Review of PSP Systems Employed Outside of British Columbia

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Executive Summary

Growth and yield data can be collected in various ways: (1) one-time measurements (temporary sample plots); (2) one-time retrospective analyses based on surviving trees (stem analysis); and (3) repeated measurements through time on single trees, or more usually groups of trees (permanent sample plots (PSPs)). The focus of this report is on the latter. The objective is to provide a summary of a selected number of PSP systems employed by various jurisdictions around the world, especially those in temperate regions. The intent is to reflect the range of approaches used, rather than attempt to describe all of the systems employed.

Initial information on various PSP systems and names of potential contacts were gathered by talking to colleagues and searching the Internet. More detailed information was gained through e-mailing, telephoning, or writing contacts. This information was augmented by general information on various aspects of PSP installation, maintenance, and analysis available in the published literature.

Information collected was limited to current PSP systems. The focus was on government (national or state/provincial) systems because of their relevance to British Columbia and the normally more accessible documentation compared to industrial systems. The bulk of the systems summarized are operational in nature rather than research installations. Research installations tend to cover a more localized area, and vary markedly in design depending upon the research objectives involved, compared to operational installations.

The PSP systems reviewed are summarized in two tables and a series of appendices. The body of the report contains a general discussion of this material.

Fixed-area plots were considerably more common than variable-area plots among the PSP systems that we reviewed. This is due to a number of reasons, including the ability to employ larger plots, easier analysis of the changes that occur, easier re-location of the PSP in the field, and the ability to measure elements besides standing trees (e.g., coarse woody debris) on a unit area basis.

PSP systems may be used for research purposes (determining responses to particular silvicultural treatments), monitoring (comparing actual trends to expected trends), inventory (providing an assessment of current stand conditions) and modelling (building, calibrating, and testing models of forest dynamics). The ideal system for each of these applications differs.

Controlled field experiments are best for assessing responses to particular silvicultural treatments. PSPs in experimentally treated areas are generally not very useful in a monitoring or inventory context. The nature of the experimental treatment applied and the care normally taken in locating the PSPs in uniform conditions mean that the sample is seldom “typical” or “representative” of either the treatments applied operationally or the land base. However, the results of controlled experiments are often used in model building and/or testing, either directly (e.g., as raw data) or

indirectly (e.g., as biological or ecological relationships expressed in the model). Normally, this happens after the fact and is not explicitly considered in the design of the experiment.

The major need in monitoring is to be able to relate findings from particular locations back to the landbase as a whole. Frequently, this need results in locating PSPs using some form of representative sampling (e.g., simple random sampling, stratified random sampling, systematic sampling). Not surprisingly, data from monitoring systems are most useful for testing the effectiveness of existing growth and yield models (i.e., in a monitoring role). Although data acquired via a monitoring system may be of use in building and calibrating some types of growth and yield models, the wide range of conditions needed by model builders are often missing. Most monitoring systems are not applicable for studying response to treatment, other than in very general terms, because of lack of control over areas and treatments and the normally sparse coverage across a broad landbase.

Most intensive forest inventories make use of temporary sample plots because of the expense involved in establishing a large number of PSPs. However, more extensive inventories (e.g., national inventories) often make use of PSPs, either exclusively or in combination with temporary sample plots. Similarly to monitoring systems, inventory systems generally rely on some form of representative sampling to locate plots so that the results can be easily related to the landbase. This causes the same limitations to using the data for examining responses to treatment, and building and calibrating growth and yield models, as was mentioned for monitoring.

For model building and calibrating, interest is in obtaining data to provide coverage across a range of specific conditions to help develop response surfaces for fitting the necessary equations. Often, PSPs are located subjectively in specific conditions/locations, either singly or in clusters, to provide these data. Relatively uniform portions of stands, free of obvious recent natural disturbances, are generally chosen. Information external to the growth and yield model is then relied on to "net down" predictions to reflect operational reality (less then fully stocking, losses to natural factors, etc.).

If purely empirical (i.e., data-based) equations are used to drive a growth and yield model, then the model could provide a good representation of present conditions if data from enough subjectively located plots were available. However, such an approach suffers from the limitation of historical bioassay data: only the conditions reflected in the data can be reliably predicted. A solution is to incorporate some degree of biological reality into the equations used to drive the growth and yield model. Greater emphasis on biological reality means greater reliance on data from controlled experiments to augment that available from PSPs in "natural" or "operationally treated" stands.

Large tree measurements such as species, dbh, and at least a sample of heights are common amongst all of the PSP systems we reviewed. A minority of the systems included stem maps or measured regeneration or small trees in any detail. A variety of non-tree measurements (e.g., site

attributes, coarse woody debris) are commonly included. No single plot size emerged as dominant among jurisdictions. In many jurisdictions, a series of nested plots are used for measuring different tree sizes.

With the possible exception of PSPs established in research installations, single purpose PSP systems appear to be less common than multi-purpose systems. The high cost of establishing and maintaining PSPs, and the increasing emphasis on monitoring, is promoting the use of representative sampling for locating plots on the ground. This decreases the efficiency of the data for growth and yield model building and calibration. Data from controlled experiments and from subjectively located plots are essential for "filling in the gaps" that exist among data acquired using representative sampling across a landbase.

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1.0 Introduction

Growth and yield data provide an important source of information for intelligent forest management. These data provide insight into changes in particular stand and tree attributes with time (stand dynamics), they provide actual trends against which expected trends can be compared (monitoring), and they may be used in calibrating and/or testing prediction equations (growth and yield modelling). They are also sometimes used for inventory purposes. Growth and yield data can be collected in various ways. These ways can be classified into three general groups: (1) one-time measurements (i.e., temporary sample plots); (2) one-time retrospective analyses based on surviving trees (i.e., stem analysis); and (3) repeated measurements through time on single trees, or more usually, groups of trees (i.e., permanent sample plots (PSPs)).

This report focuses on PSP systems. PSPs are employed by many different jurisdictions worldwide. However, there are important differences in terms of objectives, sampling strategies, variables measured, and frequency of the measurements. The objective of this report is to provide a summary of selected PSP systems employed by various jurisdictions around the world, especially in temperate regions. The intent is to reflect the range of approaches used rather than attempt to describe all of the systems employed.

Initial information on various PSP systems and names of potential contacts were gathered by talking to colleagues and searching the Internet. More detailed information was gained through e-mailing, telephoning, or writing contacts. This sometimes resulted in detailed manuals or summary papers that provided information on a specific system or systems. We augmented this information with general information on various aspects of PSP installation, maintenance, and analysis available in the published literature.

Many of the jurisdictions we contacted have a considerable legacy of PSP data collected from a variety of different systems. In some cases, these PSPs exist today only in the form of data archives; however, in other cases, the PSP's are still maintained and remeasured, although no new PSPs are being installed under the original protocol. We limited the information that we collected to active PSP systems to enable us to focus on current approaches and trends in PSP design and management.

Governments (national or state/provincial) manage many of the PSP systems summarized in this report. The predominance of these systems is partly because they are more relevant to the provincial situation in British Columbia and partly because they tend to have more accessible documentation than industrial PSP systems. We also chose to concentrate on "operational" installations rather than "research" installations. The latter installations tend to cover a more localized area, and vary markedly in design depending upon the research objectives involved, compared to operational installations.

The main body of this report contains a general summary of PSP systems based on the information that we collected and our own judgment and experience. References are cited in the text and appendices by number, rather than by authors and date, in order to save space and to improve the flow of the textual material. The general summary is followed by a list of printed references and URLs for some of the more informative Internet sites that we found. A more specific summary of the detailed information that we collected is given in the appendices. This information is listed alphabetically by jurisdiction within the broader groupings of Canada, Europe, the United States, and Other. A standardized format was used; if we were unable to find specific information from our sources, the corresponding fields were left blank.

2.0 Overview and Analysis

2.1 Types of PSPs

PSPs have been used throughout most of this century (e.g., [28, 32, 59, 71]). Numerous procedural manuals exist (e.g., [2, 17, 21, 22, 47, 54, 63]). PSPs may be either of fixed- or variable-area. Fixed-area plots are normally circular, rectangular or square in shape, although permanent strip plots have been employed (e.g., [14]). Variable-area PSPs are normally horizontal point samples, but horizontal line plots may also be used (e.g., [69, 70]).

Fixed-area plots are considerably more common than variable-area plots among the PSP systems that we reviewed (Tables 1 and 2, and appendices). This is due to a number of reasons, including the ability to employ larger plots, easier analysis of the changes that occur, easier re-location of PSPs in the field, and the ability to measure elements besides standing trees (e.g., coarse woody debris (CWD)) on a unit area basis. Despite the prevalence of fixed-area PSPs, a considerable body of literature has been devoted to analyzing variable-area PSPs (e.g., [28, 29, 35, 37, 39, 48, 50, 55, 65]). This attention is due to the complexity involved and to the desire to use variable-area plots for determining growth that were already in place for timber inventory.

2.2 Uses of PSP Systems

As mentioned in the introduction, PSP systems may be used for research purposes (determining responses to particular silvicultural treatments), monitoring (comparing actual trends to expected trends), inventory (providing an assessment of current stand conditions) and modelling (building, calibrating, and testing models of forest dynamics). The ideal system for each of these applications differs.

Table 1. Summary of measurements made on various national forest inventories[a].

Measurements	National Forest Inventories										
	Austria	**Australia**	**Canada**	**Finland**	**France**	**Italy**	**Norway**	**Sweden**	**Switzer-land**	**USA-FIA**	**USA-FHM**
Site											
Slope	Yes		Yes			Yes			Yes	Yes	Yes
Aspect	Yes		Yes			Yes			Yes	Yes	Yes
Elevation	Yes		Yes			Yes			Yes		Yes
Soil Indicators	Yes		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
Topography	Yes		Yes			Yes			Yes	Yes	Yes
Stand											
Forest type	Yes		Yes				Yes	Yes	Yes	Yes	Yes
Stand age	Yes		Yes				Yes		Yes	Yes	Yes
Stand origin	Yes		Yes				Yes		Yes	Yes	Yes
Stand history	Yes		Yes				Yes		Yes	Yes	Yes
Disturbance	Yes		Yes				Yes		Yes	Yes	Yes
Plot											
Location	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type	Perm/Tem.		Perm/Tem	Perm/Tem	Perm.	Perm.	Perm/Tem.	Perm/Tem.	Perm	Perm/T	Perm.
Design	Clster/Nest			Clster.	Nest.	Single	Nest.	Nest.	Nest.	Clstr/Ne	Nest.
Shape	Circular				Circular	Circular	Circular	Circular	Circular	Circular	Circular
Size	300/21/Var	Variable		Variable	R=6/9/15m	200/600m^2	100/250m^2	Append.	200/500m^2	Append.	Append.
Tree											
Species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dbh	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total Height	Yes	Some	Some	Yes	Yes	Some	Yes	Yes	Yes	Yes	
Height class	Yes	Some	Yes				Yes		Yes	Yes	Yes
Crown class	Yes	Yes	Yes				Yes			Yes	Yes

Table 1. Summary of measurements made on various national forest inventories (cont.)

Measurements	National Forest Inventories										
	Austria	**Australia**	**Canada**	**Finland**	**France**	**Italy**	**Norway**	**Sweden**	**Switzer-land**	**USA-FIA**	**USA-FHM**
Tree											
Crown ratio	No	Yes				Yes				Yes	Yes
Crown diameter	No									Yes	Yes
Crown length	Yes									Yes	
Crown vigor	Yes					Yes			Yes		Yes
Tree age	Yes	Yes	Some	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Tree history	Yes		Yes				Yes			Yes	Yes
Tree location	Yes	Some		Yes		Yes	Yes		Yes	Yes	Yes
Tree species	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Tree condition	Yes	Yes	Yes	Some		Yes	Yes		Yes	Yes	Yes
Bark thickness	No	Yes			Yes					Yes	
Damage/death	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regen.											
Species	Yes						Yes	Yes	Yes	Yes	Yes
Height	Yes									Some	Yes
Dbh (range)	Yes										
Percent cover	Yes							Yes		Yes	Yes
Other											
Stem vol. inf.	Yes	Yes			Yes		Yes	Yes		Yes	
CWD	Yes				Yes						
Wildlife	Yes									Some	Yes
Buffer zone	No										

[a] Note that a blank may indicate either not measured or unknown.

Table 2. Summary of measurements made on various provincial PSP systems [a].

Measurements	Provinces								
	Alberta	**Manitoba**	**New Brun.**	**Nova Scot.**	**Ontario**	**PEI**	**Quebec**	**Sask.**	**Yukon**
Site									
Slope	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Aspect	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Elevation	Yes		Yes	Yes	Yes		Yes	Yes	
Soil Indicators	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Topography	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Stand									
Forest type	Yes				Yes		Yes		Yes
Stand age	Yes		Yes		Yes		Yes		
Stand origin	Yes				Yes		Yes		
Stand history	Yes				Yes		Yes		
Disturbance	Yes				Yes		Yes		
Plot									
Location	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Type	Permt	Permt	Permt	Permt	Permt		Permt/Tem	Permt	Permt
Design	Nested	Simple	Simple	Nested	Nested		Nested	Nested	Nested
Shape	Square	Circular	Circ/Rect	Circular	Circ/Sqr		Circular	Rect/Circ.	Circular
Size	See Append.	500 m^2	400 m^2	0.4 ha	See Append.		See Append.	See Append.	100/400 m^2
Tree									
Species	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Dbh	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Total Height	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Height class	-	Yes			Yes				Yes

Table 2. Summary of measurements made on various provincial PSP systems (cont.)

Measurements	Provinces								
	Alberta	**Manitoba**	**New Brun.**	**Nova Scot.**	**Ontario**	**PEI**	**Quebec**	**Sask.**	**Yukon**
Tree									
Crown Class	Yes		Yes		Yes		Yes		Yes
Crown diameter	Yes				Yes				
Crown length	Yes				Yes		Yes		
Crown vigor					Yes		Yes		
Tree age	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Tree history	Yes								
Tree location	Yes	Yes			Some/all				Some
Tree species	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Tree condition	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Bark thickness					Yes				
Damage/death	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Regeneration									
Species	Yes			Yes	Yes		Yes	Yes	Yes
Height	Yes			Yes	Yes		Yes		
Dbh (range)	Yes								Yes
Percent cover	Yes				Yes				
Other									
Stem vol. inf.	Yes			Yes	Yes		Yes		
CWD				Yes	Yes				
Wildlife				Yes	Yes				
Buffer zone	Yes				Yes				

[a] Note that a blank may indicate either not measured or unknown.

2.2.1 Research

Controlled field experiments are best for assessing responses[1] to particular silvicultural treatments. Usually the experiment involves several treatments, including a control. In order to remove or control confounding factors, effort is made to choose a location for an experimental installation that is uniform with respect to factors that may affect tree response. Treatments are then laid out at the location (ideally with random allocation to suitable areas). The entire treatment unit may be measured through time (i.e., the treatment unit and the PSP correspond) or one of more PSPs may be located in each treated area to provide a sample of response across the entire treatment unit. The experiment may be replicated at different locations.

PSPs in experimentally treated areas are generally not very useful in a monitoring or inventory context. The nature of the experimental treatment applied and the care normally taken in locating the PSPs in uniform conditions mean that the sample is seldom "typical" or "representative" of either the treatments applied operationally or the land base. However, the results of controlled experiments are often used in model building and/or testing, either directly (e.g., as raw data) or indirectly (e.g., as biological or ecological relationships). Normally, this happens after the fact and is not explicitly considered in the design of the experiment.

As stated in the introduction, the choice was made not to summarize many designed experiments. However, two were included as examples in our summary.

The Missouri Ozark Forest Ecosystem Project (MOFEP) is a landscape experiment comparing the impacts of even-aged management, uneven-aged management, and no harvesting on a wide array of ecosystem attributes [12]. The three harvest treatments were replicated in three complete blocks on a total of nine sites in the southeast Missouri Ozarks. Each study site is approximately 400 ha in extent.

The Demonstration of Ecosystem Management Options (DEMO) study is a collaborative research effort among the Pacific Northwest Region of the USDA, the Pacific Northwest Research Station, the Washington State Department of Natural Resources, University of Washington, Oregon State University, and University of Oregon to evaluate the ecological, physical, and social effects of varying levels and patterns of green-tree retention in western Oregon and Washington [57, 58]. The DEMO study is taking place on eight study blocks: four in southwest Oregon and four in southwest Washington.

2.2.2 Monitoring

PSPs represent the best and the most robust way to improve our knowledge about changes that occur in nature [3, 11, 36]. There is a global consensus about the necessity to acquire more reliable change data on the world's forests [33, 36, 41, 43, 62]. Support for this consensus comes from recognition of: (1) increasing human population which consequently increases demands for

[1] Response is used here in the restricted sense of changes in tree and/or stand growth directly applicable to the treatment. This is different than assessing what happens after a treatment is applied, which may best be referred to as "growth after treatment".

new agricultural land, timber for industry or fuel, and land for grazing; (2) the important role that forests play in stabilizing and attenuating extreme climates and buffering climate changes; and (3) the importance of sustainable forestry within the context of overall sustainable development. Many recent applications of monitoring systems stress assessing changes to biodiversity (e.g., [1, 7, 25, 41, 43, 44, 56, 57, 58]).

Not surprisingly, PSP systems for monitoring differ among jurisdictions in many aspects, from the sampling design employed to the plot characteristics and measurements taken on each plot. The International Union of Forest Research Organizations (IUFRO) published a standards document for monitoring in 1994 [36], which has been applied in Europe.

The major need in monitoring is to be able to relate findings from particular locations back to the landbase as a whole. Frequently, this need results in locating PSPs on the landbase using some form of representative sampling (e.g., simple random sampling, stratified random sampling, systematic sampling). Although there are examples of stand-alone monitoring systems (e.g., the Austrian Forest Damage Monitoring System), many are combined with broad-scale forest inventories that cover a province/state or the entire country (e.g., Ontario [50, 51], Quebec [30, 43], Switzerland [10, 38, 53], United Kingdom [61], and New Zealand [3]). This is due to the high cost involved in establishing and maintaining PSPs, and the need for a relatively large number of PSPs to monitor with some precision across a large and diverse landbase [25].

Not surprisingly, data from monitoring systems are most useful for testing the effectiveness of existing growth and yield models (i.e., in a monitoring role). Although data acquired via a monitoring system may be of some use in building and calibrating some types of growth and yield models, the wide range of conditions needed by model builders are often missing. The representative sampling used results in most of the plots falling in the more common conditions. Most monitoring systems are not applicable for studying response to treatment, other than in very general terms, because of lack of control over areas and treatments and the normally sparse coverage across the landbase.

2.2.3 Inventory

Inventories are used to provide information on current forest conditions necessary for intelligent forest management. Most intensive forest inventories make use of temporary sample plots because of the expense involved in establishing a large number of PSPs [9, 32, 42]. However, more extensive inventories (e.g., national inventories) often make use of PSPs, either exclusively or in combination with temporary sample plots (e.g., Austria [53, 68], the proposed Canadian system [5, 17, 40], Finland [53], France [26, 53], Italy [53], Norway [53, 60], and Switzerland [10, 38, 53]). Theory is well established for continuous forest inventories comprised of PSPs (e.g., [6, 19, 23, 27, 31, 32, 62]). It is also possible to employ a mixture of permanent and temporary plots within an inventory and analyze the data using sampling with partial replacement (e.g., [18, 20, 67]). Recent interest in carbon accounting may increase the emphasis on PSPs in inventories [8, 13].

Like monitoring systems, inventory systems generally rely on some form of representative sampling to locate plots so that the results can be easily related to the landbase. This causes the same limitations to using the data for examining responses to treatment, and building and calibrating growth and yield models, as was mentioned for monitoring. However, like monitoring data, inventory data from PSPs are useful for testing growth and yield models.

2.2.4 Modelling

In model building and calibrating, the interest is in obtaining data to provide coverage across a range of specific conditions to help develop response surfaces for fitting equations. Often, PSPs are located subjectively in specific conditions/locations, either singly or in clusters, to provide these data. Relatively uniform portions of stands, free of obvious recent natural disturbances, are generally chosen. Information external to the growth and yield model is then relied on to "net down" predictions to reflect operational reality (less then full stocking, losses to natural factors, etc.).

If purely empirical (i.e., data-based) equations are used to drive a growth and yield model, then the model could provide a good representation of present conditions if data from enough subjectively located plots were available. However, such an approach suffers from the limitation of historical bioassay data: only the conditions reflected in the data can be reliably predicted. Adequately incorporating changes to existing conditions (e.g., site augmentation or degradation, long-term changes to climate, new or modified silvicultural treatments) into an empirical model is problematic.

A solution is to incorporate some degree of biological reality into the equations used to drive the growth and yield model. A range of biological reality is possible, from none at all (strictly empirical equations) to a process model based entirely on mimicking biological processes thought to govern tree and stand development. Most operational growth and yield models fall somewhere between these extremes. Greater emphasis on biological reality means greater reliance on data from controlled experiments to augment that available from PSPs in "natural" or "operationally treated" stands.

2.3 General Trends

Tree measurements such as species, dbh, and at least a sample of heights are common amongst all of the PSP systems we reviewed (Tables 1 and 2, appendices). A minority of the systems included stem maps or measured regeneration or small trees in any detail. A variety of non-tree measurements (e.g., site attributes, CWD) are also commonly included. No single plot size emerged as dominant among jurisdictions. In many jurisdictions, a series of nested plots are used for measuring different tree sizes.

As is the case in British Columbia, many jurisdictions have a legacy of subjectively-located PSPs, some of which may no longer exist on the ground. Records of the header information for these plots are generally kept internally within the managing agency, but occasionally broader compendiums are published (e.g., [15, 22]).

Among the Canadian agencies reviewed, Alberta [2, 47], Alberta Research Branch [47], Canadian Forest Products Ltd. (Alberta) [47], Manitoba, New Brunswick [66], Prince Edward Island, and Saskatchewan [47, 54] all use subjectively located PSPs. Nova Scotia selects PSP locations randomly. Ontario employs stratified random sampling [50,51]. Quebec locates PSPs using multi-stage by inventory region [30, 43]. Weyerhauser Canada (Alberta) locates plots systematically [47]. More details on these programs may be found in Table 2 and Appendix 1.

Many of the European PSP systems reviewed were part of national forest inventories (Table 1 and Appendix 2). Monitoring systems were also prevalent, sometimes as part of the inventory system and sometimes as a stand-alone system. Interest in monitoring also seems to be driving the PSP establishment agenda in the United States [7, 9, 11, 12, 24, 33] and New Zealand [3]. The need for a national monitoring system also is one of the major forces behind the push to establish a national inventory for Canada [5, 16, 40]. Carbon accounting is also becoming a factor [8, 13].

With the possible exception of PSPs established in research installations, single purpose PSP systems appear to be less common than multi-purpose systems. The high cost of establishing and maintaining PSPs, and the increasing emphasis on monitoring, is promoting the use of representative sampling for locating plots on the ground. This decreases the efficiency of the data for growth and yield model building and calibration. Data from controlled experiments and from subjectively located plots are essential for "filling in the gaps" that exist among data acquired using representative sampling across a landbase.

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Related Web Links:

Annual Forest Inventory System (AFIS)
http://www.ncfes.umn.edu/4801/afis.html
Australia, State of Victoria (State-wide Forest Resource Inventory (SFRI) Project)
http://www.nre.vic.gov.au/forests/sfri
Biomass Resource Information Clearinghouse (BRIC)
http://rredc.nrel.gov/biomass/
http://rredc.nrel.gov/biomass/forest/
Canadian National Forest Inventory Programme
http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/canfi/overview.html
The European Forest Institute
http://www.efi.fi/
Forest Health Monitoring (FHM)
http://willow.ncfes.umn.edu/fhm/fhm_hp.htm
Laurentian Forestry Center Library
http://www.cfl.forestry.ca/5oriscia.htm
The Long Term Ecological Research (LTER) Network
http://www.fsl.orst.edu/lterhome.html
The National Environmental Monitoring Initiative
http://www.epa.gov./cludygxb/sites.html
Renewable Resource Data Center (RReDC)
http://rredc.nrel.gov/
Southern Annual Forest Inventory System (SAFIS)
http://ncasil.nerc.tufts.edu:443/projects/safis/

Swiss Federal Institute for Forest, Snow and Landscape Research (FSL)
http://www.wsl.ch/
Swiss Federal Research Institute (WSL)
http://www.wsl.ch/welcome-en.ehtml
USDA Forest Service Forest Invenory and Analysis (FIA)
http://www.srsfia.usfs.msstate.edu/wo/wofia.htm
USDA Forest Service Research Stations
http://www.fs.fed.us/research/reslocation.html.

Appendix 1: Examples of Permanent Plot Systems in Canada

Alberta

The Alberta Land and Forest Service (LFS) has approximately 1000 active PSP of various kinds. Establishment began in early 1960 in stands of various ages and species compositions, but always in target types rather than on a random or grid basis. The Canadian Forestry Service (CFS) established a number of PSPs in Alberta, mostly in the foothills region of the southwestern portion of the province. Alberta Forest Management Agreement (FMA) holders have established or are in process of establishing PSPs throughout their holdings. The oldest FMA was established in 1954 and is held by Weldwood of Canada Ltd. Weldwood began to establish PSPs in 1956 on a grid pattern. The other FMA holders have placed plots in targeted stand types.

HEADER INFORMATION

Jurisdiction: Province of Alberta

Agency: Land and Forest Service, Forest Management Division, Resource Analysis Centre

URL:

Language: English

References: [2], [47]

Contact: D.J. Morgan, Head - Forest Inventory, Alberta Land and Forest Service; Telephone: (780) 422-5295

DESIGN

Objectives: The first objective (1960) was to determine the age of maximum mean annual increment in conifer stands. The objectives expanded with time to: (1) assess stand dynamics such as succession, regeneration, ingrowth and mortality; (2) develop yield curves; and (3) provide representative areas for study of management techniques.

Inventory Method: Ground/linked with aerial photo

Plot Type: Permanent

Plot Shape: Square

Plot Size: 0.10 ha, 0.15 ha, 0.20 ha (size function of number of trees present; minimum of 50 living trees)

Number of Plots/Intensity: 650 plots established; target number - at least 3000

Sampling Design: Purposive

Date of Application of Present System: April 1981 (revised: January 2000)

Other Information: Remeasurement intervals:

- every 5 years for coniferous stands <80 yrs. old or >130 yrs. old and for deciduous stands < 60 yrs. old or > 100 yrs. old
- every 10 years for coniferous stands between 80 and 130 yrs. old and for deciduous stands between 60 and 100 yrs. old

MEASUREMENTS

Tree Variables: Species; dbh of standing trees (live and dead) if ≥ 9.1 cm; height (all living trees); height to live crown; crown class; condition; age for a minimum of 3 codominant or dominant trees found in the plot buffer; sample of crown width from all trees, saplings and regeneration

Stem Mapped: Yes for alive, dead trees and saplings; no for regeneration

Sapling Variables: Same as for trees; saplings are ≥ 1.3 m in height

Regeneration Variables: From 0.10 m tall to a maximum height of < 1.3 m; species, height class

Non-Tree Variables: Slope position, slope, aspect, elevation, soils (erosion potential, drainage, texture, depth), surface vegetation, ground cover.

Description:

Other Information: Prior to 1981, the plot layout was different, consisting of a cluster of four plots instead of only one plot.

Like the plots buffers are square. The area of the buffer is function of the PSP area:

- PSP = 0.10 ha sapling/regen. plot = 62m^2 buffer = 2.25 ha
- PSP = 0.15 ha sapling/regen. plot = 94m^2 buffer = 5.625 ha
- PSP = 0.20 ha sapling/regen plot = 125m^2 buffer = 9.0 ha

Colour photographs of each plot are taken once measurements or remeasurements are taken.

Alberta Forest Service: Research Branch

The PSP's managed by the Alberta Research Branch focus on the growth and dynamics of stands younger than 20 years. The plots are established in cutblocks after an area is satisfactorily restocked (1 - 7 years after harvest). In 1988 there were 214 of these PSP's.

HEADER INFORMATION

Jurisdiction: Province of Alberta

Agency: Land and Forest Service, Research Branch

URL:

Language: English

References: [47]

Contact:

DESIGN

Objectives: Assessment of growth and dynamics of stands younger than 20 yrs.

Inventory Method: Ground

Plot Type: Permanent

Plot Shape: Square

Plot Size: 0.10 ha (for large trees), 0.04 ha (for saplings), four 1.78 m radius circular plots (for regeneration)

Number of Plots/Intensity: 214 (in 1988)

Sampling Design: Purposive; a nested plot design is incorporated

Date of Application of Present System:

Measurement Interval: during May to August, every two years.

Other information: As the seedlings grow into saplings and subsequently into trees, the size of the plot on which measurements are taken becomes larger. Once the tree stage is reached, the plot is transferred to Forest Management Division for monitoring.

A circular 8.92 m radius plot is established in the residual stand, approximately 20 m from the edge. Plot locations are based on similarity between the residual stand and the clear-cut area. All vegetation is identified on this plot, and species, dbh, and condition for all trees > 9.0 cm dbh are recorded. Height is measured on every third living tree.

MEASUREMENTS

Tree Variables: (dbh > 9.0 cm) dbh, species, condition; (dbh between 1.1 cm and 9.0 cm) dbh and height; dead trees are not tagged at establishment

Stem Mapped: Yes

Regeneration Variables: Seedlings (not include the current year germinates or stems > 1.3 m tall) in the regeneration plots are pinned and tagged to a maximum of 50 seedlings and species and height are recorded. The remaining seedlings are recorded by species and height class; age is implied from the year of planting or treatment.

Non-Tree Variables: Slope, aspect, soil (depth, texture), vegetation

Description:

Other Information:

Canadian Forest Products Ltd. (Alberta)

Canadian Forest Products Ltd. (CanFor) has established PSP's in a wide variety of densities, heights, species, ages and site conditions in order to get a representative sample of forest types growing on their FMA area.

HEADER INFORMATION

Jurisdiction: Province of Alberta

Agency: Canadian Forest Products Ltd.

URL:

Language: English

References: [47]

Contact:

DESIGN

Objectives:

Inventory Method: Ground

Plot Type: Permanent

Plot Shape: Square/rectangular (prior to 1988); Circular (1988 to present)

Plot Size: 0.04 - 0.1 ha

Number of Plots/Intensity: 175 square/rectangular plots (prior to 1988)

Sampling Design: Purposive

Date of First Application of Present System: 1988

Other Information: Measurement intervals are: (1) 5 years for conifers < 70 years and deciduous < 50 years; and (2) 10 years for conifers ≥ 70 years and deciduous ≥ 50 years

MEASUREMENTS

Tree Variables: Species, dbh for trees ≥ 5.0 cm, height for sample trees, height to living crown, tree condition, crown class, age (at point of germination, taken on trees outside the plot)

Stem Mapped: Yes

Regeneration Variables: Seedlings (not include the current year germinates or stems > 1.3 m tall) in the regeneration plots are pinned and tagged to a maximum of 50 seedlings and species and height are recorded. The remaining seedlings are recorded by species and height class; age is implied from the year of planting or treatment. (Same as Alberta Research Branch.)

Non-Tree Variables: Slope, aspect, elevation, depth to mineral soil, drainage, vegetation

Description:

Other Information: Saplings (dbh < 5.0cm, height ≥1.3m) are measured, but not tagged. Only live, standing trees are measured at plot establishment. Mortality is determined at remeasurements.

Canada's National Forest Inventory

Canada's forest inventory through the 1980's and 90's was a compilation of existing provincial and territorial forest inventories. This format could not meet the increasing demands for additional forest resource attributes, and national and international reporting (e.g., sustainable development) so a new approach was needed. The design presented here is derived from the recommendations of the Canadian Forest Inventory Committee (CFIC).

HEADER INFORMATION

Jurisdiction: Canada

Agency: Provincial governments

URL: http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/canfi/overview.html

Language: English

References: [5], [16], [17], [40].

Contact: Mark D. Gillis, RPF, Manager, National Forest Inventory, Canadian Forestry Service, 506 West Burnside Road, Victoria, BC V8Z 1M5. E-mail: magillis@pfc.forestry.ca; Telephone: (250) 363 0753

Other Links: The National PSP Catalogue:
http://www.for.gov.bc.ca/resinv/software/NSPCAT/toc.htm
Contact: Joe Braz, Resources Inventory Br., B.C. Min. of Forests; E-mail: Joe.Braz@Gems1.gov.bc.ca

DESIGN

Objectives: "... assess and monitor the extent, state and sustainable development of Canada's forests in a timely and accurate manner."

Inventory Method: Ground/aerial photography (satellite imagery - as substitutes for photos)/remote sensing

Plot Type: Permanent and temporary; fixed area plots or variable radius plots or a combination.

Plot Shape: Dependent on the jurisdiction

Plot Size: Tailored to the size of the trees to be measured (at least 30 trees - URL reference); not less than 100 m2.

Number of Plots/Intensity: Dependent on the jurisdiction

Sampling Design: Elements of the design:

1. A network (40 x 40 km grid) of sampling points across Canada. The preferred sampling intensity is a 20 x 20 km grid of sampling points (nested within the national 40 x 40 km grid). Sampling can be done randomly or systematically.
2. Stratification of the sampling points, with varying sampling intensity among the strata (Terestrial Ecozone);
3. Estimation of some attributes from remote sensing sources on a primary (large) sample;
4. Estimation of wood volumes and other detailed data from a (small) ground base sub-sample;
5. Estimation of changes in (3) and (4) from repeated measurements; and
6. Compilation of NFI attributes.

Date of First Application of Present System: Not started

Other Information: The intent is to completely sample the country within the next 5 years, covering 1/5 of the area each year in a statistically defensible manner. The first remeasurement will be spread over a 10-year period, covering 1/10 of the area each year in a statistically defensible manner. Each subsequent remeasurement will be spread over subsequent 10-year periods.

MEASUREMENTS

Tree Variables: Species, dbh, height for at least 1/3 of all trees, crown class, tree condition. For saplings and regenerating trees, dbh classes and height classes should be recorded.

Stem Mapped:

Regeneration Variables:

Non-Tree Variables:

Description:

Other Information:

1) The plot location: must be accurately documented on maps, on associated photographs and on a GIS. The location of tie-points should be very detailed.
2) A brief description of the access points and type of access must be given.
3) The plot size and shape must be described. If subplots are used for smaller trees/regeneration, sub-plot size and shape must also be described.
4) A description of the any buffer zone around the plot must be given, along with a description of activities allowed in the buffer zone.
5) A history of disturbances since plot establishment must be kept.
6) Any treatment applied to the plot must be described.
7) Plot centre and plot boundaries must be permanently marked in the field.
8) The PSP must be marked with a number unique to the agency.
9) The plot shape must be rectangular, square or circular. The plot size must be large enough so at least 50 stems would be present at maximum MAI.
10) For the main plot, as well as any subplots for smaller trees, the minimum dbh must be recorded.
11) The following plot attributes will be recorded: aspect, slope, elevation, plot age, species composition, stand origin, stand structure, and ecological clasification. At remeasurement, species composition and stand structure must be recorded.
12) The date of establishment or remeasurement must be recorded.

Manitoba

HEADER INFORMATION

Jurisdiction: Province of Manitoba

Agency: Forestry Branch

URL:

Language: English

References: David Van de Vyvere, personal communication

Contact: David Van de Vyvere; E-mail: Dvandevyve@nr.gov.mb.ca;

DESIGN

Objectives: Multipurpose

Inventory Method: ground/GIS (in progress)

Plot Type: Permanent

Plot Shape: Circular

Plot Size: 500 m^2 (radius = 12.62m)

Number of Plots/Intensity: 401 plots: 254 plots are active (174 in natural stands and 80 in managed stands).

Sampling Design: Purposive

Date of First Application of Present System:

Other information:

MEASUREMENTS

Tree Variables: Species, dbh, height for 6-8 trees that are also cored for age (the rest of the heights are ocular estimates).

Stem Mapped: Yes

Regeneration Variables:

Non-Tree Variables:

Description:

Other Information: Tolko (in The Pas, Manitoba) has adopted the same plot design. Louisiana Pacific (in Swan River, Manitoba) uses rectangular plots.

New Brunswick

HEADER INFORMATION

Jurisdiction: Province of New Brunswick

Agency: Department of Natural Resources & Energy, Forest Management Branch

URL:

Language: English

References: [66]

Contact: R. (Bob) Dick, Director, Forest Management Planning Section; E-mail: rcdick@gov.nb.ca

DESIGN

Objectives: To validate/invalidate the stand level growth and yield model being developed.

Inventory Method: Ground/aerial photographs (1:12 500 colour photos)

Plot Type: Permanent

Plot Shape: Circular for young, immature, mature and overmature stands; square or rectanglular for plantations and cutovers

Plot Size: 400 m^2 (R=11.3 m) for young, immature, mature and overmature stands; variable-sized (function of density) for plantations and cutovers

Number of Plots/Intensity: proposed 20% subsample of the stands surveyed in the Forest Development Survey. One plot/stand would yield 2413 PSPs.

Sampling Design: Stratified sampling, but the plots are picked to be representative of a stratum.

Date of First Application of Present System: 1986 (but is making use of plots previously established)

Other Information: Remeasurements are taken at 5 years intervals for all plots but for those located in overmature stands (taken at 3 year intervals)

MEASUREMENTS

Tree variables: Species, dbh, height, age (subsample), crown (living crown length), damage

Stem Mapped:

Regeneration Variables:

Non-Tree Variables: Site parameters (macrosite characteristics), heights for all competing shrubs

Description:

Other Information:

Nova Scotia

HEADER INFORMATION

Jurisdiction: Province of Nova Scotia

Agency: Nova Scotia Department of Natural Resources, Forest Research and Planning

URL: http://www.gov.ns.ca/natr/FORESTRY/

Language: English

References: Ken Snow, Forest Inventory Manager - personal communication

Contact: Ken Snow, Forest Inventory Manager; E-mail: kjsnow@gov.ns.ca

DESIGN

Objectives: Multipurpose

Inventory Method: Ground/plots centres are located using GPS and each plot is mapped in a comprehensive GIS.

Plot Type: Permanent

Plot Shape: Circular

Plot Size: 0.4 ha with a vegetation subplot of 10 m^2 located within the circular plot.

Number of Plots/Intensity: approx. 2200; target 2800 by year 2002. This will provide a precision for average volume per plot of 0.5 m^3 at a 0.05 probability level. The plot intensity will be 1 plot/1500 ha of forest.

Sampling Design: Random

Date of First Application of Present System: 1965 - 1970

Other Information: Remeasurement interval is 5 years.

MEASUREMENTS

Tree Variables: Species, dbh (for trees ≥ 9.0 cm dbh), length of live crown, damage, grade for sawlog, three sample trees of average BA are cored for age, three of the best growing trees are cored for capability; saplings of all woody species are also tallied (counted and recorded in 2 cm classes).

Stem Mapped: Yes

Regeneration Variables: All above ground vegetation is tallied on the 10 m^2 subplot

Non-Tree Variables: site information: land capability, drainage, slope and aspect; ground cover in the entire plot is recorded as to coverage by percent

Description:

Other Information: Standing CWD (snags) are tallied, as well as downed CWD. CWD sampling is done with a 60 m line transect. An additional set of 1700 plots, located in specific managed stands, are measured to develop curves based on basal area control, related to species and site.

Ontario

The history of forest growth and yield work in Ontario stretches back over 70 years, with the first coordinated provincial studies dating from late 1940s, before the development of the Ontario Forest Resource Inventory (FRI) system. Over the past three decades, numerous PSPs were established to investigate stand dynamics, productivity, and basic biological processes. Most of these plots were short-term and intended to answer questions of local silvicultural importance. During the past decade, a comprehensive provincial-wide program was developed to fill knowledge gaps and to monitor Ontario's forests.

HEADER INFORMATION

Jurisdiction: Province of Ontario

Agency: Ontario Ministry of Natural Resources (OMNR) and Ontario Forest Research Institute (OFRI)

URL:

Language: English

Other reference: [51], [52]

Contact: David J. Smith Ph.D., Ecosystem Productivity Scientist and Program Leader, Forest Growth and Yield Program. Ontario Forest Research Institute, 1235 Queen St. E., Sault Ste. Marie, ONTARIO P6A 2E5. E-mail: david.smith@mnr.gov.on.ca; Telephone: (705) 946-2981 ext.118. Facsimile: (705) 946-2030.

DESIGN

Objectives: "The purpose of the provincial growth and yield program is to improve resource management decision-making by helping managers better predict and understand the dynamics and productivity of Ontario's natural and managed stands."

Inventory Method: Ground/aerial photographs/GIS

Plot Type: Permanent, nested plots

Plot Shape: Circular/square-rectangular

Plot Size: Mortality plots: R = 45.14 m (6400 m^2) or 80 x 80 m square; growth plots: R = 11.28 m (400m^2) or 20 x 20 m square; shrub plots: R = 2.82m (25 m^2); regeneration plots: R = 1.13m (4m^2) or 2 x 2 m square

Number of Plots/Intensity: Proposed number is 12924 growth plots nested within 4308 mortality plots

Sampling Design: Stratified random sampling

Date of First Application of Present System: 1992

Other Information: When circular, a PSP is a nested combination of one mortality plot, three growth plots, nine shrub plots and 27 regeneration plots. When square, a PSP is a nested combination of one mortality plot, three growth plots, and nine (2x2 m) regeneration plots. All nested plots are randomly located within the larger sampling unit.

MEASUREMENTS

Tree Variables: Species, dbh (min. dbh is 2.5 cm), crown class, status (dead/alive), origin, quality class, deformity, decay class, height and height to live crown (sample trees), age (5 sample trees from the primary species and 2 from secondary species , bark thickness, 5-, 10-, and 15-year increments, stem analysis (several measurements of diameter, crown width (north, south, east, west, ht, ht. to live crown).

Stem Mapped: Fully or partially depending on the region for trees that are aged.

Regeneration Variables: For seedlings (0-49 cm in height): species and % cover. For regeneration (50 -130 cm in height): species and number of trees. For saplings (>130 cm in height and <2.5 cm dbh): species and number of trees.

Non-Tree Variables: Vegetation % cover (herb, ferns, grass, moss, bryophytes, and shrubs). CWD with three random transects of 45.14 m each: min diameter=7.5 cm, diameter, species, log decomposition class

Description:

Other Information: - Plot information (size, shape, location); geographical information (township, ownership, etc.); site information (ecoregion, elevation, landform, slope position, stand area, forest cover type soil assessment); stand information (stand origin, kind of disturbance, stand establishment date, silvicultural system, logging equipment, treatment history, crown closure); photographs of the plot; buffer zone, comprised from a destructive sampling buffer zone and a none destructive; sampling buffer zone, both summing up a 10 to 20 m wide area surrounding the mortality plot; nesting/feeding/escape cavity for wildlife assessment + other wildlife evidence

Prince Edward Island

HEADER INFORMATION

Jurisdiction: Province of Prince Edward Island

Agency: Department of Agriculture, Fisheries and Forestry; Natural Resources Division

URL:

Language: English

References: William M. Glen, Manager of Resource Inventory and Modelling, personal communication; Canada's National Forest Inventory Programme: http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/canfi/overview.html

Contact: William M. Glen, Manager of Resource Inventory and Modelling; E-mail: wmglen@gov.pe.ca; Telephone: 902-368-4703; Facsimile: 902-368-4713

DESIGN

Objectives: To provide growth and yield information on managed stands

Method of inventory: Ground

Plot Type:

Plot Shape:

Plot Size:

Number of Plots/Intensity:

Sampling Design: Purposive

Date of First Application of Present System:

Other information: It is proposed that the current system be replaced with the system used by the Canada's NFI Program.

MEASUREMENTS

Tree Variables:

Stem Mapped:

Regeneration Variables:

Non-Tree Variables:

Description:

Other Information:

Quebec

HEADER INFORMATION

Jurisdiction: Province of Quebec

Agency: Ministry of Natural Resources, Quebec's Forests, Department of Forest Inventories

URL:

Language: French

Other reference: [30], [43]

Contact: Pierre Morin, ing.f., Manager, Forest Inventory Department

DESIGN

Objectives: Dependent upon the plot network. BAS1 and BAS2 Networks: (1) knowledge about growth rates on different stand types; (2) knowledge about natural evolution of the stands; (3) knowledge about the impact of natural and human disturbances on forest stands; and (4) building yield tables. SCOF Network: (1) to determine the dynamics of forest stands following different silvicultural treatments. FEDE Network (private forests): same as for BAS1. SPIM Network: for monitoring insects and pathogens.

Inventory Method: Ground/aerial photo

Plot Type: Permanent

Plot Shape: Circular

Plot Size: 1/10 acre (in 1970), 400m^2 (starting with 1989)

Number of Plots/Intensity: BAS1 Network: 7156 PSPs (1977), with the following intensities: hardwood region: 4200 PSPs or 1/26 km^2; conifer region: 1486 PSPs or 1/103 km^2; boreal forests: 1000 PSPs or 1/259 km^2; BAS2 Network (1989): 7506 new PSPs from which 1000 PSPs are now in the SCOF Network. The BAS1 and BAS2 Networks were subsequently combined. The distribution of PSPs is now: hardwood region: 5254 PSPs or 1/23 km^2; conifer region: 4662 PSPs or 1/23 km^2; boreal forests: 3506 PSPs or 1/77 km^2; boreal and tundra: 246 PSPs or 1/259 Km^2. FEDE Network (1985): 602 PSPs. SPIM Network (1992): 1072 PSPs.

Sampling Design: Multi-stage sampling. Sampling was done by Inventory Regions (IR) with a pre-set number of PSPs established for each IR. All 1/20 000 photos of each IR were listed and a SRS of the photos was taken. On each selected photo, a grid was imposed and another sample was done to choose the PSP location.

Date of First Application of Present System: 1970

Other Information: Each PSP has a satellite PSP located at 425 m on a direction randomly selected from 10 pre-established directions. Each PSP has one circular subplot of $40m^2$ (R = 3.57 m) and three circular subplots of $4m^2$ (R = 1.13 m)

MEASUREMENTS

Tree Variables: Species, dbh for all trees alive or dead that are > 9.0 cm dhb, crown class, quality, level of light, % defoliation. A subsample of 9 trees is measured for height (if stand height > 7 m), crown height, and age. Saplings (1.0 cm <dbh < 9.0 cm) are recorded on the intermediate subplot for species and dbh by diameter class.

Stem Mapped: No

Regeneration Variables: Regeneration (15 cm ≤ height and dbh ≤ 1.0 cm) is dot tallied by species and height class on the three smallest subplots.

Non-Tree Variables: Site classification, altitude, slope, slope position, soil description and drainage.

Description:

Other Information: Plots are remeasured at 8 years intervals for hardwood and conifer stands and at 15 year intervals for boreal stands.

Saskatchewan

HEADER INFORMATION

Jurisdiction: Province of Saskatchewan

Agency: Saskatchewan Parks and Renewable Resources, Forestry Branch

URL:

Language: English

Other reference: [47], [54]

Contact:

DESIGN

Objectives: Growth and yield assessment.

Inventory Method: Ground/ linked with aerial photo. PSPs in Saskatchewan are located in well-stocked, even-aged stands that are distributed throughout the commercial forest zone.

Plot Type: Permanent

Plot Shape: Rectangular and circular

Plot Size: 1/5 acre for rectangular plots and $600m^2$ and $800m^2$ for circular plots

Number of Plots/Intensity:

Sampling Design: Purposive

Date of First Application of Present System:

Other Information: Tree and sapling plot sizes are the same; the regeneration plot is obtained by splitting the tree/sapling plot down the middle and seedlings growing within 1.25 m on either side of that line are dot tallied. [No information is provided about what is done on circular plots.] The remeasurement interval is scheduled as 5 years, but in actuality its depends on the available resources.

MEASUREMENTS

Tree Variables: Species, dbh for trees > 7.1 cm dbh, height, condition, crown closure, damage, age from at least 3 dominant/codominant trees. Dead trees are measured for dbh and height. Saplings are trees between 1.0 cm and 7.0 cm dbh and have dbh and height recorded that are representative for each species.

Stem Mapped:

Regeneration Variables: Regeneration is defined as trees with dbh ≤ 1.0 cm; these trees are dot tallied for species and height class.

Non-Tree Variables: Slope position, slope, aspect, soils (depth, texture, drainage), surface vegetation.

Description:

Other Information:

Weyerhauser Canada (Alberta)

HEADER INFORMATION

Jurisdiction: Province of Alberta

Agency: Weyerhauser Canada Limited

URL:

Language:

References: [47]

Contact:

DESIGN

Objectives: Growth and yield assessment and monitoring stand dynamics.

Inventory Method: Ground

Plot Type: Permanent

Plot Shape: Plots for trees and saplings are square; for regeneration, that plots are circular.

Plot Size: 0.08 ha (if ≥ 2500trees/ha, plot size = 0.04ha)

Number of Plots/Intensity: 12 plots per township

Sampling Design: Systematic sampling

Date of First Application of Present System:

Other Information: Plots that are in stands younger than 20 years of age were established in harvested areas or burns 2 years after regeneration treatments or disturbances. These plots are square. The sapling subplot is 1/4 of the size of the plot and located in one corner. The four regeneration plot are nested in the sapling subplot. They are circular with R = 1.78 m. (The same system is used by the Alberta Research Branch). Plots in mature stands do not have a sapling subplot and only four regeneration subplots.

MEASUREMENTS

Tree Variables: Species, dbh for trees > 5.1 cm dbh, height (for trees taller than1.3 m; every fifth tree is measured, the rest of the heights are estimated), live crown height, total age of the top height trees, and damage. Dead trees are recorded as well.

Stem Mapped:

Regeneration Variables: Species and height

Non-Tree Variables: Slope, aspect, elevation, depth to mineral soil, soil texture, drainage

Description:

Other Information:

Appendix 2: Examples of Permanent Plot Systems in Europe

Austrian National Forest Inventory

The first National Forest Inventory (NFI) was the "waldstandsaufnahme" and was conducted between 1952 and 1956. In 1961, the Austrian NFI set different objectives and opted for a new inventory system. Forest inventory in Austria is presently conducted on a 5-year interval basis.

HEADER INFORMATION

Jurisdiction: Austria

Agency: Federal Forest Research Centre

URL: http://www.bmlf.gv.at/ebmlf/eforst/efkontrol/effkontrol.htm

Language: English

References: [53] [68]

Contact: Vladimir Camba; E-mail: Vladimir.Camba@bmlf.gv.at; Telephone (+43 1) 21 323-7406; Facsimile: (+43 1) 21 323-7216

DESIGN

Objective: Growing stock and growth determination

Inventory Method: Ground

Plot Type: Both permanent and temporary

Plot Shape: Circular

Plot Size: Nested plots consisting of a 300 m^2 plot, a 21 m^2 plot, and a variable radius plot with a BAF of 4.

Number of Plots/Intensity: Mean area represented by a sampling unit is 377.14 ha.

Sampling Design: A sample grid method where the assessment units (tracts) are systematically laid out over all of Austria in a regular network. A tract is a square with several circular plots located around the perimeter. Since 1981, four PSP's, located in the corners of the square, have formed the tract with sides of 200 m. In former inventory cycles, temporary plots were established along the sides of the tact, which can be easily re-established for specific purposes if it was thought to be necessary.

Date of Application of Present System: 1981

Other Information: Estimation of current values, as well as estimation of change, is based only of the PSP's.

MEASUREMENTS

Tree Variables: Species, dbh (5 cm minimum), height (three sample trees per plot), diameter at 3/10 height above ground for three sample trees per plot, forking (yes/no), height to the base of the crown, age class, peeling spots, living status (dead/alive), damage, stem quality, crown class.

Stem Mapped: Yes, for trees in the variable radius plot.

Regeneration Variables: Species present, necessity for regeneration, reason for absence of regeneration, origin of seedlings, area occupied, distribution, damage, crown cover, damages done by wildlife, harvesting, or other sources.

Non-Tree Variables: Site and soil, slope, aspect, topography, climate, water regime, soil depth, soil strata and classification.

Description:

Other Information: The Austrian NFI is closely connected to the Austrian forest development plans, with several of the attributes being only relevant for forest planning.

Austrian Forest Damage Monitoring

In 1994, 7.8 % of all trees in Austrian forests were classified as damaged. Fir, pine, and oak were the genera most affected. Forest damage monitoring aims to observe and document environment-related forest changes and their changes through time.

HEADER INFORMATION

Jurisdiction: Austria

Agency: Federal Forestry Research Centre

URL: http://www.bmlf.gv.at/ebmlf/eforst/efkontrol/effkontrol.htm

Language: English

References:

Contact: Albert Knieling; E-mail Albert.Knieling@bmlf.gv.at; Telephone: (+43 1) 213 23-7307; Facsimile: (+43 1) 213 23-7216

DESIGN

Objective: To recognize the threats and cause-effect complex of forest damage in order to better combat them

Inventory Method: Remote (infra-red and aerial photographs) and ground

Plot Type: Permanent

Plot Shape:

Plot Size:

Number of Plots/Intensity: 534

Sampling Design:

Date of Application of Present System: 1994

Other Information:

MEASUREMENTS

Tree Variables: Crown

Stem Mapped:

Regeneration Variables:

Non-Tree Variables: Soil (forest floor health), chemical analysis of tree leaves (bio-indication), and air analyses (So2, NO2, O3).

Description:

Other Information:

Finnish National Forest Inventory

The National Forest Inventory (NFI) of Finland has produced large-area forest resource information for over 70 years. The first inventory involved line survey sampling was conducted in 1921-24. Except for the sampling density, the methods used in the second (1936-38), third (1951-53) and fourth (1960-63) inventories were almost the same as the first. Detached L-shaped clusters have been employed rather than continuous lines since the fifth inventory. During the eight inventory in 1989, the Finnish Forest Research Institute started to develop a new inventory system . The objective was to obtain geographically localised, up-to-date information for smaller areas smaller than was possible with the earlier inventories. The latest inventory (the ninth) started in the summer of 1996 and will be completed in 2000. The grid of 3000 PSP's, established for forest health monitoring purposes in 1985-86, was measured for the third time in

1995. New features were developed for measuring additional characteristics describing forest biodiversity.

HEADER INFORMATION

Jurisdiction: Finland

Agency: Finnish Forest Research Institute

URL: http://www.metla.fi/tutkimus/vmi/nfi.htm

Language: English

References: [53]

Contact: Dr. Erkki Tomppo, Professor and Head of National Forest Inventory; E-mail: Erkki.Tomppo@metla.fi; Telephone: +358 9 8 570 5340; Facsimile: +358 9 625308

DESIGN

Objectives: To continuously provide information about the state of the Finnish forests. Government, industry, and forest owners use this information in planning.

Inventory Method: Remote sensing (satellite image)/Ground

Plot Type: Permanent and temporary

Plot Shape: Variable radius (Bitterlich) plots

Plot Size: Variable sizes (tallied trees are selected with a relascope; the relascope factor varies by region, depending on the density of the forests.) The relascope factor is 1.5 in Central Finland. The maximum plot radius is 12.45 m (corresponding to a dbh of 30.5 cm with a factor of 1.5). A small fixed radius sample plot is used for small trees.

Number of Plots/Intensity: 41 plots by tract (number of tracts unknown)

Sampling Design: Cluster in a half square or tract, in the shape of L. One tract has 15 sample plots, of which 3 are permanent and the other 12 are temporary.

Date of First Application of Present System: 1992

Other information: A special design (two-stage sampling) was used for Lapland, as forest conditions are quite different from the rest of the country.

MEASUREMENTS

Tree Variables: Species, age, dbh, increment (every 7th tallied tree is measured as a sample tree).

Stem Mapped: Yes (only for permanent plots)

Regeneration Variables:

Non-Tree Variables: Soil

Description: Information on forest health and ground vegetation, animal observations in some inventories for estimating species distribution, and bryophyte samples for analysing the distribution and concentrations of sulphur and heavy metals.

Other Information:

French National Forest Inventory

The French National Forest Inventory (NFI) was created in 1958. Since that time, the NFI service has involved a continuous survey of French forest resources. It is currently on about a 10-year cycle and is implemented at a regional level (100 administrative units). The second inventory was completed in 1990. The third inventory is in progress now.

HEADER INFORMATION

Jurisdiction: France

Agency: IFN (Inventaire Forestier National)

URL: http://www.ifn.fr

Language: French and English

References: [26], [53]

Contact: Directeur Technique: Mr. Jean Wolsack; E-mail: jwolsack@ifn.fr; Telephone: (+33) (0)2 38 28 18 12

DESIGN

Objectives: Two targets were set: (1) land use determination, and (2) standing timber estimation.

Inventory Method: Aerial photography/ground

Plot Type: Permanent

Plot Shape: Circular

Plot Size: Three different sizes depending on the dbh of the tree: 6m radius for dbh's < 22.5 cm; 9 cm radius for dbh's between (22.5 and 37.5 cm); and 15 m radius for dbh's > 37.5 cm.

Number of Plots/Intensity: 150,000 plots (about 1.5 million measured trees).

Sampling Design: The method used is three-phase sampling. The first sampling phase is carried out using aerial photographs, the second phase involves a field check, and the third phase consists of taking measurements (tree measurements and stand descriptions).

Date of First Application of Present System: 1958

Other information: Database is in process of being related to GIS.

MEASUREMENTS

Tree variables: Height, stump height and circumference, dbh, 5- and 10-year radial increments, bark thickness at breast height, diameter at 2.60 m, 5-year height increment, age, species.

Stem Mapped: No

Regeneration Variables: Species, height

Non-Tree Variables: Site information (aspect, slope, slope position, altitude, parental material, soil texture and type, humus form, hydrology); stand information (species composition, structure, survival period, evolution phase, stand health, openings and type of openings, exploitability, productivity, logging method, % of regeneration and type of regeneration, height of regeneration and its future, distribution)

Description:

Other Information: Stumps of felled trees, snags (<5 years within the 15 m radius plots).

Italian National Forest Inventory

HEADER INFORMATION

Jurisdiction: Italy

Agency: Ministero delle Politiche agricole e Forestali

URL: http://www.politicheagricole.it/MiPA/LinksUtili/Regione/Welcome.htm

Language: Italian and English

References: [53]

Contact: Prof. Piermaria Corona; URL: http://www.unifi.it/unifi/iatf/personale/corona.htm; E-mail: piermaria.corona@unifi.it.

DESIGN

Objectives:

Inventory Method: Remote (aerial photos)/ground

Plot Type: Permanent

Plot Shape: circular fixed radius

Plot Size: 200 - 600 sq. metres

Number of Plots/Intensity:

Sampling Design: Systematic and two-phase

Date of First Application of Present System:

Other Information: Plot size of 200 to 400 sq. m. used for highly stocked stands (mainly coppices).

MEASUREMENTS

Tree Variables: Dbh, (trees with dbh > 2.5 cm), height, density, increment (core), morphological type.

Stem Mapped: Yes

Regeneration Variables:

Non-Tree Variables: Topography (elevation, slope, aspect), soil, health

Description: Tree measurements were taken only for those trees with height greater than 5 metres. All the trees within the sample plots were measured for dbh but they were sub-sampled for the height measurement.

Other Information: No GIS implementation was made for the first forest inventory. Regional and sub-regional forest inventory data are not available for the whole country. The percent of territory inventoried varies between 16 (Veneto region) to 100 % (Umbria region).

Norwegian National Forest Inventory

The National Forest Inventory of Norway began in 1919. Since then, five inventories have been carried out. The sixth one was planned for completion in 1993. Systematic sampling technique was used in all the inventories. The two first surveys employed strip sampling, whereas plot or point sampling was used for the remainder. The most current survey uses permanent sample plots.

HEADER INFORMATION

Jurisdiction: Norway

Agency: Norwegian Institute of Land Inventory

URL: http://www.nijos.no/panorama/skog94e.htm#then

Language: English

References: [53], [60]

Contact: Stein Michael Tomter, Norwegian Institute of Land Inventory, P.O. Box 115, N-1431 Ås; Telephone: +47-64-949700; Facsimile: +47-64949786

DESIGN

Objectives:

Inventory Methods: Ground

Plot Type: Permanent and temporary

Plot Shape: circular (concentric circles)

Plot Size: 100 and 250 m^2 (the former for all trees with dbh ≥ 5 cm and the second for trees with dbh ≥ 20 cm)

Number of Plots/Intensity: About 50,000 plots (about 1/3 of which are permanent)

Sampling Design: Cluster (a cluster consists of 1 permanent and 1 or in most cases 2 temporary plots)

Date of First Application of Present System: 1986

Other Information:

MEASUREMENTS

Tree Variables: Species, density, height, dbh, diameter growth

Stem Mapped: Yes

Regeneration Variables: Number of seedlings

Non-Tree Variables:

Description: There is no increment boring on permanent plots to avoid damaging the trees.

Other Information:

Swiss National Forest Inventory

The first NFI survey using the present standards was conducted between 1983 and 1985 and was evaluated in 1986. The collection of data for the second survey was carried out from 1993 to 1995, 10 years after the first inventory. The status and development of Swiss forests are comprehensively explained. The topics covered include: forest area, growing stock, increment, species composition, previous and future utilization, forest types, stand age, regeneration, damage, forest transport systems, forest management, forest habitat, biotope rating, recreation, results for individual Cantons, and comparison with other European countries.

Annual forest damage inventories began in 1985 and are fully compatible with the NFI. The objective of these surveys is to assess tree crowns for damage by airborne pollutants and other factors.

HEADER INFORMATION

Jurisdiction: Switzerland

Agency: Federal Institute of Forestry Research, National Forest Inventory Department

URL:

Language: English

References: [10], [38], [53]

Contact: P. Brassel, Swiss Federal Institute for Forest, Snow and Landscape Research, Eidgenössisches Institut für Schnee- und Lawinenforschung , Flüelastr. 11CH-7260 Davos Dorf, Schweiz / Suisse / Svizzera; Telephone: (01) 739 22 38

DESIGN

Objectives: Provide a periodic inventory of forest conditions within the country.

Inventory Methods: Remote sensing (aerial photographs) and ground

Plot Type: Permanent

Plot Shape: circular (concentric circles)

Plot Size: 200 and 500 sq. m.

Number of Plots/Intensity: 11,000 plots

Sampling Design: Two-phase, stratified systematic sampling

Date of First Application of Present System: 1993

Other Information: An annual forest damage inventory began in 1985 that is fully compatible with the FNI. It is conducted over a four-kilometer grid superimposed in that of the NFI. The objective of this inventory is to assess tree crown conditions and their changes.

MEASUREMENTS

Tree Variables: Dbh, height, increment

Stem Mapped: Yes

Regeneration Variables:

Non-Tree Variables: Soil, plant, sociological survey

Description: 130,000 trees were measured from which 44,000 were used for volume tariff construction.

Other Information:

Swiss Selection System Study

In Switzerland, the Federal Forest Police Act (1902) prohibited clear cutting in public forests and private protection forests. In 1923, the clear cutting prohibition was extended to private forests in general. The Swiss Forest Research Institute laid out three selection forest research plots in 1905. A further 17 plots had been added by 1931. These all of these plots except for three are still being surveyed today.

HEADER INFORMATION

Jurisdiction: Switzerland

Agency: Swiss Federal Institute of Forest, Snow and Landscape Research

URL: http://www.wsl.ch/welcome-en.ehtml

Language: German/English/French/Italian

References: [71]

Contact: Andreas Zingg; E-mail: andreas.zingg@wsl.ch; Telephone: +41 1 7392 335

DESIGN

Objectives: To gain information about the implications of using "close-to-nature" silviculture at a relatively small scale by applying selective treatments.

Inventory Method: Ground

Plot Type: Permanent, fixed area plot

Plot Shape:

Plot Size: From 0.5 to 2.5 hectare

Number of Plots/Intensity: 20 plots

Sampling Design: Purposive

Date of First Application of Present System: 1905

Other Information:

MEASUREMENTS

Tree Variables: Species, dbh, total height, diameter at 7 meters, height to the crown base and crown radii (sampled trees), age (felled trees), amount of branches, twigs, needles and leaves, and timber characteristics (sampled trees).

Stem Mapped:

Regeneration Variables: No information is recorded about regeneration.

Non-Tree Variables: Altitude, slope, aspect, topography, site index, site type, precipitation, temperature

Description:

Other Information: The minimum diameter limit is 7.5 cm at dbh; saplings and regeneration are not recorded systematically.

United Kingdom

In the period immediately after the establishment of the Forestry Commission (FC) in 1919, it was recognised that there was an acute need for information on the growth of major species which were being considered for plantations. Relatively little was known of the basic growth patterns and the long-term productive potential of most of the major species, notably the "promising exotics" such as Sitka spruce. The Forestry Commission, Research Branch embarked on the creation of a network of permanent sample plots to help address this need.

The Forestry Commission now has an internationally important and valuable databank of growth and yield information covering an 80-year period, which has seen significant environmental change.

HEADER INFORMATION

Jurisdiction: United Kingdom

Agency: Forestry Commission, Policy & Practice Division

URL: http://www.forestry.gov.uk/research/index.html

Language: English

References: [61]

Contact: Janet Methley, Head of Mensuration Branch, Forestry Commission Research Agency, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH; E-mail: j.methley@forestry.gov.uk; Telephone: +44 1420 526234; Facsimile: +44 1420 23450;

DESIGN

Objectives: The permanent sample plots address five main objectives:

- to provide periodic growth and yield information necessary for the development of national yield models;
- to assess the effects of specific silvicultural treatments on stand development;
- to provide information required for the development and improvement of measurement systems which may be used in normal forest practice (e.g., taper rates for volume tables, diameter distributions for stand, stock and assortment tables, data for the production of tariff tables and functions);
- to provide data for environmental/climate change research programmes; and
- to provide areas where different thinning methods can be demonstrated.

Inventory Method: Ground

Plot Type: Permanent, usually in clusters.

Plot Shape: Normally rectangular.

Plot Size: Variable

Number of Plots/Intensity:

Establishment Period	Number of Plots	Number of Plots Still Viable
1910-1919	28	0
1920-1929	183	25
1930-1939	103	10
1940-1949	288	76
1950-1959	433	118
1960-1969	272	84
1970-1979	186	50
1980-1989	147	114
1990-	93	91
Total	**1733**	**568**

Age of Trees (Years)	Number of Viable Plots	% of Total Viable Plots
> 80 years	50	9
70-79	93	16
60-69	119	21
50-59	48	8
40-49	66	12
30-39	108	19
20-29	84	15
10-19	0	0
0-9	0	0
Total	**568**	**100**

Note that plots are established in the productive phase; therefore, tree age exceeds the number of years that a plot has been established.

Country	Total No. of Plots	No. of Viable Plots (1998)	No. of Abandoned Plots
England	798	256	542
Scotland	617	201	416
Wales	318	111	207
Total	**1733**	**568**	**1165**

Sampling Design: The aim was to establish a "strategic reserve" of sample plots across a wide range of forest types to provide the growth and yield data needed to address existing forestry issues. The strategy for sample plot establishment and retention is expected to continue to anticipate national forestry policy and practice.

Date of First Application of Present System: 1910

Other Information: All plots have a buffer receiving the same silvicultural treatment, usually 10 m. Where plots are part of a replicated experiment, minimum plot size is 0.04 ha. The major governing factor concerning size is the intended duration of the experiment, so that at the age of final felling there will be sufficient trees in the plot to restrict sampling errors. Plots are usually established in uniform stands, at time of first thinning, when top height is in the region 10 m to 12 m.

MEASUREMENTS

Tree variables: Species, dbh, height (the 100 trees of largest dbh per hectare are identified from the dbh assessments and from these trees 10 are selected systematically for total height measurement). Further, ten trees are systematically selected from the dbh distribution for the whole plot (excluding trees marked for thinning) and are also measured for total height. The volume of each of these trees is assessed either by climbing the trees and measuring mid-diameters of successive 3 m sections to a 7 cm top diameter outside bark, or by using a Barr and Stroud dendrometer. Crown length and crown diameter are recorded on volume sample trees. The volume of all thinnings is measured after felling.

Stem Mapped:

Regeneration Variables:

Non-Tree Variables: Elevation, aspect, exposure, slope, topography, geology and soil, ground vegetation and a general description of the stand itself.

Description:

Other Information: There are a number of other measurements that are recorded in some plots. Up until the mid-1960's, each tree was classified at each measurement in terms of dominance class, stem form and crown class. The dominance classes were based on the conventional Kraft classes (dominant, co-dominant, sub-dominant, suppressed, dead) while the stem and crown classifications were arbitrary quality classifications. Dominance classification is now confined to replicated experiments and a number of other important plots. Stem and crown classifications are no longer recorded. However, there is now major interest in stem quality and methods of assessing stem quality on standing trees are being developed.

Approximately 120 sample plots are re-measured each year. The current establishment rate is 5 to 10 plots per year.

Appendix 3: Examples of Permanent Plot Systems in the United States

Demonstration of Ecosystem Management Options (DEMO)

Public concern over the fate of the northern spotted owl (*Strix occidentalis taurina*), and of the old-growth Douglas-fir (*Pseudotsuga menziesii*) forests on which it depends, led to increasing interest in natural resource management in the Pacific Northwest. Lawsuits initiated by environmental groups halted timber sale programs on U.S. federal lands. In response to this 'timber crisis', the Forest Ecosystem Management Assessment Team was commissioned in 1993 to formulate and assess the consequences of an array of options for managing these federal lands. This assessment was the first attempt to develop a comprehensive plan for ecosystem management on a broad geographic scale. The resulting management plan came to be known as the Northwest Forest Plan.

The Demonstration of Ecosystem Management Options (DEMO) study was established in support of this effort. This is a collaborative research effort among the Pacific Northwest Region of the USDA, the Pacific Northwest Research Station, the Washington State Department of Natural Resources, University of Washington, Oregon State University, and University of Oregon to evaluate the ecological, physical, and social effects of varying levels and patterns of green-tree retention in western Oregon and Washington. The DEMO study is taking place on eight study blocks: four in southwest Oregon and four in southwest Washington.

HEADER INFORMATION

Jurisdiction: United States of America

Agency: A joint effort of the USDA Forest Service Region 6 and Pacific Northwest Research Station. Research partners include the University of Washington, Oregon State University, University of Oregon, Gifford Pinchot and Umpqua National Forests, and the Washington State Department of Natural Resources.

URL: http://www.fs.fed.us/pnw/demo/index.html

References: [57] [58]

Contact: Brenda Woodard, Umpqua National Forest; E-mail: bwoodard/r6pnw_umpqua@fs.fed.us; Rick Abbott, Umpqua National Forest, Diamond Lake Ranger District; E-mail: rabbott/r6pnw_umpqua@fs.fed.us; Charlie Halpern, College of Forest Resources, University of Washington; E-mail: chalpern@u.washington.edu; Jon Nakae, Gifford Pinchot National Forest, Mt. Adams Ranger District; E-mail: jnakae/r6pnw_gp@fs.fed.us; Richard Bigley, Washington State Department of Natural Resources; E-mail: RBLL490@wadnr.gov

Language: English

DESIGN

Objectives: The DEMO study examines the responses of forest ecosystems in the Pacific Northwest to varying levels (percentage of basal area) and patterns (dispersed versus aggregated) of green-tree retention.

Method of Inventory: Ground

Plot Type: Permanent fixed area, nested plots.

Plot Shape: Circular for trees, saplings and snags; rectangular for regeneration and bryophytes

Plot Size: 0.08 ha for snags; 0.04 ha for trees dbh > 15 cm; 0.01 ha for trees 5.0 cm < dbh ≤ 14.9 cm; four 6 m line transects for CWD, cover/height of tall shrubs and saplings; four 6×2 m strips for density of small and regenerating trees (trees > 10 cm tall and < 5 cm dbh)

Number of Plots/Intensity:

Sampling Design: The first sampling design uses a set of permanent vegetation plots arrayed across a grid system at each site (63 or 64 grid points with 40-m spacing). The number and spatial distributions of sample plots vary by treatment (32 plots placed systematically at alternate grid points for control and dispersed treatments; 32 -37 plots per treatment placed at all grid points within the aggregates (or gaps), and at a subset of points in the surrounding matrix.

Date of First Application of Present System: 1994

Other Information: 3 -5 years measurement interval

MEASUREMENTS

Tree Variables: Canopy cover and dbh for all trees > 5.0 cm; species, canopy class, vigor, crown ratio, damage, mortality (physical conditions and causes), total height and canopy depth for sampled trees; for snags: dbh, species, height, decay class, and angle of lean

Understory Vegetation: Seedlings (< 10 cm tall): number of stems; Saplings (>10 cm tall, < 5 cm dbh): cover, number of stems, height class, origin (natural vs. planted); lichens: presence/absence; bryophytes: presence/absence; herbs: cover, height; tall shrubs: cover, height

Stem Mapped:

Regeneration Variables: See understory vegetation

Non-Tree Variables: Elevation, aspect, slope, slope configuration, ground surface conditions (mineral soil, stone, litter, log), CWD, post harvest disturbance (vegetation damage, soil disturbance)

Description:

Other Information:

Missouri Ozark Forest Ecosystem Project (MOFEP)

The Missouri Ozark Forest Ecosystem Project (MOFEP) is a landscape experiment comparing the impacts of even-aged management, uneven-aged management, and no harvesting on a wide array of ecosystem attributes. These three harvest treatments were replicated in three complete blocks on a total of nine sites in the southeast Missouri Ozarks. Each study site is approximately 1000 acres (400 ha) in extent.

HEADER INFORMATION

Jurisdiction: United States of America

Agency: USDA, Forest Service; Missouri Department of Conservation

URL: http://www.conservation.state.mo.us/

Language: English

References: [12]

Contact: Brian L. Brookshire, Silviculturist and Research Supervisor, Missouri Department of Conservation, Jefferson City, MO 65102

DESIGN

Objectives: To determine the impacts of forest management on neotropical migrant songbirds, to evaluate forest management impacts on multiple ecosystem attributes for large sites, and to provide sound scientific information for the refinement of forest management practices in Missouri.

Inventory Method: Ground

Plot Type: Permanent, fixed-area nested plots

Plot Shape: Circular for trees, square for vegetation

Plot Size: 1 plot of 1/2 acre (R= 82.8 ft); 4 plots of 1/20 acre (R= 26.3 ft); 4 plots of 1/100 acre (R= 11.8 ft); and 16 plots of 1 m^2 (square)

Number of Plots/Intensity: 648 PSP's

Sampling Design: Purposive site selection (9 MOEFP sites); random location of plots within stands at each site (at least one plot per stand)

Date of First Application of Present System: 1990

Other information: Each MOEFP experimental site was divided into areas of common slope and aspect. These were further divided into stands that averaged approximately 12 acres (5 ha) in size. Stands were used to stratify the placement of 648 permanent vegetation plots. Stand boundaries were used to implement the experimental treatments.

MEASUREMENTS

Tree Variables: For trees dbh > 4.5 in.(11cm): species, dbh, status (live or dead), crown class, size and location of cavities; height, canopy volume, form class, merchantable volume were measured for up to 15 trees per plot (5 trees from each species group). For trees with dbh ≥ 1.5 inches (4 cm) and ≤ 4.5 inches (11 cm): species and dbh were measured. Trees < 1.5 inches (4 cm) dbh and taller than 3.3 feet (1 m) were tallied by species and dbh class.

Stem Mapped: No

Regeneration Variables: N/A; 16 quadrats of 1 m^2 each were used to collect information about herbaceous vegetation

Non-Tree Variables: Slope, aspect, geology, soils

Description:

Other Information: 4 transects of 56.5 ft per plot were used to measure down dead wood ≥ 2 inches (5 cm) in diameter and ≥ 2 feet (0.6 m) in length.

Pacific Northwest

Several programs are aggregated and maintain a wide network of PSPs.

HEADER INFORMATION

Jurisdiction: United States of America

Agencies: Coniferous Biome Program (CFB) of the International Biological Program; H.J. Andrews Experimental Forest Long-Term Ecological Research program (LTER); Ecosystem Management program (EM); USFS PSPs for growth and yield (G&Y).

URL:

Language: English

References: [1]

Contact:

DESIGN

Objectives: The first plots were established by researchers from USFS to quantify timber growth in young stands of important commercial species, to quantify gross timber yield, including trees that die before harvest. The objective for installing PSPs during 1970s was to quantify composition, structure and population and ecosystem dynamics of natural forests. The most recently established plots (1990s) are intended to further the integration of ecosystem science into forest management (i.e., increase understanding of forest-stream interactions and the dynamics of multi-aged stands).

Inventory Method: Ground

Plot Type: Permanent. Contiguous rectangles subjectively placed within an area of homogeneous forest, circular plots subjectively placed within an area of homogeneous forest, or circular plots systematically located on long transects to cover an entire watershed, ridge, or reserve.

Plot Size: Rectangular plots are mostly 1.0 ha or 0.4 ha in size, but range from 0.25 ha to 4.7 ha. Circular plots are 0.1 ha.

Number of Plots/Intensity: 136 plots on a total of 129.6 ha of research sites scattered across Oregon and Washington.

Sampling Design: Subjective/systematic

Date of First Application of Present System: 1910

Other Information: Remeasurement interval is 5-6 years. For some study areas, mortality is recorded annually. Data and documentation of methods and study locations are stored in the computerised Forest Science Data Bank at the Department of Forest Science, Oregon State University. [57], [58]

MEASUREMENTS

Tree Variables: Species, dbh (minimum diameter at dbh for most areas is 5 cm), height for subsampled trees, condition (live or dead). For understory vegetation: species, cover, basal diameters.

Stem Mapped: Yes on more than half of the rectangular study areas (converted into GIS)

Regeneration Variables: For some of the plots: species, cover

Non-tree Variables: Site and topographic characteristics, CWD

Description:

Other Information:

USDA Forest Service

HEADER INFORMATION

Jurisdiction: USA

Agency: United States Department of Agriculture, Forest Service

URL: http://www.fs.fed.us/im/directives/html/fsh2000.html

Language: English

References: [64]

Contact:

DESIGN

Objectives: To determine timber growth, yield and mortality; to provide consistent, compatible, and comparatively reliable growth and yield data, and data for use in long term studies of climate change and global warming.

Inventory Method: Ground

Plot Type: Permanent

Plot Shape: Square/circular, individual units/cluster plots/nested plots

Plot Size: Fixed area/variable area

Number of Plots/Intensity:

Sampling Design: The design should be carefully developed and appropriate for the stated objective; can be random sampling, systematic sampling, purposive sampling, stratified sampling.

Date of First Application of Present System:

Other information:

MEASUREMENTS

Tree Variables: Function of the project; could include species, dbh, height, crown length, age, damage, crown class, truncated height**,** crown foliage density, height growth, radial growth, stump height, stump diameter.

Stem Mapped: Depends on the project.

Regeneration Variables: Distance to seed wall

Non-Tree Variables: Site characteristics (habitat type), aspect, slope, elevation, site index; remeasurement interval: 6-8 years, but no more than 10 years.

Description:

Others: The Timber Permanent Plot Handbook [63] provides a benchmark for establishing and maintaining PSPs.

Appendix 4: Examples of Other Permanent Plot Systems

Australia, State of Victoria

The State-Wide Forest Resource Inventory (SFRI) is a systematic inventory of the native forests in the state of Victoria that began in 1994. The mapping is scheduled for completion in 2001.

HEADER INFORMATION

Jurisdiction: State of Victoria, Australia

Agency: Forest Management Branch of the Forests Service of Victoria

URL: http://www.nre.vic.gov.au/forests/sfri

Language: English

References:

Contact: Manager Forest Resource Inventory, PO Box 500, East Melbourne, Victoria 3002, Australia; Telephone: 03 9412 4184; Facsimile: 03 9412 4592

DESIGN

Objectives: Forecasting sustainable yield, strategic planning, and a range of other investigations such as "old growth" mapping

Inventory Method: Remote (aerial photograph) and ground-based sampling; related via GIS.

Plot Shape: Circular

Plot Size: Variable radius plots

Number of Plots/Intensity:

Sampling Design: Model-based, two-stage sampling

Date of First Application of Present System: 1994

Description: Once the plot locations are selected (using stratified random sampling), two-stage sampling is performed to select trees for field measurement. In the first stage, all trees that fell within the plot are located and measurements made on them. In the second stage, a subsample of the trees on plot is selected for detailed stem profiling. A selection procedure known as "point modified list sampling" is used to select trees on the basis of merchantable height.

Other Information: The sampling was targeted to measure the relationship between volume and the attributes of the stand, namely crown cover, crown form and height.

MEASUREMENTS

Tree Variables: Dbh, species, height, crown cover, crown form, number of hollows, height of top point of the merchantable bole

Stem Mapped: Yes

Regeneration Variables:

Non-Tree Variables:

Description:

Other Information: On the sub-sampled standing trees the following variables are measured: position, class and size of all visible defects, diameter over bark at 0.5m above ground level (AGL), diameter over bark at 1/3 top point AGL, diameter over bark at top point AGL.

The following variables are measured after falling: bark thickness, diameter at top point height and one-third height to top point, diameter of pipe defect at two points on the stem, height of 'smashed' wood (wood damaged during tree felling), and the size and location of hollows. The age and growth (ring width) are measured for two trees per plot.

New Zealand, Permanent Sample Plot System

New Zealand's remaining indigenous forests are an important feature of the landscape and cover about 6 million hectares (23%). Management and protection of this resource require techniques for monitoring its status.

HEADER INFORMATION

Jurisdiction: New Zealand

Agency: Landcare Research, New Zealand

URL:

Language: English

References: [3]

Contact: R.B. Allen; E-mail: allenr@landcare.cri.nz

DESIGN

Objectives: Multipurpose: (1) determining vegetation responses to animal impacts; (2) monitoring canopy dieback in tree species; (3) describing compositional and structural

variation; (4) quantifying changes in forest cover; and (5) developing models of forest dynamics.

Inventory Method: Ground/aerial photograph

Plot Type: Permanent

Plot Shape: Square

Plot Size: 20 x 20 m = 400 m^2

Number of Plots/Intensity: Variable. Factors taken in consideration for establishing plot sampling intensity include: (1) the diversity of vegetation in the study area; (2) the resources available; and (3) the level of precision required. More than 10,000 20 x 20 m PSP have been installed

Sampling Design: Variable. Representative samples of study area including random sampling, restricted random, systematic sampling. Subjective (purposive) sampling applied in ecological studies.

Date of First Application of Present System: 1960s

Other Information: The 20 x 20 m plot is subdivided into 16 equal subplots to record saplings and 24 understory plots (circular - 0.75m^2), with their centre located on the sides of the sapling subplots.

MEASUREMENTS

Tree Variables: Species, dbh (dbh > 3.0cm)

Stem Mapped: No

Regeneration Variables: Seedlings 15 cm in height or greater are counted by species and height classes.

Non-Tree Variables: Altitude, aspect, slope, slope position, soil characteristics(drainage, depth)

Description:

Other Information: Saplings are defined as having heights greater than 1.35 m and dbh's less than 3.0cm.

New Zealand, Method for Describing Natural Vegetation

The New Zealand Forest Research Institute has a methodology (reconnaissance description - RECCE) for rapid broad-scale surveys of compositional variation in mountain forests, shrublands, grasslands and mires.

HEADER INFORMATION

Jurisdiction: New Zealand

Agency: Forest Research Institute

URL:

Language: English

References: [4]

Contact: R.B. Allen; E-mail: allenr@landcare.cri.nz

DESIGN

Objectives: Multipurpose

Inventory Method: Ground/aerial photographs

Plot Type: Permanent/Temporary

Plot Shape:

Plot size:

Number of Plots/Intensity: >40000

Sampling Design: Representative (systematic or random sample), stratified or subjective sample

Date of First Application of Present System: 1970s

Other Information: RECCE is used in combination with PSP assessment

MEASUREMENTS

Tree Variables: Trees by species and height classes, percentage cover

Stem Mapped: No

Regeneration Variables: No

Non-tree variables: Epiphytes and tree ferns, site characteristics.

Description:

Other Information: