Forest Service. As the work began on these projects, it became apparent, as many experts had advised in past decades, that land treatment of watersheds alone, without water control structures, offered only limited flood protection (American Public Works Association 1976, U.S. Department of Agriculture 1972).

Increased Management of Federal Grazing Lands

The national forest grazing lands constituted about 100 million acres (area included under forests in table 1) which had been under professional management since about 1900. Progress had been made in rehabilitating their overgrazed condition and productivity. Increased stocking levels during World War I tended to halt, slow, or reverse the overall improving trend. Distressed cattle industry conditions after World War I, combined with stockmen's insistence on long term permits and resistance to sharp reductions and redistribution of stocking, tended to extend the slow rate of rehabilitation into the 1920's. Depression and drought during the 1930's also favored the cattle industry interests with retention of large numbers of cattle on national forests. Secretary of the Interior Harold L. Ickes' drive to have the national forest range transferred to Interior Administration and stockmen's organizational support to transfer the entire Forest Service to a new Department of Conservation tended to keep Forest Service grazing policies in line with the views and interests of the livestock industry (Rowley 1985).

Official publications of the Department of Agriculture for 1940 reported that national forest ranges improved 29% in productivity during the 1920's and 1930's due to good range management and conservation measures. However, other views inside and outside the Department indicated that increased stocking on some forests had actually damaged range resources. Progress thus

appeared to be mixed (Rowley 1985). A 1936 Forest Service study, The Western Range, reported that, on the average, the forested ranges of national forests were superior in condition compared with private and other publicly administered ranges. The ranges administered by the Department of Interior were rated in the poorest condition. This was largely due to the continuation of the open range policy on the 142 million acres of public domain and lack of any management until after 1934. The fact that most of the residual public domain lands were largely within desert areas of the nation with less than 15 inches of rainfall also contributed to their poor condition. The residual public domain was largely the land the homesteaders did not want because of their generally severe aridity (O'Callaghan 1969, U.S. Department of Agriculture 1984a, U.S. Senate Committee on Agriculture and Forestry 1936).

President Hoover offered the public domain grazing lands to the Western States early in his administration but without the mineral rights. The states, burdened with problems of the Depression, were unwilling to accept them without the minerals. The states' rejection opened the way for a new effort, the Taylor Grazing Act of 1934, to close the public domain after more than 20 years of frustrated attempts to bring order and management to the remaining 142 million acres of federal open range (Carpenter 1940, O'Callaghan 1969).

The act effectively closed the public domain to further settlement and created grazing districts for the management of the 142 million acres of rangeland. The districts were placed under the administration of the Grazing Service in the Department of Interior. The Grazing Service became the Bureau of Land Management in 1946, when its functions were combined with those of the historic General Land Office. The administrative aspects of this new federal program were similar to those for the national forest grazing permit system. However, far more decisionmaking power rested with the local advisory boards in each of the grazing districts (Rowley 1985). The stockmen were influential in bringing about this preferred working arrangement. In the 1940's, their influence was great enough to cut appropriations so deeply that even the basic administrative work of the grazing districts was supported by funds provided by the advisory boards (O'Callaghan 1969). In the same years, the Forest Service, apprehensive about the potential impact of World War II food demands on range stocking and range rehabilitation took a firm stance to resist pressure for increased stocking, and was largely successful in implementing this new resolve (Rowley 1985).

Minerals Management and Production

There was little change in the federal role in minerals management from 1920 to 1945. The physical volume of mineral production grew very slowly in the 1920's and most of the 1930's. With the onset of World War II in the late 1950's, however, production expanded sharply and then continued to grow after the war into the 1950's.

Ferrous mineral production actually declined after 1920 until the war demands substantially raised output. Coal production, measured in BTU's, declined even more and returned only to the 1920 level. It became a very troubled industry in the 1930's. Crude oil and natural gas BTU production expanded steadily by factors of 4 and 5, respectively, between 1920 and 1945. Oil and energy production and nonferrous metals and nonmetal mineral production likewise expanded steadily in this transition period (U.S. Department of Commerce 1975).

CROPLAND USE AND MANAGEMENT

Cropland use remained stable from 1920 to 1945, averaging 404 million acres a year (table 1). Farm population declined from 32 million to 24 million as the U.S. population rose by 34 million to 140 million. The number of farms declined 10% to 5.9 million. Their average size rose 30% to 195 acres (U.S. Department of Commerce 1975).

The trends in farm population, farm numbers, and farm size reflected a general increase in both farm labor productivity and average yield per acre. Total farm employment declined 25% from 13.4 million workers in 1920 to 10.0 million in 1945. Cropland used per farm worker increased from 31 to 41 acres indicating a significant improvement in labor productivity. The area of cropland used per capita for domestic food and fiber needs declined from 3.1 acres to 2.5 acres indicating about a 20% increase in average yields.

Most of the improvement in production efficiency came after the worst of the Depression had passed and during World War II. The accelerating adoption of the tractor as a replacement for horses and mules was the most important contributor to improving labor productivity. The Depression slowed the rate of adoption of tractors; but World War II demands, farm labor shortages, and the recovery of general farm prosperity rapidly raised the use of tractors and improved farm equipment to new heights. The number of animal work stock, horses, and mules declined over 50% with the increase of mechanical power (table 4).

During the 1920 to 1945 period, wheat yields increased about 30% and corn yields increased about 20%. Cotton yields increased even more. The increased applications of fertilizers and lime were indicative of factors influencing productivity. Commercial fertilizer use rose from 7 million tons to 15 million tons; lime use rose from 3 million tons to 23 million tons (U.S. Department of Commerce 1975). Most of the productivity increases came after 1935, partly in response to the agricultural stabilization programs, but mostly due to rising farm prices induced by World War II demands. Plant and animal disease control were improved. New plant strains and animal breeds were introduced. Hybrid corn came into use in this period. Danish hogs were imported to develop meatier hogs. Artificial insemination for dairy cows was used for more than 4% of the dairy herd (Rasmussen 1974, Schlebecker 1975).

Throughout the 1920 to 1945 period, the state cooperative extension services, editors of farm magazines, the

Table 4.—Animal work stock, farm machinery, and equipment, 1920 to 1945.

Year	Animal work stock	Tractors	Combines	Cornpickers	Farms with milking machines
	Thousands				
1920	25,742	246	4	10	55
1925	22,569	549	—	—	—
1930	19,124	920	61	50	100
1935	16,682	1,048	—	—	—
1940	14,478	1,567	190	110	175
1945	11,950	2,354	375	168	365

Source: U.S. Department of Commerce (1975).

Department of Agriculture, and other public and private institutions worked hard to bring the results of research and more productive technology directly to individual farmers. Local county extension agents, working on a one-to-one basis with cooperating farmers, became key catalysts in improving production and productivity. They not only aided the farmer, but also provided feedback to research. The results made it obvious that new technologies would bring major improvements in American farming. The depressed economic conditions and uncertainties of the 1920's and 1930's had been a major disincentive to innovation and productivity improvement. Nevertheless, many farmers were able to make significant gains in production efficiency in this period, especially as World War II demands raised economic incentives for greater production (Rasmussen 1974).

While total cropland used remained stable in this period, the location of production shifted significantly from the Eastern States and the Corn Belt to the Northern and Southern Plains, the Mountain States and the Pacific coast (table 5). About 30 million acres dropped out of production in the East while a similar amount was added to western production. The shift was facilitated by a 50% expansion of irrigated acres, from 14 million in 1920 to 21 million in 1945 (U.S. Department of Commerce 1975). Practically all of this expansion occurred in the 17 Western States. The shift reflected a large expansion of wheat production in the Western States and large acreage declines in corn production in the East and in cotton production in the South (U.S. Department of Agriculture 1942). In the West, the expansion was achieved largely through a conversion of rangeland and pasture to crop production (Frey and Hexem 1985).

Cropland agriculture achieved new records in total production in this period. During the war years, total crop production was 18% above that in 1929. Livestock production, including range and pasture production was 38% higher. Total farm outputs averaged 32% above the 1929 production level. Total farm output per unit of total input (i.e., overall farm production efficiency) rose 28%.[7]

[7]*Estimated from table B-94 of Economic Report of the President, together with Annual Report of the Council of Economic Advisors (1986). Comprehensive farm output and input indices are not readily available before 1929.*

Table 5.—Cropland used in United States by regions, 1920, 1940, 1950.

Region	1920	1940	1950
	Millions acres		
Declining			
Northeast	29	22	20
Corn Belt	90	77	81
Appalachia	34	28	26
Southeast	29	26	24
Subtotal	182	153	151
Stable area			
Lake States	40	39	41
Delta	20	20	18
Subtotal	60	59	59
Increasing area			
Northern Plains	80	90	96
Southern Plains	43	49	45
Mountain	20	29	35
Pacific	17	19	22
Subtotal	160	187	198
Total	402	399	408

Source: Frey and Hexem (1985).

Soil Erosion and Soil Conservation

Soil erosion continued to be a growing problem in the 1920's. A few scientists had accumulated a limited body of knowledge about the nature of soil erosion and its impacts. Severe erosion effects on farmlands were widespread and visible in many parts of the country. However, the national dimensions of the problem had not been assessed or described. Scientific data on how the soil erosion process worked and methods by which it could be prevented were very limited. American farmers still remained largely indifferent to soil erosion. They generally looked upon their eroding fields with great unconcern or did not recognize the losses that erosion produced. Productivity losses were often viewed as a natural reduction of the plant-food supply by the harvested crops (Bennett and Chapline 1928, Swain 1963).

Arousing national interest in conserving the soil in the 1920's was largely the work of a single individual, Hugh H. Bennett, soil scientist with the U.S. Department of Agriculture. His personal magnetism and scientific knowledge, based on more than two decades of soil study and research, farm demonstrations, publications, and lectures, made him "the champion of American topsoil" and the founder of soil conservation as a national concept and institution (Bennett and Chapline 1928). He was dedicated to developing an understanding of the causes, effects, and costs of soil erosion and defining effective ways to prevent, reduce, or control it at the farm level. In 1926, he prepared a plan for a series of 18 cooperative erosion experiment stations around the nation which generated strong policy support at the Department of Agriculture. That year the Department undertook an educational campaign about the seriousness of erosion. It also began to urge legislation for a full-scale study of the problem.

In April 1928, together with W. R. Chapline, Bennett published a very well illustrated circular, "Soil Erosion—A National Menace." It described some of the most serious areas of sheet and wind erosion and provided supplementary information on fertility losses, effects on sedimentation and flooding, variation by soil types, causes of erosion, and ways to prevent or control erosion. The circular pointed out that soil erosion was a national problem and menace. Bennett and Chapline reported "that some 15,000,000 acres or more of tilled land had been utterly destroyed by erosion in this country is but an insignificant part of the story, for it is the less violent form of erosional wastage, sheet erosion that is doing the bulk of the damage to the land" (Bennett and Chapline 1928). They doubted that the farmer alone would achieve the soil conservation work required to control erosion.

Bennett's persistent efforts were rewarded in 1928 with Congressional funding of $160,000 to study soil erosion from a national viewpoint. By mid-1932, 10 erosion experiment stations were gathering information. By early 1933, enough data had been collected to serve as a scientific basis for an effective program of erosion control (Swain 1963). During the same period of the early 1930's, the occurrence of prolonged drought in the Plains States led to serious and widespread wind erosion. The wind erosion damage was severe, dramatic, and highly publicized. A Washington newspaper aptly supplied the label "Dust Bowl" which captured and focused national attention on the drought, wind erosion, and farm hardship problems in the Plains (Helms 1981).

The convergence of conservation problems and the need to provide employment for one-fourth of America's young men who could not find jobs led to creation of the Civil Conservation Corps (CCC) proposed by the Roosevelt Administration and established by Congress early in 1933. The work of the CCC was limited to forestry, wildlife, and park projects, prevention of soil erosion, flood control, and similar projects on federal and state lands. A broad interpretation of the flood control objective, combined with a strong demand for CCC camps in states with few public lands, led to the establishment of 161 soil erosion control camps under the direction of the Department of Agriculture by 1934. Their work on private lands was limited to controlling gullies with soil-saving dams, planting trees and other vegetation, and building water outlets for established terraces.

In a parallel effort at the Department of Interior, Secretary Harold Ickes allocated $5,000,000 for soil conservation work under the authority of the National Industrial Recovery Act of June 1933. He also established the Soil Erosion Service (SES) and in September 1933 successfully recruited Hugh Bennett to lead the new agency. By linking public works funds for staff and supplies with labor resources provided by the CCC and taking both a whole watershed and whole farm approach to soil erosion control demonstration projects, Bennett was able to quickly demonstrate the potential of a well-designed and -directed soil conservation program. His approach reduced erosion while permitting farmers to continue farming without reducing income. Costs of conservation were largely borne by the public works funds, CCC camps, and cooperating farmers. Costs included money for seed, fertilizer, equipment, and labor to build terraces, waterways, and fences, and to improve pastures. Land too steep and erodible was converted to pasture or woodland to provide year round cover. On cropland, an appropriate mix of complementary structural and vegetative practices were tailored to the needs of each farm and farmer. Fields were rearranged to follow contour lines, planting methods were changed, and the use of cover crops was introduced (Helms 1985, Kelly 1985).

The Department of Agriculture, responding to concerns about organizational duplication and to Hugh Bennett's success, worked to secure transfer of the SES from Interior to Agriculture. In March 1935, President Roosevelt unified soil conservation programs by moving the SES to Agriculture. Drought and dust storms continued to emphasize the erosion problem in 1935. In April, while Bennett was testifying on soil erosion before a Senate Committee, the sky symbolically darkened with dust from the drought-stricken West. Later that month, Congress passed the Soil Conservation Act of 1935, declaring soil erosion as a national menace. Soil conservation thus gained a permanent commitment and became the responsibility of the Soil Conservation Service in the Department of Agriculture (Rasmussen 1981). This action also integrated and elevated the role of soil surveys in the implementation of the new federal conservation program at the farm level.

The National Reconnaissance Erosion Survey, initiated by the SES at Interior in 1934 under Bennett, was published by the Soil Conservation Service in 1935. It was the first comprehensive national assessment of the soil erosion problem. Survey maps for every county in the United States displayed the location, predominant character, and intensity of erosion conditions. The survey, together with previously assembled data, made it possible to estimate the actual extent and seriousness of erosion damage to the nation's soils resources. This information established the quantitative basis for the

nation's erosion control policy at the time (Miller et al. 1985). The significance of the new information is demonstrated by the change in Bennett's estimate of ruined or severely damaged cultivated lands from "probably not less than 10 million acres" in 1928 to "100 million acres," in 1935 (Miller et al. 1985).

In 1937, because of the high cost of research and developing federally financed demonstration projects, and with the need to reach all farmers, the Department of Agriculture shifted to a direct technical assistance approach to individual farmers. By 1947, all states had enacted enabling laws that established soil conservation districts as local governmental units for administering local conservation programs, aided by technical experts from the Soil Conservation Service (SCS) who would help farmers and district supervisors prepare and implement farm conservation plans, much as Bennett had done in the demonstration projects. There are now about 3,000 districts covering over 2 billion acres, including 1 billion acres on farms. The districts are managed locally and receive federal technical assistance from SCS. This institutional arrangement successfully linked local farm interests, state governments, and federal technical assistance in the prevention and control of soil erosion.

Direct financial assistance to farmers for undertaking conservation practices was initiated in 1936 through the Soil Conservation and Domestic Allotment Act. This act was designed as the constitutional substitute for the unconstitutional Agricultural Adjustment Act of 1933. The new legislation authorized rental payments for the withdrawal of cropland from production to promote soil conservation and provide a better balance between crop production and actual domestic demands. Participation was voluntary. Farmers were paid for diverting cropland to soil-conserving crops. Payments were also authorized for implementing soil-building practices on cropland and pasture. When this legislation was amended in 1938, payments for soil-building conservation practices were retained under the Agricultural Conservation Program and became a permanent part of the conservation incentives system of the Department of Agriculture. This program is administered locally by elected state and county committees under the general administration of the Agricultural Stabilization and Conservation Service of the Department of Agriculture. Prior to World War II, the program was used to divert land out of soil-depleting crop production. War demands then shifted federal efforts from reducing production to encouraging more production to meet expanding demands.

GRASSLAND USE AND MANAGEMENT

The grasslands declined from 750 million acres in 1920 to about 700 million in 1945 (table 1). The western ranges in this period declined by over 50 million acres while grassland in the 31 eastern states gained 10 to 15 million acres. The reduction in the West was due primarily to shifts to crop production, mostly wheat.

The total number of cattle, sheep, horses, and mules supported by these grasslands increased by 10 million. Comparison of this increase with the grasslands trend suggests that a small increase in overall grassland productivity accompanied the reduction in total grasslands. However, some of the improvement was due to an increase in the use of feedstocks to supplement grassland forage.

The largest increase in livestock use was for cows kept for milk. They increased steadily from 30 million to 41 million indicating some expansion of pastures in the 31 eastern states as cropland acres declined. Beef cattle increased by 5 million to 45 million. The number of sheep rose from 37 million in 1920 to 49 million in 1942, then dropped steadily to 40 million by the end of the war. Since five sheep are the equivalent of one cow in forage use, their increase was much less significant than the changes in dairy or beef cattle numbers. The decline in horses and mules released significant grassland capacity for cattle and sheep, both in the East and West (U.S. Department of Agriculture 1942, U.S. Department of Commerce 1975).

Management Progress on the Western Ranges

At the end of World War I, the stock industry, like other sectors of agriculture, experienced the hard realities of excess capacity, decline in livestock demands and depressed prices. The costs of indebtedness and operating expenses continued. Drought in the early 1920's, grasshoppers, prairie dogs, and crop and cattle diseases seemed to combine and add to the problems of the stockmen. Cattle prices in 1922 were less than 50% of their 1919 peak level of $45. They remained in that low range through 1926. Beef cattle numbers declined from 40 million in 1920 to 30 million in 1926. Sheep prices and numbers followed the same pattern to 1922 but began to recover earlier and more strongly than cattle (Clawson 1972, Schlebecker 1963, U.S. Department of Agriculture 1942, U.S. Department of Commerce 1975).

Ranch farming grew throughout the 1920's. Stockmen increasingly turned toward supplemental feeds to safeguard against losses from severe weather conditions, extend winter feeding periods, and provide supplements at other times. At the same time, wheat farmers of the North and cotton producers of the South tended to become cattlemen. Hay and other forage crop production increased; dams for water storage and irrigation expanded; pastures became common on farms, and millions of acres of wheat and other grain stubble were used for grazing. Several million tons of grain, cottonseed cake, linseed meal, and other concentrates were shipped into the range area for feeding. Ensilage, beet pulp, pea vines, bean straw, fish meal, rice, and fruit byproducts were also used as feedstocks. Ranch farming increased labor and other direct costs but it also reduced the general hazards of the cattle business and dependency on range forage. Ranch farmers seemed to prosper more than the crop farmers or the large herders. They intensified livestock management, used the range more effectively (often because there was less available), improved water facilities and supplies, and had fewer disease and weather losses due to better care of the

livestock. Predator losses were also reduced due to better control methods. Some cattlemen even turned to sheep as markets and prices for sheep recovered more rapidly than those for cattle (Schlebecker 1963, U.S. Senate Committee on Agriculture and Forestry 1936).

Beef cattle numbers dropped to a low level of 26 million in 1928. Cattle prices recovered and in 1929, they were close to the peak World War I levels. Wet seasons in the late 1920's, good feed, and heavy selling contributed to a clear understocking of the ranges. The western cattle business was healthy and prosperous once more.

As the cattle cycle turned up in 1929, the stock market crashed and the cattle market again fell into a rapid slump. Cattle numbers continued to rise to 36 million in 1934, but prices fell to the lowest levels experienced since the beginning of the century. Drought combined with depression. Cattle starved all over the Western Plains. Despite the apparent improvement in range management and conditions at the end of the 1920's, severe drought brought disaster to the cattle themselves. Some died because of lack of food, others due to dust on the feed. Still others died because stockmen were often unable to get food loans. Once again the 1930's dramatized the unpredictability of the greatest risks of the arid range cattle industry—weather and markets. The sheep industry experience with markets and prices in this period was similar (Schlebecker 1963, U.S. Department of Agriculture 1942, U.S. Department of Commerce 1975).

The nation's beef cattle herd once more declined to 30 million in 1939. Sheep declined to only 45 million after reaching 48 million in 1934. The stock industry received some relief from New Deal financial and conservation programs. Prices improved. Renewed prosperity returned in 1940 with the onset of World War II. The weather again improved except for scattered local droughts. The long term western water developments of the New Deal impounded water in reservoirs and ponds that in earlier times would have run off. Some ranchers were able to hold some water for the next year. Beef cattle prices rose to $54—their highest levels of the century—and beef cattle numbers rose to 45 million in 1945. Sheep prices did not fare as well, remaining well below the high prices achieved in 1917–20 and 1926–29. Their numbers again rose to 49 million in 1942 and declined thereafter (Schlebecker 1963, U.S. Department of Agriculture 1942).

The range use and development pattern of this period and the large expansion of the beef cattle herd that came after 1945 indicate that the low point in the condition of the western ranges was reached in the late 1920's. Although the drought of the 1930's no doubt delayed the rate of recovery, later developments and improved management on all lands indicate a turnaround had been made in the trend of range conditions. There were wide local variations around this general trend and vegetative conditions on the range were generally well below the grass conditions or climax cover type conditions before the 1860's.

THE USE AND MANAGEMENT OF FOREST LANDS

The forest lands of the United States increased by about 6% or 35 million acres between 1920 and 1945 (table 1). The rise was due in part to the natural regeneration of abandoned crop and pasture lands, primarily east of the prairies, to forest cover as they were increasingly dropped from farm production. Changes in use classification and improvements in accuracy of area estimates were other factors. There were also some shifts out of forest use for reservoir sites, rights-of-way, and urban uses (U.S. Department of Agriculture 1958).

Wood Use Trends

Industrial wood use continued a slow downward trend from the peak levels of 1906 and 1907. It dropped from 8.2 billion cubic feet in 1920 to 7.8 billion cubic feet in 1945. The lumber share declined from 66% to 62%. The pulpwood share, a growing industrial use, rose from 8% to 24%. Veneer logs and bolts rose to 3%. Minor products including cooperage bolts, poles, piling, fence posts, hewn ties, round mine timbers, and other assorted products declined from 25% to 11% of industrial wood use. Wood use as 1% of all industrial physical and structural materials likewise continued its decline from 33% at the beginning of the 20th Century to 25% during 1919–21 and 17% in 1945 (U.S. Department of Agriculture 1958).

The absolute and relative decline in lumber use (table 3) was due largely to the steady rise in lumber prices relative to other materials. The relative price index for all lumber more than doubled between 1920 and 1945. The basic cause for rising lumber prices has been attributed to lagging productivity in the lumbering industry. It did not keep pace with productivity growth in the general economy which had risen about 2% a year since 1850. An increase in the general level of wage rates forced the cost structure of the lumber industry upwards. This was the net result of two opposing factors. Technological improvements improved the mechanical efficiencies of logging, transportation, milling and remanufacturing equipment, and processes. This tended to reduce costs. Most of the progress in reducing costs, however, was offset by declining trends in size and quality of raw material and increasing distances between harvested forest areas and the nation's major population centers as the lumber industry moved increasingly further west (U.S. Department of Agriculture 1958, Zaremba 1963).

Fuelwood use also continued to decline and provided less than 10% of the energy supply in 1945. Fuelwood was largely limited to heating and cooking on farmsteads, fireplaces, and for generating heat and power from wood residues in some wood-processing plants (U.S. Department of Agriculture 1958). The slowly declining demand for wood products eased the pressure of timber harvesting on the nation's forest inventories in this period. Rising real prices increased the efficiency of wood utilization in end uses and provided a stronger incentive for forest management. The growing demand

for pulpwood also held the promise of shorter forest rotations and fuller utilization of wood growth. However, investment in the management of private and public woodlands was not yet seen as a generally profitable enterprise. Due to long rotations, calculated rates of return were low and risk factors were high. Over 20 million acres of forestland were still being burned annually in the early 1940's. Over 90% of the area burned was on private ownership, primarily in the South (U.S. Department of Agriculture 1942, 1958).

Commercial Forest Land Ownership and Timber Inventories

Forest ownership.—Commercial forests include those lands producing or capable of producing crops of industrial wood (20 cubic feet per acre per year or more) that are not withdrawn from timber use by law or administrative regulation. The ownership of commercial forests at the end of the 1920 to 1945 period is presented in table 6 for 1952, the earliest year for which consistent commercial forest land area and inventory harvest and growth data are available. The distribution of sawtimber inventories is shown in the same table. Sawtimber is used rather than growing stock since that was the predominant source of the timber harvest in this period.

The largest shift in ownership of commercial forest lands probably occurred between the public and private sectors. From 1920 to 1945, the Forest Service added 22 million acres to the net area of national forests. Most of the area added was in the East and acquired after 1933 by purchase under the Weeks Act of 1911. The acquisitions were the result of the New Deal policy to purchase farmlands in areas of low productivity where farming had become uneconomic and many farmers were liquidating their resources and often abandoning lands due to their inability to pay taxes. These acquisitions included some cutover timber lands from lumber companies in the Lake States and the South. States, counties, and local governments, which held about half of the area of other public commercial forests, acquired a large part of their forest lands through tax delinquency or purchase in the same period (Shands and Healy n.d.; U.S. Department of Agriculture 1920 and 1944, 1958).

Until about 1930, lumber industry ownerships tended to be largely temporary. They usually disposed of their timber lands by selling them for farming or other uses. They also often allowed cutover lands to revert to local governments through tax delinquency. Some lands were sold to the federal government or exchanged for public timber harvest rights. The latter practice had largely ceased by 1945. At the end of World War II, the prospects of higher prices, the benefits of capital gains taxation (extended in 1944 to timber harvested on forest industry lands), expansion of the pulp and paper industry's markets, and improving forest protection, particularly from wildfire, were beginning to raise the profit prospects for permanent forest industry ownership and management of forest lands. Between 1945 and 1953, pulp companies which could utilize small timber based on relatively short rotations of 25 to 35 years increased their holdings by 8.5 million acres while lumber company holdings declined by 2 million acres, mainly by transfer to pulp companies. From 1935 to 1945, the pulpwood harvest rose from 6 million cords to 14 million and then to 25 million cords in 1952. Over 70% of the pulp industry growth occurred in the South. Over 90% of the growth was based on the use of southern pine for pulpwood.

Forest inventory and harvest by ownership.—National forests held over 50% of the nation's softwood inventory. It was heavily concentrated in the West, particularly in the Pacific Coast states. Almost all of it was virgin timber. The average stocking level for all national forest lands exceeded 11,400 board feet per acre. Timber harvesting in national forests was a relatively minor part of the nation's timber supply during the 1920's and 1930's. Generally, federal timberlands were less accessible than private lands. As World War II raised timber demand from Depression levels, however, national forest timber sales in the 1940's rose to 3 billion board feet, primarily supplied by the West. The war needs opened up the demand for national forest timber sales which continued to escalate to more than 10 billion board feet a year after 1957.

Forest industry lands were concentrated in the commercially valuable softwood timber types that provided the bulk of the nation's timber supplies. Over half of the

Table 6.—Commercial forest land ownership and timber inventories, 1952.

Ownership class	Area		Softwood Inventory		Hardwood Inventory	
	Million acres	Percent of total	Billion bd. ft.	Percent of total	Billion bd. ft.	Percent of total
National forests	95	19	1,048	51	31	7
Other public	49	10	255	12	29	6
Forest industry	59	12	410	20	53	12
Nonindustrial private	296	59	353	17	333	75
Farm	172	34	—	—	—	—
Other	124	25	—	—	—	—
Total	499	100	2,066	100	446	100

Source: U.S. Department of Agriculture (1982a).

industry lands were in the South, with the balance equally divided between the North and West. Stocking per acre averaged 7,800 board feet, including the hardwoods that were located mainly in the East. The lower average stocking reflected the preponderance of eastern timber types and the relatively heavier harvesting that these lands experienced during the 1920 to 1945 period. A large part of the annual sawtimber harvest came from industry lands. In 1952, they provided 40% of the softwood harvest and 12% of the hardwood cut.

Over 90% of the nonindustrial private forest lands were located east of the prairies and divided about equally between the North and South. Only 8.4% were in the West. About 58% of these lands were attached to farms and owned by farmers. For the most part, they were heavily cut over in the 1920's and 1930's as well as earlier decades. Their average stocking level of 2,300 board feet per acre reflected that harvest history and a lack of any intensified management following harvest. Despite their heavy harvest history and low average stocking, they were supporting more than their proportionate share of the nation's timber harvest in 1952. Nonindustrial private forests were providing 39% of the softwood sawtimber harvest, about the same as industry lands, and 82% of the hardwood sawtimber harvest. These harvest rates as a percent of inventory were 4.2% and 3.2%, respectively. They compare with 3.8% and 3.4% on industry lands for softwoods and hardwoods, respectively, and 0.6% and 0.1% on national forests.

Other public forest lands made up the smallest shares of the commercial forest area and inventory. Their share of the softwood sawtimber harvest in 1952 was 6% and for the hardwoods, 3%. Their intensity of utilization and management fell between that of private ownerships and the national forests.

Forest Management

The most important need for improvement in forest management at the turn of the century was the yearly reduction in area of forest land burned. Forest fires destroyed regeneration and made reforestation a risky investment. They also destroyed the value of standing timber. Over 40 million acres of forest land were being burned annually in the 1920's (U.S. Department of Agriculture 1942, 1958).

The states with the largest timber inventories were among the first to organize protection systems. In the Pacific Northwest, lumber companies that had purchased large areas of heavily stocked virgin stands pioneered both private and state efforts to protect their timber values from fire. State agencies and private protection organizations paid less attention to burned and cutover lands since there was little investment being made on these lands for future timber production. In the Forest Service, the protection of the national forests became a high priority early and a standardized system of effective fire detection and control was being formalized in the early 1920's (Davis 1983; Robbins 1985; U.S. Department of Agriculture 1942, 1958). Even so, the annual burn in the late 1920's and early 1930's averaged a half million acres, over 3% of the total national forest area.

Forest protection improved notably between 1920 and 1945 on all ownerships. The total area burned in 1945 was reduced to about 20 million acres a year and the trend was down. One of the more significant federal actions was the passage of the Clarke-McNary Act in 1924 which increased federal matching grants to cooperating states for the protection of nonfederal forest land. It allowed for inclusion of private fire protection expenditures with state funds in determining the match, and thus granted an incentive to state and private entities to increase their protection efforts. By 1945, federal matching had increased to more than $5 million a year. However, one-third of the nonfederal forest lands still were not receiving protection (Davis 1983, Robbins 1985, U.S. Department of Agriculture 1958).

The downward trend in area burned reflected efforts of the Civilian Conservation Corps program of the 1930's, strengthened state fire control organizations, improved leadership by all agencies, and greatly expanded fire control facilities and financing. Total funding for forest fire protection had risen to $12 million in 1932. In 1952, it was more than 50% higher, measured in constant 1932 dollars. Federal support provided 43%, state funds 40%, and private funding the remaining 17%. By 1952, the annual area burned was less than 12 million acres, and 96% of that was occurring on private lands, almost entirely in the East. Two-thirds of the private area burned was in the South (U.S. Department of Agriculture 1958).

Tree planting on harvested forest lands or abandoned agricultural lands remained relatively low. In 1926, the total area of acceptable tree plantations was only 352,000 acres. Most of that was in the North. The annual rate of successful tree planting was only 68,000 acres during 1926 to 1929. It rose to 184,000 acres from 1940 to 1944. The total accumulative acres of successful tree plantations in 1944 was 3.3 million acres. Two-thirds of that progress had been made in the North. A good deal of the planting was accomplished in the 1930's under the stimulus of federal emergency conservation programs, including the Civilian Conservation Corps. The total plantable area in 1952 was estimated to be 52 million acres. Almost 22 million acres were in the South and about the same in the North, mainly on private lands. The remaining 8 million acres were in the West (U.S. Department of Agriculture 1958).

A great deal of unobserved natural regeneration was occurring on millions of acres of private farm lands that were being abandoned or taken out of crop production during the Depression and later years. Naturally regenerating pine stands on these lands were to become the new or second pine forest of the South in the 1970's and later. However, in 1945, the challenge to reduce the incidence of forest fires in the southern states was still there. Burning was still a socially condoned and established practice in the South for several purposes, even though the forest industry, the Forest Service, and state foresters had begun efforts to contain and restrain the traditional burning practices (Southern Forest Resource Analysis

Committee 1969). Perhaps indicative of the risks due to forest fires, southern forest industry planting on its own lands averaged only 6,800 acres a year from 1925 to 1945 (Williston 1980).

The Forest Service assessed the growth condition of recently cut stands for all ownerships in 1952. It was based on a sample of nearly 26,000 holdings in all ownership and size classes. The productivity index was based on four criteria that affect growth after cutting: (1) existing stocking; (2) prospective stocking in nonstocked or understocked areas; (3) species composition; and (4) age of the timber at the time the cutting occurred. Recently cut lands were classified into three productivity classes: upper, medium, and lower. Ratings are shown in table 7. They were applied to the areas of each ownership that were subject to recent harvesting. The aggregate area of these types was defined as the operating area (U.S. Department of Agriculture 1958).

The public and forest industry lands received the highest productivity ratings. About 80% of the area being harvested on these lands had very favorable conditions for regrowth following harvests. The farm and other private ownerships were reported to have the "poorest condition" and greatest need for management improvement. Productivity ratings were the lowest for these ownerships in the South. Holdings of over 50,000 acres in each private owner class received the highest ratings indicating very favorable conditions for regrowth after harvests. On the average, 78% of their operating area was ranked in the upper productivity class. Only 40% of the operating area of holdings less than 5,000 acres was rated in the upper class (U.S. Department of Agriculture 1958).

Within the forest industry ownership, the ratings for lands held by pulp and paper companies were the highest of any reported category; 84% of their operating area was reported in the upper productivity class. Pulp manufacturers owned nearly 40% of the forest industry lands (U.S. Department of Agriculture 1958).

Table 7.—Productivity of recently cut commercial forest land, 1952.

Ownership	Operating area	Proportion of operating area by productivity class		
		Upper	Medium	Lower
	Million acres	*Percent*		
Public	96	80	17	3
Forest industry	44	77	19	4
Other private	42	52	28	20
Farm	53	41	37	22

Source: U.S. Department of Agriculture (1958).

Major Forest Policy Issues and Initiatives

During the 1920 to 1945 period, major forest policy issues focused on the management and protection of nonfederal forest lands. The Capper Report of 1920, prepared by the Forest Service for the U.S. Senate, was requested by Senator Capper in response to a Society of American Foresters committee report published in the Society's official Journal of Forestry in 1919. The committee, led and chaired by Gifford Pinchot, urged that the federal government regulate cutting practices on private timberland. The recommendation was predicated on a predicted timber shortage that would become a "blighting timber famine" within 50 years. The Pinchot report was the culmination of an intense debate which had been underway for several years in forestry circles over the question of federal regulation of private timber harvests. This committee report was seen by some foresters, especially in forest industry circles, as a threat to a cooperative approach to private timber harvesting that had been emerging since the Weeks Act of 1911 (Davis 1983, Robbins 1985).

The Capper Report emphasized that federal, state, and private forestry interests should cooperate to stop timber depletion. That was also the basic view of William Greeley, the Chief of the Forest Service. Although this and other policy views had been held and debated within the Forest Service, Greeley had developed, advocated, and supported such cooperation throughout his Forest Service career. The Capper Report took the position that the public had a responsibility to share in the costs of fire protection and to provide an equitable system of taxation for forest lands, their inventories, and growing stock. It made six recommendations: (1) increase cooperation with states in fire protection; (2) expand national forest areas; (3) study forest taxation and insurance; (4) restock burned and cutover federal lands; (5) provide for the periodic survey of forest resources; and (6) increase funding for forestry research.

The Capper recommendations were largely implemented by the Clarke-McNary Act of 1924 which amended the 1911 Weeks Act and emphasized a cooperative rather than coercive federal-private relationship. Timber production was included along with flood control as a justification for national forest land acquisition. It also authorized a comprehensive study of "the effect of tax laws, methods, and practices upon forest management." Other sections of the act provided for cooperative assistance for shelter belts, woodlots, and tree nurseries. The Prairie States Forest Project for planting a "tree" windbreak system to protect farm fields from wind erosion was administered by the Forest Service under this authority from 1935 to 1942 (Davis 1983, Robbins 1985).

The Forest Service undertook a decade long study of taxes, led by Fred R. Fairchild of Yale University, published as a report on Forest Taxation in the United States in 1935. The report argued that the annual property tax was essentially biased against investments with deferred yields (such as forest production), when compared to those with shorter term payoffs. The problem increased when high development values were assessed to forests. This view is still debated, but there seems to be agreement that property taxes levied on the full value of land and timber tend to reduce incentives for forestry relative to alternative uses. The ideas emerging from this study had an important influence in reducing property

tax burdens on forest lands through state legislation or reduced assessment procedures and thereby raising incentives for forest land ownership and management (Davis 1983, Robbins 1985).

The specific research and forest survey recommendations of the Capper Report were implemented by the McSweeney-McNary Act in 1928. The act greatly expanded the Forest Service forestry research capability by providing for establishing 11 regional forest experiment stations. It also authorized the systematic and continuous inventory of the nation's forest resources and directed the Forest Service to implement forest survey work in cooperation with state and private agencies. The forest survey objectives were to: (1) inventory forestlands and present supplies of standing timber and other forest products; (2) ascertain the rate of forest growth; (3) determine the forest drain due to harvesting and losses from pests and other natural causes; and (4) study future requirements for timber and other forest products.

The forest survey was initiated in 1930. It has since provided forest inventory information for individual states on a 12-year cycle. National summaries have been prepared about every 10 years with assessments of the long term outlook for timber demands and supplies. The information has become a valuable resource for the forest industry, states and many counties, and many landowners as well as the federal land management agencies (Davis 1983).

The idea of regulating forest practices did not fade away with the legislative responses to the Capper Report. The National Industrial Recovery Act of 1933, prepared with industry cooperation, provided for government control of production and price control. It also provided for formulation of forest practice rules by the forest industry based on the principle of industrial self-regulation, with states serving as the enforcement agencies. Industry support was conditioned by the excessive overproduction of lumber in the Depression years and depressed prices. This New Deal initiative, however, was aborted when the Supreme Court ruled the Act was an unconstitutional delegation of legislative authority (Davis 1983, Robbins 1985).

Federal regulation of private forest practices continued to be advocated within the Forest Service. Forest Service views on a possible program of public regulation for private forests were defined in the Copeland Report in 1933, prepared at the request of the U.S. Senate as a National Plan for American Forestry. It was an encyclopedic review of American forestry and forest industry conditions that contributed to the general forestry situation. Private ownership was defined as a dominant source of all the major problems of American forestry. A large extension of public ownership was advocated. All the major forest resources, timber, water, range, recreation, and wildlife, were addressed. Forestry research and the cooperative federal-state programs were also reviewed. Weak state and private commitments to forest management were sharply criticized. The Copeland Report complained that timberland owners accepted federal assistance to help them "shoulder a major part of the job of timber growing" but rarely did any management on their own. Nearly all states were enjoying some form of federal assistance but an inability to match federal funds reduced the impact of cooperative programs, particularly in the South where assistance was most needed.

Despite the criticism, the Copeland Report supported cooperation with the states and expansion of fire protection, insect and disease detection, and control; distribution of tree planting stock to industry and farmers at half-cost; expansion of extension forestry to farmers and industry; and expansion of forestry research. It also recommended a stronger direct federal role through the purchase of $50 million worth of private forestland annually and public regulation of logging on private lands.

The Depression and World War II preempted most of the potential impact of the Copeland Report. However, in 1935, Ferdinand A. Silcox, chief of the Forest Service, reopened the regulation issue with the declaration that "Public control over the use of private forest lands, which will insure sustain yield, is essential to stabilize forest industries and communities." He argued that private forest practices should be supervised by public agencies and not left to the forest industry. The idea was supported by the Forest Service leadership through the 1940's. It seemed to fade away as legislation proposed by Senator Clinton P. Anderson was discouraged by the opposition of the Society of American Foresters and the forest industry. That legislation approached public regulation of private forest practices through federal guidelines for state forestry administration.

Although the threat of federal regulation of forestry practices on private lands faded away, the issue produced some positive results. It raised incentives in the forest industry to employ scientifically-trained professional foresters, and to support state and federal efforts to improve forestry practices on private nonindustrial forestlands (Davis 1983, Robbins 1985, Wooten 1965). In subsequent years, various states enacted or promulgated voluntary forest practice standards for their private woodlands, often with forest industry cooperation. A few states such as California, Oregon, Virginia, and Washington enacted stronger regulatory legislation relating to harvest planning, harvesting practices, and reforestation after harvest. These initiatives have varied widely, both in their design and their results.

EVOLVING LAND USE FOR WILDERNESS, PARKS, WILDLIFE, AND RECREATION

Wilderness

As the national forest lands were expanding, the Forest Service developed its first official system for wilderness reservation with regulations for establishing primitive areas in 1929. By 1939, 75 areas encompassing 14.2 million acres of national forest were designated as primitive. In 1939, the original regulations for establishing wilderness areas were made more restrictive. By 1944, the Forest Service had reclassified and designated 4 areas totalling 1.4 million acres as wilderness. The rest of the 14.2 million acres continued to be classed as "primitive," pending reclassification (Hendee et al. 1978).

National Parks

The National Park System was largely a western system in 1920. Only 2 of its 37 diverse units were in the East—Acadia National Park in Maine and Hot Springs National Park in Arkansas. It continued to grow, and by 1933 there were 63 units, including 8 additions in the East. The latter included the Great Smokey Mountains and Shenandoah National Parks in the Appalachians, Mammoth Caves National Park in Kentucky, and Isle Royale National Park in Michigan (U.S. Department of Interior 1985b, 1985c).

During 1933, President Franklin Roosevelt added 53 new units to the system. His reorganization of the federal government consolidated all national parks, monuments, military parks, memorials, the National Capital parks, and 11 cemeteries under the National Park Service. Nearly 40 of the new units were in the East, mainly areas of historical and memorial interest. About a dozen predominantly natural areas from the national forests were added in the West. The addition of these units and the designation of the first national parkways and the first national seashore, Cape Hatteras, in the 1920 to 1945 period broadened the geographic scope and variety of the National Park System.

By 1945, there were 144 units in the Park System, totalling about 20 million acres within the contiguous 48 states. The Territories of Alaska and Hawaii had five additional units with several million acres. About two-thirds of the area of the National Park System was located in 30 national parks (U.S. Department of Interior 1985b, 1985c).

The National Park System was largely inaccessible to most Americans and only 6 million visits were reported in 1942 (U.S. Department of Interior 1985c).

State Parks

State efforts to expand state parks were very uneven in the 1920's. Activity was the strongest in the northern states from Maine to South Dakota and on the Pacific Coast. Very little progress occurred in the South or the Rocky Mountain and intermountain states. In the Depression years, however, the CCC camps were allocated to serve conservation needs in the Park System and at state parks. In the peak program year, 1935, there were 600 CCC camps—118 in the Park System and 482 serving state parks in almost every state. About 120,000 CCC enrollees and 6,000 professional landscape architects, engineers, foresters, biologists, historians, architects, and archaeologists were involved. Some states, such as New Mexico which did not have any parks, were able to establish them with CCC assistance. Others were able to advance the development of their state park systems. State park activity essentially stopped during the years of World War II. In 1950, there were 1,725 state parks with a reported area of 4.7 million acres, and total visits to state parks were reported to be 114 million (Davis 1983, U.S. Department of Commerce 1975).

Wildlife Management

In the 1920's and earlier, wildlife stocking, predator control, and protection of wildlife in reserves were the main approaches to habitat management and wildlife population rehabilitation. By 1945, habitats for 34% of the nation's larger wildlife species were protected in the national forests, national parks, and some 170 national wildlife refuges (Davis 1983).

States were improving and strengthening their game laws. In the early 1920's, an estimated 6 million sport hunters were licensed, compared to 3 million licensed hunters in 1910. Game laws became increasingly complex. The prohibition of night hunting, except for nocturnal game, was almost universal. Hunting and fishing seasons as well as creel and bag limits were greatly reduced. Fish and game law enforcement was increased. While there was clear progress in the restoration of wildlife populations, there was also debate and dissension about how best to manage them. Protection from predators and hunters did not always sustain populations. Some populations declined due to inadequate nutrition, disease, and fires. The Dust Bowl of the early 1930's was a disaster for waterfowl on the western prairies and plains.

In the early 1930's, Aldo Leopold published his classic Game Management, a text for professional wildlife management that altered the course of wildlife conservation. He recognized the role of legal protection for wildlife and provided a set of management principles to help maintain wildlife populations at optimum levels, consistent with man's requirements. Each species had its own seasonal needs for food, cover, water, and space. He addressed stocking levels, breeding potential, and habitat carrying capacity. The roles of limiting factors and hunting were also defined.

In 1934, Congress passed several laws designed to coordinate wildlife conservation on a nationwide basis. The Duck Stamp Act provided funds from hunting permits to purchase and develop wetland areas for a national system of migratory fowl refuges. A cooperative wildlife research unit program was established. It provided federal funds for wildlife research to be conducted by state land grant colleges with support from the state wildlife agencies and the American Wildlife Institute. The program began with 10 units and now includes 43 fishery, wildlife, or combined units in 31 states (U.S. Department of Interior 1984b).

The most far-reaching action of the 1920 to 1945 period was the passage of the Federal Aid in Wildlife Restoration Act, better known as the Pittman-Robertson Act (P-R Act) in 1937. The P-R Act authorized the allocation of revenues from the 10% excise tax on sporting arms and ammunition to the states for approved wildlife research and land acquisition, development, and maintenance. The P-R Act is particularly notable for its requirement that states enact enabling legislation prohibiting diversion of hunting license revenues to any use other than the administration of its fish and wildlife agency. It ended a common practice in many states of allocating fish and

wildlife agency funds to various public works not related to wildlife. The states used the P-R Act funds in the 1940's to develop and restock wildlife populations. Thirty-eight states acquired 900,000 acres of refuges and management areas. Deer, pronghorns, elk, mountain goats and sheep, moose, bear, beaver, and wild turkey were restocked (U.S. Department of Interior 1984a).

INSTABILITY AND TRANSITION END WITH AN UNCERTAIN FUTURE

The economic depression and adverse climatic conditions brought a good deal of distress to farmers, ranchers, and lumbermen as well as to conservationists and other interest groups during most of the 1920 to 1945 period. Resources were also stressed by the economic impacts of the Depression and adverse climate. Some reached the nadir of their transition in this period. Others suffered a slower recovery. A few successes such as the return of the white-tailed deer in the East, a major reduction in forest area burned each year, emerging increases in crop yields, and the growth and diversification of the National Park System brightened the resource picture. They were early indicators of the resilience of the nation's resources and their responsiveness to management and technology. Multipurpose water resource development brought the promise of improved protection against flooding. It also created a new basis for economic growth through expansion of low cost hydropower availability, better water transportation systems, and improved water supplies for irrigation and other uses to all parts of the nation.

New federal policies and programs lifted hopes for a better resource future, but the test of their effectiveness lay largely in the decades beyond 1945. World War II expansion of resource demands brought economic recovery to most resource owners and producers, but slowed the progress of many of the policies and programs planned for improving resource productivity and resource conditions. The end of World War II was welcome. It also presented an uncertain future for the nation's resources and new and unknown tests of the recently established policies and programs, emerging technology, and new management approaches as demands soon soared for all resource uses in the postwar period.

THE MODERN PERIOD OF RESOURCE MANAGEMENT AND USE, 1945–1985

From 1945 to 1985, the United States population rose by 100 million to 239 million. Total disposable real income increased 3.3 times while per capita real income more than doubled. General economic welfare and total domestic demand for goods and services increased more than 2.5 times. Agricultural exports nearly quadrupled. Agriculture and forestry generally prospered during this long period of economic growth (Economic Report of the President 1986).

In the 1980's, however, farmers and ranchers have again experienced economic distress as recession, reduced exports, and excess production depress markets and prices for agricultural commodities. Lumbermen have experienced the same distress as reduced housing starts and expansion of Canadian imports depressed lumber prices and profits.

As the population and economy steadily grew in this period, the use of land for urban development, transportation systems, parks and wildlife, and industrial purposes also expanded, from 180 million to 270 million acres (table 1). The total land available for crop, forage, and forest production declined correspondingly, by about 5%. Growth in population affluence, leisure, and mobility placed new demands on the nation's lands and resources for wilderness, wildlife, outdoor recreation, and related amenities including clean waters and clean air. Demand for natural resource products including minerals and fuels also expanded notably. These new pressures on the resources were largely met through productivity improvements, adjustments in land use, and a new emphasis on multiple use management.

Productivity, however, also rose, particularly for croplands, in response to expanding domestic and foreign demands for farm commodities. This reduced the pressure on land resources for more cropland. The production response, not only for crops but also for livestock and forest products, demonstrated a resilience of these long-used lands and resources that was neither planned nor clearly anticipated.

CROPLAND USE AND MANAGEMENT

Cropland used was about the same at the beginning and end of this period, a little more than 400 million acres. As production per acre grew faster than demands in the first part of this period, cropland shifted to other uses, leading to a decline in cropland use—to 384 million acres in 1969 (table 1). The acreage of crops harvested decreased even more, from 354 million acres in 1945 to 290 million acres in 1969.[8] After 1969, a rapid expansion in world demand and markets reversed the downward trend. The harvested crop acreage rose to a peak level of 366 million acres in 1981 in response to incentives provided largely by an expectation of continued growth in world demands, and price and income protection from federal commodity programs.

The portion of land used for crops continued to shift among the regions after 1945 but much less dramatically than during the 1920 to 1945 period (table 5). Cropland continued to decline in the Northeast, Appalachia, and the Southeast by 5 to 8 million acres in each region to 1982. In the Southern Plains, cropland use fell over 8 million acres to the lowest level since 1920. The only major cropland increase occurred in the Corn Belt where corn and soybean production expanded. In each of the other regions, the Lake states, Delta, Northern Plains,

[8]*Actual crop acreage harvested plus acreages in fruits, tree nuts, and farm gardens.*

Mountain, and Pacific, cropland used increased 1 to 3 million acres to 1982. Most of those small increases came after 1969 as exports increased.

Growth in Productivity

Indicative of the great increase in productivity, the persons supplied per worker rose from 15 to 77 (table 2). That trend applies to exports supplied abroad which was less than 2 persons per farm worker a year in 1945 and about 20 persons per farm worker in the early 1980's. Exports in 1980 made up 31% of total farm production including livestock, and 39% of the cropland output. Although exports fell sharply after 1980, they remained at high levels, accounting for 20% of total farm production and 25% of crop output in 1985. Export demands in the 1970's and 1980's became the single most important determinant of changes in cropland cultivated and harvested.

As productivity grew, farm workers declined from 10 million to 3.3 million (table 2). Farm labor dropped to 2.25% of the civilian labor force. Farm population declined at the same time from 24.4 million to 5.4 million, releasing enormous labor resources that largely became employed in other growing sectors of the national economy. Farm prices also declined relative to the general price level of all commodities, adding to the general consumer welfare.

Increases in farm productivity were a major source of the national economic growth in this period. As total farm output doubled, the mix and quality of farm inputs needed to achieve the increased production changed but the total remained constant. Productivity improvements in this way accounted for essentially all of the 40-year growth in farm production for both domestic consumption and foreign exports (Economic Report of the President 1986).

Factors Contributing to Productivity Growth

A number of factors combined to contribute to the spectacular rise in agriculture productivity in the postwar period. The most fundamental were the assurance of relatively high and stable prices provided by the commodity support programs, and strong markets in years the programs were not operative. These factors, together with crop insurance and natural disaster assistance programs, provided farmers an environment of assured rewards and reduced risk and uncertainty. Growth in domestic demands, combined with generally accelerating export demands, provided markets for a rising volume of production. When surpluses occurred, they were reduced or limited by acreage set-aside programs and government export programs which provided large volumes of food assistance at relatively low cost to developing countries in the latter 1950's and 1960's. Significant but lesser volumes of exports were donated to countries suffering major disasters. Often these export programs contributed to the later development of commercial markets for United States farm production in the recipient countries.

Another important factor contributing to productivity growth was availability of adequate farm credit for equipment, operating purposes, and real estate. A large part of the favorable credit supply was linked to reduced risk and uncertainty attributable to the federal farm programs and strong markets and market expectations. Inflation also assured cheaper money to pay off farm debts. Tax credits and other tax rules likewise contributed to a favorable environment for farm investment in new equipment, technology, and production. Low interest loans were also available from the Farmers Home Administration for those farmers who could not get credit from private sources (Farrell and Runge 1983, Paarlberg 1983, Schertz et al. 1979).

Underlying the favorable market and financial conditions was the experience with rising productivity in the late 1930's and early 1940's which provided an awareness of the potential to increase yields per acre, outputs per worker, and farm income with improved equipment and many other emerging technologies from federal, state, and industry research programs. The productivity potential of much of the new technology was enhanced by the development of new farming methods and systems combined with equipment innovations (Farrell and Runge 1983, Rasmussen 1974, Schertz et al. 1979, Schlebecker 1975).

In the 1970's, world crop shortages, a decline in the relative value of the dollar, and a strong world economy escalated world demands for American crops to unprecedented levels. The demands quickly absorbed American grain reserves that had been accumulating. High prices induced greater production and brought additional acres into cultivation. For most of the 1970's, commodity programs became inoperative since there was little or no need to limit or reduce production. In the 1980's, a world recession and a rising value of the dollar against other currencies reduced export demands for American crops; exports nevertheless remained at historically high levels (Farrell and Runge 1983, Paarlberg 1983, Schertz et al. 1979, U.S. Department of Agriculture 1984b).

The continuing and improving educational and information systems that brought the knowledge and understanding of new technologies to farm operators further contributed to productivity. These included the federal and state Cooperative Extension System, the great growth in farm journals and magazines, the expansion of industrial outreach activities to farmers as purchase of farm inputs was increased, and a significant increase in the average educational level of farm managers. These components of the information system often integrated and supplemented each other's efforts. Feedback from direct on-farm contacts and experiences with farmer problems and needs often contributed to more effective research and innovations. The proportion of farm managers with college degrees rose from 1% in 1940 to 10% in 1980; two-thirds also had completed high school compared to less than 13% in 1940 (Farrell and Runge 1983, Rasmussen 1974, Schertz et al. 1979, Schlebecker 1975, U.S. Department of Agriculture 1980a).

Farm productivity achievements in this short period have no comparable historical precedents in agriculture. They have been labelled the second American agricultural revolution (Rasmussen 1974). This achievement is of particular importance because it came at a time of rapid domestic and world population growth. The enormous increase in productivity and food production per acre had a beneficial effect in forestalling major shifts in land use from forests and grazing to crop production as domestic population and food demands nearly doubled. The expansion of food exports and American technology, likewise, probably slowed world pressures on the land and soil resources of many developing countries.

Farm Structure Changes

The same factors that encouraged the adoption of new technology and innovation in farming systems for productivity improvement also induced increases in farm size. As farm labor productivity rose, the farm operator was able to manage and cultivate more acres and increase farm income. Thus, as the number of farm workers decreased between 1945 and 1969, the number of farms declined 55% and average farm size doubled (table 8). The pattern was the same in all farm producing regions. The decline in farm numbers and increase in farm size continued after 1969 but at much slower rates. In 1982, there were only 2.4 million farms, 60% fewer than in 1945. The management of a billion acres of farmland, including cropland and associated grasslands and woodlands, was now in fewer hands.

Table 9 shows the number and distribution of farms by farm commodity sales classes for 1949, 1970, and 1982. In 1949, 79% of all sales production came from farms with less than $100,000 of gross sales, and they constituted 99% of all farms. Between 1949 and 1982, the percent of farms with $100,000 or more gross sales (1980 prices) increased from 1% to 12%. The number of farms providing this production rose from 50,000 to 302,000. Their share of sales rose from 21% to 69%. Thus, farm production and management became much more concentrated among fewer managers and larger farms (Harrington and Manchester 1985, Schertz et al. 1979).

With the increase in farm size, cultivated fields were also enlarged in order to capture the efficiencies of larger scale equipment. Farming became more specialized, again in order to capture the efficiencies of new technology. Farmers now purchase more of the inputs used in production and depend less on inputs produced on the farm. Since 1945, total farm labor inputs have declined about 80% while the farm real estate input has remained about constant. Mechanical power and machinery inputs have increased over 75%. Agricultural fertilizer, lime, and pesticides purchases have increased almost 10 times and feed, seed, and livestock purchases have more than doubled. Marketing and financial management have become a more significant aspect of

Table 8.—Number farms, acreage and size, 1945-1982.

Year	17 Western states	South	North	48 states
		Number of farms (thousands)		
1945	1,436	2,331	2,092	5,859
1969	808	864	1,054	2,726
1982	745	722	928	2,395
		Land in farms (million acres)		
1945	674	200	267	1,142
1969	690	154	215	1,059
1982	652	144	238	1,035
		Average farm size (acres)		
1945	469	86	115	195
1970	854	178	204	388
1982	876	200	256	432

Source: U.S. Department of Commerce (1975), U.S. Department of Agriculture (1942).

Table 9.—Approximate distribution of farms and value of production based on 1980 prices by farm sales class, 1949, 1970, and 1982.

Year	Over $500,000	$100,000-499,000	$40,000-99,000	$10,000-39,000	$1,000 9,999	Total
			Number of farms (thousands)			
1949	—	50	239	1,479	3,207	4,975
1970	16	190	566	690	1,413	1,875
1982	25	277	393	654	1,155	2,400
			Percent of farms			
1949	—	1	5	30	64	100
1970	1	6	20	24	49	100
1982	1	11	17	20	48	100
			Percent of sales			
1949	—	21	19	43	17	100
1970	22	32	30	11	5	100
1982	30	39	19	9	3	100

Source: Harrington and Manchester (1985).

farming, particularly on the larger farms (Economic Report of the President 1986, Harrington and Manchester 1985).

Technological Progress

Mechanization, the substitution of equipment for farm labor and animal power, continued to be the basic technology underlying the reduction in farm workers and increase in farm size. Table 10 shows the trend in equipment use from 1945 to 1983. The number of tractors continued to grow as farm numbers declined and size increased. As the number of tractors stabilized after 1965, their total horsepower continued to increase as the size and capacity of farm machines increased.

New and improved plant varieties, development of a wide range of pesticides to control fungi, insects, and weeds, and expanded use of chemical fertilizers substantially increased yields per acre. Crop production per acre doubled between 1945 and 1985 (Economic Report of the President 1986). Other factors contributing to productivity growth were the expanded use of irrigation, drainage of highly productive wetlands, double cropping, and the use of conservation tillage systems.

Irrigated croplands provide substantially higher yields than nonirrigated lands. They increased by about 30 million acres during the 1945 to 1985 period to 50 million acres. Only 10 million acres concentrated in the Southwest are associated with the extensive federal reclamation projects. The remaining 80% of irrigated lands are largely the result of nonfederal investments. In 1982, irrigated lands made up 13% of harvested cropland, but accounted for 32% of total crop value.

Corn, hay, wheat, and cotton made up 53% of irrigated acreage and 36% of irrigated crop value. Vegetable and orchard crops used less than 11% of irrigated land but produced 34% of total irrigated crop value (Hostetler et al. 1986, U.S. Department of Agriculture 1942).

The irrigated acreage grew about 7 million acres a decade from 1939 to 1969. In the decade following 1969, as export demands and farm prices rose, irrigation systems expanded by 12 million acres. The development of groundwater sources and movable sprinkler systems were important factors in achieving this expansion. Between 1950 and 1980, groundwater provided over 60% of the 82 million acre foot increase in water used for irrigation. It now provides over 40% of the 170 million acre feet used in irrigation (Hostetler et al. 1986). One-half of the irrigated acreage is in the 11 Mountain and Pacific Coast states and one-third in the 6 Plains states. The remaining 16% is in the East, where it has been expanded mainly to increase returns per acre and reduce risks due to local moisture shortages and periodic droughts (Hostetler et al. 1986).

The area of installed drainage systems remained stable during the 1920 to 1945 period at about 50 million acres. Most systems had been installed between 1900 and 1920. Between 1945 and 1980, the drainage systems increased to 110 million acres. About one-half of the 60 million acre increase was on wet soils and the other half on wetlands. The expansion of wetland drainage was most heavily concentrated in the Southeast, particularly in the Lower Mississippi Alluvial Plain, Florida, and North Carolina. Heavy wetland losses also occurred in Minnesota. About half of the wetlands converted to agricultural use were previously forested bottomland areas (Heimlich and Langner 1986a, 1986b). On a national basis, present wetland conversion rates are estimated to be about 300,000 acres a year, compared to an average yearly rate of 900,000 acres in the 1950's and 1960's. The lower current rate is attributed primarily to reduced drainage for agricultural use and secondarily, to various government programs that regulate or discourage wetland use (Office of Technology Assessment 1984).

Double cropping refers to the production of two crops on the same field in the same year. Rising prices and new technologies accelerated double cropping in the 1970's. Cropland double cropped rose from 3 million acres in 1969 to more than 12 million in 1982. About 44% occurred in the South, 32% in the North, and 24% in the Plains, Mountain, and Pacific states. Double cropping raises the productive capacity of cropland. In areas south of 40 degrees north latitude, for example, double cropping of wheat and soybeans raised per acre productivity 30% (Hexem and Boxley 1986).

Table 10.—Farm machinery and equipment: 1945-1983.

Year	Tractors	Total tractor horsepower	Combines[1]	Cornpickers picker/shellers	Pickup balers	Field forage harvesters
	Thousands					
1945	2,345	—	375	168	42	20
1955	4,345	—	980	688	448	202
1965	4,783	—	910	690	751	316
1970	4,619	203,000	790	635	795	331
1975	4,469	222,000	524	618	667	255
1980	4,775	277,000	669	690	764	301
1983	4,600	278,000	675	685	755	295

[1]*Data for 1975 and later are for self-propelled combines only.*
Source: U.S. Department of Commerce (1975), U.S. Department of Agriculture (1942).

Conservation tillage is a new farm production system, which reduces soil plowing and cultivation to a minimum, consistent with local soil, climate, and economic conditions. In general, it is any tillage system that leaves at least 30% of the surface cover as residue after planting. Typically, it relies more on herbicides and less on cultivation to control weeds. It is effective for many soil and climate conditions and suffers no yield disadvantage compared to conventional tillage with the moldboard plow. Conservation tillage became established in the 1960's and accelerated in the 1970's when energy costs were rising. Its rate of adoption has been faster than most any other practice in the history of farming. In 1983, 21% of all farmers who planted crops used some form of conservation tillage. In addition to cutting fuel and labor costs, conservation tillage also reduces erosion by as much as 50 to 90% compared to conventional moldboard plow tillage. It offers farmers the opportunity to save on costs of production and provides a low cost way to control erosion. In 1982, 100 million acres of cropland were under some form of conservation tillage (Crosson 1984, Rosenberry and English 1986).

Soil Erosion and Conservation

Local Soil and Water Conservation Districts were organized and operated in practically all rural counties of the 48 states through most of the 1945 to 1985 period. Technical assistance and conservation plans provided by the Soil Conservation Service (SCS) were available on a voluntary basis to all farmers who wished to participate. Cost share payments were similarly available under the Agricultural Conservation Program (ACP) of the Agricultural Stabilization and Conservation Service (ASCS) and the SCS Great Plains Conservation Program to finance implementation of conservation practices. The original ACP, established in 1936, had dual goals of encouraging conservation and supporting farm income. Over the years, the income support activities were phased out and those practices that are primarily production-oriented are no longer approved. The current emphasis is on long-term conservation practices and benefits.

Much of the serious erosion that was evident in the 1930's was healed with the help of these programs or by nature itself. Abandoned cropland and pasture usually regenerated to field and brush cover which often evolved to new forest cover in the East. Estimates of soil erosion on croplands declined from 3.6 billion tons in 1938 (Bennett and Lowdermilk 1938) to only 2.6 billion tons in 1967 (U.S. Department of Agriculture 1967).

In addition to conservation programs, several factors contributed to declining erosion. The total area of used and harvested cropland was at its lowest levels in the late 1960's (table 1). The number of farms had declined 50% and farm size had doubled. Farm tenancy was greatly reduced. Farm management had generally improved. Nearly 30 million acres of the more erosive cropland was withdrawn from cultivation for 10 years under the Soil Bank Program in the late 1950's and most of the 1960's. Under price support programs to reduce production, annual acreage reserves were required to be put into conservation cover crops (primarily grass). In the South, 2 million acres, planted to pine trees under the Soil Bank Program, added to the development of the South's Second Forest in the 1970's and 1980's. Drought was not a serious problem in the 1960's as it had been in the 1930's.

As large crop surpluses began to emerge in the mid-1950's and 1960's, conservation programs were criticized. They were seen as contributing to increased production per acre. Presidential budgets proposed elimination, reduction, or no-growth for conservation programs, especially in the case of ACP funding. As early as 1953, the Secretary of Agriculture tried to eliminate ACP cost sharing for production-oriented practices. Congress consistently supported conservation program funding and the authority of county and state committees and conservation districts to determine local county conservation practices and priorities. Nevertheless, the ACP level of assistance was gradually reduced by the impact of inflation on constant dollar funding. Technical assistance was reduced in the 1970's and the administration shifted program emphasis more to long-term conservation practices (Rasmussen 1981).

Persistent criticism became documented in a 1976 General Accounting Office (GAO) review and evaluation of the major agricultural conservation programs (General Accounting Office 1977, U.S. Department of Agriculture 1982b). It found that the major programs were falling short of their erosion control objectives. None were concentrating scarce resources on the most effective control measures, nor were they directing assistance to the farms that most needed help in reducing erosion. There was a lack of priorities for the most serious erosion problems. Subsequent agency evaluations confirmed these views. They reported that 52% of the ACP cost shares and 33% of conservation technical assistance for erosion control were being applied to lands where erosion was less than 5 tons per acre per year and generally not considered a conservation problem. Many critical erosion problem areas were not being effectively addressed (U.S. Department of Agriculture 1981c, 1985a). Congress, responding to the issues identified by GAO, enacted the Soil and Water Resources Conservation Act of 1977 (RCA). It directed the Department of Agriculture (USDA) to appraise the state of the nation's soil, water, and related resources and to prepare a program to further their conservation.

The RCA appraisal and program plan, involving nine USDA agencies and 34 different programs, was completed in 1982. For the first time, national conservation program priorities were established, and soil erosion control ranked first. It redirected funding to the highest priorities and established a policy for targeting critical erosion areas and other major problem areas. Focusing resources on critical problem areas became the general policy for increasing the effectiveness of national conservation programs. Strengthening state roles in conservation was also emphasized (U.S. Department of Agriculture 1982b).

As part of its soil and water appraisal work, the SCS conducts a National Resource Inventory (NRI). The first NRI was completed in 1977 and the second in 1982. In 1977, total cropland soil loss from water and wind erosion rose to 2.8 billion tons, slightly more than in 1967. About 2 billion tons of the loss was due to sheet and rill erosion, and the balance to wind erosion. The increase in total erosion was attributed to the increase in acreage of cropland used and harvested in response to export demands, and particularly to the substantial increase in row crop production. The total area planted to row crops rose from 145 million acres in 1969 to 170 million in 1974 and 195 million in 1980 (Fedkiw et al. 1981). Between 1975 and 1981, some 20.3 million acres were converted to cropland use, predominantly from rangeland, pasture, and idle lands. The new cropland had fewer conservation practices than existing cropland. About 10% of the converted acreage had wind erosion and 25% had sheet and rill erosion exceeding the acceptable limit of 5 tons per acre per year. The average erosion on all new cropland was 8.1 tons a year compared to 7.4 tons for existing cropland (U.S. Department of Agriculture 1985c).

In 1977, 77% of the cropland subject to water erosion was either nonerosive or managed with conservation practices that kept erosion within the tolerance level of 5 tons per acre per year (table 11). Thus, all the excessive erosion was concentrated on 22% of the cropland. Of the cropland eroding above the tolerance limit, 7% was so highly erodible that erosion could not be practicably reduced below the tolerance limit no matter what cropland management was applied. The total excess sheet and rill erosion was 1.3 billion tons and was concentrated on that 7% of the cropland where no type of management for crop production, except permanent grass or tree cover, would reduce it below the tolerance level. These data combined with geographic data indicated the erosion problem, though serious, was limited and not evenly distributed over the country. The RCA Program strategy, to focus resources for erosion control where the problem was most critical, appeared to be an effective response to the 1976 GAO audit and the findings of the 1977 NRI. Results from the 1982 NRI indicate that total erosion may have declined or possibly stayed about the same as in 1977. (The apparent decline may not exceed the sampling errors of the two inventories.)

Analysis of the 1982 data by soil loss and erodibility classes are closely consistent with table 11 data for the 1977 NRI. Both the total acreage harvested and the cropland used increased between 1977 and 1982. Thus, the NRI results for 1982 suggest that an increased allocation of conservation efforts to critical areas may have held the line on total erosion, even though total federal conservation funding declined 29% or $120 million in 1983 dollars. State, local government, and private funding initiatives offset about 20% of the federal decline. More importantly, their cooperation in focusing the federal program efforts on critical problem areas may have contributed even more to the effectiveness of 1982 programs.

State and local government awareness of soil erosion and related resource problems has been steadily enhanced by federal resource inventory and planning initiatives enlisting their cooperation. This includes the federal support for state assessment and planning for control of nonpoint sources of pollution from agricultural lands and other sources. State participation in the NRI and RCA planning processes have led to stronger state and local programs for erosion assessment and control. In 1984, 21 states offered cost sharing for conservation by a variety of formulas and mechanisms for a variety of conservation purposes including erosion control, nonpoint pollution and water quality improvement, water conservation, wildlife habitat, drainage, and farm, forest, and rangeland protection. In the 1960's, only one or two states offered such programs. Twenty-six states have given considerable regulatory power to the conservation districts. However, only a few states such as Iowa and Minnesota have chosen to exercise that power actively. A voluntary approach combined with economic incentives is preferred. Innovation in new state and local programs is increasingly evident. These initiatives vary

Table 11.—Cropland sheet and rill erosion by soil loss per acre and erodibility class, 1977.

1977 annual soil loss	Erodibility class: Non-erodible under any management	Manageable below tolerance	Managed above tolerance	Highly erodible	Total
Tons/ac/yr	*Million acres*				
Under 5	165	164	—	—	329
5-13	—	—	55	10	65
14-25	—	—	6	9	14
Over 25	—	—	([1])	11	11
Total	165	164	61	30	419
% of total	39	39	15	7	100

[1]*Less than 500 million.*
Source: Heimlich and Bills (1984).

widely among the states, reflecting their level of awareness of the dimensions of their erosion problem and their unique needs for soil and water conservation.[9]

The 1985 Food Security Act

The 1985 Food Security Act set the direction of farm policy and federal farm programs for the next 5 years. The 1985 Act introduces a transition toward a market-oriented agriculture based on world market prices. It does so by reducing loan rates and, therefore, the price support level for the major farm crops of wheat, feed grains, rice, and cotton. This is a major shift in policy away from the traditional programs designed to protect a depressed agriculture in its domestic market environment by assuring stable and high commodity prices. It is based on a new and wide understanding that the traditional policy is inconsistent with an export-oriented agriculture and a high and growing dependency on foreign markets to absorb rising production capacity. High domestic support prices under traditional programs encouraged expansion of production in other countries and greater competitiveness from other exporters. They also led to costly payments to farmers for income support and reduction of cropped acreage, for storage of surplus commodities, and for incentives to export more of the surplus.

This new orientation to world markets and prices calls for farmers to make improvements in productivity and reductions in unit costs their primary production strategy. In the competitive market of world trade, increases in productivity or a decrease in costs of production are translated into lower market prices. Growing demands, as world population and welfare rise, will be a source of upward pressure on prices. However, incentives to produce, combined with policies and incentives to develop and adopt new technology, will tend to keep production abreast of, or ahead of, demand. That is the usual outcome of successful competitive production.

This changing market environment will require farm managers to increase their attention to new developments in technology and innovation to reduce unit costs. It also means closer attention to market demands, markets, and prices for alternative crops and products. Financial and business management will become more important to farm enterprise success. There will be more large farms and fewer farmers. Because value of output per acre will rise even though prices may decline, there will be a stronger demand for soil conservation and coordination of efficient soil conserving practices with production operations. There will be long term pressures to concentrate farming on the most productive soils and lands and to avoid higher costs of cultivation on steeper and more erodible lands (Fedkiw 1986b).

The 1985 Act also set new policy directions for conservation programs. Congress integrated the objectives for conservation and commodity price support programs. Responding to the twin problems of excess crop production capacity and critical soil erosion, the 1985 Act authorized a long-term conservation reserve for as many as 40 to 45 million acres of highly erodible land that had been used to produce crops in any 2 of 5 years between 1981 and 1985. The program provides that farmers may sign contracts to withdraw eligible croplands from production for 10 years. In return, they will receive an annual rental payment and 50% cost share assistance for converting withdrawn lands to perennial grasses, wildlife plantings, windbreaks, or tree crops. The program goal includes planting 4 to 5 million acres of the reserve to tree crops. Data from soil surveys and the national resource inventory provided valuable information for defining cropland eligibility for the Reserve.

Cropland eligible for withdrawal under the 1985 Act includes soils considered too steep or shallow to farm in Capability Classes VI, VII, or VIII, and cropland in Capability Classes II to V eroding above the tolerance limit of 4 to 5 tons per acre per year for deeper soils and less for shallow soils. A total of 104 million acres of the 421 million acres cultivated in 1982 was eligible for participation (U.S. Department of Agriculture 1986f).

In 1986, the U.S. Department of Agriculture accepted bids to enter 8.8 million acres into the Conservation Reserve in 1986 and 1987. To maximize the effectiveness of the 1986 and 1987 contracts, eligible lands were limited to cropland eroding at least three times the soil erosion tolerance level or otherwise subject to gully erosion, and to cropland in Capability Classes VI, VII, and VIII. The average annual erosion on the 3.8 million acres withdrawn for 1986 was estimated to be 25 tons per acre. The total potential for erosion reduction through conversion to conservation cover crops was close to a billion tons a year. Some 8.2 million acres of the 8.8 million acres withdrawn was planned for conversion to grass. Tree crops were elected on 595,000 acres with 85% located in the southern states.[10]

The 1985 Act also made it federal policy to withhold eligibility for farm program participation and benefits from producers who convert wetlands to crop production after December 1985. Farmers who convert wetlands after 1985 may regain eligibility if they stop producing on those wetlands. Similarly, farmers who begin cultivation of highly erodible cropland after 1985 must certify that they are doing so under a conservation plan approved by the local conservation district to be eligible for farm program benefits. These requirements are referred to as the "swampbuster" and "sodbuster" provisions.

Another provision requires farmers who wish to participate in farm programs, and who were cultivating highly erodible land between 1981 and 1985, to plan and apply locally approved conservation plans. This cross compliance provision includes a grace period. Farmers have until 1990 to develop and begin to apply a conservation plan, and until 1995 to have it fully in effect (U.S. Department of Agriculture 1986e).

[9]*Information compiled and transmitted by the Appraisal and Program Development Division, Soil Conservation Service, U.S. Department of Agriculture by memo of June 19, 1986, to John Fedkiw.*

[10]*Current progress reports on Conservation Reserve Program implementation, Agricultural Stabilization and Conservation Service.*

These new policies discourage potential farm program participants from cultivating environmentally sensitive lands, or allow them to do so only with approved conservation plans. They affect about 80% of the nation's 2 million farmers who participate in farm programs. They also affect the use of 5.2 million acres of wetlands with high or medium potential for crop production, 118 million acres of highly erodible cropland in current use, and an additional 152 million acres of other lands with high or medium potential for conversion to cropland.

Other provisions of the Food Security Act of 1985 reduce incentives for farmers to increase yields and planted acreage primarily to increase farm program payments. Calculated historical average yields rather than actual yields are used to determine deficiency payments. Farmers are encouraged to plant less than the eligible acreage by an alternative that offers 92% of the program payments when as little as 50% of the eligible acreage is planted. The growth of eligible acreage over time is constrained in relation to past farm programs. In addition, conservation use is required for the nonplanted or diverted acreage. These conditions serve to reduce both the cost of farm programs and farm production while conserving cropland soils for other uses or crop production needed in future years.

MANAGEMENT AND USE OF GRASSLANDS

The total area of grasslands, unlike cropland, declined steadily throughout the 1945 to 1985 period (table 1), by more than 50 million acres. Total cattle numbers rose to the historic level of 132 million in 1975 and then declined to 105 million in 1986 (table 12). This was still 23% more cattle than in 1945 and 50% more than in 1920. More productive range and pasture management, reductions in grazing of other domestic animals, increased use of feeding, and improvements in cattle raising contributed to the ability of grasslands to support more cattle.

Growth of the Cattle Herd to 1975

From 1945 to 1975, the beef cattle herd increased from 16 million to 46 million head, or 177% (table 12). Dairy cattle numbers declined 60% in the same period. Growth in beef production came largely in response to growth in per capita beef consumption. It rose from 46 pounds per person per year, retail weight, in 1950–1952 to almost 95 pounds in 1976. Total beef production increased faster than population and per capita disposable income. The beef share of per capita red meat consumption increased from 38% to 46%. Beef production became a growth industry as beef became the strongly preferred animal protein source in the 1970's (Fedkiw 1985).

This was a period of general prosperity for cattlemen despite fluctuating cattle prices. Cattle numbers increased in 21 of the 30 years of this growth period. More than one-half of the increase in beef cattle occurred in the East where beef cow numbers increased 52% (table 13). Most of that increase came in the 11 Southeastern States which had over 25% of the beef cow herd in 1975. The six Plains states, including the Dakotas, Kansas, Nebraska, Oklahoma, and Texas, provided 35% of the increase in beef cows. The 11 western states shared only 13% of the increase.

Table 12.—Trends in total cattle herds, beef cows and milk cows 1945–1986.

Year	All cattle	Beef cows	Milk cows
	Million head		
1945	86	16	28
1950	78	17	24
1955	97	26	23
1960	96	26	20
1965	109	34	17
1970	112	38	13
1975	132	46	11
1980	111	37	11
1985	110	35	11
1986	105	34	11

Source: USDA, Statistical Reporting Service.

Table 13.—Beef cow herd by region, 1945–1986.

Year	11 Western states	6 Plains states	31 Eastern states	48 states
	Million head			
1945	4.6	7.1	4.8	16.5
1955	6.0	10.1	9.6	25.7
1965	7.3	13.2	13.7	34.2
1975	8.3	17.4	19.9	45.6
1980	7.0	13.9	16.1	37.0
1985	7.0	13.5	14.9	35.4
1986	6.7	12.6	14.3	33.6

Source: USDA, Statistical Reporting Service.

The productivity of the ranges, forest grazing lands, and pasture increased during this period of growth. The improvement is indicated by the decrease in average acreage of total grasslands grazed (including forested range) per unit of all animals grazed. It declined from 13.7 acres in 1959 to 10.5 acres in 1974 (Boykin et al. 1980). The increases in beef production in the East and the Plains states were achieved with substantial increases in pasture lands. Between 1967 and 1977, pasture acreage increased 30% to 134 million acres of which 54% was on private lands. The shift of land out of crop production from 1945 to 1969 and some forest land conversion contributed to the net increase in pasture land. Cheap fertilizers encouraged the expansion of pasture production, particularly in the South (Fedkiw 1985, U.S. Department of Agriculture 1981b). The feeding of harvested forages and cropland residue grazing also increased in this period, mainly in the East and the Plains states (Boykin et al. 1980).

Many other factors contributed to increases in range and beef cattle productivity in this period, including

irrigation of feed crops, and expansion of hay lands and improved pastures. Sprinkler systems facilitated this trend. One rancher observed that a thousand acres of irrigated and subirrigated land was the equivalent of 16,000 acres of grazing land (Schlebecker 1963). Advances in biochemistry introduced many new technologies in the management of grasslands and cattle.

Plant hormones and herbicides such as 2,4-D and 2,4,5-T provided improved ways to control brush, cactus, and other undesirable plants. Antibiotics increased effectiveness in combating animal diseases. New systemic poisons made worm and insect control more effective. Animal hormones as well as antibiotics and tranquilizers were introduced to increase the rate of weight gains. Bacterial parasites and sterile male technologies were also used successfully to control insects (Schlebecker 1963).

Other advances in productivity came through better breeding of higher-producing animals. Artificial insemination of range cattle was used more intensively and worked more effectively as ranchers supervised their cattle more closely. Improvements in animal nutrition, feeds, and feeding were also important (Schlebecker 1963).

Along with prolonged favorable conditions in the beef industry, range conditions also improved. Range in excellent or good condition rose from 20% to 40% between 1963 and 1977. Range in poor condition declined from 40% to 18%. This was accomplished largely through the private sector, but with some assistance from USDA conservation programs (Fedkiw 1985, U.S. Department of Agriculture 1981b).

The Decline in Cattle Grazing to 1986

After 1975, cattle numbers started on a downward trend to 105 million in 1986 (table 12), with further declines expected in the rest of the 1980's (U.S. Department of Agriculture 1986d). Each of the major regions shared in this decline with a slightly larger share of the decline in the East (table 13). The drop in cattle numbers was directly due to a decrease in per capita beef consumption from 95 pounds in 1976 to 79 pounds in recent years. It is significant because it occurred while per capita disposable income was rising. The lower beef consumption is attributed to a sharp shift in consumer preferences to poultry products. The shift was associated with a sharp decrease in poultry prices relative to beef prices and growing consumer concerns about health and nutrition aspects of red meat consumption (Fedkiw 1985).

At optimum use levels, current forage capacity is estimated at 120 to 124 million head of cattle (Gustafson 1984). The meat industry is now seen as a mature industry. That is based on the fact that total per capita meat consumption has largely remained between 200 and 210 pounds since 1967. For mature industries, growth in demand is dependent upon population growth which is expected to average 0.7% a year in the next several decades (U.S. Department of Commerce 1985). Thus, current forage capacity appears more than adequate to meet future beef demands in the context of a mature industry.

In the meantime, results of the 1982 National Resource Inventory indicate that range conditions on nonfederal lands have remained stable or improved since 1977; 39% of the rangelands were in excellent or good condition and only 16% of the private grasslands were in poor condition.[11]

Federal Lands

The federal and nonfederal lands used for grazing in 1976 are summarized in table 14. Nonfederal lands are included for comparative purposes. They do not include improved pastures or cropland pastures which totaled 134 million acres and provided 54% of the grazing capacity. Harvested cropland grazed for forage is also excluded.

Some 90% of the federal grazing lands are located in the 11 western states where they are an important part of about 16% of livestock enterprises. In 1982, there were about 27,000 farmers and ranchers with permits to graze livestock on national forests or Bureau of Land Management (BLM) lands. They represented 2% of the 1.6 million cattle producers in the United States, about 10% of the total livestock forage grazed and only 2% of the total feed consumed by cattle. Federal lands provided grazing for these 27,000 producers in one or more seasons of the year when forage on their own lands or

[11] *See note 9.*

Table 14.—Federal and non-federal lands used for grazing, 1976.

Type of grassland	Forest Service	Bureau of Land Management	Other federal	Total federal	Non-federal
			Million acres		
Rangeland	58	145	8	211	418
Forested range	44	2	1	47	113
Total	102	147	9	158	531

Source: U.S. Departments of Agriculture and Interior (1986c).

from nonfederal rented lands was not available (U.S. Department of Agriculture 1981a, U.S. Departments of Agriculture and Interior 1986c).

Grazing use of both national forests and BLM rangelands was reduced between 1945 and 1965. The animal unit months (AUMs) grazed on national forests were reduced from 9.8 million to 8.0 million in 1965, or by 18%. National forest AUM use subsequently rose by 10% to 8.8 million in 1985.[12] On BLM lands, grazing declined more or less steadily from 17.8 million AUMs to 11.2 million in 1985, by 37%.

Reduced use and improved range management both contributed to improved range conditions on national forests. On BLM lands, progress appeared to come more slowly, partly because they were the most arid and, therefore, more difficult to rehabilitate and also because of the relatively poor initial condition resulting from a long history of uncontrolled free range use. From 1945 to 1975, BLM land in poor or bad condition decreased only 3%, from 36% to 33%, even though range use was reduced 33%. Range in excellent or good condition rose only 1% to 17%. Range in fair condition increased 2% to 50%. The BLM range condition was updated in 1984 based on professional judgmental estimation procedures and range inventory and monitoring data rather than direct sampling and measurement of range conditions. The results showed range in excellent and good condition rising to 36% and the proportion in poor or bad condition dropping to 18%. The difference in methods suggests that the more recent estimates may not be as reliable as earlier estimates, although the general trend toward more improvement is a realistic expectation (U.S. Department of Interior 1984c).

The expansion of outdoor recreation interests and activities and growing concerns about environmental quality stimulated an increasing emphasis on multiple use management of the public rangelands throughout the 1945 to 1985 years. This was particularly so on BLM lands where management was seen by the public as a single use orientation. The Multiple Use Sustained Yield Act of 1960 mandates multiple use management for outdoor recreation, range, timber, watershed, and wildlife and fish purposes for all national forest lands. The possible application of this principle to lands managed by BLM was visualized by the Classification and Multiple Use Act of 1964 (C&MU). Although the Taylor Grazing Act of 1934 had provided for management of the public domain lands, it had included the reservation "pending their final disposal," which clouded the management objective (U.S. Department of Interior 1984c).

The C&MU recognized that some of these BLM lands had multiple use values that ought to be retained under federal ownership and "managed...for grazing...fish and wildlife...industrial development...mineral production... occupancy...outdoor recreation...timber...watershed protection...wilderness...or... preservation of public values." The C&MU Act authorized BLM to gather data about the public lands and resources and provided that the Secretary of Interior determine which land should be retained. In 1976, Congress enacted the Federal Land Policy and Management Act, BLM's "Organic Act." It gave statutory recognition to BLM and authorized it to enter into long range planning and intensive resource management on the basis of multiple use and sustained yield (U.S. Department of Interior 1984c).

Stockmen with federal grazing permits maintained a strong economic interest in the use of federal ranges for grazing. While they generally resisted the policy for reducing the level of stocking, they often cooperated and assisted in achieving reductions where range conditions indicated the need to do so. The livestock industry generally perceived the shift toward multiple use management as a threat to traditional grazing privileges. Improved cooperative approaches to range management are now facilitating progress in multiple use management on federal lands. Pressures from conservation and environmental interests, however, continue to call for a stronger multiple use emphasis (Rowley 1985, U.S. Department of Agriculture 1986b, U.S. Department of Interior 1984c).

FOREST RESOURCE USE AND MANAGEMENT, 1945–1985

This period is typified by the rapid growth of demands for all the multiple uses of public forest lands. There emerged an unending debate about the proper balance of commodity production with amenity uses. The enactment of the National Environmental Protection Act in 1970 seemed to intensify this conflict as various interest groups found new ways to intervene in the management of public lands.

Large increases in lumber and plywood prices in response to rising housing demands and their contribution to the national problem of double digit inflation intensified efforts to find ways to increase timber supplies from public lands after 1970. There was also a continuing concern for improving the management of woodlands owned by farmers and other nonindustrial private forest owners who held 59% of all commercial forest land. Generally, timber growth and management performed better than projected, despite the increased timber demands placed on the nation's forest lands. The amenity use of the forests also expanded greatly. In 1985, it was apparent that the nation had not exhausted the capacity of the forests to further expand supplies for most of the demands on its resources. The conflicts, nevertheless, continued.

Land Ownership Shifts

Forest land increased somewhat as cropland continued to decline in the 1950's and 1960's (table 1). The trend reversed itself in the late 1960's when crop production rose again in response to rapid growth in export demands that continued through the 1970's and early 1980's. Urban and industrial development also tended to reduce the total forest land area after World War II. The net decline from 1940 to 1982 was about 6% or 35 million acres. The

[12] *Data provided by the Forest Service Division of Range Management for National Forests in memo dated 7/16/86 to John Fedkiw.*

decline in the commercial forest area segment, however, was just 17 million acres. In 1977, commercial forests totalled 470 million acres in the contiguous 48 states, about 82% of the total forest land (U.S. Department of Agriculture 1982a).

The shifts in use among commercial forests, agriculture, and other uses were much greater than the indicated net changes as illustrated in table 15. For four southern states between 1967 and 1980, for example, the total shift from forest to other uses was more than double the net decline of 2.5 million acres. The changes in land use associated with that net decline totalled 8.5 million acres. Nationally, between 1979 and 1982, about 11 million acres of forest and grasslands were converted to cropland use, while 4 million acres of cropland shifted to other use, for a net gain of 7 million acres of cropland. Thus, the dynamics of land use over time are far greater than the usually reported net changes.

The ownership of commercial forests also shifted after World War II. Forest industry lands increased by 9 million acres, mainly in the North and South where regenerated forests were still young and regrowth was rapid. Almost all the added acreage came from farm and other private ownerships. Total forestry industry lands were 69 million acres in 1977 with 53% in the South (U.S. Department of Agriculture 1982a). Farmer and other nonindustrial private ownerships declined by 18 million acres. However, this net decline included a reduction of 56 million acres of farmer-owned woodlands and an increase of 38 million acres in other classes of private owners. The decline in farm woodlands came with the reduction in number of farms and the decline in total farm land from 1.16 billion acres in 1950, the historic peak, to 1.05 billion in 1977. The decline in farm woodlands was 35 million acres in the South and 20 million in the North (U.S. Department of Agriculture 1982a).

Total public commercial timberland also declined in this period, from 144 million acres to 136 million. Three-fourths of the decline occurred on national forests, largely due to shifts of land to the wilderness system.

The Forest Inventory, Growth, and Harvest

The nation's softwood sawtimber inventory remained stable throughout this period at 2.0 trillion board feet. The hardwood sawtimber inventory rose from 0.4 to 0.6 trillion board feet. This favorable inventory increase in the last 40 years occurred even though the total industrial wood harvest averaged somewhat more than the historic peak achieved in the 1900 to 1910 decade (Davis 1983, Ulrich 1985, U.S. Department of Agriculture 1982a). Thus, the nation was able to meet its wood demands on a sustained yield basis, even though there were periodic projections and reports that such was unlikely with the level of forest management that was being practiced. Actually, periodic projections of future inventories since 1933 consistently underestimated both the growth and growing stock levels that the commercial forests achieved in the last 50 years. The low point in the standing volume of timber appears to have occurred between 1930 and 1940 (Davis 1983).

The current inventory is about one-third of the original volume at the time of colonial settlement. About one-half of the decline resulted from land clearing for farming and other purposes. The rest of the decline occurred on lands that remained in forest use and were generally regenerated to young, growing forests. Forests managed for commercial production achieve optimum net growth and yields with ages and inventories substantially lower than found in the original old growth forest heritage (Davis 1983).

In 1976, the annual growth of softwood growing stock was 12.3 billion cubic feet, 23% greater than the 10.0 billion cubic feet of harvest. Nationally, growth exceeded removals on national forests, other public ownerships, and farmer and other private ownerships. Harvests exceeded growth only on western forest industry ownerships. This was largely due to the rapid harvest of remaining old growth inventories on those lands. Softwood growth was greater than the harvest on industry lands in the North and South.

This favorable situation for softwoods has been projected to continue in the face of rising demands until the year 2000 or later, if forest management remains at pre-1976 levels. However, historic data indicate that management, as reflected in actual growth performance, does improve. Particularly important for softwoods is reforestation after harvest. Investment in tree planting is growing. Trees were planted on 2.7 million acres in 1985 (U.S. Department of Agriculture 1986a). That compares with

Table 15.—Changes in commercial forest lands in four southern states, 1967–80.

State	Net change in forest area	Diversions to Agriculture	Diversions to Other uses	Total diversions	Additions from Nonforest agriculture	Additions from Non-Commercial forest	Total added
	Million acres						
AR	-1.6	1.1	1.0	2.1	0.5	a	.5
FL	-0.6	0.5	0.8	1.3	0.3	0.4	0.7
MS	-0.4	1.3	0.5	1.8	1.4	a	1.4
SC	+0.1	0.1	0.2	0.3	0.4	a	0.4
Total	-2.5	3.0	2.5	5.5	2.6	0.4	3.0

[a]*Under 50,000 acres.*
Source: U.S. Department of Agriculture (1983).

1.9 million in 1976 and 0.5 million acres in 1940 and 1950. The outlook for further increases in reforestation is good. The opportunities for economic investment in managing softwood timber stands are extensive and more than adequate to increase softwood timber growth consistent with projected long term demands (Fedkiw 1983, U.S. Department of Agriculture 1982a).

Hardwood growing stock growth in 1976 was 9.4 billion cubic feet, more than twice that year's harvest of 4.2 billion cubic feet. This was a much more favorable management and inventory situation than for softwoods. Hardwood inventories have been projected to increase for a decade or two after 2000 despite expected rapid growth in hardwood demands. Although farmers and other nonindustrial private owners hold over 70% of the hardwood inventory, the favorable growth and harvest relationship occurs on all ownerships nationally. A hardwood quality problem was identified in the first half of the post-World War II period. However, Forest Service survey data and special studies show a significant general improvement between 1963 and 1977 in the hardwood log and tree grade inventory (Fedkiw 1983). Reflecting this trend, hardwood log, lumber, and plywood exports from the United States increased 3.4 times between the early 1960's and the 1980's. The United States became a net exporter of all hardwood products for the first time in the 1980's (USDA Forest Service 1986g).

Growth of the Nation's Demand for Housing and Timber

The nation's demand for housing rose sharply after World War II. Initially, it was largely a response to unfulfilled demands from the Depression and War periods. Rapid family household formation, home replacements, regional shifts in population distribution, and the rising economic welfare of the population added to the strength of that demand. The demand was enhanced by the Housing Act of 1949 which established national policy for housing and provided insurance from the Federal Housing Administration for level payment, self-amortizing, long-term mortgages, and mortgage guarantees from the Veterans Administration for war veterans to buy homes without any down payment. This mortgage protection increased the flow of capital into housing from commercial banks, savings, loan associations, and insurance companies (McKenna and Hills 1982). In the 1970's and 1980's, housing demands increased further and remained strong as the children of the postwar period began to form their own households.

Housing starts had averaged 360 thousand a year from 1930 to 1945, less than half that of the 1920's. Immediately after the War, they rose to 1.1 million a year. In the 1950's and 1960's, they averaged 1.5 million, and in the 1970's, 1.8 million, including 5 years with over 2.0 million units. The high interest rates of the late 1970's and the recession in the early 1980's brought housing starts to less than 1.2 million. In 1983, 1984, and 1985, they were again over 1.7 million a year (Economic Report of the President 1986, U.S. Department of Commerce 1966).

Annual softwood consumption was only 18 billion board feet during the 1930's. War demands and then housing starts raised consumption to 27 billion feet during the 1940's. In the 1950's and 1960's, softwood lumber consumption averaged 32 billion feet and in the 1970's, 37 billion. The 1980's raised consumption to 38 billion board feet; and in 1983, 1984, and 1985 when demands were strongest, average annual consumption was 43 billion feet (Ulrich 1985, U.S. Department of Agriculture 1982a).

Softwood plywood emerged as a new wood product for military housing during World War II. In subsequent years, it became a substitute for lumber sheathing in residential housing and other construction. Its consumption rose almost annually from less than 3 billion square feet in the late 1940's[13] to more than 16 billion square feet in the 1970's and 20 billion square feet in 1984 and 1985 (Ulrich 1985, U.S. Department of Agriculture 1982a).

Table 16 shows the growth in housing starts and softwood consumption, production, and net imports in cubic feet. Total supplies in the 1950's and 1960's increased

[13]*Based on 3/8-inch average thickness, 2.4 square feet of plywood are about equivalent to the volume of a board foot of timber. Thus, 2.4 billion square feet of plywood would be about equal to a billion board feet of lumber.*

Table 16.—Housing starts and softwood timber consumption, production and net imports, 1950–1983.

Year	Housing starts	Softwood timber[1]		Net imports	
		Consumption	Production	Total	Lumber
	Millions	*Million cubic feet, roundwood equivalent*			
1950–54	1.6	7.9	6.8	1.1	0.3
1955–59	1.4	8.3	7.2	1.1	0.4
1960–64	1.5	8.4	7.2	1.2	0.6
1965–69	1.4	9.4	8.3	1.1	0.7
1970–74	1.9	9.9	8.8	1.1	0.9
1975–79	1.7	10.7	9.5	1.2	1.1
1980	1.3	10.3	9.3	1.0	1.2
1983	1.7	10.4	9.7	1.7	1.6

[1]*Excludes fuelwood use.*

Source: Ulrich (1985), Economic Report of the President (1986), U.S. Department of Agriculture (1982a).

sufficiently to keep lumber and plywood prices at or below the general price level (table 3). As housing demands rose in 1969 and the 1970's to new heights, lumber and plywood prices rose sharply, from a relative price index of 100 in 1967 to 154 in 1978, 54% above the general price level for all commodities (table 3).

Hardwood lumber consumption has remained very stable since 1920; consistently averaging about 7 billion board feet a year. Average prices for hardwood lumber have stayed at or below the general price level since 1950. Total consumption of hardwood industrial roundwood increased from 2.0 billion cubic feet in the early 1950's to about 2.6 billion cubic feet in recent years. The net increase was due to the increased use of hardwoods for pulpwood. The production and consumption of hardwood roundwood for fuelwood rose spectacularly as energy costs increased in the 1970's, from 0.4 billion cubic feet in 1970 to 3.2 billion cubic feet in 1983 (Ulrich 1985).

Emergence of the National Softwood Timber Supply Issues

Softwood timber supplies became a national concern in the late 1960's and the 1970's. During this period, the rise in softwood lumber and plywood prices far outstripped the aggregate inflation rate. Softwood stumpage prices rose relatively more than lumber and plywood. Net lumber imports from Canada also rose to new levels (table 16). Thus, softwood sawtimber was again demonstrating the symptoms of economic scarcity on the supply side and raising the cost of housing.

Softwood timber supplies for housing became the subject of repeated national studies during the Johnson, Nixon, Ford, and Carter Administrations. The administration studies looked mainly to the large national forest inventories as the most effective source of greater timber production to reduce lumber and plywood prices and some of the general inflation. Nontimber interests in national forest use and management opposed and successfully resisted expansion of national forest timber sales. Two comprehensive legislative proposals for national forest management and financing were presented in Congress. Both had extensive hearings, but neither was passed. In 1974, the conflicting interests were able to agree on a systematic national planning approach to national forest use and management and other Forest Service forestry programs and Congress passed the Forest and Rangeland Renewable Resources Act of 1974 (RPA). Three 5-year RPA program plans have since been developed, in 1975, 1980, and 1985, and sent to Congress. Each set goals for long-term expansion of national forest timber harvests and other multiple uses. National forest timber sales and harvests, however, have remained at or below levels achieved in the early 1960's.

Continued opposition to timber harvests led to a successful court suit against clear cutting on the national forests. The ruling became an immediate threat to national timber supplies and quickly produced the National Forest Management Act of 1976 (NFMA). The new legislation responded to the court findings by clarifying the authority for clear cutting as an acceptable system of management. It also provided guidelines and a 1985 deadline for developing national forest land management plans based on "consideration of the economic and environmental aspects of various systems of renewable resource management...for outdoor recreation (including wilderness), range, timber, watershed, wildlife and fish...." The guidelines included opportunities for "public participation in planning for and management of the National Forest System."

National forest planning pursuant to NFMA now begins with the definition of public issues and concerns by various interest groups and individuals. That is followed by analysis of 8 to 15 management alternatives, each responding in some degree to the issues and projected resource demands. NFMA planning concludes with public review and comment on the resulting analysis and the Forest Service preferred plan. Using public comments and planning results, the Forest Service selects the alternative and plan that maximizes net public benefits subject to responding effectively to the issues. Final plans have been approved for 88 national forests. Draft plans have been released or approved for release for 34 forests. Only one forest is still in the planning stage in mid-1988.

The principal substantive legislation to emerge from Congress relating to timber supply was the authorization of two financial incentive programs to encourage tree planting on private lands. One was the Forestry Incentive Program authorized in 1973 and funded annually at $12 to $15 million for cost shares to nonindustrial private landowners. The other was the 1980 Reforestation Tax Incentives legislation that provided a 10% tax credit and a 7-year amortization for tree planting investments on private lands.

National Forest Management

The strongest demand pressure on national forest management after World War II was to expand timber supplies in response to the national housing needs. Annual timber harvests rose from an average of 2.8 billion board feet during the war years to 12.1 billion board feet in 1966, almost one-half billion feet a year. After 1966, timber sales ranged between 10 and 12 billion feet per year and harvests, fluctuating with economic conditions, ranged between 7 and 12 billion feet annually to 1984.

National forest sustained yield levels had substantially exceeded actual harvests during the war years. Thus, expansion was directed to increasing harvests on the individual forests to the allowable cut level or whatever portion of that level the market would take. In 1961, the Forest Service identified the long term sustained harvest potential of national forests to be 21.1 billion board feet by the year 2000. That included an intermediate goal of 13 billion feet in 1972 (U.S. Department of Agriculture 1961). The actual harvest in 1971 and 1972 averaged 12 billion feet. Timber sales volume, however, was only 10.5 billion feet.

The rapid rise of national forest harvests in the 1950's and early 1960's, largely in the West, was instrumental in maintaining a stable log supply for established mills and sustaining related jobs and income in the dependent communities. From 1952 to 1962, the western log supply from industry and other private lands declined 4.6 billion board feet (table 17). National forest harvests rose 4.5 billion feet. Harvest increases from other public lands modestly increased the total log supply. This performance, together with the increase in softwood lumber imports were important factors in stabilizing softwood lumber prices in the 1950's and early 1960's (table 3). They also contributed to a slowing of softwood sawtimber harvests in the South (table 17). Stumpage prices for southern pine sawtimber actually declined in this period.

Southern pine lumber production fell from 10 billion board feet in 1950 to 6 billion in 1960. Thereafter, southern lumber production rose slowly but did not exceed 10 billion feet again until 1984 (Ulrich 1985). The increased national forest harvest in this way contributed to the building of the southern pine sawtimber inventory in the 1950's and 1960's and the opportunity for expansion of sawtimber production to new levels in the 1970's and 1980's. The ability to balance harvests with timber inventories and age class distribution among public and private ownership classes over several decades was a major strategic achievement in a mixed economy. It reduced the pressures for more rapid industry and labor migration as well as demands for capital to build new plants in new locations. The national forest harvest increase thus added to national economic growth. It also produced a better distribution of forest age classes and management conditions for sustaining and increasing future timber supplies. This macro-aspect of American forestry has not been well understood despite the fact that it was a major management achievement.

The expansion of forest management for timber production required rapid development of the road system to provide for wide dispersal of sales areas and to access extensive forest areas for protection from fire, insects, and disease. The road system contributed to reducing the average annual area burned to 0.1% of the national forest lands. By 1960, the forest road system included 162,400 miles of forest roads plus 24,400 miles of public roads. This road access, combined with 106,500 miles of supplemental foot and horse trails, opened up a vast area of the national forests for public use for outdoor recreation, fishing, and hunting. In 1960, there were 92.5 million recreation visits. One-fourth of those were primarily for hunting and fishing. Hunters bagged 659,000 big-game animals, one-third of the big game taken in the entire country (U.S. Department of Agriculture 1961). The elk population increased from 154,000 in 1940 to 296,000 in 1960.[14]

As the demands for a wide range of outdoor recreation opportunities grew, national forest management responded to user interests. Landscape zones and travel zones were identified and management was modified to protect aesthetic values. Congress also began to designate National Recreation Areas. Throughout the 1950's and 1960's most of the response to growing user demands was achieved through land use adjustments. Those adjustments modified timber management plans and tended to reduce the timber harvest potential.

Multiple use management became a dominant principle in national forest management along with sustained yield. Both principles were formalized with Congressional enactment of the Multiple Use Sustained Yield Act in 1960.

National forest road construction in the year 1960 totalled 4,691 miles and rose to more than 6,000 miles in the latter 1960's (U.S. Department of Agriculture 1961). The acceleration of road development was perceived by wilderness interests as a threat to future allocations of national forest land to wilderness preservation in the West. By 1959, the Forest Service had formally designated only 12 areas and 3.9 million acres for wilderness preservation. The slow progress added to the concerns of wilderness interests, and between 1959 and 1964, the Forest Service accelerated wilderness reviews and designated an additional 42 areas and 5.2 million acres. Some 34 primitive areas and 5.4 million acres, however, still remained undesignated when Congress passed the Wilderness Act of 1964 which created a National Wilderness Preservation System to be made up of federally owned lands designated by Congress. The act also directed the Secretaries of Agriculture and the

[14]*Data provided by Division of Wildlife Management, Forest Service, U.S. Department of Agriculture.*

Table 17.—Softwood sawtimber harvest by region and ownership, 1952-1976.

Years	West					South	North	
	National forests	Forest industry	Other private	Other public	Total	All owners	All owners	Total
	Billion board feet							
1952	5.5	11.6	6.5	1.9	25.5	11.9	1.8	39.2
1962	10.0	9.8	3.7	2.9	26.4	10.9	1.4	38.7
1970	11.8	11.4	3.2	3.8	30.2	14.9	2.0	47.1
1976	10.3	12.2	3.0	4.2	29.7	18.9	2.2	50.8

Source: U.S. Department of Agriculture (1982a).

Interior to review federal lands suitable for Wilderness System designation by Congress (Hendee et al. 1978). By 1985, there were 327 designated wilderness areas on national forests totalling 32.1 million acres. Additional designations were being considered by Congress or under study by the Forest Service. Other wilderness areas had been designated or were under study on national parks and refuges and the lands administered by the Bureau of Land Management. In 1977, the total remaining roadless area potentially suitable for designation as wilderness areas was reported to be 145.5 million acres (Hendee et al. 1978).

Since 1960, national forest timber and range forage production has remained more or less stable. Mineral development and production, particularly for energy supplies, expanded in response to stronger domestic demands and prices. Congress provided for the designation of wild and scenic rivers in 1968, the protection of endangered species in 1973, and the preservation of historical and archeological sites in 1974 and eastern wilderness areas in 1975. These initiatives added to the multiple use management emphasis. In 1985, there were 20 wild and scenic rivers in national forests with a length of 1,154 miles and 12 National Recreation Areas totalling almost 2 million acres. There are 93 threatened or endangered wildlife species that have been identified on national forests. Two-thirds have recovery plans approved by the Fish and Wildlife Service of the Department of the Interior that focus on high priority species such as the rare Kirtland Warbler and the grizzly bear.

The largest increase in national forest use probably has been in general outdoor recreation. Recreation visitor days, based on 12 hour units of use by individuals, rose from 165 million in 1965 (when the visitor day unit of measure was adopted), to 225 million in 1985. One-third of the use was at developed sites such as campgrounds, picnic areas, ski areas, lodges, and visitor information centers. The remaining visitor activity was widely dispersed and dependent upon access to all parts of the national forests. Mechanized travel by visitors on the forest road system was the largest dispersed activity—50 million visitor days. Fishing, hunting, and hiking were the next most important activities totalling 44 million visitor days. Wilderness use was 12.5 million visitor days. The available forest area for wilderness use averaged 586 acres per visitor day, based on 150 days a year of accessibility of national forest lands for public use. The corresponding availability for all other recreation uses averaged 118 acres per visitor day. The capacity for additional recreation use is very large for most types of recreation.

Forest Management on Private and Other Public Lands

The most important management achievement on private and other public lands from 1945 to 1985 was the extension of the area protected from forest fires from 350 million acres to 840 million acres. The average area burned on protected and unprotected lands was reduced from 11.5 million acres before 1955 to less than 3.0 million acres after 1970. The area burned on protected lands was reduced from 3.6 million acres or 1.0% a year in the 1950's to 1.8 million acres or 0.2% between 1979 and 1983. This was largely accomplished through state protection organizations. Their annual expenditures rose from $132 million in constant 1972 dollars to $224 million. The federal financial assistance share fell from 25% to 7% by 1981. The Forest Service continues to provide general technical assistance and coordination for the state protection systems through its State and Private Forestry programs. The focus is on increasing the cost-effectiveness of state efforts (Fedkiw 1983, U.S. Department of Agriculture 1982a).

Tree planting has risen steadily since 1945 (table 18). Tree planting is primarily for reforestation of harvested lands, but also for afforestation of nonstocked lands that have previously been idle or used for crops or pasture. Practically all planting is for softwood species to obtain prompt regeneration with preferred species and to assure stocking with improved trees. Improved planting stock is increasingly being used for forest regeneration.

Most of the increase in planting has occurred since 1970 with slightly more than one-half on forest industry lands. The rise in industry planting is associated with an increase in both land ownership and harvests and with the economic advantage of prompt, planned restocking with improved nursery stock. The forest industry has been a major investor and supporter of research and seed orchard development for improved planting stock for all ownerships. Many firms have their own seed orchards and tree nurseries.

Tree planting on other public ownerships is low due to small forest area and the large proportion of holdings that are hardwood forests. Hardwood stands are usually regenerated naturally. National forest planting is a function of a more or less stable level of annual harvesting and a backlog of unstocked lands. The regeneration of the backlog is now largely completed, so national forest tree planting will mainly respond to the rate of harvesting.

Planting on other nonindustrial private lands has grown slowly and has seriously lagged the acres of softwood harvested on those lands. The high planting levels

Table 18.—Average annual tree planting by owner group, 1950–1985.

Year	Forest Industry	Other private	National forests	Other public	Total
	Thousand acres				
1950–54	177	304	66	49	596
1955–59	319	794	97	81	1,291
1960–64	501	741	146	185	1,573
1965–69	549	429	133	251	1,362
1970–74	840	402	122	274	1,632
1975–79	1,093	454	291	129	1,967
1980–84	1,232	662	300	121	2,315
1985	1,441	885	255	113	2,695

Source: U.S. Department of Agriculture (1985d).

achieved between 1955 and 1964 were due to afforestation of farm lands, primarily in the South, under the Soil Bank Program. Those Soil Bank plantings began to contribute to the increase in southern harvests after 1970.

The 1979 RPA Assessment of forest and range land resources identified the lag in reforestation on nonindustrial private lands, particularly in the South, as a major cause of a projected shortfall in softwood timber supplies after 2000 (U.S. Department of Agriculture 1981a). Most of the recent upward trend in planting nonindustrial private lands is occurring in the South where 84% of all nonindustrial private reforestation was done in 1985. The federal forestry incentive program enacted in 1973 contributed to the 1975–79 rise in tree planting on these lands. A number of state and industry supported cost share programs introduced since 1970 have also contributed to the growth.

The softwood growing stock inventory on all ownerships increased 29% between 1952 and 1977. Nonindustrial private ownerships contributed 95% of that net increase. The hardwood growing stock inventory rose 47% in the same period with nonindustrial private lands adding 62% of the net increase. These growing stock inventory increases are indicators of the growing importance of nonindustrial private holdings to both the current and future timber supplies (Fedkiw 1983).

Long-term timber demand and supply projections show that harvests from nonindustrial private lands will be the major source of future increases in both softwood and hardwood supplies. The hardwood will come from forests of the North and South; the softwood harvests, largely from the South. The continuation of pre-1976 management intensities on nonindustrial private lands will not be sufficient to sustain supplies at the projected higher demand levels. Only about a third of the nonindustrial private lands being harvested presently receive professional forestry assistance. That does not appear to be enough (Fedkiw 1983; U.S. Department of Agriculture 1981a, 1984a, 1985b).

Timber prices will rise relative to the general price level, strongly for softwoods, but only selectively and generally slowly for the more abundant hardwoods. Although Canadian imports have driven softwood lumber and stumpage prices below their projected long-term trend in the last few years, it is unlikely that Canadian forest inventories and management can sustain the recent import levels. The outlook for higher real prices in the future should make new investments in improved forest management more attractive on public and private lands. The increase in planting on private lands since 1976 will contribute to the increase in softwood supplies, mainly in the South. It appears to have a momentum of its own. Tree plantations have been found to be more profitable than crop or forage production on some 17 million acres of marginal crop and pasture land in the South (U.S. Department of Agriculture 1983) where the Conservation Reserve program, authorized in the 1985 Farm Security Act, is accelerating tree planting on former croplands.

The task of improving management on nonindustrial private forest lands appears formidable in terms of its 8 million ownerships. However, three-fourths of the land area is held by only 8%, about 640,000 owners whose woodland holdings exceed 100 acres. This distribution pattern holds in the South, North, and West. A survey sample of harvested southern pinelands held by nonindustrial private owners found that 84% of the acres harvested were from ownerships with 100 acres or more woodland (Fesco et al. 1982). The efficiency of both logging and management rises as tract size increases to about 80 acres. Less than 40% of the harvested acres in this study received professional assistance for harvest planning or for reforestation. Harvests were determined by the logger or timber buyer on 35% of the harvested area and by the owner on 25%. The study found that owners had the right ideas about harvesting their lands but lacked site-specific knowledge to apply the most effective management. Loggers and buyers are interested in the profitability of their operations and generally do not have any long-term economic interest in the future productivity of harvested lands (Fedkiw 1983, Fesco et al. 1982).

The value of professional forestry assistance to private landowners was recently documented by a study of 40 ownerships with harvests in 20 counties in the Georgia Piedmont area (Cubbage et al. 1985). Half of the tracts received professional assistance with the harvest and management. On the other half, the owner or logger made the determinations. The assisted and unassisted tracts were paired within each county on the basis of similarity of conditions. Landowner characteristics within the two groups were also similar except for the employment of the professional services. The study found that landowners using professional assistance received 58% greater stumpage prices for the timber sold. Their residual stands were better stocked with desirable species for future harvests and would produce substantially greater future earnings. These benefits imply that forest landowners cannot afford not to use professional services in managing their tracts. The message, however, is not reaching the large majority of the nonindustrial private owners, including more than 60% of those with holdings greater than 100 acres. Effective educational and technical assistance, especially to help this latter group to learn the benefits of professional services, appears to have a high potential for success in improving the management, productivity, and earnings of the larger private holdings.

The Role of New Technology in Forest Management and Productivity

New technology has been one of the most significant factors in extending and increasing timber supplies and improving forest productivity. It has made it possible to utilize practically all timber species for commercial products. Research developed the original pulping processes, then the various ways to pulp hardwood species of all densities, and substitute them for the scarcer and more expensive softwoods. It also found ways to utilize wood residues from both softwood and hardwood lumber and

plywood mills for pulp production. As prices of lumber rose relative to pulpwood, chip-and-saw equipment was introduced to chip the exterior of pulp logs while retaining interior squares for the more valuable lumber stock.

Softwood plywood and particle boards have substituted for sawn lumber boards. More recently, wafer boards, flakeboards, and oriented strand boards have provided panel stock with the strength qualities of plywood and ability to utilize the lower grade and lower cost hardwood species in place of more expensive, higher grade, softwood sawlogs. New processes now also use lower grade hardwood logs to produce high quality hardwood cuttings and blanks for the furniture industry. Emerging dry press pulping technology makes it possible to substitute lower value, more abundant hardwoods for the vast quantities of southern pine timber used to make liner board for the freight packaging industry. We are in a period of abundance of new and emerging technology in wood utilization and wood products whose benefits of improved timber supplies and reduced costs can be captured rather swiftly. These new technologies have important implications for forest management as well as forest industry. Utilization rigidities associated with specific species will be reduced together with related geographic constraints on sources of supply and plant locations which should reduce transportation and marketing costs, lower product prices, and give a boost to total wood demands. Requirements for large tree sizes and longer rotations should be reduced which should bring savings in the capital costs of holding larger volume managed timber inventories. The impact of new technology has been reflected in timber demand and supply projections insofar as it can be credibly visualized and predicted, but it is difficult to convert the potential impact of new technologies into a reasonable trend type projection.

MINERALS USE, PRODUCTION, AND LAND MANAGEMENT

U.S. Use and Production

World War II mineral needs marked the beginning of a rapid increase in the demand for all minerals in common use after 1945. The postwar surge of research in many fields also brought significant changes in technology and many requirements for new mineral materials. For the first time in American history, consumption of nonfuel minerals began to rise more rapidly than production. By 1979, imports exceeded exports by more than $2 billion (1967 dollars) and in 1984 and 1986, the value of net imports of nonfuel minerals exceeded $6 billion (Cameron 1986, Dorr n.d.). The pattern was similar for mineral fuels. Production rose from 31 quadrillion BTUs in 1945 to nearly 65 quadrillion BTUs in 1985. Consumption rose from 30 quadrillion BTUs to nearly 75 quadrillion BTUs in the same time period (U.S. Department of Commerce 1975, 1976, 1984).

Increased dependence on net mineral imports is an indicator of economic scarcity. It is in large part the result of deficiencies in production of minerals and fuels from domestic mines and mills. Mine production of metals peaked in 1970 and then declined, though somewhat unevenly. In 1984, U.S. dependence on imports exceeded 50% for 21 out of 32 important nonfuel mineral commodities evaluated (Dorr n.d.). This dependency ranged from 9% for aluminum to more than 90% for columbium, sheet mica, strontium, manganese, bauxite and alumina, cobalt, tantalum, fluorspar, and the platinum materials group. Imports dependency was 23% for iron and steel and 19% for iron ore.

For mineral fuels, the U.S. went from virtual self-sufficiency in the 1940's and early 1950's to about 15% dependency on imports in the early 1980's as measured by BTU production and consumption. That dependency came entirely in the petroleum resource area where import dependency rose to about one-third in the early 1980's. As dependency on petroleum imports rose, coal production (mainly bituminous), increased from an historic low of 22% share of BTU production and a 17% share of consumption in the early 1970's to 29% and 22%, respectively, in the 1980's (U.S. Department of Commerce 1976, 1987).

Deficiencies in U.S. production arise from the lack of economic deposits of some minerals such as sheet mica, tin, and diamonds. In other cases, it is the depletion or exhaustion of high-grade ore deposits as in the case of iron ore. Very large reserves of low grade iron ore remain and some are being mined. Imports of higher grade ores and concentrates, however, are increasing. Even though U.S. production and consumption of minerals rose notably in the postwar period, its share of world production declined from 23% in 1950 to 11% in 1980; its share of world consumption fell similarly from 25% to 13%. Improved world supplies relative to U.S. supply potentials also contributed to domestic production deficiencies. Because mineral processing involves the handling of large volumes of material and great weight reduction, the smelting, refining, and processing capacity tends to locate near major new mineral deposits. For example, most of the new alumina and aluminum plants are being built in places like Brazil, Venezuela, and Australia where the large world reserves of bauxite are located. For the same reason, new ferrochrome plants in South Africa, Zimbabwe, Brazil, and India are supplanting American plants (Cameron 1986, Dorr n.d.).

Analysis of price trends for minerals indicate that the prices of many important minerals and fuels rose relative to the general price level after 1970, another indication of economic scarcity. This was a reversal of the general trend for the preceding 100 years when the relative prices of minerals and fuels were generally stable or declined. The economic scarcity interpretation, however, has some weakness because the rise in mineral and fuel prices after 1970 also reflected the rise of the exchange rate against the U.S. dollar, OPEC actions to raise oil prices, and higher costs of mineral activities associated with environmental and land management changes after 1970. Through 1983, the price evidence on economic scarcity is not totally convincing (Myers and Bennett 1985).

Nevertheless, the U.S. mineral position is viewed as weak for a number of important metals. Considering known reserves, this position is expected to become progressively and significantly weaker through 2005. The solution is seen to be in the discovery and development of new, economically productive deposits and expansion of reserves. The western states and Alaska, where federal lands are extensive, reportedly have the potential for large contributions of lead, zinc, copper, molybdenum, and perhaps tungsten, mercury, antimony, and nickel. Exploration for metals other than gold or silver, however, is virtually at a standstill (Cameron 1986).

Land Management

Generally, the postwar growth, land use and management, and legislation and administrative regulation at the federal, state, and local levels have acted to withdraw and restrict access to public lands for mineral exploration and have added to the difficulties and costs of exploration and development (Cameron 1986). Regulation is directed toward environmental objectives, protection of the surface uses and benefits (including the environment), and to eliminate abuse of the mineral laws. For the most part, the land use and management legislation and administrative law came after the passage of the National Environmental Protection Act in January 1970.

Subsequent federal legislation which affected the complexity of and access to mineral exploration and development included:

- Clean Air Act and Amendments of 1970;
- Clear Water Act of 1972;
- Endangered Species Act of 1973;
- Forest and Rangeland Renewable Resources Planning Act of 1974;
- Toxic Substance Control Act of 1976;
- Federal Land Policy and Management Act of 1976;
- National Forest Management Act of 1976; and
- Surface Mining and Coal Reclamation Act of 1977.

Prior to 1970, the Wilderness Act of 1964 provided authority for major federal land withdrawals for a National Wilderness Preservation System. By 1988, almost 90 million acres had been designated by Congress and additional acres were being considered and studied. Any lands not claimed or leased for minerals were closed to entry after 1983. However, data collection, including prospecting for minerals and other resources, is permitted—providing the activity is compatible with wilderness preservation. But, subsurface exploration for effective assessment of "hidden" mineral deposits appears to be largely foreclosed and effective exploration for operability is practically precluded. Theoretically, Congress can withdraw areas from wilderness status for mineral purposes, but that seems unlikely unless there is positive evidence of a significant mineral deposit. These circumstances are seen as seriously circumscribing mineral exploration and development in wilderness areas, even though information gathering and prospecting are permitted (Cameron 1986).

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) established a federal and state regulatory framework to prevent resource abuses that had characterized surface coal mining. It pertains to both public and private lands. Similar laws in states such as North Dakota, Wyoming, Colorado, and Montana preceded SMCRA in the late 1960's and early 1970's, when western states were anticipating an increase in demand for coal and a need to control the environmental effects of coal mining. SMCRA is implemented mainly through state legislation and regulation no less stringent than the Federal Act. Permits and performance bonds to assure reclamation are required of all operators engaging in coal mining. Performance standards, inspections, and penalties are also included. SMCRA also provides for reclamation of abandoned mine lands estimated at 1.1 million acres at the beginning of the reclamation program. This program is funded by fees paid by permitted coal mine operators on each ton of coal mined. Total fees collected for reclamation through early 1988 exceeded $2 billion. Permits issued for mining and reclamation operations in the past 10 years exceed 25,000 and affect over 3.4 million acres (Office of Surface Mining, Reclamation, and Enforcement 1987).[15]

Congress also passed a Mining and Minerals Policy Act in 1970 to address environmental issues. Its purpose was to foster and encourage private enterprise to develop economically sound and stable domestic mining and mineral industries and the orderly development of domestic mineral resources. Unlike the positive response to the environmental legislation, little was done to achieve the purposes of the 1970 Mining and Mineral Policy Act and no grassroots constituency developed to address issues in the mining area (Dorr n.d.).

Ten years later, Congress passed the National Materials and Minerals Policy, Research and Development Act of 1980 in response to mining industry concerns with the increasing restrictions to explore for, develop, and produce minerals on federal land which constitute about one-third of the U.S. land area. It was also a response to expressed concerns about potential shortages of critical and strategic materials should foreign sources for supply be disrupted. The 1980 Act declared it to be national policy to promote an adequate supply of materials and to consider "a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs" (Dorr n.d.).

The President transmitted a National Materials and Minerals Program Plan and Report to Congress in 1982 as required by the Act. The Bureau of Land Management is developing an Automated Land and Mineral Record System in response to the report sections addressing data collection and land availability. The objectives of this automated public lands information system are to define: which federal lands are held under the 1872 mining law, which are leased, which are withdrawn from location or leasing or both; which are open with restriction and

[15] *Personal conversation with Bobby Rakestraw, Soil Conservation Service, U.S. Department of Agriculture, Washington, DC.*

what types of restriction apply; how much and which land the federal government owns, where it owns surface rights but not subsurface or vice versa; and where jurisdictional responsibilities overlap and where regulations conflict (Dorr n.d.).

PARKS, RECREATION, AND WILDLIFE

Parks and Recreation

After World War II, public visits to the National Park System increased to 50 million by 1950 and 72 million by 1960. This trend paralleled the increase in visits to the National Forest System. Expanding use made park maintenance and development projects, deferred during the war, a new priority for the National Park Service. The major response was Mission 66, a 10-year rehabilitation and capital development program begun in 1956. The goal was to improve the System's facilities and resource preservation for the occasion of its 50th anniversary in 1966 (U.S. Department of Interior 1985c).

Acceleration of river basin development by the Corps of Engineers and the Bureau of Reclamation after the war threatened the integrity of various units of the National Park System. Strong opposition of conservation organizations and the National Park Service, generally but not always working together, largely stemmed these and similar threats to the integrity of the System and brought it through relatively unscathed (U.S. Department of Interior 1985c).

In 1964, the management of the Park System was organized into three park categories—natural areas, historical areas, and recreational areas—each with its own management concept and principles. Natural areas focused on preservation while maintaining compatible historic features. Historical areas reverse these emphases. In recreation areas, both historic and natural preservation were subordinated to management for outdoor recreation uses (U.S. Department of Interior 1985c).

Between 1945 and 1984, the number of National Park System units more than doubled and the area of the System tripled (table 19). Most of the increase came between 1978 and 1980 when over 47 million acres were added in Alaska. The System area in the contiguous 48 states totals 31 million acres. Wilderness areas have been designated by Congress within 39 units of the Park System. They total 38 million acres with 90% in Alaska (U.S. Department of Interior 1985b, 1985c).

The rapid growth of the Park System in recent years led to a general sense that it was expanding too fast. New park acquisitions slowed after 1980. Park visitors increased to 332 million in 1984, more than four times the level reported in 1960. The current focus of management is to emphasize improvement of stewardship rather than major new expansion. Restoration and improvement to stabilize and upgrade existing park resources and facilities is now the central policy. The separate management categories for natural, historic, and recreational areas were abolished in 1977. They have been replaced by a single set of management guidelines that cover the range of characteristics that occur in the park units. Parks are now zoned according to their various natural and cultural features. Zones are managed according to appropriate guidelines (U.S. Department of Interior 1985c).

Table 19.—Area and components of the National Park System.

Component	Federal area Units	Federal area Acres	Percent of total area
National parks	48	47,971,577	60
National preserves	12	21,106,350	26
National monuments	77	4,724,442	6
National recreation areas	17	3,687,006	5
National seashores	10	597,025	1
National rivers	4	359,993	a
National lakeshores	4	224,674	a
Wild scenic rivers	8	208,911	a
National parkways	4	163,226	a
Historical parks	26	150,790	a
Scenic trails	3	126,858	a
Subtotal	213	79,320,852	
Others	124	119,541	
Total	337	79,440,393	

[a]*Less than 0.5%.*
Source: U.S. Department of the Interior (1985b).

The Outdoor Recreation Resources Review Commission (ORRRC), authorized by Congress and appointed by President Eisenhower in 1958, was another important development for the nation's recreational interests. Its charge was "to determine the outdoor recreation wants and needs of the American people now and what they will be in the years 1976 and 2000; to determine the recreation resources of the Nation available to satisfy those needs...and to determine what policies and programs should be recommended to ensure that the needs of the present and future are adequately and efficiently met." The Commission published its findings and recommendations in 1962. The need for outdoor recreation opportunities was reported most urgent near metropolitan areas. Considerable land was available for outdoor recreation but it was not well located to meet the most urgent needs. The Commission made 52 highly specific recommendations. The most significant, perhaps, was to establish a national public land acquisition and recreational development program supported with federal and matching state funds. Congress responded with the enactment of the Land and Water Conservation Fund in 1964 through which 5.6 million acres of local, state, and federal park and recreation lands were acquired and developed in or near heavily populated urban centers. Other responses to ORRRC recommendations were the legislative establishment of natural systems of wilderness and wild, scenic, and recreational rivers and trails. In addition, more than 100,000 acres of surplus federal land was transferred to states and communities for park and recreation purposes. A Bureau of Outdoor Recreation was established in 1962 in the Department of the Interior but it has since been abolished (Davis 1983, Diamond et al. 1983).

State park development expanded rapidly after the war, responding to the boom in outdoor recreation and tourism that came in the 1950's. By 1970, the state parks numbered 3,425 with a total area of 8.6 million acres. They reported over 482 million visits in that year. Leadership of the state park movement during this period shifted from citizens and civic organizations to professionals. The National Conference of State Parks, formed in 1920, merged with the National Association of State Park Directors to form the National Recreation and Park Association. The management of state parks increasingly was placed in the hands of professionally trained park and recreation managers. The total professional staff serving state parks rose from 400 in 1950 to 3,400 in 1970.

In 1984, the area of state parks had expanded to more than 10 million acres and reported visitors were 666 million (Davis 1983, U.S. Department of Commerce 1987). The high level of visits to state parks and their relatively small acreage, compared to those for national forests and parks, emphasizes the local nature of a very large segment of recreation interests and demands as recognized in the ORRRC study in 1962.

Wildlife Management

State wildlife management programs thrived as the Pittman-Robertson (P-R) program expanded rapidly after World War II. In 1950, the P-R program was supplemented by the Dingell-Johnson Federal Aid in Fish Restoration Act giving states assistance for protection and management of sports fisheries similar to the P-R program. Obligated funds for both programs increased from less than $14 million in 1947, measured in constant 1982 dollars, to $57 million in 1965 and $95 million in 1984 (U.S. Department of Interior 1985a). States were enabled to purchase outright about 4 million acres of wildlife habitat. In 1984, state leases and cooperative agreements for wildlife management were in effect in 4,400 areas encompassing almost 40 million acres of public and private lands in all 54 states and territories. Practically all the acreage was available for hunting. Over 560,000 acres had been acquired and were being developed or managed as wildlife refuges. Populations of many birds and mammals of both game and nongame species have been restored, including the white-tailed deer, whose number has risen from less than a half million in 1920 to more than 14 million today. Nearly 4 million were harvested in 1980. Wild turkeys, which were scarce outside a few southern states in 1930, now number 2 to 3 million. Their harvest exceeded 250,000 in 1980; hunting seasons are permitted in 45 states. Elk numbered only about 100,000 in 1920, and now approach 500,000 with over 75% located on national forests. Similar accounts of population restoration can be cited for the gray and fox squirrels, Canada geese, antelope, beaver, black bear, desert bighorn sheep, mountain lions, bobcats, and many others (Trefethen 1975; U.S. Department of the Interior 1983, 1984a).

During the years 1980 to 1983, the total number of licensed hunters averaged a record 16.5 million. Total hunter days were almost 400 million in 1980. The upward trend in hunters, however, appears to be levelling with the influence of urbanization, higher education, rising population age, and the growing proportion of white-collar workers. Some organized opposition to hunting and game-oriented wildlife management emerged in the 1970's. This has fostered a growing management emphasis on protecting nongame species, including predators such as wolves, panthers, and coyotes (Fedkiw 1986a; Trefethen 1975; U.S. Department of Interior 1983, 1984a).

Federal refuges also expanded in this period. There are now 434 refuges in all states and territories except West Virginia. Excluding Alaska, their total area is 1 million acres. The 16 national refuges in Alaska total 17 million acres. In addition, there are 150 federal waterfowl management areas totalling 1.7 million acres and 58 wildlife coordination areas with 400 thousand acres.

The passage of the Endangered Species Preservation Act in 1966 and successive legislation has obligated the nation to protect all native animals and plant species whose survival is endangered through all or a major part of their range in the foreseeable future. The legislation established a distinction between endangered and threatened species. Threatened species are those likely to become endangered throughout all or a major part of their range in the foreseeable future. The Secretary of the Interior, who administers the act, identified 323 endangered species and 87 threatened species as of June 1986 (table 20). Federal agencies are obliged to manage their resources and programs in ways that do not jeopardize the listed species or destroy or adversely modify their critical habitat. The Department of Interior cooperates with states and the private sector to protect and manage ecosystems that endangered and threatened species depend upon. One hundred ninety-eight recovery plans have been developed for protecting 233 of the listed species on federal, other public, and private lands.

WATER RESOURCE PLANNING AND DEVELOPMENT AFTER 1945

Water resources development under federal programs accelerated rapidly in the 1940's and 1950's. The unprecedented authorizations of the 1944 Flood Control

Table 20.—Number of endangered and threatened species.

Species group	Endangered	Threatened
Animals	271	60
Mammals	45	4
Birds	76	5
Fish	43	25
Other[a]	56	26
Plants	103	27
Total	323	87

[a]*Snails, clams, crustaceans and insects.*

Act were a major force and influenced federal appropriations for water resource projects into the 1960's. The abolishment of the National Resources Planning Board in 1943 by Congress effectively undermined centralized executive branch oversight of water resources planning and development programs. Congressional attitudes increasingly favored ultimate decisionmaking on public works projects based on preferences of the congressional delegations of each district. Thus, projects sponsored by Members of Congress seldom received effective opposition except where there was serious local opposition. Each of the federal water resource agencies formed liaisons with its congressional committees and a separate approach based on its history, its jurisdiction, and the interests of the geographic clientele served by its programs. The Corps' emphasis focused on the needs of localities for structures that could deal adequately with catastrophic floods. The Bureau of Reclamation was motivated by its sense of the national importance of western regional economic development. The Soil Conservation Service favored maximum amounts of planned watershed protection from the viewpoint of agricultural soil and water protection for the nation (Burges 1979).

In 1954, Public Law 566 gave the Department of Agriculture authority to help local organizations plan and develop watershed improvement works for flood prevention and agriculture use, and conservation of water for watersheds smaller than 250,000 acres. This included Soil Conservation Service assistance with investigations and surveys, as well as the planning and evaluation of projects including structural works of improvement. This technical and financial assistance was furnished through PL 566 project agreements between the Soil Conservation Service and local organizations (Helms 1988, U.S. Department of Agriculture 1972).

Wise use and efficiency considerations continued to dominate water resource planning and development through the 1960's. Benefit/cost analysis and related principles and standards became important tools in justifying projects and assuring their efficient design. By the 1960's, however, the pace of water resource project construction was slowing as most of the big dams were completed. Many major river systems were heavily regulated or controlled—the Tennessee, Missouri, Colorado, Rio Grande, Ohio, Columbia, Arkansas, Red, Mississippi, and those in California's Central Valley. There were few large river systems remaining for major work. Most of the efficient opportunities for water resource improvement works, including small watersheds, had been identified and completed or were under construction. Pressure for retrenchment of federal investment increased during the 1960's. Increasing emphasis was placed on state water resource planning and greater state and local financing (U.S. Department of Agriculture 1972, Willeke 1979).

Toward the end of the 1960's it became evident that despite the development of major flood control works, property damage and loss from flooding were persistently rising on the flood plains. Although flood protection measures were effective in controlling floods, they were also inducing expanded investments and development on the better protected flood plains. Federal policy emphasis thus shifted toward nonstructural measures, such as more effective use of flood insurance, restriction of intensive development, and greater use of the flood plains for recreation and aesthetic purposes and other less intensive uses.

Water Quality

Water quality and related amenity interests in water resource development received increasing attention after World War II, but largely in ad hoc terms until the 1970's. Recreation, for example, was authorized as an appropriate multipurpose objective in the 1944 Flood Control Act. In 1954, the Fish and Wildlife Coordination Act provided for systematic assessments of the expected effects of federal water resource projects on fish and wildlife. The assessments were prepared by federal and state fish and wildlife experts and often led to the addition of mitigation measures, such as fish screens, ladders, and hatcheries or the use of reservoir storage capacity for conservation objectives (U.S. Department of Agriculture 1972). Recreation developments around reservoir areas expanded rapidly in the 1960's in response to booming outdoor recreation demands. Beginning in the 1960's, channelization of upstream watershed habitats was seen as harmful to fish and wildlife aquatic habitats and was strongly restricted in federal programs. The drainage of wetlands was likewise seen as having similar adverse effects and also restricted in federal programs.

Systematic planning for water quality and related amenity and environmental considerations began following the passage of the National Environmental Policy Act of 1969 (NEPA). The Act addressed a multiplicity of environmental concerns relating to all resources and stated general national goals and policies. In particular, it required the preparation of environmental impact statements describing the effect of significant proposed actions and decisions, and alternatives to those actions, on environmental conditions. Both a draft statement subject to public review and comment and a final statement reflecting response to public review comments were required. In this way, environmental quality analysis and planning became a part of federal water resources planning and development along with economic efficiency and engineering effectiveness in the early 1970's. The NEPA process similarly affected planning and development for all other resources in federal programs (Ortolano 1979).

In 1972, the Clean Waters Act made "fishable and swimmable" water a national goal for the nation's surface waters. By the late 1980's, substantial progress had been made in reducing discharges of pollutants such as organic matter, sediment, nutrients, salts, and bacteria from point sources such as industrial plants and municipal wastewater treatment facilities. Nonpoint sources of pollution such as urban runoff or sediment from erosion of agricultural lands were seen as the major causes of degradation where water quality was still a problem. In such locations in 1986, nonpoint sources were

impairing use in 75% of the lake acres, 65% of the stream miles, and 45% of the estuaries (Hanmer 1988).

In 1986, the EPA National Water Quality Inventory estimated that about 75% of the nation's surface waters that were assessed were clean enough for fishing and swimming (U.S. Environmental Protection Agency 1987). When the more distant lakes and upper reaches of streams which were not assessed and largely free of pollutants are included in the base, this percentage would probably be closer to 90%.[16]

A joint National Fisheries Survey conducted by the U.S. Fish and Wildlife Service and the Environmental Protection Agency in 1982 found that sport fish, such as rainbow trout and largemouth bass, are found in 73% of the Nation's inland waters and that 67% of streams are suitable as sport fish habitat (Council of Environmental Quality 1985). The preliminary results of the 1985 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation show a substantial increase in the number of number of people fishing and fishing days of participation since 1980 (U.S. Department of Interior 1987). The number of people who fish increased almost 11%, more than double the population growth rate. Total days of fishing increased over 15%. The number of days per person fishing and average length of trips also increased. Total outdoor recreation growth was about the same as population growth (Domestic Policy Council 1988). Thus, the relative increase in fishing demand since 1980 can be seen as an apparent response to the improving quality of surface waters. The increase in total days of fishing was greatest for inland waters, 17%, compared to 7% for saltwater fishing.

OUR TRANSFORMED HERITAGE

Today, the nation's transformed heritage of forests, grassland, and croplands covers 1.63 billion acres compared to 1.75 billion acres in 1880 and probably somewhat more in the presettlement period (table 1). This excludes 362 million acres in Alaska which is still largely undeveloped rangeland and forest. It also excludes Hawaii and various territories.

Other land uses total 266 million acres. They include the places where most Americans live and work, their travel ways, and their parks and wildlife refuges. When account is taken of the lawns, gardens, trees, and shrubs in these areas and their aesthetic qualities, they represent an important part of our transformed heritage. Their value often exceeds the highest values placed on the nation's more remote and extensive forests, grasslands, and croplands.

Another contrast is in the numbers of Americans supported by these resources. They have grown by 120 times to 240 million. In addition, exports provide equivalent support for 100 million or more people in other lands. Yet, the capacity to produce more remains large, and the potential of technology to expand that capacity is also seen as large. Resource protection, improved management, technology, wise use, and time have revealed the resilience of our natural resources, in many ways unexpected in the 19th and early 20th centuries. They have also confirmed their renewability. Mineral resources, since they are not renewable, have been reduced. There are weaknesses in the domestic supply of some important minerals relative to demands. Our dependence on new technology and imports has increased.

Time has also tested our policies and programs and our resource managers, both public and private. They appear to have served Americans well. Time has likewise taught us that it may require decades, rather than years, to bring about the resource productivity and conditions that best serve the nation's needs. Resource assessment, planning, and foresight are important determinants for assuring resource abundance.

EPILOGUE

Most renewable resources and their outputs appear to be sufficiently abundant to meet the needs of the nation with prudent management and the promise of emerging and new technology. Generally the quality of these resources and their outputs is improving. To the limited extent that forecasts can be made with any degree of reliability, the foreseeable future should see continued relative abundance and improving resource quality and outputs. This applies to crops, livestock, and timber as well as to the croplands, grassland, and forests. It also applies to wildlife, parks, wilderness, and related recreation and aesthetic opportunities. Certainly the claim can be made that a great deal of progress has been achieved in resource production, productivity, and conditions during the past several decades.

Nevertheless, there are continuing issues and problems relating to resource production, productivity, conditions, and use on public and private lands. They are the subject of considerable debate among diverse individuals and organizations. As this debate goes on in our democratic environment, resource management and use continue to respond to the objectives of resource owners and managers, the market place, and the requirements of our laws and regulatory institutions.

National economic conditions limit how fast or effectively national needs can be addressed, and they impact the management and use of renewable resources and minerals. So, a major challenge is how to assess resource issues in the context of total national concerns, and how to relate them to each other in some sense of priority.

In the face of visible improvement, relative abundance, favorable programs, and trends, the resource management debate seems to be related more to: (1) the balance of resource uses and the distribution of their benefits to different segments of our society; (2) the rates of improvement among the resources uses and conditions; (3) the local and specific exceptions to the general trend; and (4) the general impact of these matters on the future welfare of the nation. Factors conditioning the debate include:

[16] *Telephone conversation with Rob Wolcott, U.S. Environmental Protection Agency, Washington, DC, September 21, 1988.*

- The current multiplicity of single resource interests;
- Philosophical differences over the value of uses ranging from pristine, natural conditions to intensive use and management;
- Lack of adequate and reliable data on the actual dimensions of some resource issues and problems;
- The relative roles of the federal, state, and local governments and the private sector;
- Efforts to reduce public spending that emphasize the question of who should pay for the cost of improving resource productivity and conditions;
- Expanded use of the democratic opportunity to make a case before federal, state, and local legislative, executive, and judicial representatives; and
- Recognition of the limited ability of the marketplace to respond to issues of value and preference of all resource interests.

Past debates and action have often altered the use and management of renewable resources as public and private landowners have responded to the marketplace. Public consensus continues to be difficult to achieve with the growing fragmentation of resource interests. Nevertheless, some debate is healthy and contributes to the laws, programs, and regulations that help to bring about favorable resource conditions and trends.

Much of the nation's resource improvement resulted from problems—which began as private, local, or state problems—that fell into the hands of the federal government when the Great Depression disabled the capabilities of states and the private sector to deal with them. Now, as renewable resources are on an upward path, a more appropriate balance may properly return stronger control to the states, local governments, and the private sector to deal with them.

Past performance clearly indicates that our resources are both resilient and renewable. This is true for soils, forests, grassland, wildlife, fish, and both air and water quality. The most important historical lesson, however, is the need for continuous vigilance. With the enormous and growing pressures of population and economic growth, and the intensifying public use of renewable resources for most all purposes, the strongest assurance for continuing improvement lies in the periodic measurement and open, public assessment of resource productivity and conditions for meeting ongoing and future needs of the nation. Measurement must be sufficiently intensive to establish "baseline data" for monitoring the renewable resources and be useful for national, state, and substate assessments.

Adverse resource conditions and trends, when they arise, are usually localized and contained within state borders. Their identification at those levels helps to assure they do not become larger problems. That is the task of measurement and assessment—to identify emerging resources issues and problems and credibly quantify their actual dimensions and distribution. This is a primary role—"vigilant stewardship"—for federal and state resource agencies, together with delivery of resource information to the nation's policy leaders, the general public and experts alike. When serious problems are found, policy questions and options need to be raised, evaluated, and debated in terms of what, if anything, should be done, by whom, and for whom.

With the foregoing in mind, the lead role for resource measurement and assessment lies largely with the federal government, mainly because that is the only way complete, standardized, and geographically consistent information can be acquired at a reasonable cost. However, there is a substantial role for state and local governments and the private sector in gathering needed data. This is exemplified by the important state and local government and private participation in the forest survey and the national resource inventory conducted by the U.S. Department of Agriculture's Forest Service and Soil Conservation Service, respectively.

State capabilities in resource assessment and management have increased substantially in recent years, along with their managerial and financial capability to respond to critical problems. These capabilities will grow in response to perceived or emerging resource needs, if periodic resource data and assessment information are made available to the public and its leadership. Land use and related resource planning is widely recognized as a state role and often seen as constitutionally reserved to the states. The growth of state interests and capabilities in resource assessment and planning reflects the growing understanding of state leaders and their citizens that knowledge of resource conditions and trends are important for assuring their economic, social, and environmental welfare.

A number of continuing resource issues will require the attention of policy leaders, resource managers, and the public now and in the future. These include:

- Adjusting public and private agricultural production management and expansion of export markets to improve the economic welfare of the farming and ranching industries;
- Conserving agriculture lands that are vulnerable to serious soil erosion and other forms of resource degradation;
- Developing a more rational basis for allocating lands to wilderness use in relation to other resource needs and determining how much of the current 30 to 40 million acres of federal land presently under review warrants conversion and addition to the designated 88 million acres of the National Wilderness Preservation System.[17]
- Determining how to meet the outdoor recreational needs of a population increasing in size and affluence, working out the appropriate federal, state, and local government and private roles, and establishing policies for financing increased facilities, services, and maintenance that are equitable to users and taxpayers alike (Diamond et al. 1983, Fedkiw 1986c, Schaub 1983).

[17] *Data on designated wilderness areas and additional areas under review provided by Forest Service, Division of Recreation Management.*

- Preventing or avoiding adverse effects of pollution on surface and groundwaters, particularly from the use of pesticides and fertilizers (Association of State and Interstate Water Pollution Control Administrators 1985, Environmental Protection Agency 1984, Gianessi et al. 1986, Holden 1986, National Research Council 1986, Schaub 1983, U.S. Geological Survey 1985);
- Managing harvests and road development on national forests in a way that balances wilderness, recreational, wildlife, and timber needs of the nation;
- Managing the use of the increasingly valuable surface and groundwater supplies, particularly in the arid sections of the West (Englebert and Schewring 1984, High Plains Associates 1982);
- Assuring an adequate supply of minerals and energy sources.

Other continuing issues relating to resource management include the loss of wetlands, sodbusting on highly erodible soils, salinization, desertification, and control of predators on domestic stock. These are largely site-specific issues or problems, with more or less uncertain dimensions, but they have received some national attention. Additional issues, such as threatened and endangered species, recovery of wildlife populations, the management of nonindustrial private lands, and range conditions have been more prominent and received more attention. One resource issue has abated as a result of improved measurement and assessment and dropped from the national agenda. That was the concern for an apparent accelerated and unacceptable rate of loss of farmlands in the 1970's (Easterbrook 1986). However, it may remain an issue in some states and at local levels.

Some resource problems originate largely in urbanized and industrial areas. They include acid rain, ozone and other photochemical oxidants, the rising concentration of carbon dioxide and other atmospheric chemicals, and solid and toxic wastes that are disposed of on the land. These problems potentially threaten the production and use of renewable resources to a far greater degree than those associated more directly with resource use and management.

The foregoing issues are indicative of our vigilance and concern for croplands, grassland, and forests and their production and services. Most are the subject of some degree of research, systematic measurement, and assessment, as well as a great deal of debate and rhetoric. These characteristic ways in which we address issues reflect our national education and scientific orientation. They also reflect the political dimensions of our society. Although these processes can benefit from better public education and information about our land and renewable resources, there is a clear consensus for vigilance over the nation's resources. There is less consensus about how, by whom, and to what extent each of the issues should be addressed and who should bear the cost burden. But, we should be thankful for the vigilance. Landowners and managers, meanwhile, will continue to manage both public and private land and await the outcome of the debate, influencing it where they can.

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