A HISTORY OF FOREST SURVEY IN ALASKA
Part II of a History of Forest Research in Alaska

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Cover Photo Information (From Upper Left, Clockwise)

Ron Dippold (Juneau FSL) and Harry Johnson (BLM) unload a Grumman Goose on the Kuskokwim Forest Survey, 1967.

David Born (Juneau FSL) scribes a witness tree near plot center on the first Kenai Forest Survey, ca 1961.

Jim LaBau (Juneau FSL) boarding an H-21 Air Force helicopter to measure a Forest Survey plot near Galena, Alaska, ca 1962.

Ken Winterberger (center back) and crew measuring a plot on the Porcupine Forest Survey, 1978.

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Acronyms

ATLAS	**Aggregated Timberland Assessment System**
AVHRR	**advanced very high resolution radiometer**
BRP	**Blue Ribbon Panel**
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**
FORTRAN	**Formula Translation**
FPL	**Forest Products Laboratory**
GPS	**Global Positioning System**
HV	**horizontal-vertical**
IBM	**International Business Machines**
KPC	**Ketchikan Pulp Corporation**
NAPAP	**National Acid Precipitation Assessment Program**
PI	**photo interpreted**
PNW	**Pacific Northwest**
PPA	**probability proportional to plot area**
PPS	**probability proportional to tree size**
RET	**Resources Evaluations Technique**
ROS	**Recreation Opportunity Spectrum**
RPA	**Resources Planning Act**
TPO	**timber products output**
TRAS	**Timber Resource Analysis System**
UNIVAC	**Universal Automatic Computer**
USDA	**U.S. Department of Agriculture**
USFS	**U. S. Forest Service**
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 m3

Acknowledgments

There are several entities that need acknowledgment for their vision and contribution to this work, most prominent being John Sandor, Roger Burnside, Beth Schulz, Fred Larson, and Arland Harris. Matthew Breest redrew many figures. Jane Oakley, Oakley Associates, Anchorage, made a valuable contribution by providing an editorial review. I also acknowledge other contributors, too many to list, who provided input and editorial comments (See page 26).

Introduction

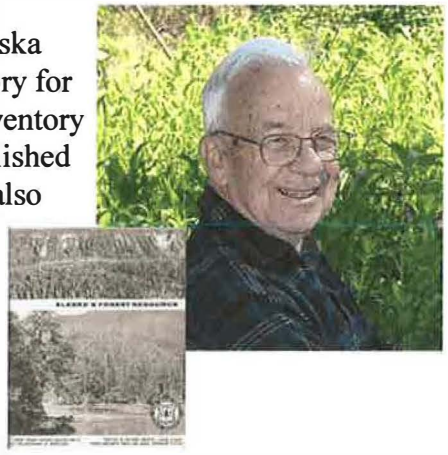
The history of the Alaska Forest Survey program (later renamed to Forest Inventory Analysis-FIA), as it evolved within the U.S. Department of Agriculture (USDA) Forest Service, is an interesting story. The story begins in the early 1950s. This paper is for those readers who wish to understand the evolution and contribution of the Alaska Forest Survey program. Considerable attention is given to describing five different plot designs that were used since the 1950s and in explaining how the focus and goals of the Alaska Forest Survey program changed over time.

The National Forest Survey program has always been faced with a variety of conflicting objectives—timber volumes, reproduction success, species composition, and tree quality. The Alaska Forest Survey program has faced the same changing objectives over time. Statistical efficiency for one objective often compromised the estimate of other attributes. Difficulties occurred in estimating growth, mortality, removals, forest type, condition class, and other multi-resource variables that the inventory estimated. The earliest Alaska 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 and Alaska's timber supply and consumption has expanded to a multi-resource and multi-functional program.

In Remembrance

O. Keith Hutchison (1917-2011) was Project Leader at the Alaska Forest Research Center and Juneau Forestry Sciences Laboratory for 20 years (1959-1979). Under his leadership, the first forest inventory for Alaska was completed. Results of that inventory were published in 1967. Scores of other Alaska forest inventory publications also emerged under his leadership.



1967 Hutchison, O. K., 1967. Alaska forest resource. Res. Bull. PNW 19. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p.

Background

The concern for forest resources existed early in U.S. history, resulting in several early efforts to estimate those resources. 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. An early assessment of forests of the world was completed by Zon in 1910. 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.

At the same time, Kellogg (1923) put forth an appeal for a national forest inventory. Clapp (1926) made a strong request for a national forest survey which led to passage of the McSweeney-McNary Act (1928). The McSweeney-McNary Act ordered 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:

> "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 the National Forest Survey program was G.M. Granger with the title of Head Economist (Stuart 1930).

In the years shortly after World War II, in an effort to establish a pulp industry in southeast Alaska, a series of 50 year sales were awarded in Ketchikan, Wrangell and Sitka (Bruce 1960; Greeley 1954), and another was attempted on Admiralty Island (Lockhart 1966). These and other smaller proposed timber sales provided the impetus for conducting statistically based forest surveys in southeast Alaska.

Evolution of Alaska Forest Survey Techniques

The earliest Forest Survey efforts took place in the southeastern United States and in the Douglas-fir region of the Pacific Northwest (PNW). Graves (1912, 1917) set down principles and guidelines for timber surveys (Photo 1) and included a standard classification for forest types. Doig (1976; 1977) described that first PNW forest survey occurring in the Pacific Coast Cascade Douglas-fir forests in the 1930s (Cowlin 1932; Andrews and Cowlin, 1940). That first inventory in Oregon and Washington used a combination of type maps and line transects with sample plots.

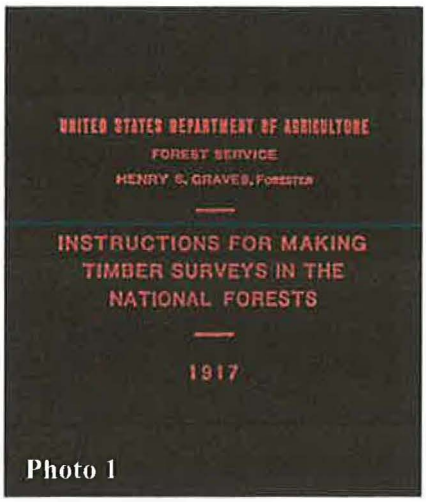


Photo 1

The sampling method (Figure 1) 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). Statistical reports were issued, and an impressive analytical report was published in 1940 (Andrews and Cowlin 1940).

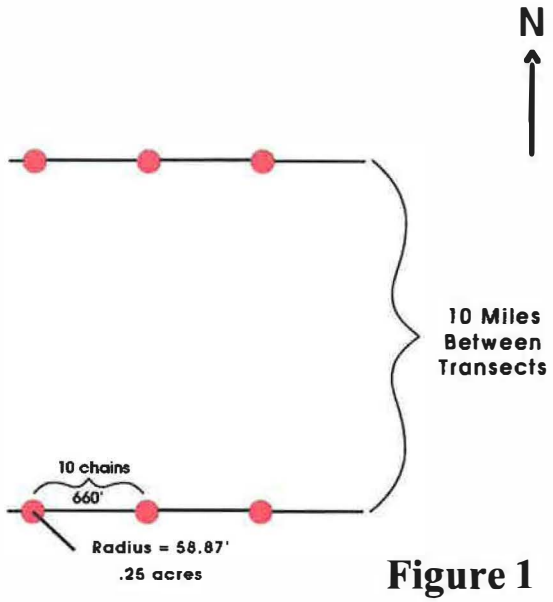


Figure 1

In the late 1930s and just following World War II, the various Forest Survey units in the lower 48 began to use nested circular or nested rectangular plot designs. By the time Forest Survey came to Alaska in the early 1950s, the plot design proposed for Alaska by the Washington Office was a series of three nested rectangles.

That initial Alaska Forest Survey used a 2-phase sampling design (Bickford 1952). The ground plot system (USDA 1954) was a three subplot rectangular series, each subplot being 2 chains (132 feet) long and 1 chain wide, with a 2-chain distance between the first and second subplots and again between the second and third subplots (see Figure 2). The total transect for the three subplots covered 10 chains (660 feet), oriented up and down the slopes of the area sampled. It basically covered one acre of area. Austin Hasel and Robert Larson, statisticians of the Forest Service Washington Office Research Division, developed this system (Hasel 1961).

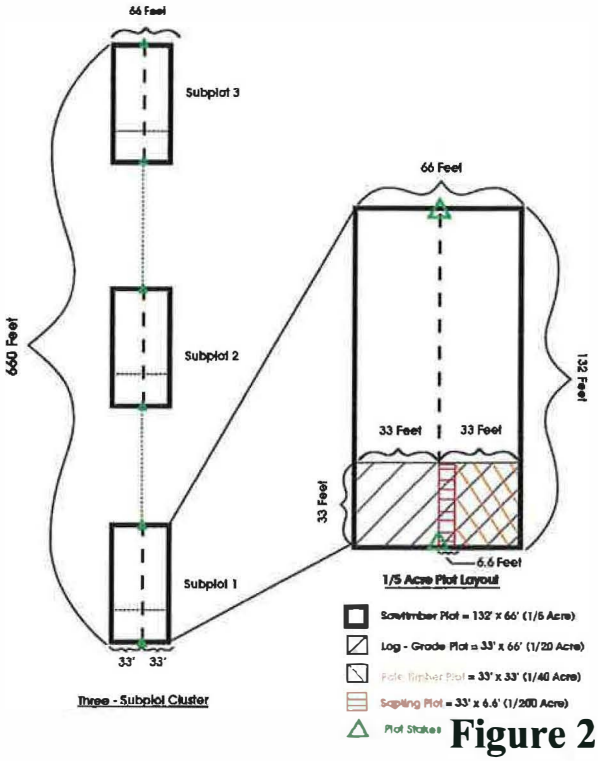


Figure 2

There was a great deal of interest in the data resulting from the initial Forest Survey of Alaska. Regional Forester Frank Heintzlman (1928, 1949), with support from the Washington Office, was on a professional mission to bring forest industry to southeast Alaska. Pulp mills would process the hemlock forests, with sawmills utilizing the larger Sitka spruce forests. The first mills were scheduled to go into Ketchikan and Wrangell, and so the Forest Survey assessment focused on the southern areas of southeast Alaska, The Ketchikan Pulp Corporation (KPC) survey unit, focused inventories to supply that KPC mill.

Ray Taylor was the first Director of the Alaska Forest Research Center in Juneau. A. P. Caparoso was appointed as the first Project Leader for Alaska Forest Survey.

There was apparently a preliminary KPC "pulp-timber survey" done as early as 1944, which was brought under question when Taylor's research teams developed type maps in 1949 and 1950 (Geier 1998, p.60). Subsequently, the Research Center and KPC set up a new inventory process. Those inventories combined crew members from the Forest Service and the Ketchikan Pulp Corporation (KPC). Some of the people working the initial field crews, who later were to make substantial contributions to Alaska Forest Research included Arland Harris, Tom Laurent, Paul Haack, Tom Jones, and John Sandor (later Regional Forester). Tom Kelly was one of the significant field leaders from KPC.

The southeast Alaska Forest Survey initial effort began in the KPC unit about 1953 and worked north, completing the effort in the Yakutat unit in 1957. That initial southeast Alaska Forest Survey chronologically focused on the following units:

Juneau Unit, 1955
Sitka Unit, 1956
Petersburg-Wrangell Unit, 1956
Ketchikan Unit, 1957
Ketchikan Pulp Unit (primarily on Prince of Wales Island), 1957
Yakutat Unit, 1957

The usual Forest Survey variables were measured on the ground plots for seedlings, saplings, poletiimber, sawtimber, timber quality, and mortality (USDA 1954). There were 700 ground plots measured on commercial forest land throughout southeast Alaska in this effort, systematically sampled from a list of 23,265 photo plots.

There was a 3-year hiatus as the data were worked up and reports (USDA 1957, 1958a, 1959a, 1959b, 1962) were prepared by A.P. Caparoso's Forest Survey team, with the assistance of staff from Region 10. These reports resulted in Region 10 writing Unit Management plans (Weisgerber and Johnson 1958) and other related articles (Lockhart 1966). Also during that 3-year hiatus, preparations were being made to conduct the Forest Surveys in the Chugach National Forest and Interior Alaska.

In 1959, A.P. Caparoso transferred to the Intermountain Forest and Range Experiment Station in Ogden, Utah, and O. Keith Hutchison replaced "Cappy" as head of the Forest Survey at the Alaska Forest Research Center in Juneau. At that time, the Alaska Forest Research Center's Forest Survey unit added several new faces: Wilbur Farr, Jim LaBau, and Jim Bones, and a year later J. David Born, supported by Robert Mattson from Region 10.

In 1961, the Forest Survey began inventory of the Chugach National Forest. It was subdivided into three sections:

Unit 1 Prince William Sound (PWS) Mainland and Island Archipelago
Unit 2 Afognak Island Unit (later transferred to the Afognak Native Corporation in the late 1980s)
Unit 3 Kenai Unit

Paul Haack was the field supervisor for that work, with most of the field work being done by Karl Hegg, Bill Farr, Dave Born, Robert Mattson, Jim LaBau, and Jerry Meyer. The field work took two years, and used the same field plot design as was used in southeast Alaska. There were 74 plots measured on commercial forest land on Unit 1, 55 plots on Afognak, and 70 plots on the Kenai Unit using the initial coastal Alaska forest survey system (Figure 2).

One of the challenges in the Chugach Forest Survey was to develop volume tables for Units 1 and 2 (PWS and Afognak). Paul Haack, Tom Laurent and Bill Farr were actively involved in collecting the tree data for those volume tables (Haack 1963c).

Plot layout was very challenging on some of the Prince William Sound islands. One plot on Latouche Island had a 200 percent slope, and required hanging on from tree to tree when working this plot. Afognak Island was quite interesting from a number of aspects. One of the main routes of ground transportation followed the trails of the huge Kodiak bears. Another interesting aspect was that all of the sawtimber trees had about 1 inch of ash on the tops of branches, due to ash fall from Mt Augustine on the Alaska mainland. The ash had to be removed to measure tree diameters just above branches on these larger trees. Where soil pits were dug, the ash layer was evident for up to 6 inches below the duff .

The inventory of the Kenai unit was unique. It was the only area of coastal Alaska's Forest Survey where access was available from an established road system, requiring less use of helicopters and float planes.

About 1963, after completion of the Chugach Forest Survey, the focus of the Alaska Forest Survey turned to the rest of Alaska north of the Chugach National Forest. The inventory design used in Interior Alaska called for breaking the rest of the state into 10 inventory units, as follows:

Unit 1 The Susitna River Unit
Unit 2 The Kenai Unit (west of the Chugach National Forest)
Unit 3 The Tanana/Fairbanks Unit
Unit 4 The Upper Tanana Unit
Unit 5 The Copper River Unit
Unit 6 The Upper Yukon Unit
Unit 7 The Lower Yukon Unit
Unit 8 The Kuskokwim Unit
Unit 9 The Bristol Bay Unit
Unit 10 The Norton Sound Unit

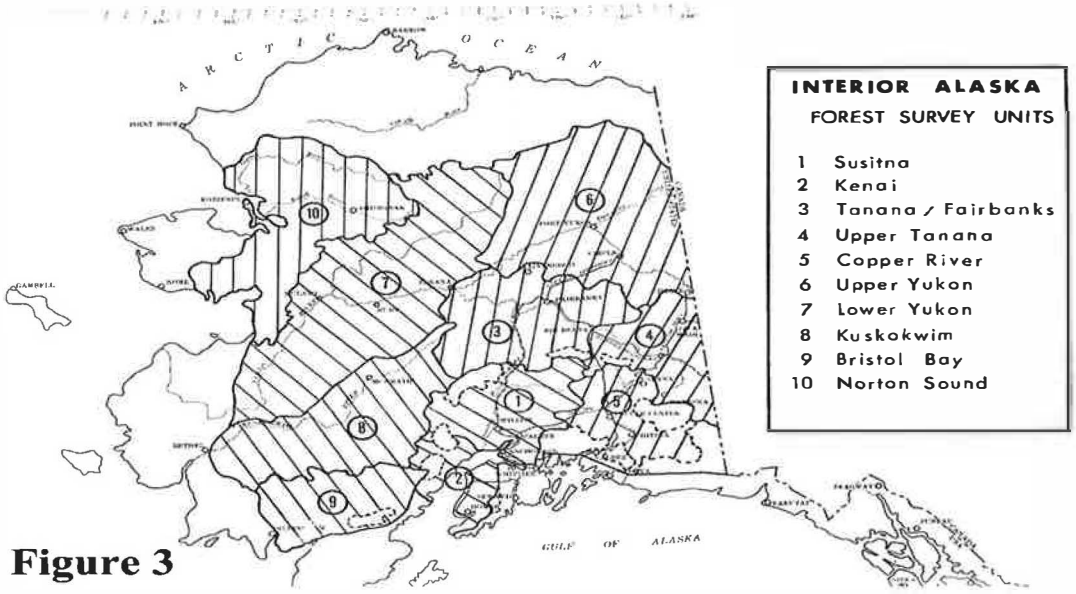


Figure 3

Each of these units had 1:5,000 black and white infrared photography flown on flight lines 25 miles apart, perpendicular to the general direction of the main drainage. (Figure 3. Map from Hutchison, 1967)

The "Interior Alaska" Forest Survey design was intended to be a three-phase sampling design. The intention was to have a photo interpretation phase, underlain with an "air-check" phase, and then a visit of ground plots. During the first phase, any points interpreted as "commercial forest" would have tree heights and crown diameters measured to be used for an estimate of volume at the second phase. Paul Haack provided much of the leadership in developing this design (Haack 1962) with the help of the Washington Office. Haack also developed a set of aerial stand volume tables for use in estimating volume during the second phase (Haack 1963a) and normal volume tables (Haack 1963b) for use in assessing volumes..

It was a good concept, but, there were problems developing the statistical estimators for the three phase design, and so final estimates were worked up as with a two-phase design, using only phase 1 and phase 3 estimates. The phase 2 aerial stand volume estimates were not used in the final analysis.

The ground plot design was a single .5 acre plot, 5 chains (330 feet) long and 1 chain (66 feet) wide. The usual Forest Survey variables were measured for seedlings, saplings, poletiimber, sawtimber, and mortality. There were about 100 plots taken on commercial forest land throughout interior Alaska in this effort (Figure 4).

About the time the "Interior Alaska" Forest Survey got underway, a new concept in Forest Survey design began to emerge. It was called "variable plot sampling," (Bitterlich 1948; Grosenbaugh 1952, 1958; Spada 1960) , later known as "prism cruising" (Bruce 1955). Some testing of the new "variable plot sampling" design was completed on the .5 acre Interior Alaska plot design in anticipation of having to use that design in the future (Hegg 1967).

In 1967, Hutchison prepared a publication (Hutchison 1967) that served for decades as the only report on all the forest inventory statistics for Alaska, and provided the first Alaska forest statistic to be used in the National Forest Survey reports (USDA 1973). This report gave an overview of both coastal and interior Alaska Forest Survey results. An earlier

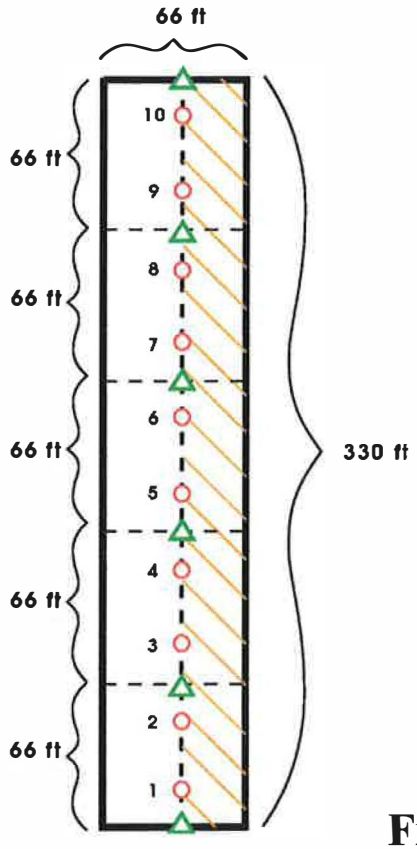


Figure 4

Plot Size

- Sawtimber Plot - size = 330 ft by 66 ft (1/2 Acre)
- Poletimber Plot - size = 330 ft by 33 ft (1/4 Acre)
- Seedling-Sapling Plot - size = 4.16 ft radius (1/800 Acre)
- Plot Stake

National Forest Survey report had listed the southeast Alaska statistics found in the 1950s inventories (USDA 1965).

After completion of the Interior Forest Survey in 1963, the Forest Survey efforts in Alaska were divided between Interior Alaska with Karl Hegg heading up field crews as efforts were directed at cooperating with Alaska State, BLM, and Bureau of Indian Affairs to do special inventories over a period of about 10 years. The new 10 point design served as the basis for these inventories, and resulted in several local inventory reports.

In southeast Alaska, in the early 1960s, the Sierra Club along with other environmental groups, began to oppose the long-term timber sales and procedures used in harvesting old-growth stands. These resulted in a series of court cases (Adasiak 1971), two brought against the Forest Service and one against the State of Alaska. One of the tactics used by some of the long-term sale companies to try to get into contingency areas was to say that the timber inventory volumes reported by Forest Survey were not sufficient to support their long-term sales. The Sierra Club picked up on this, and one of their tactics used in the two Forest Service lawsuits was to question the statistics reported by Forest Survey in southeast Alaska.

It was decided that a "re-measurement survey" should be conducted in southeast Alaska to re-evaluate the forest area and volume statistics reported in the 1950s inventories. The re-measurement survey took 5 years, and covered the following units in the following order:

Juneau Unit, 1964
Sitka Unit, 1965
Petersburg-Wrangell Unit, 1966
Ketchikan/ Prince of Wales Island Units, 1967
Yakutat Unit, 1968

There were about 250 grounds re-measured on commercial forest land throughout southeast Alaska in this re-measurement survey. There was a special sub-sample of young-growth plots added because there were so few young-growth plots sampled during the 1950s inventories. Results of these re-measurements affirmed that the areas and volumes estimated in the 1950s inventories were not overestimated, and if anything, slightly underestimated. The results of these re-measurement studies are reported in Hutchison and LaBau (1975). In a statistical analysis, comparing initial inventory average volumes with those of the re-measurement study, there was no statistical difference when tested at the 5% level of probability, thus affirming the validity of the inventories done in the 1950s. This negated the Sierra Club's court claim that the volumes were not present to support the long-term timber sales. The US Forest Service prevailed in the Alaska courts. California courts eventually reversed the Alaska Court rulings, but not on the basis of insufficient timber volumes.

During this time, there was also a cooperative effort with the State of Alaska to inventory the Haines/Skagway Unit (LaBau and Hutchison, 1976).

Also at this time, the Washington Office decided to change forest inventory systems and use the variable plot sampling system nation-wide. A study was set up in Alaska establishing ten 3.5 acre stem mapped plots in the Juneau and Petersburg units to collect plot data to decide what ground- plot design should used for measuring coastal Alaska.. Computers were used to test several designs for accuracy and precision estimates of basal areas on these 10 stem mapped plots. The 10 test plots were laid out to cover areas 7 x 5 chains in size, and all trees 3 inches and larger were stem mapped within those 10 plots. Slope

corrections were made throughout the plots. These stem mapped data were sampled on a computer using the variable plot sampling method.

The following designs were tested, giving 35 combinations to evaluate for accuracy and precision:

Grid-points per sample plot	5	7	10	15	20		
Basal Area Factors tested	5	10	20	40	75	120	200

A program had to be written to perform the tests. Paul Haack prepared the initial program in FORTRAN II for an IBM 1620 computer. The program was eventually re-written to run on the Bonneville Power 7094 in Portland. Jim LaBau used this study for a Masters Thesis at Oregon State University in 1967 (LaBau 1967). Results indicated that the most precise and most accurate combination for using variable plot sampling in southeast Alaska was the 75 factor prism on a 7 point plot. Eventually, the decision was made to use the 75 factor prism with the new standard 10-point cluster (Figure 5).

During the 1970s a reinventory program was initiated in southeast Alaska with Jim LaBau as Field Supervisor. Simultaneously,10-point inventory plots were measured in interior Alaska with the variable plot design under the leadership of Karl Hegg, but with a 30 factor prism.

The 1970s nation-wide forest inventory efforts followed the new 10-point National design (USDA 1967). The inventory plot design used variable plot cruising on the 10-point equi-distant grid of sub-points (Figure 5). In coastal Alaska, Region 10 National Forest Systems providing funding and personnel (USDA 1970). The southeast survey units, were inventoried by the following dates:

Juneau Unit, 1970
Sitka Unit, 1971
Petersburg-Wrangell Unit, 1972
Ketchikan/ Unit, 1973
Prince of Wales Island Unit, 1974
Yakutat Unit, 1975

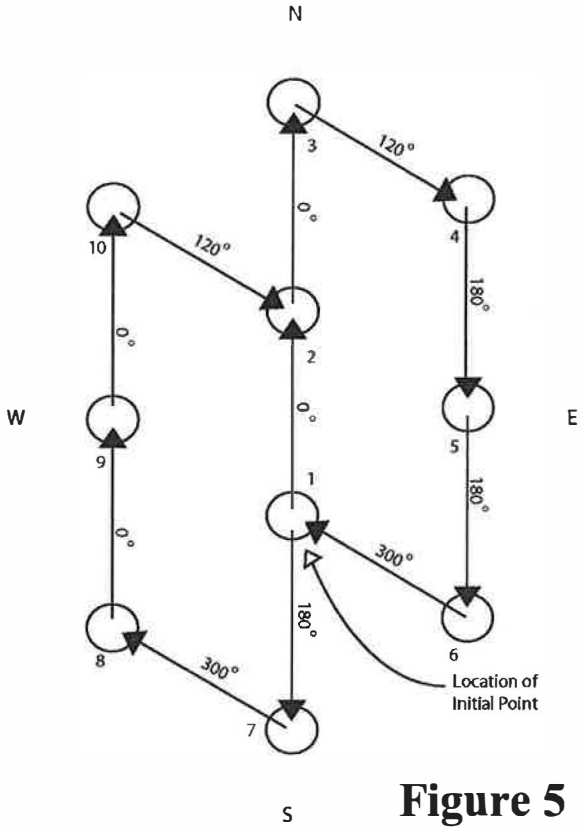


Figure 5

In 1976, there was also a cooperative effort with the State of Alaska to conduct an inventory on State lands in the Yakataga Unit. In 1976, Region 10's Timber Management staff assumed inventory responsibilities for the Tongass and the Chugach National Forests, and conducted another round of inventories between 1976 and 1980, focusing on getting "in-place" information, and tying the data to GPS. During this same period, localized forest inventories continued in interior Alaska, in cooperation with state and federal agencies.

In 1975, a special application of 3-P sampling (Grosenbaugh 1971) was implemented in evaluating timber sale volume on the Paranosa sale on Afognak Island. Tommy Thompson, Afognak Ranger on the Chugach National Forest requested that a special 3-P design be developed for use in that timber sale layout. The statistical design was developed by Floyd Johnson, head statistician of the PNW Station. Forest Survey crews from the Juneau Forestry Sciences Lab assisted in on-site sampling layout. It was a highly successful sale layout, as later reported by Dippold (1981).

During the late 1970s, the interior Alaska Forest Surveys expanded over local and regional areas, using improved remote sensing techniques (Hegg etal 1981).

In 1979, Keith Hutchison retired as Project Leader for the Alaska Forest Inventory and Analysis (FIA) program with 44 years of service in US Forest Service Research, 20 years of that in Alaska. Jim LaBau was appointed Project Leader, and the headquarters for the project was moved to Anchorage. LaBau had received a transfer to the Research Evaluations Techniques Program (RET) in Fort Collins, Colorado in 1975, and for four years, worked with a team evaluating state-of-the-art resource inventory techniques. In 1979, LaBau was transferred back to Alaska and brought with him RET Techniques and ideas for implementing the latest natural resource inventory techniques in Alaska. These included implementing:

Use of landsat remote sensing (Aldrich 1979; Colwell 1968)
Use of low altitude color infrared photography
Inclusion of horizontal/vertical (HV) vegetation sampling (McClure etal 1979; Cost 1979)

With the help of John Hazard of the PNW Station and Hans Schreuder of the Rocky Mountain Station's RET unit at Fort Collins, a four-phase sampling system was developed with the intention of completing a state-wide inventory of Alaska using this system (Winterberger 1984; Schreuder etal 1995; Li etal 1984). The grid for the design sampled Landsat on a 5 kilometer grid (5 km), 1:63,000 high altitude color infrared (IR) photos every 10 km, 1:5,000 low altitude photos every 20 km, and a 19 point ground sample plot every 40 km (Figure 6).

The ground plots were photo interpreted into level 4 vegetation types (Viereck etal 1992), and summarized as in-place data in a digital format. Aerial stand volume tables were developed for measuring plot volumes on the low altitude photos (Setzer and Mead 1988). Fred Larson was the Field Supervisor for this effort.

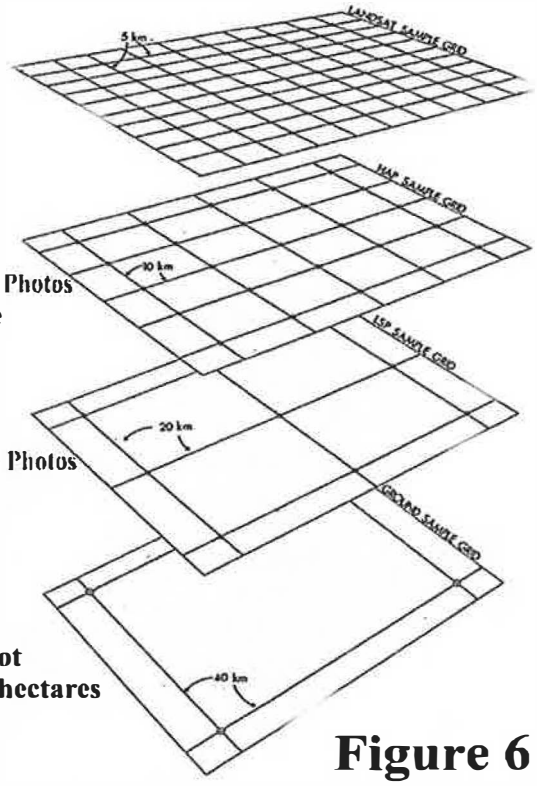


Figure 6

Procedures were developed by the University of Alaska Fairbanks for estimating tree biomass (Yarie and Mead 1982) and plant foliar cover in the 4th phase using a "Horizontal /Vertical " descriptor (Figure 7). Subsequently, biomass coefficients were developed for Interior Alaska by Yarie and Mead (1988) and for southeast Alaska (Yarie and Mead, 1989), thus facilitating the estimate of understory phytomass. With these data in hand, it was possible to respond to a Washington Office request for a nationwide report on forest biomass (Cost, etal., 1990).

The high altitude color IR photos already existed, having been flown in a state-wide project in cooperation with several state and federal agencies during the late 1970s and early 1980s. The low altitude photos had to be flown, and that was done with the assistance of Richard Meyer of the RET unit out of Fort Collins., Colorado.

All of southeast Alaska was inventoried using the four-phase system in the early 1980s, along with the Tanana River basin in interior Alaska. As the sample system was directed to some of the more remote areas of Alaska, two weaknesses in the system evolved. The first was the difficulty of obtaining cloud-free scenes for the low altitude photography. The second was that interpretation of first phase Landsat imagery did not perform as hoped. The Landsat phase accounted for only about 5% of the sampling error. There were also other problems in developing estimators for the four phase design. Problems also arose in that the correlation of data information between the lower levels was not as high as had been expected.

About 1990, the four-phase sampling system was abandoned. A new system was developed by Fred Larson and Ken Winterberger using Landsat as a stratifying media, and sampling from the 1:63,000 color IR photos in a modified 2-phase sampling approach (van Hees 1999). That system was used in the inventory of the Upper Yukon and Upper Susitna units. Winterberger and Kharouk (2000) later published on a method for monitoring forests using remote sensing.

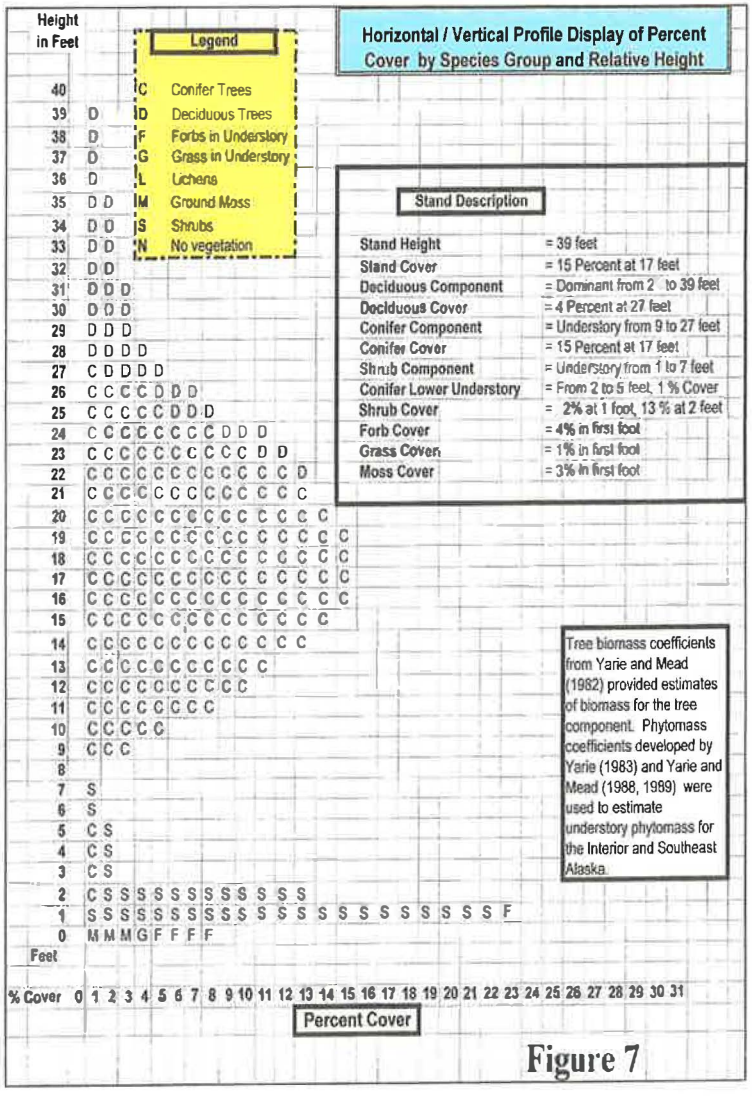


Figure 7

In the late 1980s, the Research arm of the Forest Service developed a new Forest Health Monitoring (FHM) program, in response to concerns about acid rain and other environmental concerns. FHM was headquartered in Raleigh, NC under the leadership of Joe Barnard and Sam Alexander (Bechtold etal 1993). That system divided the whole United States into hexagonal sampling units 6000 km apart based on satellite imagery, and at the center of each of those hexagons, a 4-point ground sample plot (about 1 acre in size) was established (Figure 8).

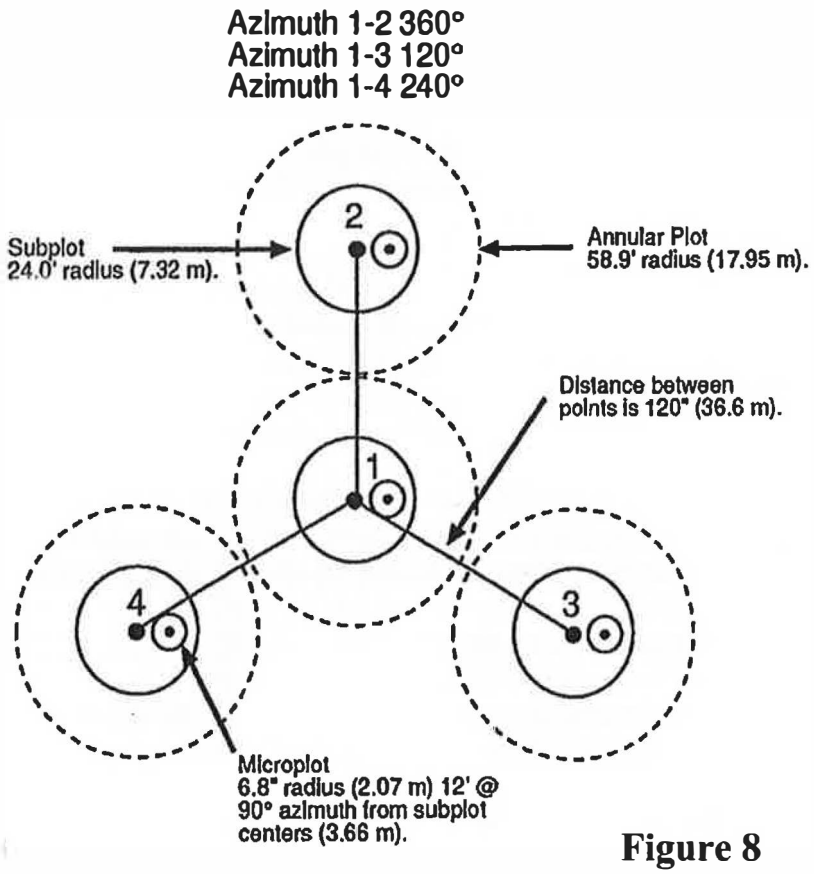


Figure 8

The system used a quasi type-mapping approach to collect the ground plot data as an in-place data set, sensitive to vegetation shifts within the plot. FHM collected data on the 4 points focused on the standard tree mensuration attributes. In addition, FHM also measured and observed attributes on tree crown condition, tree defect and damage, mortality, soils, and vegetation diversity and structure.

In the mid-1990s, following about 6 years of implementing the FHM system, Forest Survey (by now called Forest Inventory and Analysis–FIA) adopted the FHM design. This was the first change in national Forest Survey (FIA) design since 1967. The new design was first implemented in Alaska in 1995. The new standard 4-point plot was called the P2 plot.

About 1998, FIA began the implementation of Annualized Inventory, at which time, a Phase 3 (P3) plot was added with data collected on 1/16th of the P2 grid. On these plots, detailed information was to be collected on tree crown condition, downed woody materials, lichen communities, soils, and vegetation diversity and structure, many of the old FHM variables. The Annualized Inventory concept was intended to measure 1/10th of the grid each year. See Woodall etal, 2011 or Bechtold and Patterson, 2005 for more detail.

After a decade, budget realities forced the program to reconsider and suspend the P3 indicators, which require more crew members than standard P2 plots. Simplified methods to describe understory vegetation, search for invasive plant species, and measure downed wood have been implemented on the P2 plots. Other indicators are undergoing consideration for measurement.

As of the printing of this paper (2013), the P2 FIA design was being applied to re-inventories of southeast Alaska.

Special Considerations for the Original Alaska Forest Surveys

From the initiation of Forest Survey in southeast Alaska, special considerations had to be made in conducting a successful program. Transportation was a major consideration. In coastal Alaska, much use was made of boats, including the Forest Service Ranger Boats (Photo 2).

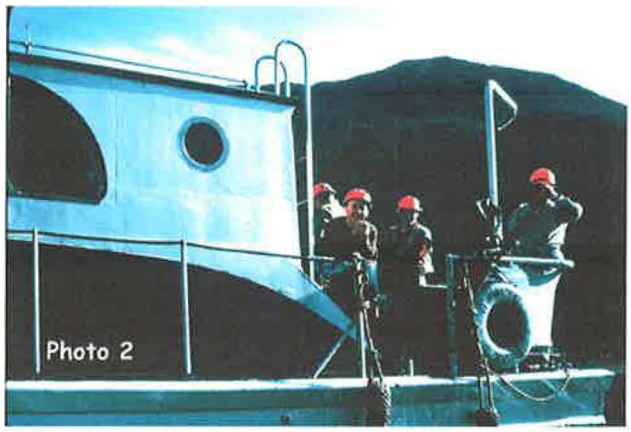


Photo 2


Photo 3

Also, special training had to be given to the field crews in the handling of skiffs in an ocean environment (Photo 3).

Special training also had to be given to field crews on the use of large caliber rifles for bear protection and in the safe helicopter and float plane travel (Photos 4 and 5).


Photo 4


Photo 5

As emphasis moved from timber inventory to multi-resource inventories, inventory techniques were added to measure other resources, such as vegetation and soils. (Photos 6 and 7).


Photo 6


Photo 7

Training was also required in the use of aerial photography to access remote plots. (Photo 8). The application of remote sensing techniques (Photo 9) also required giving special training to staff. Ken Winterberger was sent for a year of University training to improve his skills in understanding and applying satellite imagery interpretation to Alaska Forest Survey needs.


Photo 8


Photo 9

The Influence of Aerial Photogrammetry and Remote Sensing in Alaska Forest Surveys

After World War II, Richard Wilson of the Washington Office was influential in getting Forest Survey units to incorporate aerial photogrammetric techniques in their inventory procedures. Some of the people using 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). The 1997 revision of the *Manual of Photographic Interpretation* (Lund 1997) contains an entire chapter devoted to forestry.

The use of photo-interpretation 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, non-forest. Finally, these points were systematically or randomly sub-sampled 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 sampling level, such as forest density, forest composition, and stand height using stereoscopically measured tree heights.

A.P. Caparoso's Forest Survey crews took advantage of aerial photos acquired by the US Navy in 1949 to implement a two-phase (Bickford 1952) sampling design for use in southeast Alaska. There were two scales of photos in this 1949 Navy project (1:40,000 vertical stereo photos and 1:20,000 oblique photos, shot to the side of each of the vertical photos). The Regional Office of the Forest Service also used the 1:40,000 photos to make timber type maps for later use in administrative activities. The type maps were produced at a scale of 2 inches per mile (1:31,680). The sampling grid on the 1:40,000 photos consisted of about 20 photo points per effective area of a photograph. Each photo point was photo interpreted. The main categories of interpretation were non-forest, non-commercial forest, and commercial forest. A sub-sample of the commercial photo points were systematically selected for ground visitation and the establishment of the ground plot shown in Figure 2. If there was some question whether a type call on the 1:40,000 was commercial forest or non-commercial forest, the photo point was included in another subset of "questionably commercial" to be given further evaluation in an air check from fixed wing aircraft.

The same general procedure was used in the early 1960s in the Forest Survey of the Chugach National Forest, except the "questionable commercial" category was dropped. The photography for the Chugach Forest Inventory was flown at a nominal scale of 1:15,840, making it easier to discern between commercial forest and non-commercial forest. The effective areas of these photos were also type mapped for timber types with the idea of making 1:32,680 type maps for administrative use, but timber management on the Chugach National Forest did not receive sufficient emphasis to follow through with making the timber management type maps.

In the initial "Interior Alaska" Forest Survey in the early 1960s, there was an intention to use aerial photography in a "state-of-the-art" design. The intention was to have a photo interpretation phase (about 40,000 photo points), underlain with a 10% "air-check" phase (about 4,000 air check points), and then 10% of the "air check" phase (about 400 ground plots) would be visited on the ground. During the first phase, any points interpreted as "commercial forest" would have tree heights and crown diameters

measured to be used for an estimate of volume during the second phase.

Since aerial stand volume tables had been developed, 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). Farr and LaBau had been given special training in measuring tree heights and volumes (Moessner 1960) before transferring from Caparoso's staff in Ogden to Alaska in 1960.

In the southeast Alaska re-measurement studies of the mid-1960s, new 1:15,840 scale photography was available, so plot locations were transferred from the 1949 1:40,000 photos, and re-established using the newer photography. The newer 1:15,840 photos were used in the southeast inventories in the 1970s and 1980s. For the special interior Alaska regional inventories in the 1970s, special photo projects were flown in cooperation with Alaska state and federal agencies. By 1980, new 1:63,360 color infrared photos were available and used in both the special interior inventories and in the four-phase inventory in southeast Alaska.

In the 1980s, the emphasis was on in-place inventories. Landsat imagery and GPS interfaces came into use thus making the inventory data more useful to forest management personnel. In the 1990s, satellite imagery became more refined and more easily interpreted with improved accuracy, and aerial photos began to fall into less use. Ken Winterberger used Lidar remote sensing to prepare a forest map of Alaska (Photo 10).

Photo 10

In the early 1990s, Ken Winterberger, in cooperation with the USGS EROS staff in Anchorage cooperated in the production of a nationwide vegetation type-map, including Alaska (Zhu and Evans 1994), based on interpreted satellite imagery (Photo 11). With the introduction of the new FIA/FHM system, the first phase of data collection moved almost exclusively to satellite imagery.

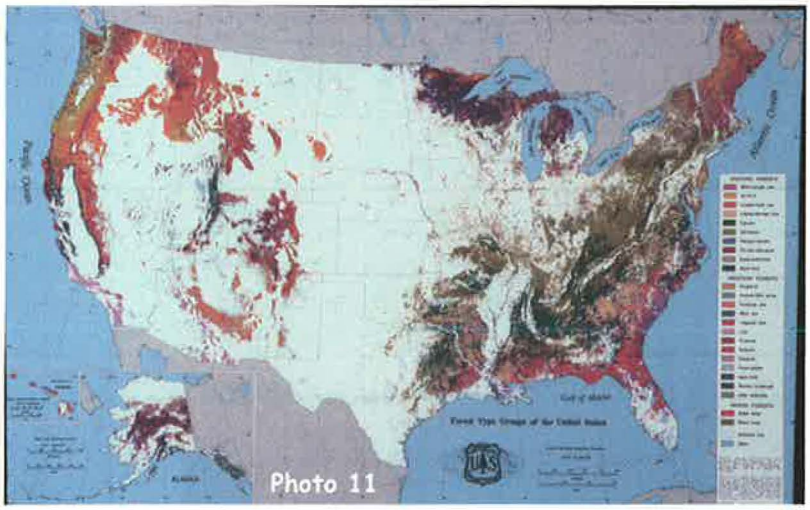


Photo 11

Other Forest Survey Science Contributions

Alaska's Forest Survey personnel were often involved in special studies, most of which added to or aided in the gathering of Forest Survey data. One such area was the collection of volume table information. Many Alaska Forest Survey personal and cooperating researchers collected data and prepared volume tables for Alaska tree species and for aerial photo volume assessment (Bones 1968; Bruce 1984; Farr and LaBau 1971, 1976; Haack 1963a, 1963b), The Forest Survey staff also assisted with mill studies in southeast Alaska (Bones 1962, 1962b, 1963a, 1963b) (Photo 12) to determine sawmill recovery and internal defect of trees (Kimmey 1956; Farr etal 1976).


Photo 12


Photo 13

In the early 1960s, a team from the Forest Products Laboratory, assisted by Forest Survey crews did a special hardwood mill recovery study at Wasilla (Photo 13).

There were also special studies to assess down wood (Larson 1984, 1992) vegetation biomass and phytomass (Smith and Larson 1984; Yarie and Mead 1988) and wildlife habitat relationships (LaBau and Fox 1984; LaBau etal 1986).

The Legacy of Forest Survey in Alaska Research

This Legacy begins in the early 1950s and the start of Forest Survey in Alaska and the installation of plots in the KPC Unit. (Photo 14 by Arland Harris shows John Sandor, Tom Jones and Tom Kelley loading up to fly to a KPC plot –ca 1954).

The most important aspect of the Alaska Forest Survey was the production of timber and related resource bulletins. This began with in-service publications in the 1950s that gave detailed information on area and volumes of timber on the various inventory units of southeast Alaska. Much of the impetus for long-range timber sales hinged on the findings reported in these in-service documents.

The same can be said of the numerous Resource Bulletin reports for state lands at Haines, Yakataga, the Chugach National Forest and the interior Alaska units, although reports for the Chugach and interior units, seldom led to local establishment of timber sales. As previously mentioned the Forest Survey data for southeast Alaska and for the State of Alaska's Haines unit stood the test in Sierra Club court cases in the 1970s.

There were dozens of Resource Bulletins published that presented the timber resource information throughout Alaska, as well as numerous conference papers, Research Notes and Bulletins that present the results of the various special studies noted in the previous section.

However, one additional legacy of Alaska Forest Survey (FIA) is related to the preparation and compilation of the periodic input required by the Washington Office. One such early report, excluding Alaska was the USDA (1932) assessment. The first comprehensive, science-based national assessment was the Timber Resource Review (TRR) (USDA 1958b). The next national assessment was in 1965 (USDA 1965), and included data on southeast Alaska, but the first national assessment that included timber and area estimates for all of Alaska was the "Outlook for Timber in the United States" (USDA 1973). That assessment included projections of Alaska's timber resources to the year 2020, using the areas, volumes, growth, mortality, and timber cut estimates in the projection via the TRAS (Timber Resource Analysis System) program (Larson and Goforth 1974). The RPA (Resources Planning Act)was passed in the mid-1970s, and further emphasized the importance of these national timber assessments. In 1982, another assessment was produced (USDA 1982), with50 year projections into the future, using an updated and refined version of TRAS (Alig etal 1982). Other national assessments followed (Waddell etal 1989; Haynes 2003), but unfortunately, these later assessments were never able to rely on a totally updated database for Alaska. The last totally inclusive Alaska inventory report was that of Hutchison (1967).

The legacy holds. For more than 75 years, the emphasis of Forest Survey (FIA) has been collecting quality data. The program has evolved from one of timber focus to multi-resource sampling. 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 research 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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CREDITS

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Table 1–Time-line of major Alaska Forest Survey history and related developments

1741	Georg W. Steller, a member of Vitus Bering's Russian expedition, visited the Alaska coastline making first recorded observations of coastal forests.
1741-1778	Journals were written from about 90 expeditions by Soviet naturalists, primarily assessing fur availability, but also gathered information on flora and fauna.
1778	The voyage of Englishman James Cook in 1778 along the Alaska coast also resulted in the gathering of important scientific information.
1794	George Vancouver, who had served on Cook's 1778 voyage, conducted his own expedition and published his journals from it in 1798 with information on Alaska natural resources.
1800-67	Various Russian scientists and naturalists continued studies of vegetation in Alaska and established the first afforestation effort in Unalaska about 1807.
1867	United States purchases Alaska.. Various military studies broadened understanding of Alaska forests.
1879	John Muir visits coastal Alaska, making observation about coastal forests.
1880	Tenth US Census included observations by Ivan Petroff which were influential in shaping American perceptions of Alaska's forests.
1889	The E. H. Harriman expedition to Alaska in 1989 recruited more than 20 scientists, including forester Bernard Fernow, to tour the Alaska coast making observations on forests and other natural resource aspects.
1905	U. S. Forest Service established.
1915	Henry Graves, Chief of the Forest Service who replaced Pinchot, visited Alaska. He focused forest research on Alaska..
1928	The McSweeney-McNary Act, passed putting Research on a par with other Forest Service activities, and established forest inventory in the United States.
1948	Alaska Forest Research Center established in Juneau with direction to do Forest Survey in Alaska.
1952	First preliminary Alaska Forest Survey effort begun in the area of Ketchikan and Prince of Wales focusing on long term timber sale areas (KPC, etc.).
1955-57	General Tongass NF Forest Survey started in the Juneau Unit using a 3 sub-plot double sampling inventory design, supported by 1:40,000 photography.
1958	USDA published the *Timber Resource Review* with the first statistics on Alaska forests, (primarily for the Tongass).
1960-62	General Chugach NF Forest Survey started in the Cordova unit using the same 3 sub-plot inventory design that had been used on the Tongass NF, supported by 1:20,000 photography.

1960-64	Special studies underway using Forest Survey crews to develop volume tables for the Tongass and Chugach NFs, evaluate lumber recovery at a Wasilla mill and at a Wrangell mill.
1961-63	First Forest Survey of interior Alaska underway, using a ½ acre rectangular plot supported by 1:5,000 black and white infrared photography.
1964-69	About 170 Forest Survey plots revisited on the Tongass NF to verify the original Forest Survey estimates and gather better growth and mortality data.
1964-69	Several subunit inventories were established in interior Alaska to provide the State and BLM with better inventory data in those units.
1965	USDA published the *Timber Trends for he United States* with the first statewide statistics on Alaskan forests.
1967	Keith Hutchison publishes *Alaska Forest Resources*, a comprehensive overview of Alaska's Forest Survey data along with a Forest Products overview (PNW Forest Resource Bulleting PNW-19).
1970-79	A new National 10-point variable plot system was initiated throughout Alaska, involving a complete new inventory of the Tongass and Chugach NFs and inventories of special study units in interior Alaska.
1981	A new 4-phase inventory design began testing in Alaska using a 20 acre type-mapped ground plot, supported by three levels of remote sensing (1:6,000 low altitude color infrared photos, 1:63,000 high altitude color infrared photos and Landsat imagery. It was applied throughout southeast Alaska and in the Tanana and Susitna River units in interior Alaska. It was finally rejected due to problems getting low altitude photography.
1982	USDA published the *An Analysis of the Timber Situation for the United States* with an update of Alaska forest inventory data..
1989	Wadell, etal published *Forest Statistics for the United States, 1987* with another update of Alaska forest inventory data..
1989	A new photo mapping/Landsat supported design was used in interior Alaska for about 5 years.
Ca 1990	Forest Health Monitoring (FHM) Program initiated at Research Triangle Park, NC under Joe Barnard
1995	The 4-point fixed area plot system (used by FHM) was adopted nationally by Forest Survey (FIA), and continues to be used as of the writing of this history in 2013.
1998	FIA begins implementing the "Annualized Forest Inventory System," designed to revisit a subset of inventory plots each year.
2001	USDA published the *U. S. Forest Facts and Historic Trends*.
2009	Smith, etal published *Forest Resources of the United States, 2007* with another update of Alaska forest inventory data.

Table 2.--Historical Acreage Summary for Four Southeast Alaska Forest Inventories, 1955-2000

		Thousand Acres												
	Table #	Total Acres All Lands In SEA		Acres Forest Land	Acres CFL	Acres Old Growth 150 yrs +	Acres Young Sawtimber -150 yrs	Acres Pole Timber -150 yrs	Acres Seeds-Saps -150 yrs	Acres Non-Stocked -150 yrs	Acres All Young Growth -150 yrs	Acres of NCFL	Acres of Wilder	Acres Non Forest
Original 6 Survey Reports														
All Owners, 1955-57	Table 1	15,911	*	10,317	4,594							5,695	104	5,593
NF Ownership	4 thru 6				4,552	4,098	147	70	190	47	454			
Hutchison, 1967														
SEA Totals all owners*	Table 2	24,148		11,201	4,884	4,238	242	139	208		589	6,123	194	12,947
* Includes over 400M acres on BLM and State Lands														
Six Reinventory Reports, SEA														
All Owners, 1970-75	Highlights	15,166	*	10,487	6,206	4,281	275	49	267		591	4,281		4,679
Region 10 Reports, 1982-85														
All Owners, 1982-85		16,988	*	10,053	5,745	5,204	148	63	328		539	4,304	6,527	6,934
Van Hees, 2000 Report														
All Owners, Post 1990	Table 2	22,900		10,900	4,100							6,800	10,700	11,900
NFS Owner	Table 6				3,423	2,730	312	80	253	47	692	5,900	6,700	7,600

*** In these 3 inventories, Ice fields were eliminated from the inventory base, thus the drop in total acres.**

Photo on Back Cover:

The photo on the back cover is of the "Maritime Maid," an 85 foot boat with helicopter pad, which will accommodate a crew of 12 Forest Inventory people plus a boat and copter crew of 6. The "Maritime Maid" has been used by Forest Inventory crews in coastal Alaska since 1995.

The idea for use of this type of ship was originally conceived by the Field Supervisor, Fred Larson, who eventually earned the moniker "The Admiral."


MARITIME
MAID