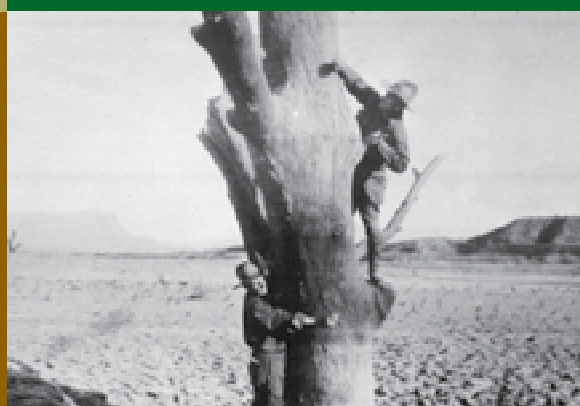
United States
Department
of Agriculture

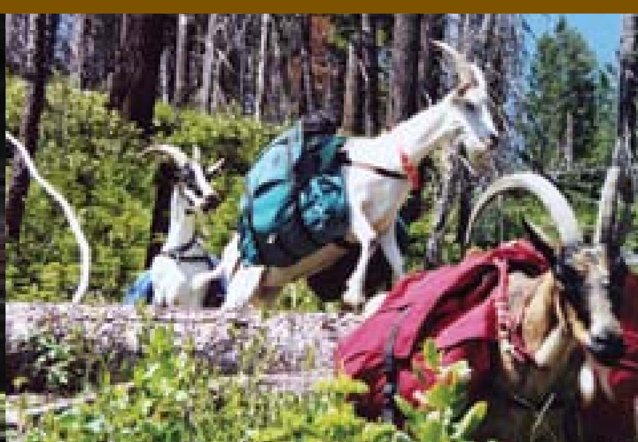
Forest Service

FS-877

June 2007

A History of the Forest Survey in the United States: 1830–2004





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A History of the Forest Survey in the United States: 1830–2004

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Front cover photos: Top two photos: unknown subjects, places, and times. Bottom left: goats used to carry forest survey gear in Idaho Wilderness (date unknown). Bottom right: Leanne Egland and crew partner measuring a Minnesota plot in 1977.

Back cover photos: Far left: Training Mexican foresters in the Southern Station in the early 1990s. Middle: Project leaders meet in Mississippi and cypress swamp, circa 1989; pictured left to right: Jim Bones, Jim LaBau, Clyde Fasick, Hans Schreuder, Roy Beltz, Dwane Van Hooser, John Peters, Bert Essex, and John Poppino. Far right: Joe McClure, project leader for Southeast Forest Survey, with the McClure caliper.

Abstract

This publication presents a history of the Forest Survey (now known as Forest Inventory and Analysis) program in the United States as it evolved within the U.S. Department of Agriculture (USDA) Forest Service over a period of more than 100 years. It draws on the writings of several authors who have published on various aspects of the Forest Survey program. A review is presented of nine ground plot designs used in the Forest Survey and Forest Inventory and Analysis (FIA) programs since 1931. This publication also highlights the major events contributing to the current FIA program, beginning as far back as 1830.

It is impressive to look at the many contributions of various people working with the Nation's Forest Survey program, as well as the various methodologies that have contributed to understanding and updating the national forest survey statistics.

It is especially timely that this historical report should occur at the time the Forest Service just celebrated the anniversary of its 100 years of service to the American people.

A History of the Forest Survey in the United States: 1830–2004 is available on the Web at http://www.fs.fed.us/institute/History_ForestSurvey_06_0306pw.pdf.

Thanks to Thomas Hoekstra and the Inventory and Monitoring Institute without whose vision and commitment to inventory and monitoring and to the Forest Service this publication would not have been possible.

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In remembrance of Jim Bones, whose contributions to Forest Survey and this paper were truly significant.

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Acknowledgments

Many people provided support for and input to this paper. The list reads a bit like the "Who's Who" of forest inventory. Those contributors are listed in alphabetic order by regions of the country.

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Jim has more than 80 published papers and reports on resource inventory and assessment. He received a B.S. degree from Colorado State University in 1957 and an M.S. degree from Oregon State University in 1966. He is a member of Xi Sigma Pi and a Fellow of the Society of American Foresters.

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James T. Bones (deceased) worked for the Forest Service for 40 years, primarily in various aspects of forest inventory. During that time, he worked at the Pacific Northwest Research Station (Portland, OR), the Institute of Northern Forestry (Juneau, AK), the Northeastern Forest Experiment Station (Upper Darby, PA), and with the Washington Office. In Washington, DC, he worked in the Forest Inventory and Analysis (FIA) section of the Forest Service's Research Division. He also spent part of his career researching timber removals.

Jim received his B.S. degree in soil conservation from Utah State University in 1952 and an M.S. degree in forest management from the same university in 1956. He then did postgraduate work at Pennsylvania State University in 1978. Bones served as a United Nations forestry advisor for the government of Colombia in South America for several years. He was also active on the international scene in boreal forestry, particularly through the International Boreal Forest Research Association. He served on the Canadian Forest Inventory Committee and, over the years, was instrumental in providing North America forest inventory data to the United Nations Food and Agriculture Organization in Rome. He was an inspector for the American Tree Farm System. During his career, Jim published more than 100 papers and reports on resource inventory and assessment.

Jim Bones died September 5, 2004, after contributing to this paper for more than 2 years.

Neal P. Kingsley

Neal P. Kingsley worked for the Forest Service for more than 35 years, primarily in the field of forest resource inventories and analysis. He first served for 20 years as a resource analyst at the Northeastern Forest Experiment Station (Broomall, PA), then for 5 years as project leader of the Management and Utilization Alternatives for Private Non-industrial Private Forests project (Delaware, OH). He then served as program manager of the FIA program of the North Central Forest Experiment Station (St. Paul, MN). Neal's particular area of interest is nonindustrial private forest ownership. In the early 1970s, he initiated and developed mail canvasses of nonindustrial private owners to understand their intentions and motivations. These canvasses have since evolved into a national program.

Neal has authored more than 85 papers and reports and given more than 30 presentations dealing with resource inventories, timber removals, and landowner attitudes and intentions. He received his B.S. degree in forest management from the University of New Hampshire in 1961 and his M.S. degree in forest economics from the same university in 1963. He has been a member of the Society of American Foresters since 1958 and currently serves on the board of directors of the Minnesota Forestry Association. Neal and his wife, Gretchen, live in White Bear Lake, MN.

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Gyde has published nearly 200 papers and reports on resource inventory and assessment. He holds forestry degrees from Utah State University and the University of Washington. He is a fellow of the Society of American Foresters and a member of the International Society of Tropical Foresters and the Global Association of Online Foresters.

Gyde currently runs the small international consulting firm Forest Information Services, which specializes in networking, Web and library searches, literature synthesis, report writing, and technical support in resource inventories and assessments. He also publishes the free weekly e-mail newsletter, *Forest Information Update*, which reaches more than 7,000 natural resource specialists worldwide. Gyde resides in Gainesville, VA, with his wife, Dora.

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W. Brad Smith is currently associate national program manager for FIA Forest Service Research and Development in Washington, DC, providing budget and policy guidance for the national FIA program. Brad received a B.S. degree in forestry from Purdue University in 1975 and an M.S. degree in forest management from the same university in 1977. He is member of Xi Sigma Pi and the Society of American Foresters.

Brad, who has been with FIA for 28 years, spent 15 years at the North Central Forest Experiment Station (St. Paul, MN) developing forest growth models and serving as timber products analysis group leader. He has published 125 papers and reports on resource inventory and assessment.

Brad currently serves as the national database coordinator for FIA; Montreal Process inventory specialist for the United States; national correspondent for the United States to the United Nations, Food and Agriculture Organization, Global Forest Resource Assessments and the United Nations, Economic Commission for Europe International Team of Specialists on forest inventory; North American Forestry Commission Inventory

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Acronyms

3-P	Probability proportional to prediction
AAAS	American Association for the Advancement of Science
AFIS	Annual Forest Inventory System
AFPA	American Forest and Paper Association
ATLAS	Aggregated Timberland Assessment System
AVHRR	advanced very high resolution radiometer
BRP	Blue Ribbon Panel
CFIC	Canadian Forest Inventory Committee
COBOL	Common Business Oriented Language
d.b.h.	diameter at breast height
EPA	Environmental Protection Agency
EROS	Earth Resources Observation Systems
FAO	Food and Agriculture Organization of the United Nations
FHM	Forest Health Monitoring
FIA	Forest Inventory and Analysis
FIADB	Forest Inventory and Analysis Database
FINSYS	Forest Inventory Analysis System
FIR	Forest Information Retrieval
FORTRAN	Formula Translation
FPL	Forest Products Laboratory
FREP	Forest Resources Evaluation Program
HV	horizontal-vertical
IBM	International Business Machines
NAPAP	National Acid Precipitation Assessment Program
NC	north-central (region)
NE-FIA	Northeastern FIA (program)
NIMS	National Information Management System
PI	photo interpreted
PPA	probability proportional to plot area
PPS	probability proportional to tree size
RET	Resources Evaluations Technique
ROS	Recreation Opportunity Spectrum
RPA	Resources Planning Act
SAFIS	Southern Annualized Forest Inventory System
SPR	sampling with partial replacement
TPO	timber products output

TRAS	Timber Resource Analysis System
UNCED	United Nations Committee on Economic Development
UNDP	United Nations Development Projects
UNECE	United Nations Economic Commission for Europe
UNIVAC	Universal Automatic Computer
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

Metric Equivalents

1 inch = 2.54 centimeters

1 foot = 0.3048 meters

1 mile = 1.609 kilometers

1 acre = 0.4047 hectares

1 chain = 66 feet = 20.1 meters

1 board foot = 1/424 m^3

Introduction

The history of the Forest Survey program in the United States, as it evolved within the U.S. Department of Agriculture (USDA) Forest Service over a period of more than 100 years, is an interesting story. We have drawn on the writings of several authors who have published on various aspects of the Forest Survey program.

This paper is designed for those readers who wish to understand the evolution and contribution of the Forest Survey program in U.S. forestry. Considerable attention is given to describing the different plot designs that were used and in explaining how the focus and goals of the Forest Survey program changed over time. The Forest Survey program has always been faced with a variety of often conflicting objectives—timber volumes, reproduction success, species composition, tree quality, etc. Statistical efficiency for one objective often compromised the estimate of other attributes. Many difficulties were faced in estimating growth, mortality, removals, forest type, condition class, and many other multiresource variables that the inventory estimated. The early forest surveys were mostly exploratory in nature and evolved into increased emphasis on change, condition, quality, and other descriptive characteristics. The changes in design over time attempted to meet the emerging objectives and challenges.

Because of the vision and fortitude of the leaders of the Forest Survey program, a concept that began as an effort to monitor the Nation's timber supply and consumption has expanded to a multiresource and multifunctional program.

Previous History Papers

Several people have written papers and articles summarizing the history of Forest Survey. One of the more interesting summaries is an in-service paper by Crafts (1948), Chief of the Division of Forest Economics in the Washington Office. This paper, "Pertinent Facts about the Forest Survey," provides estimates of forest land inventoried by forest surveys between 1945 and 1948. It also provides several testimonials to the value of forest survey data to the "users" of that time, as well as budget information. A short paper by Chase (1964) of the Lake States Forest Experiment Station also gives a good overview of the forest survey in the Lake States in its early years. In 1975, in celebration of the Pacific Northwest Research Station's 50th anniversary, the station commissioned Doig (1977) to write a history of the station. This paper highlights the start of the Forest Survey program in the Pacific Northwest Region beginning in the Douglas-fir region in the early 1930s with the fieldwork completed in 1935 and a publication of results in 1936. This work by Doig includes several interesting anecdotes about the early years of the Forest Survey program in the Pacific Northwest.

Lund (1984) provides an overview of forest and rangeland inventory experiences. A publication by Hazard and Law (1989) gives a good overview of the Forest Survey program focus and procedures in the early 1980s. This paper also presents a summary of the various attributes measured or estimated by the different Forest Survey units and presents a very good bibliography of papers published by the scientists. A paper by Van Hooser and others (1992) presented at the 100th anniversary of the International Union of Forestry Research Organizations summarizes the history of forest inventories in the United States to that date.

Gregoire (1993) presents an overview of sampling designs used in the early days of forest inventories, with much of the focus given to how forest sampling methods developed in the early years are evolving into some of the methods used in the late 20th century. A paper in the *Journal of Forestry* by Powell and others (1994) references trends in implementing multiresource inventories as part of the national focus. Cost (1996) presented a paper on the history and future of the Forest Inventory and Analysis (FIA) program. Geier (1998) provides a good overview of the history of the Forest Survey program in Alaska. Frayer and Furnival (1999, 2000) give an overview of various sampling techniques used in forest survey since its inception, focusing on some of the newer sampling methods of the late 20th century. Finally, a short in-service paper by Bolsinger (2002) presents a history of FIA with a west coast perspective.

Background

The concern for forest resources existed early in U.S. history. The first record of a statewide forest inventory was in **1830** in Massachusetts (Cameron 1928). From the mid-1800s through the early 1900s, timber harvesting in the northeastern and north central regions removed massive amounts of the Nation's wood resources. Shortly after the end of the Civil War, a potential shortage of forest supplies raised concerns. In **1874**, the House of Representatives recommended that the U.S. Department of the Interior create a Commissionership of Forestry to compile forest statistics and make certain investigations. The bill made no progress, however, nor did a similar bill introduced in the following Congress. Eventually, Congress attached the following rider to the free-seed clause of the legislative, executive, and judicial appropriation act of August 15, 1876 (19 Stat. L., 143, 1[57]):

1830—The first statewide forest inventory is conducted.

1874—The U.S. Department of the Interior establishes the Commissionership of Forestry.

> For purchase and distribution of new and valuable seeds and plants, sixty thousand dollars: *Provided,* that two thousand dollars of the above amount shall be expended by the Commissioner of Agriculture as compensation to some man of approved attainments, who is practically well acquainted with methods of statistical inquiry, and who has evinced an intimate acquaintance with questions relating to the national wants in regard to timber to prosecute investigations and inquiries, with the view of ascertaining the annual amount of consumption, importation, and exportation of timber and other forest products, the probable supply for future wants, the means best adapted to their preservation and renewal, the influence of forests upon climate, and the measures that have been successfully applied in foreign countries, or that may be deemed applicable in this country, for the preservation and restoration or planting of forests; and to report upon the same to the Commissioner of Agriculture to be made by him in a separate report transmitted to Congress (Smith 1930:7).

In the early 1870s, Dr. Franklin B. Hough made a presentation that spoke to this concern, as noted in Smith (1971: 693-694):

> After Hough read this speech before the American Association for the Advancement of Science (AAAS), the following day a resolution was passed to memorialize (petition) Congress on the necessity of the Federal government to fund a Federal agent to report to Congress on the state of the nation's forests. The AAAS appointed a nine-member committee, which was headed by Hough. Hough and his friend George B. Emerson roughed out the petition and by February of 1874, they arrived in Washington to gather additional support and personally discuss the memorial with President Ulysses S. Grant, who in turn sent it to Congress. In part, the memorial discussed forest preservation and

growth to be of “great practical importance” to the nation, and that timber shortages were inevitable in the near future, and that Congress should pass a law to create “a commission of forestry,” appointed by the president and the Senate to study and report on the state of the nation’s forests. More than two years later, on August 15, 1876, Congress appropriated $2,000 which was to be used to “appoint a man of approved attainments” to study and report on forest supplies, harvesting, imports and exports, uses, and growing conditions, as well as conditions in other countries. Hough was appointed as the first federal forestry agent. He was assigned to the Commissioner of Agriculture. Within a year, he compiled a 650-page book titled Report upon Forestry **1877**. Congress was so impressed with this massive work that 25,000 copies were ordered printed in 1878. In 1878, officers at various Army posts were requested by Hough to fill out questionnaires regarding local forest conditions. Hough remained at this work until 1883 (producing two more reports), when he was replaced by Nathaniel H. Egleston.

1877—The USDA (Hough) publishes a report of forest conditions.

1879—The USGS gathers forest data.

From its beginning in **1879**, the U.S. Department of the Interior, U.S. Geological Survey (USGS) gathered forest data (Smith 1930). The USGS mapped forests, including Alaska, in the late 1880s and early 1900s as part of setting aside forest reserves.

1886—Egleston publishes “Facts and Figures in Respect to the Forests of the Country and Their Consumption.”

Egleston (**1886**) provided one of the earliest reports on the national forests in “Facts and Figures in Respect to the Forests of the Country and Their Consumption,” in the *Proceedings of the American Forestry Congress of 1885* in Boston. In 1897, Congress enacted the Organic Act, setting the stage for a new paradigm for managing national lands.

1909—The USDA publishes “The Timber Supply of the United States.”

In 1905, the Forest Service was formed with Gifford Pinchot as the first chief. In the first decade of the century, Kellogg (**1909**) prepared one of the earliest Forest Service reports on the timber situation of the United States (Zon 1910). By 1920, significant removals were being made from the forests of the Southeastern and Pacific Northwest States. Congress was concerned that the United States might be running out of wood resources to supply the future construction and pulp needs of the country. Doig (1976) notes the 32-percent discrepancy between national timber estimates made in 1909 (estimated 400 billion board feet in Circular 97), and 1910 (estimated 530 billion board feet in Circular 166). Although the 130-billion-board-feet difference in the reports was primarily due to the inclusion of Pinion-juniper in the 1910 summary, the need for a science-based national timber inventory system was evident.

In **1919**, Henry S. Graves, the Chief of the Forest Service, requested that:

1919—Chief Graves requests funds for surveying U.S. forest resources.

> "…funds should be provided whereby the Federal Government in cooperation with State and private interests may make a survey of forest resources of the country. This would determine the quantities of timber suitable for different industrial uses, the current consumption of forest products, the probable requirements of the different regions for material, the possible production of the forests by growth to meet these requirements, and other matters which will aid in developing and carrying out the national forest policy" (Graves 1919: 10)

In 1923, Zon and Sparhawk published a two-volume book, *Forest Resources of the World* (1923), which included an introduction by Gifford Pinchot. It brought together statistical summaries of forest resources for all nations. Volume II, Chapter 4, focused on "The Forest Situation in Northern North America," including Canada, Alaska, and the lower 48 States.

About this same time, Kellogg (1923) put forth an appeal for a national forest inventory. In addition, in an action that may have led to passage of the McSweeney-McNary Act, Clapp (1926) put forth a strong appeal for a national forest survey.

In **1928**, Congress passed the McSweeney-McNary Act, ordering the USDA to conduct periodic inventories of the Federal, State, and private forest lands and to report the results to Congress each decade. The language of that act instructed the Department:

1928—The McSweeney-McNary Act establishes Forest Survey.

> "to make and keep current a comprehensive survey of the present and prospective requirements for timber and other forest products, and of timber supplies, including a determination of the present and potential productivity of forest land therein, and of such other facts as may be necessary in the determination of ways and means to balance the timber budget of the United States."

The Secretary of Agriculture assigned this task to the Forest Service. Based on Section 9 of the Act, the ensuing program called the "Forest Survey" was often referred to as the "Timber Survey" because of the initial orientation to timber assessment. The first appointed head of Forest Survey was G.M. Granger with the title of Head Economist (Stuart 1930).

Two important reports on the status of timber supplies emerged in 1920 and 1932. The *Capper Report* by the Forest Service (U.S. Senate 1920) focused on timber depletion, lumber prices, exports, and ownership. This report provided overviews of the timber supplies of major regions of the country. A second Forest Service report (USDA 1932) focused on the forest situation in the United States and provided the format for later national summaries. Both of these reports provided basic type maps for the Nation, excluding Alaska. The *Copeland Report* followed as a lengthy report to the Senate (U.S.

1933—USDA publishes *Copeland Report*: "A National Plan for American Forestry."

Senate **1933**). These early reports were not based on data collected from a systematic forest inventory.

Smith (1930: 94) describes the Forest Survey program as:

> "one of the most important and complex projects ever undertaken by the Forest Service…. This is a nationwide, comprehensive determination of forest resources; of present and potential growth; of the drain upon the forests not only by cutting but through fire, disease, and insects; and of the present and future needs of the country for forest products."

Most of the early forest survey work was done on a cooperative basis. Some surveys were conducted independently, while others were done with State and private cooperation. Statistical work was performed in cooperation with the U.S. Census Bureau and involved many public and private agencies (Smith 1930). Eventually, the Forest Service adopted criteria for statistical reliability and required that all reports contain tables or statements of sampling error.

Responsibility for Forest Survey

The Department of Agriculture assigned the Forest Survey program to the Research division of the Forest Service. Each of the major regional experiment stations performed inventories of the forest resources within its region. Forest Survey units were initially located in the Northeastern; Central States; Lake States; Southeastern; Southern; Intermountain, including Rocky Mountain Station ; and the Pacific Northwest Experiment Stations. Over the years, several units merged. The Pacific Southwest Station had a Forest Survey unit covering California and Hawaii for 38 years. Eventually, the Pacific Northwest unit in Portland, OR, assumed all forest survey responsibilities for the west coast. In 1966, the Lake States and Central States units merged and became the North Central unit. The Alaska unit, initially established as the Alaska Forest Research Center, merged with the Pacific Northwest unit. In 1997, the Southern Station unit merged with the Southeastern Station unit and the Intermountain Station unit merged with the Rocky Mountain Forest and Range Experiment Station.

The earliest focus of Forest Survey was simply to estimate timber land area and volume of wood. Soon, Forest Survey recognized the need to collect growth and mortality data. Later, the need became apparent for collecting sawlog and pulpwood harvest data, as well as product utilization and wood industry data. Finally, in the late part of the 20th century, Forest Survey, by then called Forest Inventory and Analysis (FIA), began to focus on making long-term timber supply projections, collecting multiresource data, conducting ownership studies, measuring nontimber attributes, and, eventually, focusing on a biomass analysis. In 1999, FIA assumed responsibility for the plot component of the Forest Service's national Forest Health Monitoring (FHM) program. Table 1 shows a timeline of major Forest Survey history and developments.

Table 1.—*Timeline of major forest survey history and related developments.*

Date(s)	Development
1830	First statewide forest inventory in Massachusetts
1874	U.S. Department of the Interior Commissionership of Forestry established to compile forest statistics
1877	U.S. Department of Agriculture (USDA) (Hough) publishes reports of forest conditions
1879	U.S. Geological Survey (USGS) gathers forest data
1886	Egleston publishes "Facts and Figures in Respect to the Forests of the Country and Their Consumption"
1897	USGS charged with mapping forests
1897	Congress passes Organic Act
1903	Gifford Pinchot develops a strip sampling method
1905	Forest Service established
1907–09	USDA estimates total U.S. timber inventory at 400 billion board feet
1909	USDA publishes "The Timber Supply of the United States" (Kellogg 1909)
1910	USDA estimates total U.S. timber inventory at 530 billion board feet
1910	Zon publishes USDA bulletin *Forest Resources of the World*
1912	Forest Service Chief Graves sets down principles and guidelines for timber surveys
1919	Chief Graves requests funds for surveying U.S. forest resources
1923	Zon and Sparhawk publish *Forest Resources of the World*
1928	McSweeney-McNary Forest Research Act establishes Forest Survey program in USDA
1930	Lake States Forest Experiment Station receives Forest Survey funds
1930	Forest Service begins forest survey in Pacific Northwest's Douglas-fir region
1931	USDA publishes "Status of the Inventory Phase of the Forest Survey of the Douglas-fir Region"
1931	Central States Experiment Station starts doing forest surveys
1932	Forest Service begins forest surveys in the Southern States in Mississippi
1932	USDA publishes "The Forest Situation in the U.S."
1932	Cowlin publishes "Areas of Types in Oregon and Washington Counties"
1932	Lentz publishes "Forest Survey of the Mississippi Delta"
1933	USDA publishes *Copeland Report*: "A National Plan for American Forestry"
1938	Forest Service completes forest survey fieldwork and reports for Michigan, Minnesota, and Wisconsin
1941–45	Forest Survey program on hold during World War II
1946	Forest Service incorporates use of aerial photographs and fixed area plots within forest survey techniques
1946	Central States Experiment Station begins second forest survey
1946	Forest Service begins forest survey in Missouri
1947	Stott publishes "Continuous Forest Inventory"

Table 1.—*Timeline of major forest survey history and related developments (continued).*

Date(s)	Development
1948	Crafts publishes estimates of forest lands inventoried by Forest Survey between 1945 and 1948
1948	Bitterlich publishes on angle gauge cruising
1948–49	Forest Service completes forest survey in Kentucky and Illinois
1952	Grosenbaugh publishes article on plotless cruising in *Journal of Forestry*
1952	Spurr publishes his book *Forest Inventory*
1953	Forest Service begins forest surveys in southeast Alaska
ca 1955	Forest Service begins forest surveys in Intermountain and Rocky Mountain States
1955	Bruce publishes *Prism Cruising*
ca 1956	Moessner develops photointerpretation training kit for Forest Survey
1958	USDA publishes *Timber Resource Review*, the first national report
1958	Forest Survey program begins evaluations of plotless cruising (10-point sample)
ca 1960	National Forest System begins management inventories to fit into national assessments
1960s	Jim Bones, Dave Born, and Colin McLean assist with international efforts
1960	Forest Service begins timber surveys begin in interior Alaska
1962	Bickford publishes *Two-phase Sampling*
1962	Ware and Cunia publish *Sampling with Partial Replacement*
1963	Bickford, Mayer, and Ware publish on the Northeastern Forest Survey, combining double sampling and sampling with partial replacement
1964	Young publishes on forest biomass
1965	USDA publishes “Timber Trends for the United States,” the second national report
1967	USDA publishes *Forest Survey Handbook* (4809.11) implementing 10-point sampling, core tables, and definitions
1968	Frayer, Wilson, Peters, and Bickford publish on FINSYS-1
1970s	Frayer conducts forest inventory training workshops at Colorado State University
1971	Grosenbaugh publishes on 3-P cruising
1973	USDA publishes “Outlook for Timber in the United States,” the third national report
1974	Congress passes Forest and Rangeland Resources Planning Act of 1974 (RPA)
1974	Larson and Goforth publish “TRAS: A Timber Volume Projection Model”
1975	Kingsley completes land ownership canvas in New Jersey
1975	Langley publishes on use of satellite imagery in forest sampling
1975–80	Forest Service establishes Resource Evaluation Techniques Program at Fort Collins, CO
1976	Congress passes Federal Land and Policy Management Act
1976	Congress passes National Forest Management Act of 1976
1977	Congress passes Soil and Water Conservation Act
1977	Forest Service updates national Forest Inventory and Analysis (FIA) statistics
1978	Cooperative Forestry Assistance Act adds to Forest Survey role
1978	Congress passes Forest and Rangeland Renewable Resources Research Act
1978	Barnard publishes on FINSYS-2 data processing system
1979	Hahn publishes on the Forest Resources Evaluation Program (stand growth projection system)
1979	McClure and others publish on multiresource inventories

Table 1.—*Timeline of major forest survey history and related developments (continued).*

Date(s)	Development
1979	Cost publishes on horizontal-vertical vegetation sampling
1979	Brooks publishes on wildlife habitat
1980–95	Lund and others coordinate forest inventory workshops around the world
1980s	Forest Service tests satellite imagery for inventory applications in Alaska and Southern States
1981	Forest Service uses first portable data recorders in the South
1982	USDA publishes “An Analysis of the Timber Situation in the United States”
1983	Born and Barnard publish on Table/Output FINSYS-2
1985–95	Forest Survey remote sensing specialists prepare forest type maps for United States, Canada, and Mexico using Landsat imagery
1987	USDA updates national FIA statistics
1988	Forest Service publishes South’s Fourth Forest Study
1989	Forest Service initiates Forest Health Monitoring (FHM) program
1990	USDA publishes “Forest Biomass Resource of the United States”
1990	USDA publishes “An Analysis of the Timber Situation in the United States: 1989–2040”
1990s	Several FIA people assist with International Inventory and Monitoring
1991	Rudis publishes on inventorying wildlife habitat
1992	Brooks publishes on FHM program
1992	Forest Service updates national forest inventory statistics
1992	Forest Service develops national FIA database
1992	American Forest Council calls for the Blue Ribbon Panel
1992	The United Nations Conference on the Environment (UNCED) sponsors the Rio de Janerio United Nations Conference on the Environment and Development
1992	The American Forest and Paper Association (AFPA) publishes first USDA Blue Ribbon report
1993	UNCED sponsors the Fourth Montreal Protocol on conservation and sustainable management of forests
1995	Forest Service makes FIA data available on the Internet
1995	FIA begins using FHM plot design (4-point plot adopted)
1997	Forest Service updates national FIA statistics
1998	Congress passes Agriculture Research, Extension, and Education Reform Act (Farm Bill)
1998	AFPA publishes second USDA Blue Ribbon report
1999	Forest Service implements new national strategic plan (required by the Farm Bill) and initiates annual inventory
1999	Forest Service implements Annual Forest Inventory System (AFIS) and Southern Annual Forest Inventory System (SAFIS)
2000	United Nations Economic Commission for Europe publishes on temporal and boreal forest assessment
2001	USDA publishes on the national FIA database
2001	United Nations Food and Agriculture Organization publishes “Global Forest Resource Assessment”
2001	USDA publishes “U.S. Forest Facts and Trends”
2002	Forest Service updates national FIA statistics

Table 1.—*Timeline of major forest survey history and related developments (continued).*

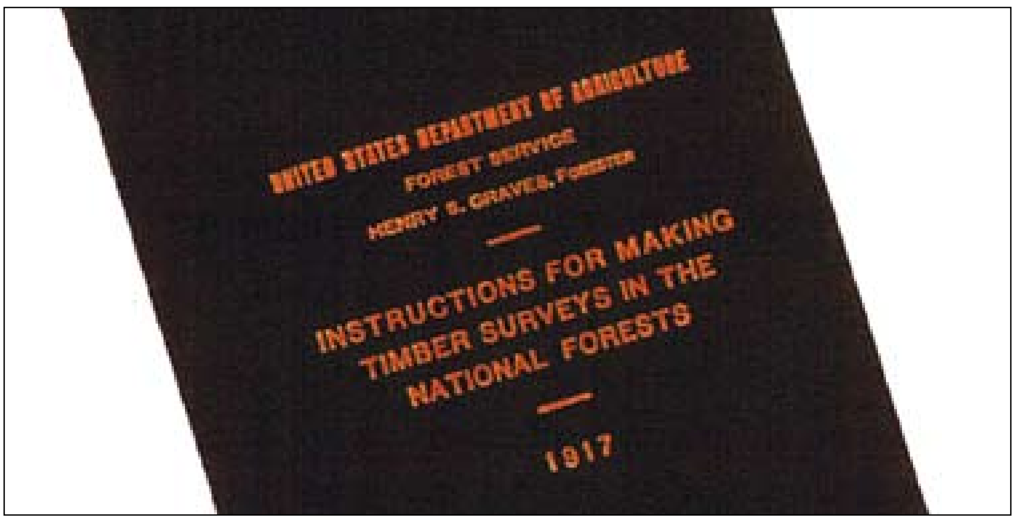
Date(s)	Development
2003	USDA publishes “National Report on Sustainable Forests”
2003	USDA publishes “Projections for the 2000 Timber Assessment”
2003	USDA publishes the *Revised Forest Survey Handbook*
2003	Harrington publishes summary of 1930 Forest Survey reports by Cowlin

ca = circa.

Evolution of Forest Survey Techniques

In the early 1930s, after the implementation of the Forest Survey program, regional reports based on systematic inventories began to be published (Cowlin 1932,Lentz 1932). Previously, the Forest Service used sampling techniques that were labor intensive and less efficient. Forest inventory methods go back to the days of Gifford Pinchot, who developed a strip-sampling method (1-chain wide and 10-chains long) for the U.S. Bureau of Forestry (Graves 1903). The plots were small squares. The crews consisted of three people, a tallyman, and two measurers. Graves (1912, 1917) set down principles and guidelines for timber surveys and included a standard classification for forest types (see photo 1). He recommended one-chain wide strips as an alternative to complete enumeration. He suggested measuring diameter at breast height (d.b.h.) and height to a given top diameter. He also recommended an area accuracy of plus or minus 5 percent over a section of land.

Photo 1.—*A 1917 field manual for timber surveys.*



Gregoire (1993: 59) mentions the "exacting comparisons that were made between strip and line plot cruises in the late 1920s."

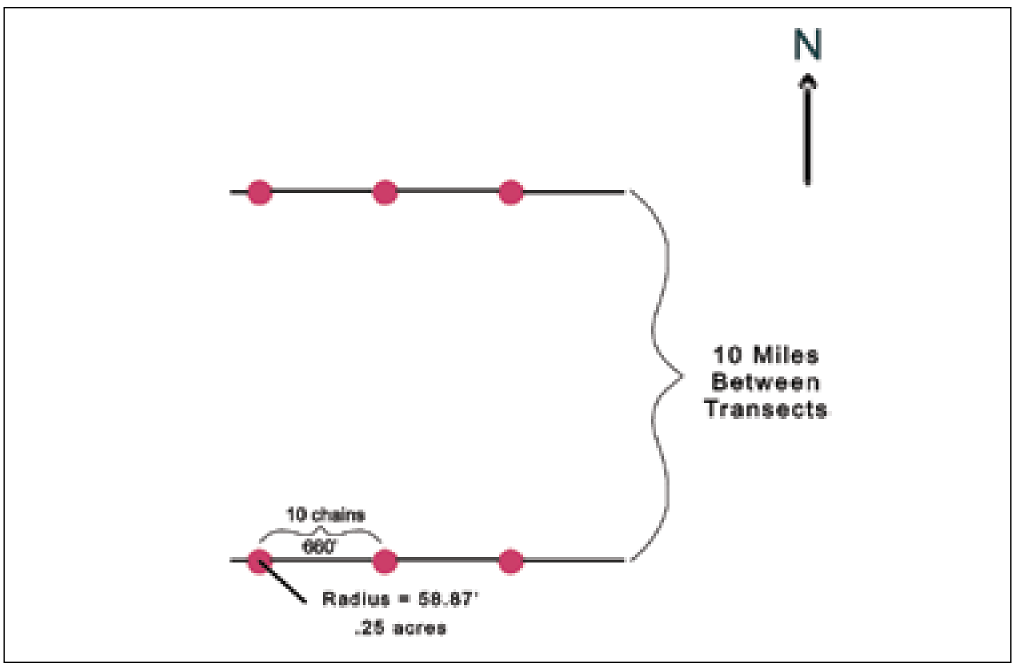
Doig (1976) described the first forest survey occurring in the Pacific Coast Cascade Douglas-fir forests in the 1930s. The first inventory in Oregon and Washington used a combination of type maps and line transects with sample plots. Statistical reports were issued, and an impressive analytical report was published in 1940 (Andrews and Cowlin 1940). A publication by Harrington (2003) includes three reports of forest survey activity in the Pacific Northwest Region in the 1930s. The sampling method was a modification of a Swedish line-transect survey. This sampling design may have initially come from Finland (Ilvessalo 1927). The line transects were 3 miles apart and circular 1/4-acre plots were measured every 660 feet (10 chains). The line-transect method was also used by the Southern Station's Forest Survey program, which commenced in the early 1930s. A Washington Office overview (USDA 1985) describes an early Southern Station's sampling method as one that "followed compass lines spaced 10 miles apart and sampled 1/4-acre plots at intervals of 660 feet along these lines." The line transects ran in an east-west direction (Rudolf 1985). Gregoire (1993) also mentions that the first forest surveys in the South in the early 1930s used a systematic line-plot design. In the Lake States and in Virginia, the initial sampling design was also one of strip samples laid out on maps and then transposed to ground strips, with the ground crews walking those transect lines and collecting ground samples. Later, the system evolved into one of measuring selected attributes on ground plots at intervals along that line, as described above and as shown in figure 1.

Problems apparently arose in estimating sampling errors with the systematic line-plot method. In the late 1930s, prominent statisticians recommended abandoning the systematic cruise strip- and plot-methods (Schumacher 1938). The forest survey methods, however, did not change much until after World War II when sampling methods incorporated aerial photogrammetric techniques.

1941–1945—The Forest Survey program was on hold during World War II.

According to Doig (1976), by 1938, 45 percent of the forest land in the contiguous United States was inventoried. From **1941** through **1945**, World War II interrupted the program and the Forest Survey program did not restart until after the war.

Figure 1.—*Forest survey sample plot design, Southern Region, circa 1931.*



Forest Survey Following World War II

The Influence of Aerial Photogrammetry and Other Military Equipment

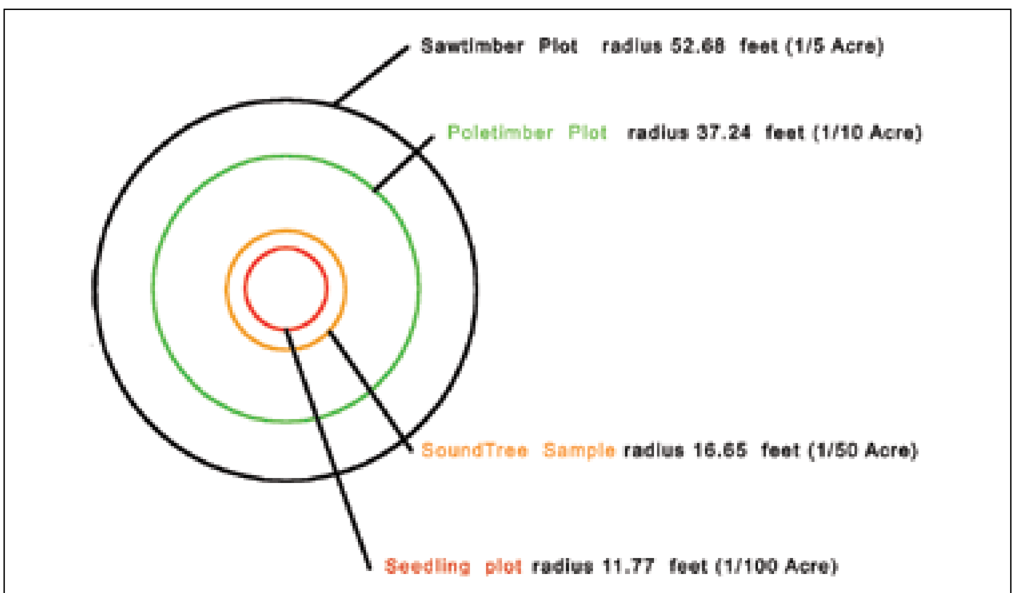
Funding for the Forest Survey program resumed in 1946, as indicated by this comment in Merz (1981: 66):

> On July 1, 1946, the Station was furnished funds to resume forest economics research and to begin Forest Survey activities in the Central States…. About 25 staff people were recruited, many of them war veterans, to take field plots; make product supply, growth, and drain studies; do photo interpretation work; and make statistical analyses.

Likewise, Rudolf (1985: 106) reports, "the second forest survey for the Lake States began in late 1946."

According to Merz (1981: 69), after World War II, "Forest Survey work originally began in Missouri in 1946 " and was completed in 1947, moving on to Kentucky in 1948. The forest survey of Illinois was also completed about this time. The plot system applied in the late 1940s in Missouri, Illinois, and Kentucky was one using a series of concentric nested circular plots (see figure 2) (USDA 1948). The Eastern Forest Survey units used this plot design through the 1950s.

Figure 2.—*Central and Lake States sample plot design, late 1940s.*



Post World War II—Line-transect plots are replaced with nested-circular plots.

After World War II, line-transect sampling was replaced with sampling from nested-circular plots or sometimes nested-rectangular plots. The survey crews generally consisted of two people—one person recording, and one person measuring. The Forest Survey program began to use aerial photos (see photo 2) around 1946 to navigate to the plot area. In many cases, it took hours to reach a plot area, so the idea evolved to use a cluster of plots to capture as much information as possible at a given site in one day. Morgan (1960: 40) discusses the effect of moving away from line transects to the new photo-based sample as follows:

> In 1946, results of the first survey of the Lake States were 10 years old and becoming obsolete by changing forest conditions. During this year, a new inventory was begun, but with a difference. Survey lines were no longer run across hundreds of miles of wild country. Instead, forest areas were mapped on aerial photos and only selected plots were measured on the ground. More plots were measured in heavily forested areas, fewer in poorly stocked and brush areas. The new techniques cut the number of plots required to one-third of the original total, while adding even more accuracy to permit publishing statistics for individual counties.

After World War II, the Forest Survey program started in the rest of the Western United States, including the Intermountain and coastal Alaska regions in the mid-1950s and interior Alaska and Hawaii in the 1960s. The first baseline inventories for all States except

Photo 2.—*Southeast Alaska crews (Arlene Davis and Carrol Speich) study access to Sumdum plot 095, circa 1983.*

Nevada and Alaska were finished by 1964. By 1967, the Forest Survey program covered the entire country except Nevada. Nevada, the last State inventoried, was completed in 1977. By then, the Northeastern, North Central, Southeastern, and Southern Stations finished as many as four or five iterations of the reinventory cycles, although many did not meet the goal of completing the cycles on a 10-year basis, as directed in the McSweeney-McNary Act. Continuous forest inventories came on the scene in the 1940s and were applied, especially in the Southern States, with good success (Stott 1947, 1968).

Post World War II—Aerial photos influence forest survey methodologies.

World War II had a profound influence on forest survey methodologies. Many of the young foresters went off to war, some of whom learned new skills and used new military equipment that would change forest survey methods. One of the most important skills learned was that of aerial photointerpretation, used in conjunction with military intelligence efforts during the war to evaluate enemy positions, bombing results, etc. After World War II, Richard Wilson was influential in getting Forest Survey units to incorporate aerial photogrammetric techniques in their inventory procedures.

Some of the people influenced by this new skill, which they ultimately brought into the Forest Service programs, were Robert Pope, Robert Aldrich, Robert Colwell, Karl Moessner, Eugene Avery, Keith Hutchison, and Al Hahn. Spurr (1948) wrote the first definitive book on using aerial photos in forestry. Avery (1967) wrote a subsequent book on the subject, and these two books became the major early references for the use of aerial photos in forestry. Another important document used in training people in the application of aerial photos was the *Forest Photogrammetry Training Manual* by Moessner (1960). U.S. personnel translated this training manual into Spanish for use in Colombia during the 1960s. The latest revision of the *Manual of Photographic Interpretation* (Lund 1997) contains an entire chapter devoted to forestry.

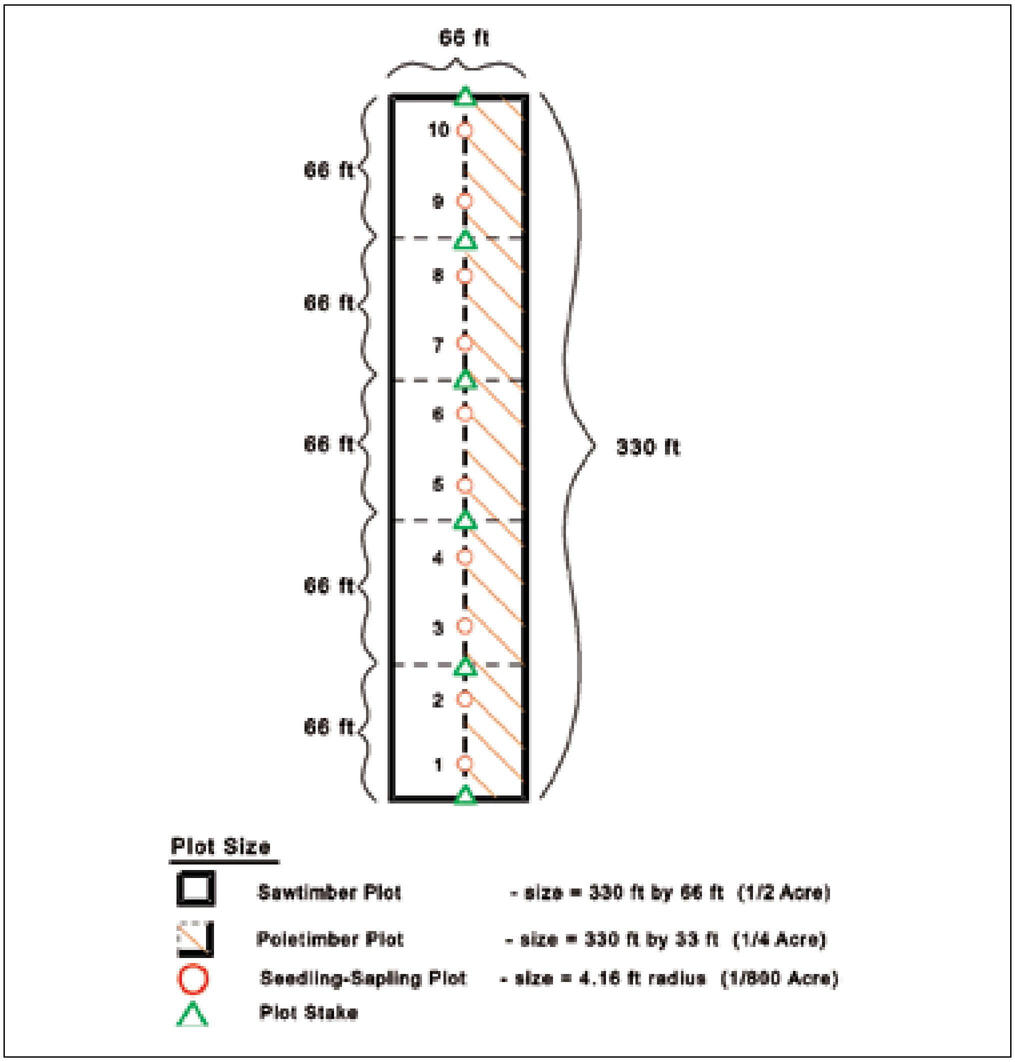
The use of photointerpretation in the Forest Survey program facilitated a new sampling design (two-phase sampling or double sampling with stratification) introduced by Bickford (1952). He presented the concept of stereoscopically classifying a grid of points on an aerial photo. The points were stratified into a set of classifications, such as forest, nonforest, etc. Finally, these points were systematically or randomly subsampled to obtain a subset of points for visitation on the ground, where the needed forest and tree attributes were measured or estimated. It was often possible to collect a great deal of information at the photo level of sampling, such as forest density, forest composition, and stand height using stereoscopically measured tree heights. If aerial stand volume tables existed, forest volumes could be estimated at the first (photo) phase (Moessner 1963, Haack 1963a). The new photo stratified sampling greatly improved the estimation of forest resources (MacLean 1972).

Eventually, more sophisticated multiphase and multistage sampling systems were developed. In the first forest survey of interior Alaska (Haack 1962), an attempt was made to use three-phase sampling. The middle phase employed stereoscopically measured tree-height measurements and aerial stand volume tables were used to make an estimate of forest stand volumes at this second phase. This phase was followed by a ground-plot evaluation of forest and tree attributes (phase 3) (see figure 3). In the 1970s, Canadians made major contributions to conducting forest inventories using large-scale aerial photography (Bonner and Aldred 1974).

1970s—Satellite imagery provides new options for sampling.

The improvement of remote-sensing methodology in the mid-**1970s**, such as Landsat and other satellite imagery, provided many new options for multiphase (Li and others 1984, Schreuder and others 1995) and multistage sampling (Colwell 1968). Robert Heller and Robert Aldrich pioneered some of the most important contributions in this arena. Langley

Figure 3.—*Interior Alaska sample plot design, 1961.*



(1975) performed one of the first surveys of forests from space using imagery from Apollo space missions.

At first, attempts to use satellite imagery were not very helpful. Initial tests in Alaska (Winterberger 1984) showed that the Landsat phase of a four-phase sampling design (see figure 4) accounted for less than 5 percent of the sampling variation (see photo 3). The

Figure 4.—*Alaska four-phase sample plot grid, mid-1980s.*

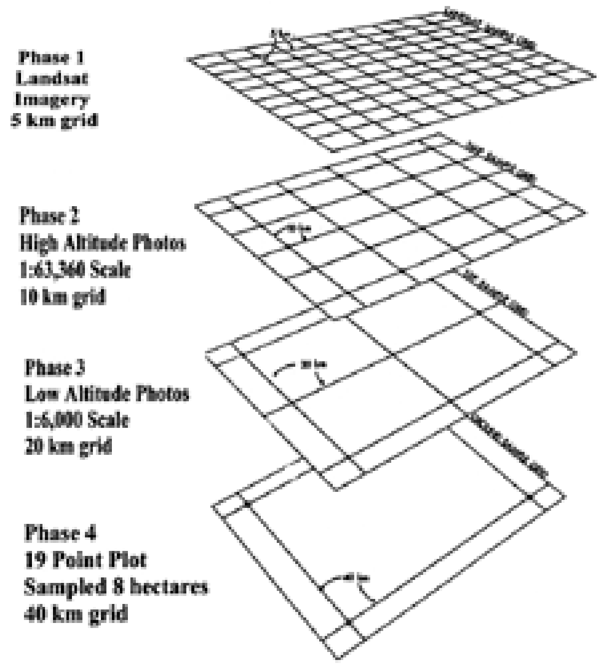
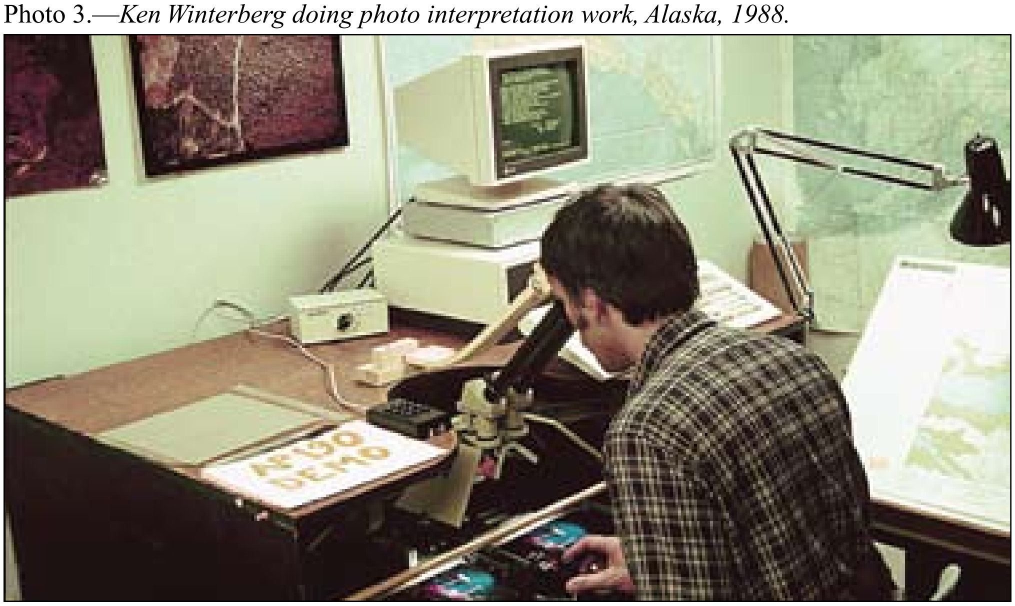


Photo 3.—*Ken Winterberg doing photo interpretation work, Alaska, 1988.*



Alaska four-phase design was abandoned, primarily because it was very expensive and it was almost impossible to get all the photo coverage needed for phases two and three.

Over time, foresters from Finland (Tomppo 1996), the United States (Titus and others 1975), and the United States with Russia (Winterberger and Kharouk 2000), among others, made significant advances in remote-sensing techniques, especially with the use and interpretation of high-resolution satellite imagery. In the 1980s, techniques evolved using satellite imagery to stratify basic vegetation types into groups allowing more efficient sampling on the ground (van Hees 1999). Special advanced very high resolution radiometer (AVHRR) applications were used in mapping the forests of the Southern United States and Mexico (Zhu and Evans 1992, 1994; Zhu 1994) (see photo 4). Ken Winterberger of

Photo 4.—*U.S. forest cover type map based on AVHRR imagery and FIA plots, prepared by Southern Station crews (Zhu and Evans 1994).*

the Alaska FIA unit, in cooperation with the USGS Earth Resources Observation Systems (EROS) Data Center, used AVHRR to map the forest types of Alaska.

Other spinoffs from World War II that proved to be important to the forest survey effort were Jeeps and helicopters (see photo 5). Jeeps provided access to otherwise inaccessible plots throughout the West and helicopters were first used in remote areas in the Intermountain Region and in Alaska in the late 1950s.

Helicopters and amphibious aircraft also became essentials in supporting the Forest Survey program in Alaska, Maine, and other regions. These new extended modes of transportation made remote areas much more accessible but presented some new challenges in safety associated with flying (see photo 6).

Photo 5.—*Helicopter accesses southeast Alaska plot, circa 1966.*

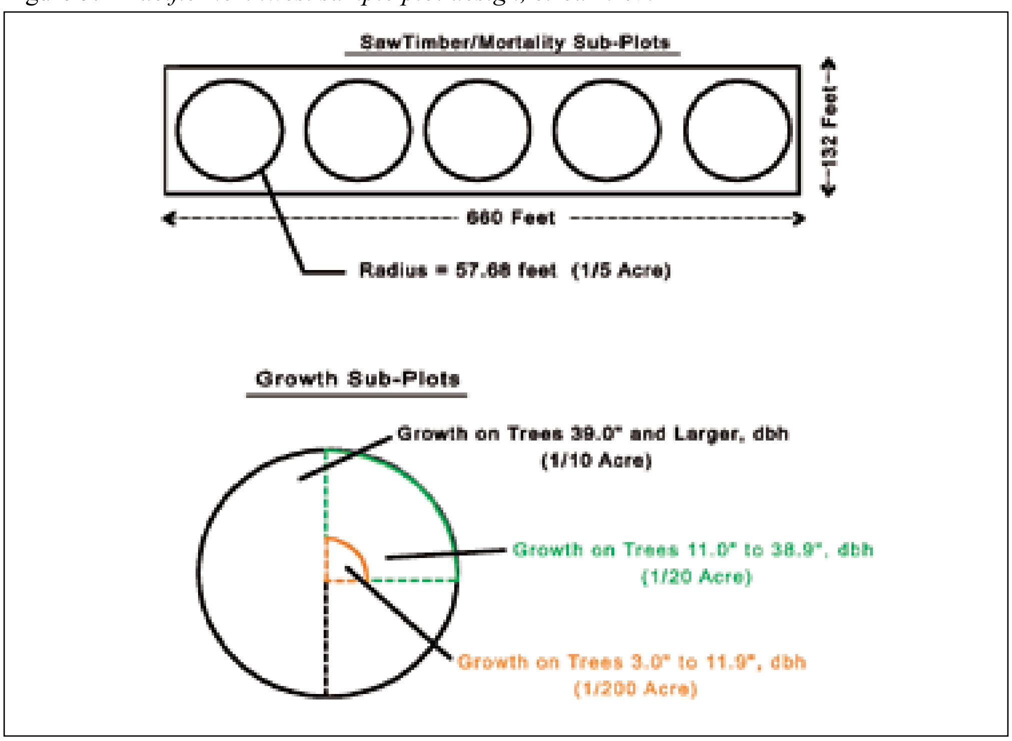
Photo 6.—*Cessna float plane takes off from small Alaska river, circa 1963.*

Changes in Goals of Forest Survey and Ground-Plot Designs

To understand the reasons for changes in plot designs, we need to chronologically step back a few years. Over time, the name “Forest Survey” was changed to “Renewable Resources Evaluation” and then to “Forest Inventory and Analysis.” From this point forward, we will use Forest Survey and FIA interchangeably. While the application of photointerpretation and photogrammetric techniques played an important part in post-World War II sampling techniques, there were major changes in ground sampling methods within the next two decades. With the increased use of aerial photogrammetry, the use of line-transect sampling disappeared. A goal evolved to evaluate a 1-acre site at each photo point, sometimes using photogrammetric methods, such as parallax measurements, for tree height determination. In addition, using photo mensuration methods along with compasses and maps, the crew navigated to the photo point location on the ground and gathered the needed data at that location.

In the late 1940s, in the Pacific Northwest Station, the ground plot consisted of five nested 1/5-acre circular subplots, 2 chains apart, within an area 2-chains wide and 10-chains long, running either uphill or downhill (USDA 1947) (see figure 5). The plots were selected from a map grid.

Figure 5.—*Pacific Northwest sample plot design, circa 1947.*



1950s—Multiple clusters are used to improve sampling efficiency.

About 1955, under the influence of Bickford (1952), two-phase sampling designs emerged. The ground plots in the new two-phase design took on new configurations. In the mid-1950s, the ground plot unit in the Intermountain Region was a two-plot cluster (USDA 1957a), 5 chains (330 feet) apart (see figure 6). Each subplot consisted of a series of nested plots, 1/3-acre for mortality, 1/5-acre for sawtimber and for wood quality, 1/50-acre for poletimber, and 1/300-acre for seedlings and saplings. About the same time, the Pacific Northwest Station's Forest Survey changed to a ground plot configuration of three 1/5-acre nested plots, 6 chains apart, along a north bearing (USDA 1957b). In the early 1950s, Alaska sampled a nested rectangular plot configuration. That ground plot system (USDA 1954) developed as a three subplot rectangular series, each subplot being 2 chains (132 feet) long, with a 2-chain distance between the first and second subplots and again between the second and third subplots (see figure 7). The total transect for the three subplots covered 10 chains (660 feet), oriented up and down the slopes of the area sampled. Austin Hasel and Robert Larson, statisticians of the Forest Service Washington Office Research Division, developed this system.

Until about 1950, most ground plots were sampled with designs oriented to the concept of probability proportional to plot area (PPA). Grosenbaugh (1952, 1958) introduced a new angle-gauge, tree-sampling system, which had been developed by Bitterlich

Figure 6.—*Forest survey sample plot design, Intermountain Region, circa 1955.*

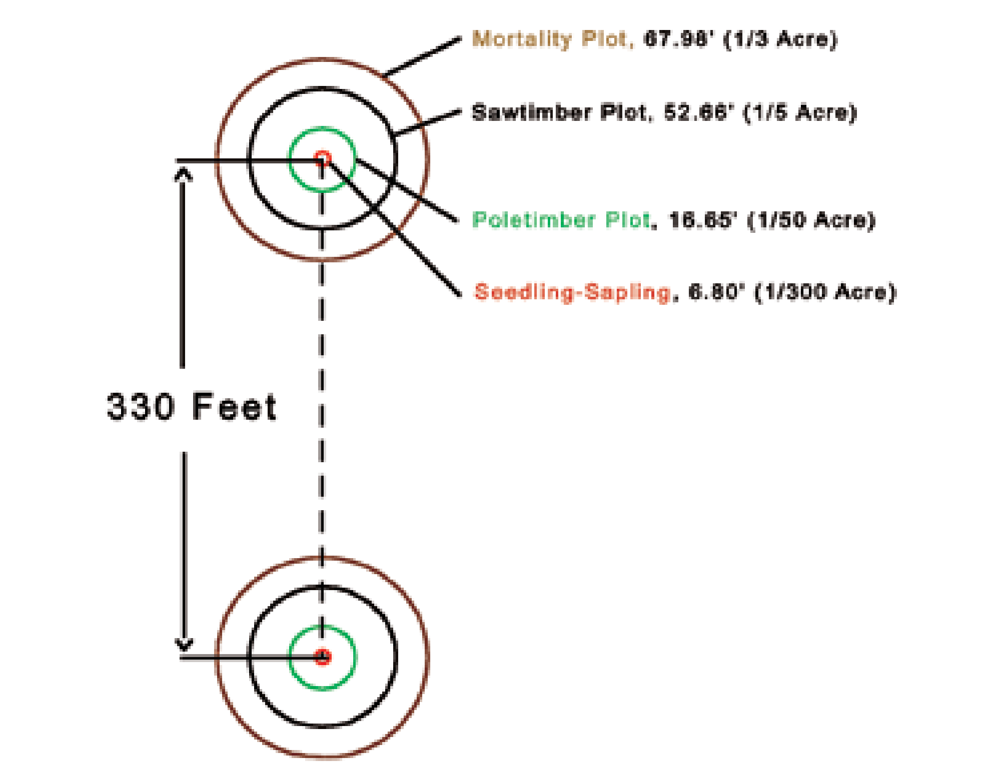
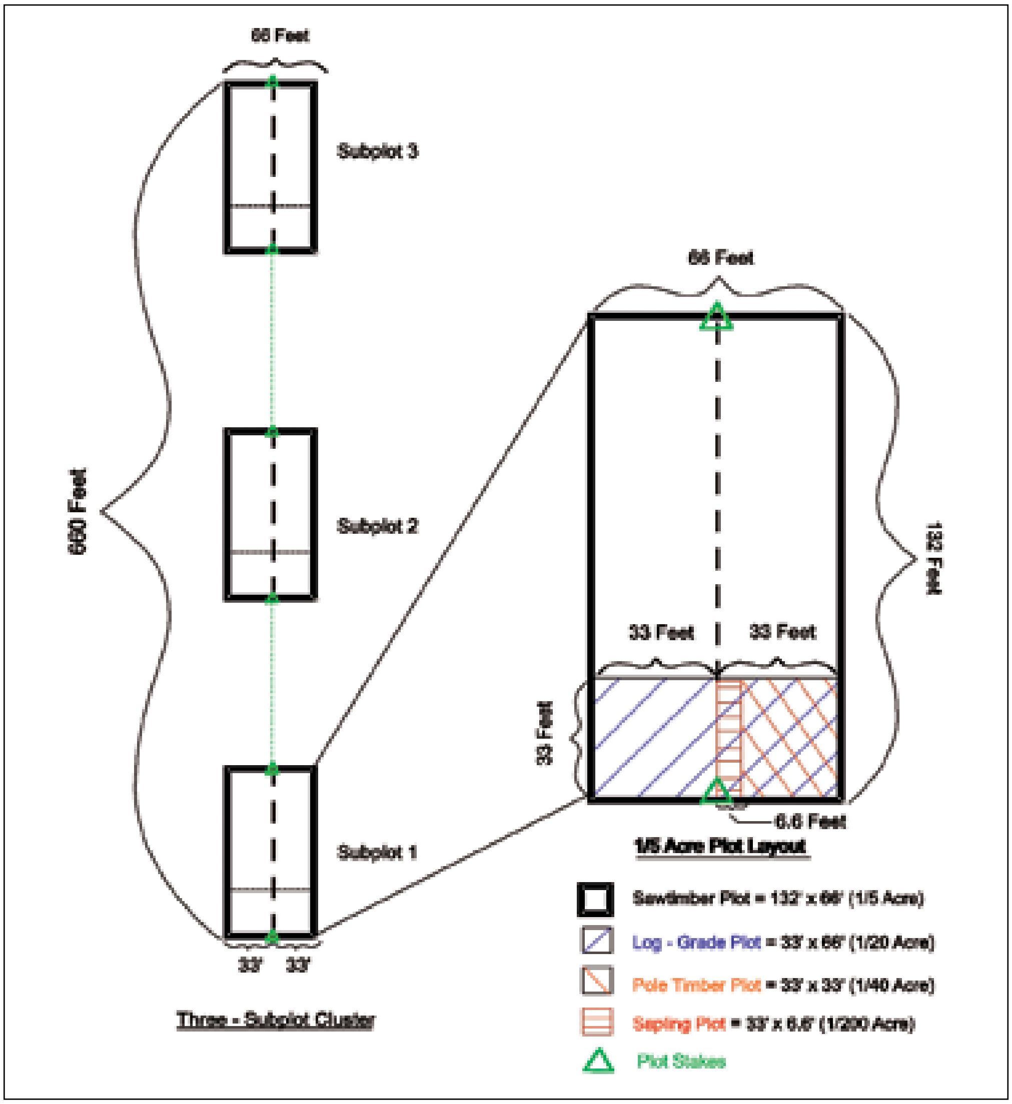


Figure 7.—*Coastal Alaska sample plot design, 1950s.*



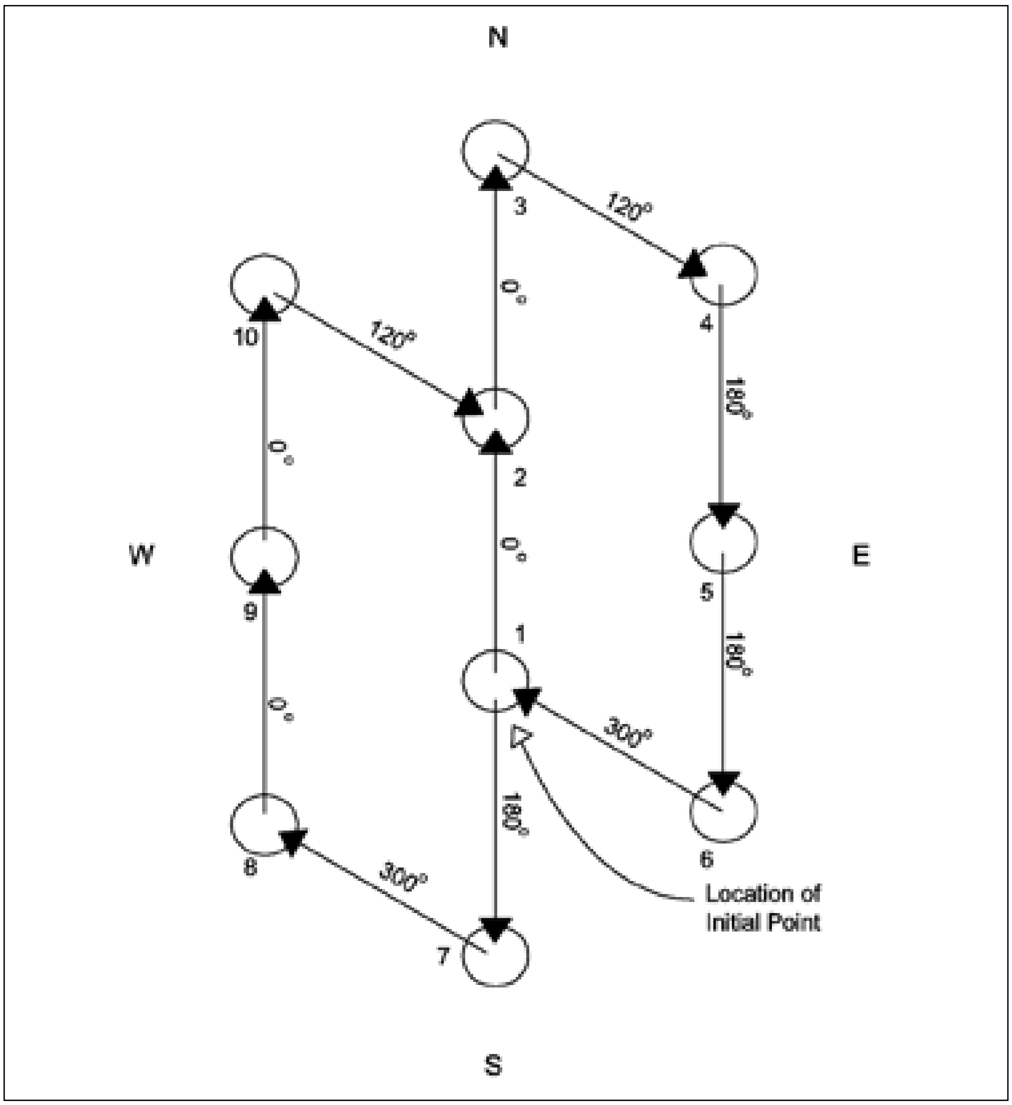
1950s—Point and prism sampling improves large tree data gathering.

(1948) in Austria, later known as variable-plot cruising or point sampling. This method initially used an optical wedge or angle gauge to select sample trees and proved to be very efficient for sampling large trees. This new tree sampling system introduced the tree sampling community to probability proportional to tree size or basal area (PPS) sampling. A major improvement to PPS sampling evolved when Bruce (1955) developed the concept of using glass prisms, rather than angle gauges, to select sample trees. By 1960, the Forest Service was experimenting with the new sampling approach in the Forest Survey program and in their timber sale layouts (Spada 1960).

In the early 1960s, a new ground sampling design evolved in the Forest Survey program using a 10-point cluster confined within a 1-acre area where trees were sampled from each point using PPS. It was hoped that this design would provide a better description of forest conditions around the 1-acre ground plot. This new concept, called the "area condition class," was used for the next two decades. The architects of this new concept were Spada (1960), Hasel (1961), Joe McClure, Joe Christopher, Mel Metcalf, Jack Wikstrom, and others. In 1967, the Forest Service's Washington Office issued a national handbook of procedures (USDA 1967, 1970) directing all Forest Survey units to use the 10-point variable plot cluster system (see figure 8).

This design was first field tested in the early 1960s throughout the Nation, including Alaska. It was often used in a two-phase sampling mode with a stereoscopically classified photo grid serving as the first phase. Over time, however, some of the units began using a systematic map grid to locate the first-phase sample points. The 1967 handbook included a standard plot design, sampling accuracy guidelines, core variables, definitions, and core

Figure 8.—*Forest survey sample nationwide sample plot design, 1970.*



tables, primarily based on the tables presented in the Timber Resource Review (USDA 1958). The 1967 handbook was later updated (USDA 2002, 2003a).

The 10-point ground plot system was adopted by most of the Forest Survey units from the early 1960s through the mid-1980s. During that time, new sampling systems evolved and some of the Forest Survey units branched off, testing and implementing the new designs. The Northeastern Forest Experiment Station decided to try “sampling with partial replacement” (SPR) (Barnard 1974, Scott 1984, Scott and Köhl 1994, Ware and Cunia 1962). In this sampling design, some previously established plots were remeasured and supplemental plots added. On the first few cycles of remeasurement, the system proved quite efficient. Sampling estimators became very complicated, however, as more inventory cycles were added (Scott 1986).

Also, about 1970, a new concept of “sampling probability proportional to prediction” (3-P sampling) (Grosenbaugh 1971, Schreuder and others 1968) evolved and caused considerable debate. Many applications were tried in timber cruising (Dippold 1981, Bell and Dilworth 1988), but the FIA units did not generally use 3-P sampling, primarily because of the commitment to continue using the 10-point system. An exception occurred at the Southern Experiment Station where 3-P was applied in the remeasurement program in the early 1970s (Van Hooser 1974), but the process was never adopted by FIA beyond that limited effort.

Another important statistical concept evolved related to the choice between sampling with optimum allocation vs. sampling with proportional allocation. Sampling with proportional allocation (usually proportional to area) is intuitively simpler, but depending on sampling goals, it could be less efficient. Bickford and others (1963) introduced sampling with optimum allocation (often proportional to timber volume) to the Forest Survey program. It usually improved sampling efficiency by reducing “in strata” sampling error for an intended goal. Optimum allocation sampling—based on timber volume strata predetermined from aerial photos—was used extensively in the Forest Survey program in the West during the 1970s with the 10-point cluster and PPS plot sampling. This meant systematically driving the ground samples into high-volume forest stands and therefore plots were not truly random in distribution. The Forest Inventory Analysis System (FINSYS) (Barnard 1978, Frayer and others 1968, Barnard and Born 1978, Born and Barnard 1983) allowed for analyzing data for either optimum or proportional allocation. Optimally allocated sampling systems can cause problems with statistical analysis when plots are remeasured if goals of the inventory change over time or if new sampling systems are imposed. For this reason, the Northeastern FIA (NE-FIA) program shifted in the 1960s from optimum allocation to proportional allocation during the second measurement cycle for both remeasured and new plots.

The computer became one of the most revolutionary factors in the evolution of the Forest Survey and FIA programs. During the early days of the Forest Survey program, the analysis was performed on mechanical calculators and tabulators and all written reports and associated tables were tediously prepared on typewriters, requiring numerous revisions to correct errors found by visual editing. About 1960, a new tabulation system evolved using punch cards on the International Business Machines (IBM) 650 electronic tabulators. A leader in this area was Robert Miller and his team at the Pacific Southwest Station. The Northeastern Forest Experiment Station, at the same time, used the Universal Automatic Computer, commonly known as UNIVAC. These machines were a major breakthrough in compiling data summaries and greatly decreased the time it took to prepare reports. Few people, however, are aware of the time-consuming efforts put forth in hand wiring the electronic boards needed to run these data tabulators. If a new report table was required, a new board had to be wired with scores of wires moved and tested. It was very different from today's desktop computers.

Early 1960s—Introduction of computers brings paradigm shift in processing field data.

About 1960, IBM introduced the much faster 1410 and 1620 computers with punch card input and data tape storage that replaced the previously used tabulators (Haack 1964). The IBM 1620 had 16 kilobytes of random access memory and data were generally stored off the system on 14-inch diameter, half-inch wide data tapes. One of the great advantages of this change was that the machines were programmable with the latest software (Formula Translation, or FORTRAN, for scientific analysis and Common Business Oriented Language, or COBOL, for business applications). The Forest Survey program began to hire or train specialists who could write computer programs to edit, compile, and analyze the data and prepare computer output reports. Changes began to occur in the collection of field data. In 1961, Illinois collected data on Porta-punch cards for faster input into the computers. By 1964, Forest Survey staff of the Northeastern Station had made a major breakthrough in data handling and report preparation in the form of FINSYS (Frayer and others 1968, Barnard 1978). This comprehensive program provided for data editing, compilation, and the tabulation of results, with the option of applying up to six different sampling methods. As the report tables came forth from the compilation phase, tables of sampling errors were also produced. W.E. Frayer was the primary contributor to the statistical "engine" in FINSYS, which was a significant advantage to the data handler, data analyst, and resource analyst. FINSYS training events were initiated across the Nation for people working in the Forest Survey program and timber sale inventories and FINSYS drove the processing of the national timber reports for two decades. NE-FIA continues to use FINSYS to this day.

Forest Survey staff also began conducting special support studies to take advantage of the computer. Haack (1963b), Bones (1968), Farr and LaBau (1971, 1976), Bruce (1984),

Ongoing—Forest Survey staff conducts special studies.

Larson and Winterberger (1988), and Larson (1990) used computers to develop volume tables to improve the forest survey estimates of Alaska standing volumes (see photos 7a and 7b). Farr and others (1976) used computers to derive cull estimation functions to compute net volumes for the forest survey estimates for coastal Alaska.

About 1980, the Southern Forest Survey unit was one of the first to acquire their own computers large enough to handle the entire inventory process. Roy Beltz was instrumental in this effort, obtaining a DEC VAX minicomputer machine with 1 megabyte of memory.

Staff in the North Central Station developed the stand-projection program called Forest Resources Evaluation Program (FREP) (Hahn and others 1979). FREP was a system to update data for North Central forest stands. In the early 1980s, portable data recorders came on the scene (Beltz 1981, Larson and others 1990). This constituted a major paradigm shift in collecting field data. Data collection was easier and provided for in-the-field real-time editing of recording errors. Errors were also eliminated due to transcribing or keypunching the field data from the field cards or tally sheets to computer cards for use on the main computers. Hand-in-hand with this innovation evolved phone transmission of data from the field recorder to the main computer, thus greatly reducing the time needed to get the data ready for the analysts to begin their task of compiling reports. The time

Photo 7a.—*Gyde Lund scales logs in a special mill study using forest survey crews, Wrangell, AK, 1965.*

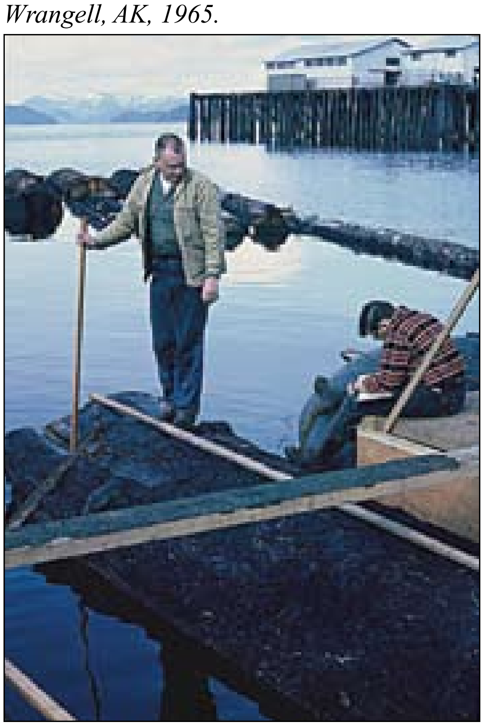


Photo 7b.—*Ros Carpenter (Forest Products Lab) grades a birch log while Bill Farr and Jim Bones watch, Wasilla, AK, 1961.*

lag for production of final forest survey reports dropped from years to months, putting the information in the hands of the users in near real time.

NE-FIA developed a generic data recorder program called TALLY to make it easy to generate data collection forms and to check the data for range, list, and logic errors (Scott 1990). FHM adopted TALLY nationally. FIA continues to use it.

Some of the more important products of Forest Survey were the national timber assessments published about every 10 years. Shortly after World War II, an important national report called "Gaging the Timber Resource of the United States" was published (USDA 1946). It projected the national timber situation to the year 2003. Twelve years later, a major report to Congress on the status of the U.S. forest resources came forth with the printing of the *Timber Resource Review* (USDA **1958**). This report included data for all the United States except Alaska. In 1965, the USDA (**1965**) published the first truly nationwide forest survey report, including Alaska inventory results. The report was commonly referred to as *Timber Trends in the United States*. The *Timber Trends* study, completed at the Washington Office in 1964, put a great deal of emphasis on using remeasurement data with lessons that carried forth for decades. Since the 1960s, the Forest Service has prepared increasingly sophisticated reports on a decadal basis (USDA 1973, 1982, 2001; Waddell and others 1989; Powell and others 1993; Smith and others 2001; Haynes 1990, 2003).

1958 and 1965—*Timber Resource Review* and *Timber Trends in the United States* are published as national reports.

Starting with the 1963 report, the Washington Office placed emphasis on using the current data to project forest product wood and fiber use 50 years into the future. It was necessary to develop an analysis system that could make these projected estimates (Larson and Goforth 1974). The result was a Timber Resource Analysis System (TRAS), a tree projection system developed in the Washington Office. It was important because it allowed the resource analysts to make projections of timber volume, growth, mortality, and harvest for decades into the future. Forest Survey also used TRAS to make backdated computer runs to try to improve the consistency of growth and removals data, a very important application. This system, applied in two national reports to Congress (USDA 1973, 1982), served in many local and State reports across the Nation. In subsequent years, the original TRAS program was improved (Alig and others 1982) and eventually replaced by the Aggregated Timberland Assessment System (ATLAS), a more refined technique (Mills and Kinard 1992, Mills and Zhou 2003). Besides being reports to Congress, these national reports served as input to the United Nations World Forest Resource assessments.

Moving Beyond Timber Inventory Into Multiresource Inventories

Early 1970s—Concerns of environmental groups focus the need for multiresource inventories.

In the **early 1970s**, a new forest management paradigm evolved in response to concerns raised by many environmental groups opposed to certain forest management procedures, especially timber harvesting. The Forest Service and the timber industry found themselves facing serious challenges in courts of law; forest survey statistics were also challenged. The Alaska Forest Survey staff spent hundreds of hours preparing testimony defending 1950 forest survey statistics, which were brought into question in three major court cases in the 1970s (Sierra Club vs. Hardin in the early 1970s, Zieske vs. Butz in 1973, and Sierra Club vs. State of Alaska in 1979). All three cases were initially litigated in favor of the Forest Service, but through appeals to U.S. 9th Circuit Court of Appeals, the Alaska court rulings favorable to the Forest Service were reversed. Ultimately, forest survey statistics validity prevailed in the courts.

The Forest and Rangeland Resources Planning Act of 1974 (RPA) greatly influenced sampling strategies and broadened sampling focus to include more than just the timber aspects of the forest ecosystem. The RPA also mandated updates of forest inventory data every 10 years, as well as for other resources such as wildlife, grazing lands, and the status of soils. Another event of the 1970s was the advent of Agriculture Handbook 475 on ecosystem inventories, which proposed a more holistic look at the resource (Garrison and others 1977). With the passage of the National Forest Management Act of 1976, more changes evolved in FIA sampling strategies, oriented to examining multiresource factors.

In the mid-1970s, special funding became available to set up a new Resources Evaluations Technique (RET) research program. The site chosen for this research was the Rocky Mountain Station at Fort Collins, CO. Richard Driscoll was assigned as program manager. The program staff included about 20 people from various disciplines (forest inventory, rangeland inventory, forest economics, soils survey, wildlife assessment, recreation analysis, integrated resource analysis, remote sensing applications, and statistical research and support). RET was an interagency program with representatives from the USDA Forest Service, Soil Conservation Service, and Economic Research Service and U.S. Department of the Interior, Bureau of Land Management and U.S. Fish and Wildlife Service. The program also had interactive connections with several other entities, including Colorado State University.

The RET staff published more than 80 papers and technical reports in the early 1980s. One of the major efforts was the development of a National Land Classification System (Driscoll and others 1984). A major outcome of RET was a review of the state-of-the-art remote sensing in natural resource inventories (Aldrich 1979). RET was also assigned the compilation of timber data and the 50-year projection of timber data for the 1980 National Resources Planning Act report (LaBau and Brink 1980, Van Hooser and LaBau 1982, Alig and others 1982, USDA 1982). A 3-year data collection trial occurred from 1976 to 1978, primarily at a site in Grand County, CO. The sampling design and data collection was orientated to an ecological multiresource inventory procedure to answer questions on all measured resources and several interactions. RET was initially planned as a "sunset" program and much of the data analyses remained uninterpreted when RET was terminated in the mid-1980s. Hans Schreuder's Statistical Support Project, which was part of RET, did continue on for many years in support of FIA efforts (Birdsey and others 1995; Olson and Schreuder 1997; Schreuder and Thomas 1991; Schreuder and others 1995, 2004; Schreuder, 2004).

Authorization for expanding the nationwide resources inventory program came with the Forest and Rangeland Renewable Resources Research Act of 1978. For a short time during the mid-1970s, the Forest Survey program was renamed Renewable Resource Evaluation. This name was dropped in the mid-1980s in favor of the more specific name—Forest Inventory and Analysis.

Mid-1970s—Southeastern Forest Survey develops a method to profile vegetation.

Significant early progress in the development of multiresource inventories evolved at the Southeastern Station in the mid-1970s (see photo 8) (McClure and others 1979, Lennartz and McClure 1979, Lennartz and others 1983). Other Forest Survey units also

Photo 8.—*Noel Cost measures a tree with the McClure caliper while John Nesbit measures bark thickness, Virginia, circa 1966.*

implemented multiresource inventory systems (Hegg and others 1981, Brooks 1986). Schreuder and others (1993) presented statistical methods for sampling multiresources. The evaluation of downed wood became a major interest in multiresource inventories (Larson 1984, 1992). One of the first important inventory technique modifications for assessing understory vegetation evolved at the Southeastern Forest Survey unit (Cost 1979) in the development of a method to assess the horizontal and vertical distribution of understory and tree crown information for the 1-acre sample sites. This system came to be known as the horizontal-vertical (HV) vegetation profiling system and was adopted to conditions in the Intermountain Region (O'Brien and Van Hooser 1983, O'Brien 1984) and to Alaska (Smith and Larson 1984) (see photo 9). About this same time, Robert Brooks of the Northeastern Research Station worked on developing a vegetation layering technique to evaluate wildlife habitat. In addition, a technique developed by Bev Driver at the Rocky Mountain Station called ROS (Recreation Opportunity Spectrum) was tested at some survey units to evaluate recreation opportunities. ROS, however, was given minimal consideration by most survey units because its criteria were most adapted to the Intermountain West and did not work well in less mountainous regions.

Photo 9.—*Establishing vegetation plot, Susitna River unit, Interior Alaska, circa 1979.*

In the late 1980s, Forest Service researchers developed other strategies for assessing nontimber attributes, including evaluations of understory vegetation, soils (see photo 10), downed wood, and wildlife use and populations (LaBau and Fox 1984, LaBau and others 1986). Some significant new direction in resource analysis came from the work of Victor Rudis (1990, 1991) at the Southern Station. The Washington Office cited Rudis' work with inventorying non-timber attributes (such as wildlife, recreation, range, and hydrology) as a new direction to be included in emerging FIA efforts.

Photo 10.—*A soils pit on the Upper Porcupine unit, Interior Alaska, circa 1978.*

Ownership Surveys

In the late 1960s, clients of FIA began to raise questions about the 3.9 million private forest land owners in the Northern United States who held 130 million acres of forest land (Birch 1996). Why do they own forest land? Do they manage it? Will they sell timber? Who are they? Are these ownerships becoming more fragmented?

To answer these and many more questions, the Northeastern Station initiated mail canvasses of the owners of field plots that fell on private, nonindustrial forest land (Kingsley 1975). Although a number of studies of private owners were conducted earlier, few related the results to statewide forest resource inventories. To do this, the new design used in the inventory report was applied to estimate the total acreage owned by responding owners. With this design, the probability of owners being sampled was dependent on the rate of sampling and the acreage they owned. The areas in large ownerships (those with a probability of selection approaching 1) were subtracted and formed a separate, enumerated stratum. The remaining forest land was divided by the number of “small acreage” sample locations represented by the remaining valid questionnaires to determine the area represented by each sample plot. In this way it was possible to estimate not only the total number of private ownerships by various categories, but also what proportion of the total private ownership they owned by size classes of ownership.

1970s—Ownership canvas of private forest land use was implemented.

While these studies could not answer the perennial question of how much timber was available from private lands, they did provide important information about a previously poorly understood, but important, segment of the resource. Soon they became standard companion reports to all forest inventories in the Northeastern Region. These studies also identified the dominant interests of private owners in resources other than timber (Brooks and Birch 1986).

In the 1980s, similar studies were completed in the Lake States (Carpenter and Hansen 1985, Carpenter and others 1986). In 1978, the first nationwide ownership study was conducted (Birch and others 1982) A second nationwide study was made in 1992 (Birch 1996). Beginning in 2002, an annual ownership study was initiated. In this study, a portion of field plot owners received questionnaires each year until the entire population was sampled over an anticipated inventory cycle. The first cycle is projected for completion in 2007. The ownership studies continue to yield important information about private forest lands (Butler and Leatherberry 2004).

Other Forest Survey Dynamics

About this same time, strong direction came from the Washington Office to produce estimates of biomass from the forest inventory data. Harold Young from the University of Maine had been a proponent of assessing forest biomass for many years (Young and others 1964, Young 1977, Young and others 1978). The Northeastern Station led a national team to produce the biomass estimates on a State-by-State basis using the FIA data compiled for the 1990 RPA report (Birdsey 1990, Cost and others 1990). At the same time, other emphases were being placed on inventorying for biomass and phytomass. In Alaska, the University of Alaska Fairbanks and the Alaska FIA unit developed coefficients to estimate phytomass from the forest soil duff to the tops of the trees. It was possible to do this by plant and tree species and by their respective positions in the forest stand (Yarie and Mead 1988). These coefficients were related to stand phytomass using the Southeastern Station's HV system (Cost 1979).

1980s—The Northeastern Station leads a national biomass assessment.

In the late 1980s, one of the most important changes in Pacific Northwest Station sampling came in an effort to develop trends. The design involved a "permanent" grid of points at fixed intervals. To meet the required accuracy requirements, a photointerpreted (PI) grid was established at intervals of .85 miles and ground plots were subsampled from the PI grid at intervals of 3.4 miles. This grid was established over Washington, Oregon, and California and was the basis for field sampling into the mid-1990s. When the Pacific Northwest Station's crews reinventoried western Washington, the Washington Department of Natural Resources wanted more ground plots to improve the sample frequency for small areas, so crews ground sampled on a 1.7-mile grid. The State of Washington paid for the intensified ground sample. The photo sample grid did not change. About the same time, the Pacific Northwest Station also incorporated a ground plot design that established a 5-point ground plot, colocated with the previously established 10-point plot (Bell and Dilworth 1988).

In the early 1970s, Joe McClure at the Southeastern Station led the development of the Forest Information Retrieval (FIR) system in the Southeast. FIR was applied by thousands of users to develop resource summaries for any geographic area within the Southeastern Region. A few years later, Roy Beltz at the Southern Station developed online access for users of FIA data. Both of these developments were instrumental in highlighting the value of FIA data for users of the data. Resolving the differences in the data led to a common Eastwide and Westwide database and, in the **early 1990s**, to the nationwide FIA Database (FIADB), (Hansen and others 1992, Woudenberg and Farrenkopf 1995, Miles and others 2001). Visit the Web site at http://www.fia.fs.fed.us to access the FIADB. A Washington

Early 1990s—The nationwide FIADB was developed.

Office pamphlet gives an excellent overview of some of the recent analyses of these data (USDA 2001).

One of the important dynamics of the Forest Survey program was the Annual Meeting of Forest Survey Project Leaders from the Research Stations (see photo 11). These meetings were held at various places around the United States. During these meetings, each unit shared important new ideas and concepts about forest survey, which often led to their adoption by other units. These meetings also provided a forum for some great discussions about the best approaches to forest inventory.

Photo 11.—*Project leader meeting, Alberta, MI, 1992 (Kneeling: Noel Cost, Hans Schreuder, Gyde Lund, and Roy Beltz. Standing: Jim Bones, John Peters, Dan Oswald, Dwane Van Hooser, Neal Kingsley, and Brad Smith).*

Forest Survey National Leadership

In addition to the forest survey of the Nation's forest resources, the Forest Service inventories a variety of natural resources on the lands that it administers. In a review of national direction, the Washington Office found 14 laws, at least 57 manual sections, and 20 national handbooks dealing with or touching on Forest Service resource inventories. The field units further supplemented many of the handbooks. For example, at least 34 regional and station supplements related to timber inventories alone. On further investigation, an overlap of responsibilities was also found. Agencywide, the same data were often collected in the same area, but by different resource specialists and at different times. Some data without apparent uses were being collected and stored while some lands and resources were not being inventoried at all. The Washington Office also realized that, although the quality of inventory data varied from field office to field office and among resource functions, the information was often being treated equally in forest planning, RPA programming, and developing national assessments (Lund 1987). Given these findings, as well as the forecast of declining budgets, the Washington Office determined that new direction, encouraging better coordination and quality control, was needed.

To deal with these multiresource national data problems, the Deputy Chiefs for the National Forest System and Research created the Resource Inventory Coordination Task Group and authorized member involvement. Jim Bones of the Washington Office chaired the group.

The Deputy Chiefs issued an Interim Resource Inventory Glossary in 1989 (USDA 1989). The glossary covered terms the agency needed for the management of the timber, wildlife and fisheries, recreation, rangeland, water, soil, land, and mineral resources of the National Forest System lands.

The Washington Office issued the Resource Inventory Handbook in 1990 (USDA 1990) and a Planning Manual supplement in 1991 (USDA 1991). This Resource Inventory Handbook defined specifications for minimum information needs for forest plans and national assessments (e.g., data elements, precision requirements, common reporting units, and timing frequencies). In the interim, the Washington Office had issued "A Primer on Integrating Resource Inventories" (Lund 1986), which provided the field offices with general principles for achieving integration, types of integration (multilocation, multilevel, multiresource, and temporal), and integrated inventory planning, implementation, and maintenance.

1990—The Washington Office issues new direction to deal with multiresource national data problems.

In addition to the Resource Inventory Handbook, FIA members participated in the development of the Timber Permanent Plot Handbook (USDA 1992). This handbook provided direction to Forest Service personnel who had the responsibility for establishing field plots used to determine timber growth, yield, and mortality. The purpose of this handbook is to ensure compatibility in the establishment and measurement of permanent plots and to promote sharing of the resulting data among Forest Service units and other groups collecting and reporting growth and yield data.

In the mid-1990s, the Federal Geographic Data Committee created a vegetation subcommittee to develop a vegetation classification standard for Federal agencies to use. Fred Kaiser chaired this committee and Gyde Lund was the executive secretary. The result was the issuance of the Vegetation Standard for the United States (Vegetation Subcommittee 1997).

Forest Survey in the International Arena

During the 1960s, the United Nations Development Projects (UNDP) funded research throughout the developing nations of the world and the Forest Survey program furnished inventory expertise. These preinvestment inventories sought financial assistance from agencies such as the World Bank to fund projects based on the findings of the researchers. The United Nations Food and Agriculture Organization (FAO) in Rome recruited researchers with special skills for these UNDPs. For example, beginning in 1965 the FAO Economics Division recruited Jim Bones as the aerial photo and mapping specialist for a development project in Colombia. A Federal law allows the Forest Service's International Forestry Branch to furnish specialists for up to 3 years to assist foreign governments in carrying out these UNDPs. These specialists are also able to transfer new technology and assist in training local workers. Bones spent 2 weeks in Rome and then went on to Bogota, Colombia, where he worked for 3 years. While in Colombia, he arranged for new aerial photos of the project area, taught a graduate-level photointerpretation course at Columbia National University, developed aerial volume tables for tropical stands, created land use maps with the new photos, and prepared part of a final report to the United Nations. Jim returned to the United States in February 1968 and transferred to the Northeastern Station.

A few years later, David Born of the Intermountain Forest and Range Experiment Station initiated a cooperative agreement with the Republic of China. Born helped the Republic of China foresters develop a forest inventory plan. Another early international effort was that of Colin MacLean, who made several trips to Micronesia to assist with forest surveys in the American Pacific Trust Islands.

In the 1980s, at the Washington Office level, Charles Van Sickle and Jim Bones worked closely with Canadians such as Joe Lowe of the Canadian Forest Inventory Committee (CFIC). They cooperatively input North American data to FAO in Geneva, Switzerland, to support the presentations of international summaries on forest statistics in developed countries. The Washington Office also supported the FAO program in Rome by sponsoring FIA personnel (Ray Czaplewski, Jack Spencer, Karen Waddell, Joanne Faulkner, and Jim LaBau) to assist with K.D. Singh's program to provide worldwide forest inventory statistics for developing countries, with special emphasis on tropical deforestation.

FIA has a long-standing special relationship with the CFIC, which includes representatives from all the provinces, territories, and Forestry Canada in Ottawa. CFIC has allowed FIA a permanent nonvoting seat on the committee for more than 20 years. Jim Bones, Doug Powell, Gyde Lund, and Brad Smith have served as official U.S. representatives to CFIC and provided opportunities for neighboring FIA unit personnel to participate when possible. FIA reciprocated and Canada now has a permanent nonvoting seat on the FIA Management Team at U.S. FIA annual meetings.

Gyde Lund served on the United Nations Economic Commission for Europe, the Food and Agriculture Organization (FAO) Temperate and Boreal Forest Resource Assessment (UNECE 2000) Team of Specialists in Geneva, and with the International Organization of Forest Research Organizations in the early to mid-1990s. Their focus was to broaden the scope of resource inventories globally toward multiresource values. Brad Smith continued this work in the late 1990s, joining the International Team of Specialists for the 55-nation team and served as national correspondent for the United States to the 2000 FAO Global Assessment (FAO 2001). Smith was also a major contributor of FIA data and analysis to the Heinz Center's *State of the Nation's Ecosystems* (Heinz Center 2002), and the Sustainability Roundtable's *2003 National Report on Sustainable Forests* (USDA 2003b).

Ongoing—FIA makes important contributions to international forestry.

During the early 1990s, the international effort focused on cooperation among boreal-forest nations (Finland, Sweden, Norway, Canada, Russia, and the United States). Eldon Ross, Jim Bones, and Jim LaBau were involved early on in the establishment of the International Boreal Forest Research Association (LaBau and Isaev 1995), focusing on sharing forest research among the boreal countries. Andy Gillespie, Ken Winterberger, and Jim LaBau had special cooperative projects with Russian scientists that resulted in productive interchanges of information and several shared papers at international conferences (Winterberger and Kharouk 2000). Gillespie was one of the Co-Chairmen, along with Evgene Vaganov of the Sukachev Institute of the Forest Russian Academy of Sciences, for the 1999 workshop on "Assessment Methods of Forest Ecosystem Status and Sustainability," held in Krasnoyarsk in August 1999. Gerhard Raile, Tom Schmidt, and Dan Wendt of the North Central Station spent a combined 3 years with the International Institute of Applied Systems Analysis in Vienna, Austria, working to develop databases and provide analysis of data for the Russian Federation's Siberian inventory.

Also, Chip Scott of the Northeastern FIA unit was invited to Birmensdorf, Switzerland, for a total of 4 months over 5 years to assist with the design of the second Swiss National Forest Inventory. His experience with sampling with partial replacement was used to overcome some design problems with the first inventory (Scott and Köhl 1994).

International cooperative efforts also took place between FIA staff of the Southern Station with foresters in Mexico (see photos 12a and 12b) in the development of a map of Mexico's forest lands from satellite imagery (Evans and others 1992). Gyde Lund of the Washington Office also made important contributions to international forestry relations as an international liaison (see photo 13) and through planning and assisting in the conduct of several international conferences on forest inventory (Cunia 1979, Lund and others 1981, Lund and others 1987, Lund and Preto 1990, Päivinen and others 1996). The Washington Office also sponsored several key work sessions to support the international Forest Resources Inventory effort. Some FIA projects hosted foreign nationals for several months.

Photos 12a and 12b.—*Training Mexican foresters at the Southern Station in the early 1990s.*

(a)

(b)

Photo 13.—*Gyde Lund participates in the Forest Service, U.S. Agency for International Development, and U.S. Geological Survey effort in Sudan, meeting with Sudan Forest National Corporation and Survey Department in December 1989.*

Emergence of the Forest Health Monitoring Program

The Forest Health Monitoring program grew out of techniques research that took place in the New England States in cooperation with State foresters of that area (Brooks and others 1992a, 1992b). In 1980, Congress established the National Acid Precipitation Assessment Program (NAPAP), to conduct a comprehensive 10-year research, monitoring, and assessment program on the causes, effects, and controls of acid rain. This interagency scientific research, monitoring, and assessment program studied the effects of sulfur and nitrogen oxides on the environment and human health. NAPAP acted as a coordinating office between six Federal agencies, which also fostered cooperation among its members, other governments, States, universities, and the private sector. Robert Brooks of the Northeastern Station was important in this activity. In addition, the National Vegetation Survey was part of the Forest Response Program of NAPAP and was lead by Joe Barnard.

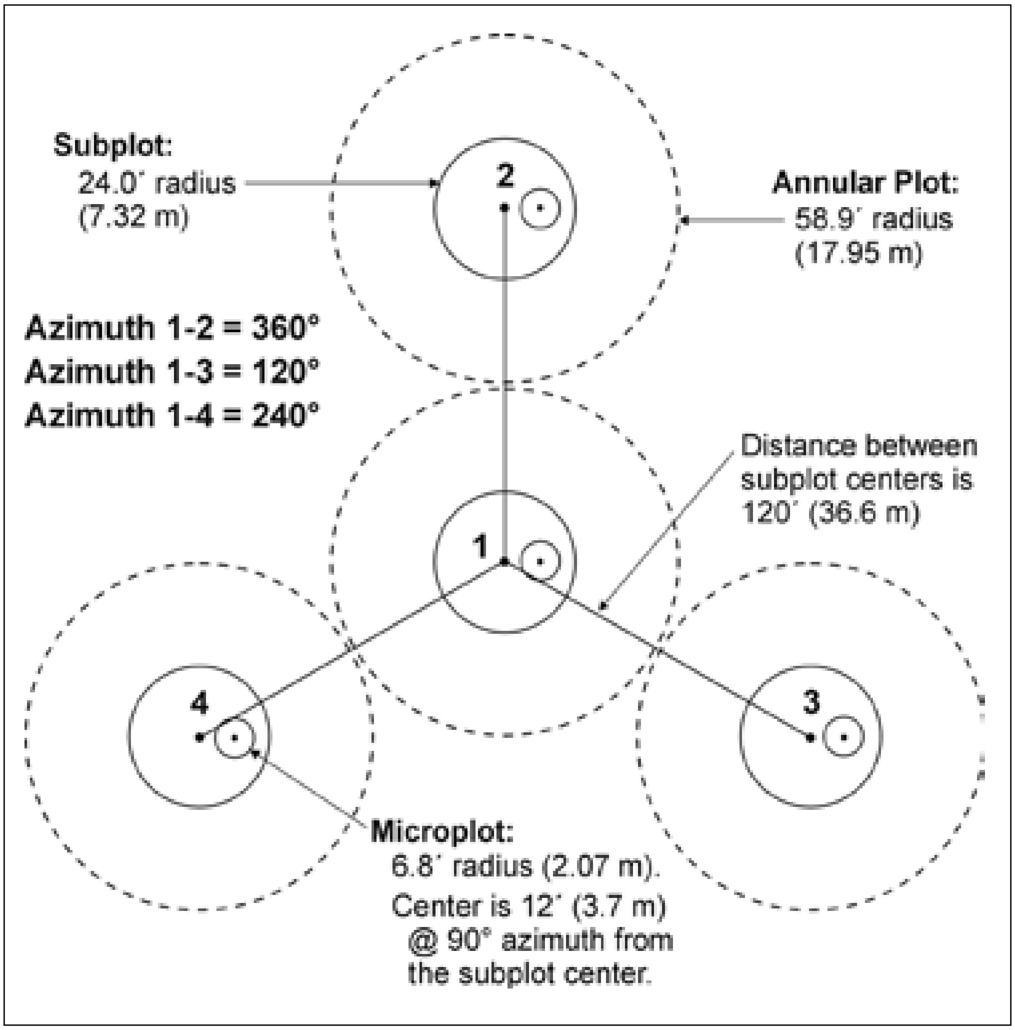
In 1989, the new FHM (Bechtold and others 1993) program evolved within the Forest Service in cooperation with the Environmental Protection Agency (EPA). Joe Barnard of the Northeastern Station was assigned as one of the initial program co-leaders for FHM, stationed at its headquarters in Research Triangle Park, NC. The program's initial purpose was to look for degradations in forest health and subsequently to try to establish a cause and effect relationship for the degradation. This process involved major modifications of sampling design and procedures.

1990—The FHM attempts to detect degradations in forest health.

The design reverted to PPA sampling using a nationwide map grid from which forested ground plots were selected for possible visitation. This process involved a new four-point cluster ground plot system (see figure 9) (Scott 1993) and initially included sampling attributes for trees, understory vegetation, downed wood, soils, foliar contamination from heavy metals or ozone, crown classes, and factors affecting forest health degradation (pathological and entomological, etc.). The ground plots were established State by State with the goal of remeasuring the plots on a 4-year cycle. The Eastern States were sampled first, with priority States in the West being added as funds permitted (Colorado and California first, then other units in the Pacific Coast, Intermountain, and Lake States were added as funding came available).

During the early 1990s, the Forest Service, cooperating with EPA, systematically installed the FHM plot grid system throughout the United States, particularly in the Eastern States, California, and Colorado. In the mid-1990s, FHM assisted the European Baltic states and Indonesia in implementing a modified grid system. Several Forest Survey people assisted with that program (William Bechtold, Jim LaBau, Gyde Lund, Barbara Knight, Paul Rogers, Bill Cooke, and others). FIA adopted the FHM plot design in 1995.

Figure 9.—*FHM sample plot design, 1993, and FIA sample plot design, 1995.*



About 1993, a debate evolved in FHM over how well the four-point cluster could be applied in the large tree stands of the West (one giant redwood would completely bury a cluster point, resulting in inaccurate area expansions of the data in those situations). Some were concerned that the small sample clusters would not adequately sample mortality, a basic driver in forest health evaluations (LaBau and Hazard 2000). Ultimately, the Pacific Northwest inventory station FIA staff endorsed the need for larger mortality plots. They incorporated the measurement of larger mortality plots into their inventory and monitoring techniques. Gray verified the need for that change in his analysis of sampling large trees in the Pacific Northwest Region (Gray 2003).

Early Reflections on the Forest Survey

Wherever Forest Survey people would get together from their respective regions, especially at the Project Leadership Team meetings, the stories would fly about who had the most unusual working conditions. In the early days, the Lake States folks would relate stories of their trips into the woods on skis or snowshoes in subzero winter weather, and their summer canoe trips into lake country overrun with biting insects. The Alaska folk could always be counted on for a story or two about encounters with the huge Alaska (Kodiak) brown bears. The Alaska crews had numerous encounters with the bears, but they only had to kill one in 50 years. At the start of field season each year, the Alaska crews had to undergo training with a .375 Magnum rifle. The Southern Station folks told about taking plots in the alligator- and snake-infested cypress swamps and having to dive down underwater to measure tree d.b.h. The next day, they might be encountering backwoods moonshiners protecting their still from the "government men." In later years, the California folks could relate to that when they encountered booby-trapped marijuana fields on their plots. Such encounters go on today and the debate also goes on as to whose plots are the most difficult to measure.

According to the history of the Lake States Forest Experiment Station, Rudolf (1985: 38) reported:

> The idea of forest surveys, which has now spread to the entire country, was born in Michigan in 1922. […] In that year, the State began county-by-county "land economic surveys" which included…a complete inventory of timber and growth. From its inception in 1923, the Station cooperated first with Michigan and later with Wisconsin and Minnesota in promoting such surveys ….

Rudolf further states (1985: 39):

> The Station received its first allotment of Forest Survey funds in 1930…

The design may have evolved from a system used in Sweden and, in the late 1920s, modified for use in the Southern United States (Rudolf 1985: 105).

Again, according to Rudolf (1985: 39):

> Lines were to be run east and west across the state with intervals of 10 miles. Along these lines, a fifth-acre sample plot was to be taken of forest cover every 10 chains (1/8 mile).

Rudolf (1985: 39) also reports that:

> Before the end of 1934, inventory figures were available for Minnesota, the first State in the United States to be so completed in the Forest Survey.

Rudolf (1985: 106) also notes:

> By 1938, all the field work and most of the compilation had been completed for the three Lake States (Minnesota, Michigan, and Wisconsin) and a report on timber supplies, growth, and depletion in the region was issued.

The first forest survey of the Lake States began in Minnesota in 1933. Survey of the Lake States was concluded in Wisconsin early in 1937 (Morgan 1960). It was in the early 1930s that forest survey was initiated in the Central States. In a history of the Central States Experiment Station, Merz (1981) reported that in 1931 the station first participated in activities that would be known as “forest survey.”

Rudolf (1985: 40) goes on to tell of the challenges encountered in the early forest survey efforts in the Lake States:

> A number of crews ran nearly 15,000 miles of line and measured 120,000 plots in Minnesota, Wisconsin, and Michigan. In the course of this trek, the men endured temperatures from -58^{o} to +108^{o}F; struggled many miles through brush and timber on snowshoes; felt the stings of hungry mosquitoes, pesky no-see-ums, and angry wasps; spent many nights in tents, or if lucky in unheated cabins during sub-zero weather (see photos 14a and 14b); waded and swam numerous streams and lakes; … survived bouts with typhoid fever, ill-tempered farm dogs, aggressive bears, and belligerent bulls; broke through the surface of burning peat bogs; and out maneuvered militant farmers (sometimes with shotguns).

Photos 14a and 14b.—*Crews measuring winter forest inventory plots in the Upper Peninsula of Michigan, circa 1978.*

(a)

(b)

In a footnote, Rudolf (1985:40) states:

> I learned that the northern Lake States swamps were tougher going than the southern swamps (see photo 15) which had poison ivy, water moccasins, and chest-deep water—while they were obstacles and nuisances, that did not compare with walking all day in sphagnum and sedge swamps, plowing through alder and hazel brush…. Since I was the only young forester—to my knowledge—with experience in both regions, there was no one, and even today there may not be anyone, to dispute my claim…. The Survey crews working in all the U.S. Forest regions felt they had it the worst, but, in my judgment and experience, the survey crews of all other forest regions really had a 'picnic in the woods' every day as compared to those hardy souls of the Lake States Forest Survey (Kaufert 1976).

Photo 15.—*Marty Curran working in Southern FIA swamps, circa 1983.*

Gafvert (1938) gives another very interesting account of forest survey experiences in an in-service Lakes States Experiment Station report titled *Tough Trips on the Lake States Forest Survey*. This document has interesting accounts of tough working conditions. Crews would go out for several days in canoes in the Lake States, paddling over a series of lakes to reach the plot area. Canoes were also used in Maine on the initial forest survey in the late 1950s.

Some interesting accounts of forest survey in the Pacific Northwest Region are found in Doig (1977). Robert Cowlin, the first leader of Forest Survey in the Pacific Northwest and later Pacific Northwest Station Director, estimated that it took 960 person-days to measure the quarter-acre plots on the 3-mile line transects in the first years. He goes on to give the following account (Doig 1977: 13).

> “The 8-hour day was unheard of, for in some instances it would take several hours or more to reach the line in the morning and a like amount of time to reach the camp, night lodging, or automobile at the end of the day.”

Despite the hard work, most Forest Survey people felt fortunate to have such an interesting and rewarding job, perhaps best expressed by Philip A. Briegleb, who joined the Pacific Northwest Station’s Forest Survey in 1929, later serving as the Pacific Northwest’s Station Director from 1963–71, when he said (Doig 1977: 26).

> “I thought the job on Forest Survey…was the best possible job in the world. It was exploring an unknown resource, in beautiful places, with some wonderful timber—and getting paid for it.”

Legacy of the Forest Survey

The initial goal of the Forest Survey program was to inventory the status of the wood and fiber resources of the United States and periodically report those results to Congress. The results surpassed the earliest hopes of McSweeney and McNary, the authors of the 1928 legislation. Over time, other significant findings were gleaned from forest survey data that spoke to emerging issues of the time.

Early results of the forest survey finally gave national planners the estimates of the area and of associated wood volume for the Nation. Early on, data were also collected to estimate the consumption of wood and fiber. Matching these timber drain estimates against the inventory, and making projections into the future, the national planners could make sound projections on the future of forest resources in the Nation. Forest Economists used these data and results to produce impressive milestone assessments by the forestry community in the Nation and the world (USDA 1958, 1965, 1973, 1982, 2001; Waddell and others 1989; Powell and others 1993; Smith and others 2001; Haynes 1990, 2003). Early assessments showed a shrinking forest area and decreasing timber supply. Later assessments chronicled the increase of forest area, the recovery of wood volume, and the increase of net growth of the Nation's forest lands (MacCleery 1993). Over time, managed forests produced a surplus of growth beyond current demands for the following reasons:

- Improved utilization by wood product users.
- Reestablishment of forests.
- Regulation of forest practices.
- Increased wood recovery by wood manufacturers.
- Greater control of wildfires and insects.
- More salvage of mortality.

In addition to meeting the requirements of the initial legislation, the data and results of forest survey were used locally and regionally to provide important administrative and policy guidance. In every region, county, and State, reports of wood and fiber resources ensued and were periodically updated. State and local planners used these reports in making decisions about their forest resources.

The Forest Survey program was a major contributor to the recently completed *National Report on Sustainable Forests—2003* (USDA 2003b). Concerns about forest sustainability have always been the major reason for doing forest surveys. In the recent report, the only indicators that could be reported on with any confidence were those based on FIA data.

The South's Third, Fourth, and Fifth Forest Reports relied on forest survey data, greatly influencing forest policy in the South (Gadbury and others 2004). The Fourth Forest Report led to greater emphasis on gaining consistency among the two Southern Forest Survey units, greater understanding of treatment opportunity data, compiling inventories on an age class basis, and recognizing planted pine as a timber and management type.

The 1978 northern California report by Oswald (1978) showed that projected timber volumes were not what had generally been expected by industry. The study was very controversial and demonstrated the value of FIA data and analysis. The study was partially responsible for causing a shift in direction of harvesting in the West.

The Eastern Forest Survey units worked closely with the State Forestry Offices in the collection of the data from State to State. This cooperation extended not just to data collection, but in some cases the State Forestry Offices provided support such as purchasing new aerial photography coverage, providing field personnel, and conducting various phases of the inventory.

In the Western United States, the Forest Survey units worked closely with the National Forest System to collect data on national forest lands. In Alaska, the Forest Survey unit continuously collected data on national forests, except for a short time in the 1980s. In the 1950s and 1960s, the Intermountain Station was responsible for collecting forest survey data on national forest lands.

Maps have historically been important media in delineating forest area. John Sandor, former Alaska Regional Forester and a member of the early 1950s Alaska Forest Survey staff, referenced the extensive early forest mapping work of the U.S. Geological Survey. The USGS did extensive work in the late 1890s surveying and mapping for Forest Reserves (many of which later became national forests), and these data were summarized in the USGS Twentieth Annual Report (1898–99) Part V, Titled Forest Reserves. These maps covered major forest areas of the United States including an 1882 forest survey map for Alaska showing timber, tundra, and glaciers. Recently, forest survey information contributed to the development of forest type maps on a national scale (Zhu and Evans 1994). Type maps were developed from forest survey information for the Forest Service, particularly in Region 2, the Pacific Northwest, and coastal Alaska. These maps were the basis for statistics and analyses related to timber supply and location and served for decades in forest management decisionmaking. In southeast Alaska, the initial forest survey provided the basis for establishing 50-year timber sales.

Forest Survey collected ownership information to determine not only the amount but also the potential source of the timber and fiber resource. The survey information indicated changes in nonforested and nonstocked areas (e.g., cotton fields in the South), producing significant regeneration in young forests. This change actually caused a net increase in forest land in certain areas. Most recently, it has been possible to determine from forest survey data that, over time, a significant amount of forest land has been lost to urbanization and road building.

As issues of endangered species evolved, forest survey data provided answers about the extent of habitat (Rudis 1991, Lennartz and McClure 1979, Lennartz and others 1983). In the 1990s, when the debate intensified on how much old-growth forest remained in the Nation, forest survey results were used to address that issue (Bolsinger and Waddell 1993, Beardsley and Warbington 1996, Beardsley and others 1999). As medical science determined that extract of yew (Taxus) had promises in treatment of breast cancer, the Pacific Northwest Station reoriented its data collection to gather inventory data on the Pacific Yew, a species that previously had not been a focus of inventories because it had no commercial value (Bolsinger and Jaramillo 1990). Although no Forest Survey papers were published on this subject, findings of the inventories were shared with the medical community (Bolsinger personal communication).

As issues of forest health evolved even before the 1990s, FIA data were used to estimate causes of tree death, acres of forest damaged, and volumes of wood and fiber lost to compromised forest health. With the advent of Geographic Information Systems, forest survey data were correlated in space, giving the land manager not only important management information about available resources, but also where the resources were located. On the Biscuit Fire in Oregon, FIA data were used to locate areas with salvable dead trees, killed by the fire. Burn severity was evaluated. In the past few decades, the importance of predicting wildfire risk and intensity has increased. In many FIA units, attention is now focusing on evaluating fuel loads, measuring fire-laddering potential in stands, and providing data on other variables that might help model wildfire intensities and rate of spread. In a similar vein, in recent years FIA teams have gone into areas of the Southern and Southeastern States and in tropical forest areas of the Caribbean to assess the forest damage done by hurricanes. Assessments were also made of hurricane damage from Hurricanes Hugo and Andrew to forests on the U.S. mainland (Sheffield and Thompson 1992, Jacobs and Eggen-McIntosh 1993).

It might seem that to some degree the various Forest Survey units went off in different directions over the years. The Northeastern Forest Experiment Station developed one set of techniques, the Pacific Northwest Station another, the Alaska unit another, and so forth. The Washington Office made little effort at nationwide conformity until the implementation of the 10-point system (USDA 1967). To an outsider, this approach may appear wasteful, but it really allowed much-needed exploration and research of techniques on a regional basis. Some Forest Survey unit's research was quite successful and adopted by other Forest Survey units. Certain techniques proved better than others did—several innovations worked in a number of regions and not in others, and a few did not work out at all. Overall, this process turned out to be the strength of the total program and is an important element of the success and legacy of Forest Survey.

It is important to note that much of the Forest Service's economics research emerged from FIA. In the past two decades, economics research has been in a partnership role with FIA. For example, the RPA timber assessments were largely supported by economics research, as was the development of ATLAS.

Early on, in a related area of forest economics, Forest Survey estimated the total volume of timber removed from the inventory. These studies took the form of timber utilization studies. Forest Survey, however, did not initially estimate the portion of these removals that found their way into timber products such as pulpwood, sawlogs, veneer logs, and other products. Beginning in the late 1950s and early 1960s, forest survey field crews sought out logging operations to estimate how much of the total volume being harvested was utilized for products and how much usable material was left in the woods or was destroyed in logging. They first estimated the volume of the standing tree by forest survey standards and then estimated the volume that was actually utilized as product. It should be pointed out that often more material was used as product than was estimated by forest survey standards.

The most significant part of the legacy of Forest Survey is the publication of thousands of county, State, and national summaries of forest inventory statistics over the past 65 years. Although these reports are not cited here, they could be the subject of an entirely separate paper. Generally, the publications cited in this paper, except for the decadal RPA reports, focus on inventory techniques development by Forest Survey and FIA staff. Another major part of the legacy are the thousands of inventory and FHM plots established by Forest Survey and FHM crews over the past 70 years. Table 2 provides an overview of when and where the Forest Survey and FIA plots were established and the year reports were produced.

Many Forest Survey clients expressed a need to know the total timber output of products. Soon Forest Survey units began producing companion reports based on mail canvasses of timber product producers and consumers to estimate the total volume of timber products output (TPO). As a result, the Eastern units conducted annual mail canvasses of pulp mills and periodic canvases of other timber product producers, usually in conjunction with forest surveys in the various States. In regions where survey cycles became increasingly longer, these mill surveys would provide critical information for modelers attempting to conduct midcycle updates of the forest resources.

Among those who conducted some of the early TPO and utilization studies were Blyth (1971), Blyth and Smith (1980), Blyth and others (1988), and Smith (1991) in the North Central Region. Kingsley (1966) along with Dickson (1968) conducted some of the early studies in the Northeastern Region. Other regional studies were conducted by Brian Wall in the Pacific Northwest and Herb Knight and Dan Bertelson in the Southern Region. Bones (1962, 1963a, 1963b) was involved in timber utilization studies in Alaska.

Table 2.—*Forest Inventory and Analysis dates of statistics by State (1930–2003).*

Region/State	Timeframe								Annual inventory initiated*
	1931–40	1941–50	1951–60	1961–70	1971–80	1981–90	1991–99	2000–04	
Northern Region									
Connecticut			1957		1972	1985	1998	2004	2003
Delaware			1957		1972	1986	1999	2004	2004
Illinois		1948		1962		1985	1998	2004	2001
Indiana		1950		1967		1986	1998	2004	1999
Iowa			1954		1974	1990		2004	1999
Kansas	1936			1965		1981	1994	2004	2001
Maine			1959		1971	1982	1995	2004	1999
Maryland		1950		1964	1976	1986	1999	2004	2004
Massachusetts			1953		1972	1985	1998	2004	2003
Michigan	1935		1955	1966		1980	1993	2004	2000
Minnesota	1936		1953	1962	1977	1990		2004	1999
Missouri		1947	1959		1972	1989		2004	1999
Nebraska			1955			1983	1994	2004	2001
New Hampshire		1948	1959		1973	1983	1997	2004	2002
New Jersey			1956		1972	1987	1999	2004	2004
New York			1953	1968		1980	1993	2004	2002
North Dakota			1954			1980	1994	2004	2001
Ohio			1952	1968	1979		1991	2004	2001
Pennsylvania			1955	1965	1978	1989		2004	2000
Rhode Island			1953		1972	1985	1998	2004	2003
South Dakota	1935			1962		1980	1995	2004	2001
Vermont		1948		1966	1973	1983	1997	2004	2003
West Virginia		1949		1961	1975	1989		2004	2004
Wisconsin	1936		1956	1968		1983	1996	2004	2000

* Year that new annualized inventory began, measuring plots (15% in East and 10% in West) in each State every year.

Table 2.—*Forest Inventory and Analysis dates of statistics by State (1930–2003) (continued).*

Region/State	Timeframe								Annual inventory initiated*
	1931–40	1941–50	1951–60	1961–70	1971–80	1981–90	1991–99	2000–04	
Southern Region									
Alabama	1935		1953	1963	1972	1982	1990	2004	2001
Arkansas	1935	1949	1959	1969	1978	1988	1995	2004	2000
Florida	1936	1949	1959	1970	1980	1987		2004	2001
Georgia	1936		1953	1961	1972	1982	1989	2004	1999
Kentucky		1949		1963	1975	1988		2004	1999
Louisiana	1936		1954	1964	1973	1984	1991	2004	2000
Mississippi	1934	1947	1957	1967	1977	1987	1994		
North Carolina	1938		1955	1964	1974	1984	1990	2004	2000
Oklahoma	1936		1956	1966	1975	1986	1993		
South Carolina	1936	1947	1958	1968	1977	1986	1993	2004	1999
Tennessee		1950		1961	1971	1980	1989	2004	1999
Texas	1935		1955	1965	1975	1986	1992	2004	2001
Virginia	1940		1957	1966	1977	1984	1992	2004	1998
Interior West Region									
Arizona				1962		1985	1999	2004	2001
Colorado			1959			1983		2004	2002
Idaho			1954			1981	1991	2004	2004
Montana		1949			1980	1989		2004	2003
Nevada						1989		2004	2004
New Mexico				1962		1987	1999		
Utah				1961	1978		1993	2004	2000
Wyoming				1960		1984			
Pacific Coast Region									
Alaska—Southeast				1967	1975	1984		2004	2003
Alaska—Other				1967	1975	1987	1994		
California		1946	1953	1963	1975	1985	1994	2004	2001
Hawaii				1961	1970	1986			
Oregon	1933-36		1955	1963	1973	1986	1992	2004	2000
Washington	1933-36		1955	1963	1973	1980	1991	2004	2002
Puerto Rico						1980	1990	2003	
U.S. Virgin Islands								2004	
American Samoa						1986		2001	
Guam						1986		2002	
Republic of Palau						1986		2003	
Federated States of Micronesia						1986			
Northern Mariana Islands						1986		2004	
Republic of the Marshall Islands						1986			
All Inventories	**18**	**15**	**33**	**36**	**36**	**56**	**39**	**51**	**45**

* Year that new annualized inventory began, measuring plots (15% in East and 10% in West) in each State every year.

Toward the Future

In the late 1980s, the North Central Station's FIA unit began working on an annualized forest inventory system (AFIS) concept based on the Ph.D. thesis of Mark Hansen. The concept was to integrate modeling and disturbance-based sampling into a systematic inventory to produce inventory estimates in a more timely and cost-effective way. The Minnesota Department of Natural Resources and the FIA National Techniques Unit in Ft. Collins, CO, actively supported this work.

As research progressed on AFIS, scientists at the Southern Research Station adapted the basic concept (SAFIS) but dropped disturbance detection and modeling for the simpler process of measuring a uniformly spaced 20 percent of all the plots in a State each year. This simpler approach was supported by increased financial input from the States and formed the basis of the national annualized inventory system that FIA uses today. Although disturbance-based sampling proposed by the AFIS pilot project did not become part of the national system, it was the beginning of annualized inventories and many of its remote sensing, modeling, and sampling design features continue to be part of program research to make FIA inventories more efficient.

In the 1990s, the need for change in how FIA conducted business became the focus of many public debates. These debates intensified as budgets stagnated and FIA resource data became older and less viable for planning purposes. Vocal clients called for a review and reinvigoration of the FIA aimed at developing a more responsive program that could deliver a more robust suite of information about the Nation's forests in a more timely manner.

In **1991**, a Blue Ribbon Panel (BRP) reviewed the FIA and FHM programs (American Forest Council 1992a, 1992b). This panel presented its findings to Forest Service Chief Dale Robertson in October 1992 and then to Chief Jack Ward Thomas in October 1994. At about the time of the first BRP, Jim Bones, Brad Smith, and Doug Powell published *A Blueprint for Forest Inventory and Analysis Research and Vision for the Future* (Program Aid 1512) outlining many of the tenets of the First BRP Report (USDA 1993).

1991—First Blue Ribbon Panel reviews forest inventory programs.

A second BRP met in 1997 (American Forest and Paper Association 1998) and a third met in 2001 (American Forest and Paper Association 2001) to reemphasize the resource communities' support and desire for continuous improvement in the FIA program. Dr. John Moser of Purdue University was a very active participant in these BRPs. The general recommendation of each committee was that FIA and the plot phase of the FHM programs be merged, using a national grid system and the four- point cluster plot design (see figure 9). A further recommendation was for the survey interval to be cut back from the earlier 5-year request to an annualized inventory operating across all States, simultaneously taking 15 percent of the plots annually (7-year plot cycle) in the East and 10 percent of the plots annually in the West (10-year plot cycle).

As early as March 1995, FIA began preparing for a very different future. For the first time since 1967, a new plot design was adopted as the new national standard for FIA. Beginning with the 1996 field season, all new inventories would be established with the new plots. In addition, a national cell grid approach was adopted to integrate the newly merged FIA/FHM plots into a consistent national framework. The new base cell grid consisted of hexagons about 6,000 acres in size for the base FIA plots and roughly every 1/16th of these plots would have added forest health measures taken. The migration to this new grid was done in such a manner as to minimize the loss of historic plot data.

In 1997, organizational changes in Research coincided with BRP calls for stronger action. A new staff called Science Policy, Planning, Inventory, and Information was created with Dr. Richard (Rich) Guldin as Director. Rich embraced the challenge of bringing FIA into the 21st century and appointed Dr. Andrew (Andy) Gillespie as the FIA National Program Leader. Brad Smith served as Associate National Program Leader. Under Andy's leadership, FIA embarked on some of the most significant program changes in seven decades.

After the 2001 update session, the Blue Ribbon Panel again presented their findings to Chief Michael Dombeck, other Forest Service staff, and the National Association of State Foresters. A memorandum of understanding was signed to establish a general framework for implementing the annualized FIA program. The language and concept were consistent with the direction contained in the Agriculture Research, Extension, and Education Reform Act of 1998 (Farm Bill) and assured that the Congressional intent would receive priority and full funding within the agency. The new FIA leadership in Washington, DC, would concur.

Until 1998, FIA sampled each State on a periodic basis with cycles ranging from 7 to 15 years. The Agricultural Research, Extension, and Education Reform Act of 1998 amendment to the Forest and Rangeland Renewable Resources Research Act of 1978 (PL 95-307) revised the previous mandate to provide (1) annualized State inventories with data collected in each State each year; (2) 5-year reports for each State and the entire Nation, including an analysis of forest health; (3) national standards and definitions, including a core set of variables to be measured on all sample plots and a standard set of tables to be included in the 5-year reports; and (4) a strategic plan to be presented to Congress on how the changes would be implemented.

In addition to defining how the FIA program would transition to annualized inventories, the Strategic Plan also addressed many of the recommendations of the earlier Blue Ribbon Panels on FIA and set the stage for changes that would reshape the FIA program (Van Deusen and others 1999).

Successful implementation of the strategic plan required close collaboration among many partners to deliver desired outcomes. These partners include three branches of the Forest Service—Research and Development, National Forest System, and State and Private Forestry—as well as State forestry organizations represented by the National Association of State Foresters. The new organizational structure possessed the following elements:

1. An executive team composed of Forest Service senior executives and State foresters to provide the broad oversight for policy issues.

2. A management team composed of FIA program managers and other partners who make decisions regarding FIA program elements of national concern.

3. Technical bands composed of groups of individuals with expertise in various technical areas who are responsible for developing methods and approaches needed to implement the FIA program. Current major band themes are Data Acquisition, Analysis and Reporting, Information Management and Compilation, Remote Sensing, and Statistics.

4. Regional management teams composed of representatives of the partners in each of the five FIA geographical regions involved in developing regional enhancements to the national FIA program and in implementing the FIA program within their respective region.

5. User groups composed of a broad array of FIA program customers including State and other Government organizations, researchers, industry, environmental organizations, and others who use FIA information. User groups exist for each regional program as well as for the national program, and provide valuable feedback for improving the FIA program.

By the end of 2004, through dedicated leadership and the initiative of the new organizational structure, 45 States (82 percent of the Nation's forests) were active in the new annualized inventory system and a dozen States were preparing to conduct the first remeasurements of the new plot design and develop trend data.

The future of FIA, as in the past, is still timber, but it is so much more. A National Information Management System (NIMS) has been completed and will serve both internal and external data needs. Work is under way to develop a set of standardized map products such as forest type maps, biomass maps, and a myriad of other spatial products. Since the mid-1980s (Rudis 1991), FIA and its cooperators have published more than 1,400 papers and articles on nontimber uses of FIA data. Clearly, FIA's client list and program value will continue to grow to meet the needs of monitoring the sustainability of the Nation's forest ecosystems.

In addition to traditional field work, the new FIA continues to conduct surveys of private forest owners to assess their ownership objectives, track wood harvested from America's forests, and conduct utilization studies on active logging operations to provide the factors needed to link the input (trees standing in the forest) with the output (wood products produced by a mill).

Collaborative relationships with universities, industry research organizations, interest groups, and other Federal agencies have been strengthened, allowing FIA to gain increased experience in specialized areas, as well as gain access to creative scientists outside of the Forest Service.

For more than 75 years, the emphasis of FIA has been data quality. The new program continues this tradition with a Quality Assurance program that includes documentation of methods, training for data collectors, checks of data quality, peer review of analysis products, and continuous feedback to ensure that the system improves over time. The search will go on for more efficient and more cost-effective ways of fulfilling the FIA mission. Dedicated men and women will continue to evaluate forest inventories and forest health, producing information and analyses that will serve generations well into the future.

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