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**General Technical
Report RM-174**

Basic Assumptions

A Technical Document Supporting the 1989 USDA Forest Service RPA Assessment

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" (Section 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 af 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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Major Changes in Assumptions

There have been many changes in the U.S. economy in the decade, 1979-1989. During this decade, trade and budget deficits, interest and inflation rates, and energy costs have influenced short- and long-term prospects for the U.S. economy. Despite the many short-run shocks to the economy during the past decade, the general outlook for the broad measures of economic activity is one of growth and increasing affluence of the U.S. population. This outlook parallels the history of the past 50 years during which the U.S. economy was buffeted by world war, recession, and other dislocations but still managed to more than quadruple its gross national product net of inflation and deflation.

There are four major revisions in the basic assumptions underlying the RPA Assessment—projections of population, gross national product, energy prices, and per capita consumption of beef, veal, lamb, and mutton. These revisions were made based on new information obtained since the basic assumptions were made for the 1979 RPA Assessment.

Population

For the 1979 RPA Assessment, population was projected under three sets of assumptions termed "low," "medium," and "high." In most subsequent analysis in the Assessment, the medium projections were given emphasis. For the 1989 RPA Assessment, only one population projection was made. It used the Bureau of the Census middle series projection with a high immigration assumption (750,000 per year). The high immigration assumption is an attempt by the Bureau of the Census to account for net illegal immigration. The 1989 RPA Assessment projections of population for 2030 are about 8% higher than the medium projections for the 1979 RPA Assessment (table 1). This largely reflects the higher immigration assumption.

Gross National Product

The 1979 Assessment had low, medium, and high projections of gross national product. As shown in table 2, the 1989 RPA Assessment projection is lower than the medium projection from the 1979 RPA Assessment until 2020. By 2030, the projection from the 1989 RPA Assessment is about 8% higher.

Per capita disposable income in 2030 was assumed to be $25,840 for the medium projections in the 1979 RPA Assessment and $23,530 in the 1989 RPA Assessment. For both Assessments, the income projections indicate rising affluence of the U.S. populace, with real per capita purchasing power more than doubling by 2040 for the 1989 RPA Assessment.

Energy Costs

There were no explicit energy cost projections for the 1979 RPA Assessment. For the 1984 Supplement to the 1979 RPA Assessment, energy price assumptions were:

Table 1.—Projections of U.S.population (million) from the 1979 and 1989 RPA Assessments.

Year	1979 Assessment			1989 Assessment
	Low	Medium	High	
2000	245.9	260.4	282.8	274.9
2010	250.9	275.3	315.2	294.3
2020	253.0	290.1	354.1	312.1
2030	249.3	300.3	392.8	325.5
2040	N.A.	N.A.	N.A.	333.4

Table 2.—Projections of U.S. gross national product (in billions of 1982 dollars) from the 1979 and 1989 RPA Assessments.

Year	1979 Assessment			1989 Assessment
	Low	Medium	High	
2000	5,180	5,780	6,470	5,402
2010	6,320	7,400	8,710	7,031
2020	7,330	9,010	11,140	9,166
2030	8,600	11,100	14,410	11,957
2040	N.A.	N. A.	N.A.	15,627

Year	1984 Supplement	1989 RPA Assessment
	—cost per barrel (in 1982 dollars)—	
2000	99.06	29.68
2010	114.90	47.27
2020	133.23	50.00
2030	133.23	50.00
2040	N.A.	50.00

The projections for the 1989 RPA Assessment are considerably lower than for the Supplement, based, in part, on the softness of energy prices in the 1980's. There is much uncertainty about future crude oil prices, however. For the 1989 RPA Assessment, prices were arbitrarily levelec at $50, on the assumption that at this price, conservation and use of substitute energy sources would become wide-spread.

Beef, Veal, Lamb, and Mutton Consumption

The 1979 RPA Assessment projected low, medium, and high levels of consumption of beef, veal, lamb, and mutton. The 1989 RPA Assessment assumes that total consumption of these types of meat will remain at 110 pounds per capita per year throughout the projection period. As shown in table 3, per capita consumption projections for the 1989 RPA Assessment are considerable lower than for the 1979 RPA Assessment.

This change in assumption is based on the trend in actual consumption over the past decade, a growing awareness of the importance of diet in personal health, and the price competitiveness of poultry and other substitute foods. Also, many Americans' daily diet is one of choice, whereby increased incomes may affect the variety of foods eaten, but not the quantity.

Introduction

The decade of the 1980's has been characterized by sudden and far-reaching changes in the short-run context for making long-term projections, especially for fiscal and monetary policies and energy prices. In making the general assumptions for the Assessment and Appraisal, there is little basis for judging the accuracy of predictions about long-run levels of population and economic growth, or any of the other determinants of demands and supplies. The intent is to make assumptions, based on historical trends, knowledge about developments which affect these trends, and reasonable expectations about future changes. Because of the uncertainty of long-run projections, alternative futures are analyzed in the Assessment. These futures are based on assumptions about alternative values for variables that could significantly affect demands and/or supplies of soil, water, forest and range land resources.

Historical trends underlying the basic assumptions are shaped by massive social, political, technological, and institutional forces that are not easily or quickly changed. Recent trends are likely to persist over the long run with some short-term fluctuations.

Table 3.— Projections of per capita consumption of beef, veal, lamb, and mutton (pounds carcass weight) from the 1979 and 1989 RPA Assessments.

Year	1979 Assessment			1989 Assessment
	Low	Medium	High	
2000	140	141	143	110
2010	141	145	147	110
2020	138	145	148	110
2030	137	148	153	110
2040	N.A.	N.A.	N.A.	110

Population

Changes in population greatly affect the demands placed upon the Nation's soil, water, forest, and range land resources. These changes in population also influence the size of the labor force, a major determinant of the level of economic activity and related materials use.

In the past 50 years, the population of the United States increased by more than 100 million people (table 4). Projections of the WEFA Group, based on projections of the Bureau of the Census, indicate that population is likely to continue to grow during the next 50 years. The WEFA Group projections using the Census Middle Series projections with a high immigration assumption—the projections used in the Assessment and Appraisal—show annual population growth declining from about 1% in the 1970's to 0.2% in the decade 2030-2040.

The decline in the rate of population growth reflects the Bureau of the Census assumptions about fertility rates. Fertility rates have fluctuated widely in recent decades, but since the 1950's have fallen sharply. The medium projection is based on an assumed fertility rate of 1.9—a level close to current birth expectations of females of child-bearing age. The current fertility rate is below this figure, and approximates a level which would end population growth in the first part of the 21st century.

Legal immigration accounts for a significant part of U.S. population growth. Projections of population (table 4) assume net immigration of 750,000 people per year. This assumption is an attempt by the Bureau of the Census to account for net illegal immigration.

Geographic distribution of population has a strong influence on state and regional demands for many products, particularly those that must be produced and

consumed at the same place. State projections prepared by the Bureau of Economic Analysis are used as the basis for regional projections of demands upon soil, water, forest and range land resources. The Bureau projections show significant differences in population trends among the states and regions. Generally, the fastest growth is projected to be in the South and on the Pacific Coast. Rapid growth also is projected in some areas of the Rocky Mountains. The major population concentrations, however, remain in the North Central Region, and along the Atlantic and Pacific coasts.

The age distribution of the population is another significant factor in estimating demands for many products. The Bureau of the Census projection by age classes indicates a substantial increase, during most of the projection period, in the number and proportion of people in the middle-age classes—the classes that have the highest income levels and the largest demands for goods and services.

Gross National Product

In recent years, changes in the consumption of many soil, water, forest, and range land products have been closely associated with changes in the Nation's gross national product.

Between 1929 and 1986, the gross national product, measured in constant 1982 dollars, increased more than five times (table 4). Annual changes have fluctuated widely, from as much as 18.8% to -19%. The highest sustained rate of growth occurred in the 1960's, when it averaged 4.2% per year.

The wide fluctuations in annual rates of growth in the gross national product have reflected factors such as differences in the rates of change in the labor force, rates of unemployment, hours worked per year, and productivity. These factors probably will continue to cause fluctuations. The WEFA Group projections have business cycles with downturns in the economy in 1990.

Table 4.—Population, gross national product, and disposable personal income in the United States, selected years 1929-86, with projections to 2040.

	Population		Gross national product		Disposable personal income		Per capita disposable personal income	
Year	Millions	Annual rate change	(billions 1982 dollars)	Annual rate change	(billions 1982 dollars)	Annual rate change	1982 dollars	Annual rate change
1929	121.8	—	709.6	—	498.6	—	4091	—
1933	125.7	0.8	498.5	-8.4	370.8	-7.3	2950	-7.8
1940	132.1	0.9	772.9	7.9	530.7	6.2	4017	5.4
1945	139.9	1.1	1354.8	-1.9	739.5	-1.3	5285	-2.4
1950	152.3	2.1	1203.7	8.5	791.8	8.0	5220	6.2
1955	165.9	1.8	1494.9	5.6	944.5	5.6	5714	3.8
1960	180.7	1.6	1665.3	2.2	1091.1	2.2	6036	.1
1965	194.3	1.3	2087.6	5.8	1365.7	5.8	7027	4.5
1970	205.1	1.2	2416.2	-.3	1668.1	4.3	8134	3.1
1975	216.0	1.0	2695.0	-1.3	1931.7	1.9	8944	.9
1976	218.0	1.0	2826.7	4.9	2001.0	3.6	9175	2.6
1977	220.3	1.0	2958.6	4.7	2066.6	3.3	9381	2.2
1978	222.6	1.1	3115.2	5.3	2167.4	4.9	9735	3.8
1979	225.1	1.1	3192.4	2.5	2212.6	2.1	9829	1.0
1980	227.7	1.2	3187.1	-0.2	2214.3	0.1	9722	1.1
1981	230.1	1.0	3248.8	1.9	2248.6	1.5	9769	0.5
1982	232.5	1.0	3166	-2.5	2261.5	0.6	9725	-.5
1983	234.8	1.0	3279.1	3.6	2331.9	3.1	9930	2.1
1984	237.0	0.9	3501.4	6.8	2469.8	5.9	10419	4.9
1985	239.3	1.0	3607.5	3.0	2542.2	2.9	10622	1.9
1986	241.6	1.0	3713.3	2.9	2645.1	4.0	10947	3.1
PROJECTIONS								
2000	274.9	0.7	5402	2.8	3827	2.4	13920	1.6
2010	294.3	0.6	7031	2.6	4922	2.3	16730	1.6
2020	312.1	0.5	9166	2.8	6136	2.4	19660	1.8
2030	325.5	0.3	11957	2.7	7660	2.2	23530	1.9
2040	333.4	0.2	15627	2.7	9599	2.3	28790	2.1

Sources: Historical Data: Council of Economic Advisors 1987. Economic Report of the President. Feb. U.S. Gov. Print. Off. Washington, DC. Projections: The WEFA Group Special Report to the Forest Service. Copy on file with USDA Forest Service, Washington, DC.

1998, and 2003. After 2003, no attempt was made to project business cycles, and economic growth is assumed to increase smoothly. The assumed rates of growth in gross national product lead to a value of $5.4 trillion (1982 dollars) in 2000—1.45 times that of 1986 (table 4). By 2040, this projection would reach $15.6 trillion—4.2 times that of 1986.

The composition of outputs from the U.S. economic system will partly determine the types of materials needed by the economy. Available projections indicate that transportation, trade, and other services may account for a slowly growing share of total economic activity. Even though there is some decline in their relative importance, the expected increases in manufacturing and construction activities are large. This means that the U.S. economy probably will continue to produce large quantities of physical goods. In turn, large supplies of energy, minerals, and other raw materials will be needed to produce these goods.

The future adequacy of supplies of raw materials to meet the Nation's needs continues to be a concern despite the deflationary environment of the mid-1980's. Concern is also evident about the ways the various programs designed to protect or improve the environment will affect the kinds of goods produced, productivity, and various other factors which determine the rate of growth in economic activity. Despite these uncertainties, there is no apparent basis to assume that the growth trends of the past will not continue into the future.

Disposable Personal Income

Disposable personal income (i.e., the income available for spending or saving by the nation's population) is another important determinant of the demand upon soil, water, forest, and range land resources.

Projections of disposable personal income made by the WEFA Group show that disposable personal income would increase to $9.6 trillion by 2040 under the terms of the underlying assumptions—3.6 times the level of 1986 (table 4).

These assumptions indicate that per capita disposable personal income will rise to $28,790 by 2040—2.6 times the 1986 average. This growth means that the Nation will have a growing population with much greater purchasing power than today.

Institutional and Technological Change

Institutional and technological changes have substantially influenced demands upon soil, water, forest, and range land resources. These changes also have influenced supplies of many renewable resources. For the Assessment and Appraisal, it was assumed that a stream of institutional and technological changes would continue and would affect demands and supplies of the various renewable resources. It was also assumed that the effects of these changes would be similar to those that have taken place and that are accounted for in the historical data used in preparing the projections. Assumptions about important technological changes affecting crop and product yields and other uses of the renewable resources are specified in the Assessment and Appraisal reports. Other important assumptions for agriculture are discussed in later sections of this report.

Institutional changes that lead to the reservation of forest and range lands for designated uses such as wilderness, parks, and wildlife refuges have occurred for a long time; this development is considered in the projections of forest and range land areas.

Energy Costs

The long-term outlook for energy costs can be confusing because of the weakness of energy prices in the 1980's. According to Wharton Econometric Forecasting Services, worldwide demand for crude oil is likely to approach capacity levels around 2000, even without production restraint by the Persian Gulf countries. This consumption growth, by steadily depleting oil reserves, will create significant upward pressure on real oil prices in the 1990's and beyond. Projections of the Department of Energy show world oil prices increasing from 1986 levels of $13.97 per barrel to $51.10 per barrel in 2010 ($1982). If the Department of Energy projections were extended to 2040 based on the relationship between energy prices and gross national product, the price per barrel would be near $100 in 2040. This price was judged to be so high as to be unreasonable.

Conservation and development of alternative energy sources would act to slow the rate of increase in energy prices. For the purposes of this Assessment, the price per barrel is assumed to level off at $50 in 2020 and stay at this price through 2040. The price of $50 is assumed to be high enough to stimulate development of alternative energy sources with implications for the demand for timber and timber products, especially fuelwood. The following world oil prices are assumed for the 1989 RPA Assessment:

Year	Dollars per barrel *(constant $1982)*
2000	29.68
2010	47.27
2020	50.00
2030	50.00
2040	50.00

Various mathematical models were used in the second RCA Appraisal. Two key models were the National Interregional Agricultural Projection System (NIRAP) and a national linear programming model developed by the Center for Agricultural and Rural Development (CARD). The NIRAP model incorporates basic assumptions such as GNP and other projections of macroeconomic variables with various statistical relationships to estimate production, domestic demand, imports, and exports of the primary agricultural commodities. It is a predictive model in that it is an attempt to simulate the actual behavior of agricultural markets. The CARD model determines the least cost method of allocating resources to produce specified levels of crop and animal products. The CARD model does not attempt to simulate actual behavior of U.S. agricultural markets. Instead, it assumes that the U.S. agricultural sector operates efficiently and allocates production among regions so as to minimize costs of production.

The CARD model uses energy prices as an input, but is not designed to measure the impacts of changes in relative prices of energy on the structure of the agricultural sector. The prices of the various energy sources are used in the CARD model to compute a composite energy cost based on quantities and types of energy required by agriculture. These prices were developed from the Farm Enterprise Data System (FEDS). In the CARD model, relative prices of energy were assumed to be unchanged through the projection period.

Capital Availability

Much capital will be required to make the necessary investments in management, physical facilities, and processing plants to accommodate increased demands for forest and range land resources and agricultural products. The question of capital availability was addressed in the 1979 RPA Assessment and was judged not to be an obstacle to industry expansion. This judgment is supported by more recent assessments of capital availability in the future. For example, for the period through 2005, Wharton Econometric Forecasting Associates expects fixed investment growth to be strong, with an average growth rate of 2.9% per year. Wharton expects investment in plant and equipment to average 5.1% growth per year for durables manufacturing and 3.9% for nondurables. This kind of growth is consistent with historical investment levels. For example, investment in producers' durable equipment increased at an average annual rate of 6.5% in the 1960's and 5.2% in the 1970's.

Given the projected increases in gross national product expected to be generated by the U.S. economy after 2005, there is no basis for expecting a change in the situation for capital availability depicted by Wharton through 2005. Therefore, it has been assumed that capital availability will not significantly constrain long-term economic growth in general or intensified use of forest, range, and agricultural lands.

Beef, Veal, Lamb, and Mutton Consumption

Per capita consumption trends for meat—beef, veal, lamb and mutton—from domestic animals that graze will greatly influence the need for rangeland, feed grains and roughages.

Annual per capita consumption of beef, veal, lamb, and mutton declined from a record-high of 133.3 pounds in 1976 to about 110 pounds (carcass weight) in recent years. Possible reasons for this downturn include changing tastes and preferences and relative prices of other food products. The 1984 Forest Service Supplement assumed that per capita demand for beef, veal, lamb, and mutton would rise to 148 pounds by 2030. The Second Appraisal used the estimates in table 5. The 1989 RPA Assessment assumes that per capita consumption of beef, veal, lamb, and mutton will remain stable at 110 pounds per annum through 2040. Even stable per capita consumption would lead to increased demand because of population increases.

Distribution of Agricultural Trade Among U.S. Ports

The distribution of U.S. agricultural exports and imports among major ports is determined by many variables. Some of the more important ones are the quantity and location of foreign and domestic demand, inland and ocean transportation rates, and port and storage handling capacity. A panel of commodity, international agricultural trade, and transportation specialists used a modified Delphi approach to project the future distribution of exports and imports for the port areas of Atlantic, Great Lakes, Gulf and Pacific for 1990, 2000, and 2030. The assumed distribution of exports and imports was used to allocate the distribution of the exports and imports computed with the NIRAP model.

Land Areas by Class of Land

Various systems have been developed to classify land areas by type of land in the United States. Seemingly minor differences in criteria for classification can lead to significant differences in area by class of land. The data in table 6 show, as of 1982, those classes of land that the Forest Service and Soil Conservation Service have reconciled. These data were used in the 1984 Forest Service

Supplement and the Second SCS Appraisal. These data are also used in the 1989 RPA Assessment.

The 1982 National Resources Inventory (NRI) compiled by the Soil Conservation Service was the source of data for the land base used in the CARD model. The number of acres available were estimated for each RCA land group and divided into dryland and irrigated acres for the 105 producing areas used in the CARD model.

Projections of Land Area by Cover Type

The Second RCA Appraisal and the 1989 RPA Assessment differ in their needs regarding land area projections. The Appraisal projections start with existing crop and pasture area and projections of future levels of crop and animal production at the national level. The linear programming model—CARD—then allocates crop and animal production among regions to minimize the costs of production of the specified output levels. Forest land areas are specified by assumption and are used as inputs into the CARD model. With these procedures and the other assumptions in the CARD model, the findings of the Second RCA Appraisal (Review Draft) suggest that there will be more than enough cropland to produce projected output levels. Considerable acreages of cropland are assumed to go idle and no attempt is made to specify the type of cover that might develop on idle cropland.

Table 5.— Per capita consumption of selected food products (pounds per person) in 2000 and 2030 assumed for the Second RCA Appraisal.

Item	1982		2000		2030	
	retail wt.	carcass wt.	retail wt.	carcass wt.	retail wt.	carcass wt.
Beef	77	104	80	108	80	108
Veal	2	2	2	2	2	2
Pork	60	65	60	65	60	65
Lamb	2	3	2	3	2	3
Total red meat	141	174	144	178	144	178
Chicken[1]						
broilers	NA	49	NA	55	NA	55
mature chickens	NA	3	NA	3	NA	3
Turkey[1]	NA	11	NA	13	NA	15
Total poultry	NA	63	NA	71		73
Total red meat and poultry	NA	237	NA	249	NA	251
Dairy products[2]	540		520		510	
Eggs[3]	36		33		30	
Fish	13		18		27	

Source: Future Agricultural Technology and Resource Conservation, Iowa State University Press. 1984.

[1]*Ready-to-cook.*
[2]*Fresh milk equivalent.*
[3]*Pounds.*

Table 6.—Land areas in the United States by class of land.[1]

Class of land	Area (thousand acres)
Non-federal land:	
Crop[2] and pasture land[3]	529,851
Rangeland[4]	44,466
Transition land[5]	35,603
Forest land[6]	409,284
Other land[7]	159,776
Total, nonfederal	1,575,980
Federal land:	
Rangeland[4]	328,887
Forest land[6]	276,417
Other land[7]	73,504
Total, federal	687,808
Total land	2,254,788
All land:	
Crop[2] and pastureland[3]	529,851
Rangeland[4]	770,353
Transition land[5]	35,603
Forest land[6]	685,701
Other land[7]	233,280
Total land	2,254,788

[1]*Data as of 1982.*

[2]*Land use for the production of adapted crops for harvest, alone or in rotation with grasses and legumes. Adapted crops include new crops, small grain crops, hay crops, nursery crops, orchard and vineyard crops, and other similar specialty crops.*

[3]*Land used primarily for the production of adapted, introduced, or native forage plants for livestock grazing. Pastureland may consist of single species in a pure stand, grass mixture, or grass-legume mixture. Cultural treatment in the form of fertilization, weed control, reseeding, or renovation is usually a part of pasture management in addition to grazing management. Native pasture is included in pastureland in these land areas statistics.*

[4]*Land on which the climax vegetation (potential natural plant community) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing and browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundra, and certain forb and shrub communities. It also includes areas seeded to native or adapted introduced species that are managed like native vegetation.*

[5]*Land that meets the definition of forest land based on cover characteristics, but where the predominant vegetation is grass or forage plants that are used for grazing. The Soil Conservation Service has classified and reported most of the lands as rangeland; the Forest Service has classified and reported these lands as forest land. In most instances, these lands are noncommercial timberland ecosystems such as pinyon-juniper, chaparral, and post oak. Transition land is an interim category used in this report to classify part of the area in such ecosystems. Work is underway in the Forest Service and Soil Conservation Service to resolve classification differences and show all such land as rangeland or forest land in future reports. Some of the area in noncommercial timberland ecosystems is classified as forest and range land in this report.*

[6]*Land at least 10% stocked by forest trees of any size, or formerly having had such tree cover and non currently developed for nonforest use. The minimum area for classification of forest land is 1 acre and must be at least 100 feet wide. Forest land is distinguished from rangeland in transition vegetation types if the tree canopy cover exceeds 10%. Forest lands include cutover areas temporarily unstocked as well as young stands and plantations established for forestry purposes which do not yet have 10% crown cover.*

[7]*A category of land cover and land use that includes farmsteads, other land in farms, strip mines, quarries, gravel pits, borrow pits, permanent snow and ice, small built-up areas, and all other land that does not fit into any other land cover land use category.*

The 1989 RPA Assessment uses predictive instead of normative models such as CARD. For the 1989 RPA Assessment, projections were needed for the area of range and forest cover. The Assessment projections used as a starting point the data which were reconciled by the two Agencies for 1982. Projections of range area were then based on area trends in the NIRAP projections. The national range area data were disaggregated to regions as necessary in the 1989 RPA Assessment, based on expert judgment and the NIRAP projections of changes in land area (table 7). Forest land area is expected to decrease and other land area to increase through the projection period.

Agricultural Technology

In the Second Appraisal, projections were made to the year 2030. These projections required many assumptions about growth factors influencing the supply and demand of agricultural products. A major assumption is the rate of growth in agricultural production technology. Changes in efficiency of production inputs, crop yield, and animal product output are considered in the Appraisal and Assessment.

Changes in the rate of growth in technology can be expressed as "agricultural productivity" or "crop production technology" growth rates. The question in both cases is how much output can be produced from a given set of the resources. In the Second Appraisal, both agricultural productivity and crop and animal production growth rates were used. Agricultural productivity is the flow of outputs (quantity produced) relative to inputs (resources used), and generally includes labor, land, services, and capital. It is a composite percentage change in technology. An increase in agricultural productivity may result from an increase in outputs or a decrease in inputs. Agricultural productivity would increase if plant and animal yields remain constant and resources used to achieve a given output level decrease.

Crop and livestock annual growth rate in production technology is an individual animal or crop yield response to management, genetics, or other inputs, such as fertilizer rates, placement of fertilizer, feeds, pesticides, etc. It does not include land or labor and some other capital inputs. This technology change is expressed as a percent change in yield for an individual crop or animal. A production technology increase in output of a crop or animal can result from additional inputs or better efficiency (genetic improvement) from the inputs being applied.

After a review of available information, it was assumed that the composite agricultural productivity rate of increase would be 1.6% per year, based on current knowledge. The productivity of rangeland was assumed to increase 0.7% per year. These annual increases were assumed for the period, 1980-2030.

For the major food and fiber crops and animals, assumptions about the annual rate of growth in production technology were based on the results of a USDA symposium[1] held in December 1982. These assumptions are the estimates made by a team of experts for the 11 major crops, livestock, and poultry shown in tables 8 and 9. These estimates were used rather than the composite 1.6% where possible. The most probable estimates shown in table 8 were used in the Appraisal base scenarios.

Table 7.—Average of land area (million acres) by type, 1982, with projections to 2040.

Year	Forest	Range	Other	Total
1982	722	770	763	2,255
2000	717	806	729	2,252
2010	714	806	730	2,250
2020	709	807	732	2,248
2030	703	807	736	2,246
2040	696	807	741	2,244

Table 8.—Annual growth rates (percent) in production technology for selected crops by confidence of estimate, 1982-2000, 2001-2030, and 1982-2030.

Confidence estimate and time period	Crop					
	Feed-grains	Alfalfa	Wheat	Cotton	Rice	Soybean
Most probable						
1982-2000	1.89	1.02	2.28	1.01	3.30	2.65
2001-2030	1.20	0.75	0.96	0.96	0.75	1.07
1982-2030	1.46	.85	1.46	.98	1.93	1.66
High						
1982-2000	2.65	2.09	3.16	1.89	5.22	4.48
2001-2030	1.50	1.24	1.20	.65	.61	0.81
1982-2030	1.93	1.56	1.93	1.11	2.33	2.17
Optimistic						
1982-2000	3.93	2.65	3.93	3.93	6.29	5.22
2001-2030	1.36	1.50	1.36	1.36	.52	1.58
1982-2030	2.32	1.93	2.32	2.32	2.64	2.93
Low						
1982-2000	1.02	.53	1.25	0	2.28	1.47
2001-2030	.75	.43	.61	.61	.96	.7
1982-2030	.85	.47	.85	.38	1.47	.98

Feedgrains consist of barley, corn, corn silage, oats, sorgum, and sorgum silage.
Source: Future Agricultural Technology and Resource Conservation, Iowa State University Press, 1984.

Land Conversion Rates

The Federal and private land base can be used for many purposes and can be converted from one purpose to another. Generally, the land base is classified by use as forest, range, pasture, cropland, and urban, and other.

Table 9.—Annual growth rates (percent) in production technology by type of animal and unit, 1982-2000, 2001-2030, and 1982-2030.

Type of animal	Unit	1982-2000	2001-2030	1982-2030
Beef	Liveweight marketed per breeding female	1.2	1.0	1.0
Pork	Liveweight marketed per breeding female	1.6	0.7	1.0
Dairy	Milk marketed per breeding female	1.6	1.0	1.0
Sheep	Liveweight marketed per breeding female	1.6	1.0	1.1
Broiler Chickens	Liveweight marketed per breeding female	1.4	.2	0.6
Turkeys	Liveweight marketed per breeding female	1.8	0	.7
Laying hens	Number of eggs	1.0	.2	.5
Catfish	Age to one pound	2.2	3.1	2.3

Source: Future Agricultural Technology and Resource Conservation, Iowa State University Press, 1984.

For the purposes of the Appraisal, it was assumed that to the year 2030, agricultural and forest land would be converted to non-agricultural uses at the rate of 1.5 million acres per year. It was further assumed that of the 1.5 million acres, 63.8% would come from cropland, 17.5% from pasture, 13% from forest, and 5.7% from other sources.

Over time, it could reasonably be expected that land would shift from one use to another, depending on the relative economics of the various land uses. Assumptions were necessary to project these land use changes in the CARD model. Of primary importance was information on the potential for conversion of land to cropland. This information was taken from the 1982 NRI, in which land was classified as having low, medium, or high potential for conversion to cropland. These categories were distinguished from each other according to characteristics such as erosion potential. The following assumptions were especially important in projections of land conversion rates using the CARD model.

1. The data source for initial land area was the 1982 National Resources Inventory.
2. Only area in the contiguous 48 states was considered.
3. Only private lands were considered to be eligible for conversion.
4. Forest, pasture, and range lands with potential for croplands are the only major land uses included.
5. Within forest, pasture, and range lands with potential for croplands, only medium and high potential croplands could be converted.
6. There were four categories of potential cropland by producing area: medium potential forest, high potential forest, medium potential pasture/range, and high potential pasture/range.
7. Each acre of potential cropland that entered the model was a composite based on the distribution of potential cropland among the eight Appraisal land groups within each producing area.
8. A composite acre ratio was developed separately for lands with potential for forest and for lands with potential for pasture/range cropland by producing area.
9. Annual rates of conversion to cropland were developed separately for forest land and for pasture/range lands. These conversion rates were developed by CARD Market Region, and there was no distinction between medium and high potential lands.
10. The data used to calculate the rates of conversion were those relating to cropping history in the 1982 NRI.
11. The potential cropland conversion base for the CARD model was 143.2 million acres.

The annual conversion rates from one land use to another available for use in the Second Appraisal are shown in table 10 for the 31 Market Regions in the CARD model. Because of a surplus land situation, no potential land was converted to cropland in the final analysis using the CARD model. Instead, the model retired land through 2030.

In some Market Regions, the annual rates of land conversion discussed previously would result in conversion of large areas of land to cropland after several years into the projection period. Constraints were placed on total land conversion in the CARD model to limit this conversion. Total land conversion allowed between 1982 and 1990 was 80% of the land available and 100% by 2000 if the land would have been needed.

Table 10.—Annual rates of conversion (thousands of acres) from one land use to another and the net effect for the Major agricultural land uses by market regions.[1]

Market region	Pasture range land to cropland	Forest land to cropland	Pasture range land to forest land	Net cropland	Net pasture range land	Net forest land
1	3.50	2.93	2.03	6.43	-5.53	-0.90
2	19.10	-2.17	6.7	16.93	-25.8	8.87
3	48.63	42.37	-9.67	91.00	-38.96	-52.04
4	49.60	42.10	-34.30	91.70	-15.30	-76.40
5	49.80	3.93	-9.13	53.73	-40.67	-13.06
6	64.27	-2.7	-5.03	61.57	-59.24	-2.33
7	34.67	8.17	5.33	42.84	-40.00	-2.84
8	227.27	21.07	-22.43	248.34	-204.84	-43.50
9	112.13	37.30	-34.63	149.43	-77.50	-71.93
10	92.43	22.63	-8.23	15.06	-84.2	-30.86
11	36.83	4.30	-1.40	41.13	-35.43	-5.70
12	157.93	16.47	-9.0	174.4	-148.93	-25.47
13	82.57	27.77	-24.37	11.34	-58.2	-52.14
14	157.77	86.83	-37.57	243.60	-119.2	-124.40
15	278.17	16.10	-33.13	294.27	-245.04	-49.23
16	209.30	0.87	-5.10	210.17	-204.20	-5.97
17	126.97	0.23	-.23	127.20	126.74	-0.46
18	135.47	4.53	-22.53	140.00	-112.94	-27.06
19	80.00	0.70	-20.80	80.70	-59.20	-21.50
20	15.20	0	-3.73	15.20	-11.47	-3.73
28	1.23	0	-22.33	1.23	21.10	-22.33
29	49.73	-8.70	-12.07	41.03	-37.66	3.37
30	62.07	-24.97	-6.70	37.10	-55.37	18.27
31	56.60	7.13	4.47	63.73	-61.07	-2.66

Source: 1982 National Resources Inventory

[1]*Results based on cropping history from the 1982 National Resources Inventory.*

The maximum potential percentage conversion and associated acreages are shown in table 11.

Conversion for Pasture/Rangeland and Forest Land

Projections of areas converted from non-cropland to cropland uses depended in part on conversion costs. Conversion costs used in the 1980 Appraisal were updated and used in the Second Appraisal (table 12). These data were developed on aggregations of Major Land Resource Areas (MLRA's) and then were adjusted to the 10 USDA crop production regions.

Public Grazing Resources

Roughage available on rangeland provides a major source of feed for grazing livestock. In the CARD model, the amount of roughage by area determined the location of the livestock-range industry. The volume of roughage produced on public lands in 1982 was estimated to total about 6.7 million tons. For the purposes of the Second Appraisal, it was assumed that this volume of roughage would be available annually throughout the projection period.

Interest Rates

Two types of interest rates are needed for some analyses done with the CARD model. An interest rate is needed to discount projected costs and returns for long-term investments, such as conservation structures. A short-term interest rate is also needed for analysis of the annual cost of production, such as when farmers borrow money for planting crops. A real interest rate of 4% was used in analysis of long-term investments. This is the same interest rate used by the Forest Service in evaluating long-term investments. The rationale for the 4% rate is discussed in Row et al. (1981). It is especially important that the two Agencies use the same long-term interest rate in evaluating the competition between forests and crops for the same land. A review of interest rates in 1985 and consideration of historical links between long-term and short-term rates were the basis for an assumption of 6.9% for the short-term real interest rate to be used in the CARD model.

Table 11.—Maximum conversion to cropland rate[1] from potential pasture/range land and for potential forest land by market region, percent, and acres, for the years 1990, 2000, and 2030.

Market	Pasture/range land conversion rate						Forest land conversion rate					
	1990	2000	2030	1990	2000	2030	1990	2000	2030	1990	2000	2030
	percent			*1,000 acres*			*percent*			*1,000 acres*		
1	8.6	19.3	100.0	56	126	653	4.1	9.2	100.0	47	105	1,147
2	15.3	34.3	100.0	306	688	2,004	-2.3	-5.1	100.0	-35	-78	1,531
3	50.5	100.0	100.0	778	1,542	1,542	10.1	22.8	100.0	678	1,525	6,685
4	28.4	63.8	100.0	794	1,786	2,798	14.4	32.4	100.0	674	1,516	4,675
5	26.9	60.6	100.0	797	1,793	2,961	6.4	14.4	100.0	63	141	984
6	38.6	87.0	100.0	1,028	2,314	2,661	-2.0	100.0	100.0	-43	-97	2,108
7	42.7	96.0	100.0	555	1,248	1,300	7.9	17.8	100.0	131	294	1,648
8	80.0	100.0	100.0	3,459	4,324	4,324	18.9	42.6	100.0	337	759	1,780
9	45.9	100.0	100.0	1,794	3,911	3,911	12.2	27.5	100.0	597	1,343	4,890
10	52.3	100.0	100.0	1,479	2,826	2,826	15.4	34.6	100.0	362	815	2,352
11	49.5	100.0	100.0	589	1,192	1,192	5.5	12.3	100.0	69	155	1,262
12	80.0	100.0	100.0	2,114	2,642	2,642	45.1	100.0	100.0	264	585	585
13	50.1	100.0	100.0	1,321	2,638	2,638	28.9	65.0	100.0	444	1,000	1,537
14	52.5	100.0	100.0	2,508	4,777	4,777	30.5	68.7	100.0	1,389	3,126	4,548
15	56.0	100.0	100.0	4,451	7,955	7,955	31.4	70.6	100.0	258	580	821
16	39.4	88.6	100.0	3,349	7,535	8,504	57.0	100.0	100.0	14	24	24
17	36.2	81.4	100.0	2,032	4,571	5,614	9.7	21.9	100.0	4	8	38
18	18.0	40.6	100.0	2,168	4,877	12,012	9.8	22.1	100.0	72	163	737
19	19.8	44.6	100.0	1,280	2,880	6,464	5.5	12.3	100.0	11	25	220
20	11.9	26.9	100.0	895	2,013	7,494	0	0	100.0	0	0	0
21	41.0	92.2	100.0	1,400	3,151	3,416	0	0	0	0	0	0
22	74.4	100.0	100.0	2,772	3,724	3,724	80.0	100.0	100.0	4	5	5
23	20.0	45.0	100.0	639	1,437	3,197	-70.7	-100.0	100.0	-8	-12	12
24	17.0	38.2	100.0	69	155	406	-80	-100.0	100.0	-4	-5	5
25	30.7	69.0	100.0	547	1,230	1,783	12.9	29.0	100.0	19	43	149
26	55.2	100.0	100.0	589	1,067	1,067	8.1	18.3	100.0	8	17	92
27	46.5	100.0	100.0	243	523	523	0	0	100.0	0	0	1
28	2.1	4.7	100.0	20	44	934	0	0	100.0	0	0	1
29	35.9	80.9	100.0	796	1,790	2,214	-8.9	-20.1	100.0	-139	-313	1,556
30	80.0	100.0	100.0	950	1,187	1,187	-80.0	-100.0	100.0	-71	-89	89
31	80.0	100.0	100.0	768	960	960	80.0	100.0	100.0	17	21	21
Total	—	—	—	40,542	76,905	103,678	—	—	—	5,159	11,655	39,493

[1] *The conversion rate used was two times the annual rate from the 1982 National Resources Inventory not to exceed 10% per year. Therefore, the maximum change for a Market Region in 1990 would be 80%.*

Note: Potential land available (1,000 acres): Year 1990, 45,701.9; Year 2000, 85,559.9; Year 2030, 143,171.0

Other Assumptions

In addition to the assumptions outlined above, the projections of demands and supplies for the products included in the Forest Service Assessment and Soil Conservation Service Appraisal rest on a variety of other specified and implied assumptions. These are addressed in the appropriate places of the Assessment and Appraisal documents.

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Table 12.—Conversion costs (dollars per acre) for non-cropland to cropland cost by region.

Region[1]	Pasture/range land		Forest land	
	Total cost	Annual cost	Total cost	Annual cost
1	64	4.690	223	16.379
2	127	9.345	223	16.379
3	127	9.345	458	33.694
4	165	12.167	458	33.694
5	165	12.167	458	33.694
6	89	6.552	331	24.334
7	89	6.552	331	24.334
8	127	9.345	458	33.694
9	51	3.744	331	24.334
10	51	3.744	229	16.847

Source: Economics Staff, SCS, 1980 RCA.

[1] *The 10 regions are developed along Producing Area boundaries.*

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