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Multipurpose Resource Inventories

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Introduction

Resource inventories are often functionally oriented and confined to areas where resource management opportunities are the highest (e.g., timber inventories were only conducted as commercial forest land). However, many lands are now managed for a variety of benefits, including water, forage, wildlife habitat, wood, recreation, wilderness, and minerals. International agreements and recent legislation often require that we take an integrated approach in our decision-making, resource planning, and inventories. In order to address increasing concerns about the environment and sustainable development and to reduce costs, we are finding we need more information than we normally collect in traditional timber inventories. Faced with new information requirements and decreasing budgets, many resource inventories in the future will have to change from the traditional functional inventories we conduct now. They will have to meet more needs with less funding. Future inventories will need to concentrate on measuring basic resource attributes in a manner that will permit multiple use interpretations. The inventories must be comparable across forests, states, and regions. They must also promote a continuity of information and direction between major decision levels. Lastly, future inventories must link to the past, provide a basis for monitoring plan implementation, and provide information on changes and trends.

Multipurpose resource inventories (MRIs) help meet our needs. MRIs are data collection efforts designed to meet two or more needs. Integrated, coordinated, and multiple resource inventories are forms of multipurpose inventories. Such inventories help meet the new information requirements. Fundamental to the successful development and implementation of MRIs are information needs assessments, cooperation and coordination, standardization, objectivity, and control.

Background

In one regard MRIs are new, yet in another they have been around since humans evolved. The data-gathering techniques were reconnaissance-type, multipurpose inventories conducted by the scouts of the tribes and reported verbally. The primary use of these exploratory inventories was to determine if the lands should be settled. When the capability of the lands to produce food and shelter became exhausted, humans simply moved on.

As land became scarce and human populations grew, settlement took place. With settlement came more specialized information needs and data collection techniques to fill them. Timber inventories, soil surveys, agricultural censuses, mineral surveys, and wildlife censuses, emerged. **Table 1** lists some of the specialized or focused inventories that were conducted by the US Department of Agriculture (USDA) Forest Service on its national forests in 1987.

Most inventories were conducted for specific functional uses and generally confined to areas where those functional management objectives were to be emphasized. Some inventories, even at the national level, were redundant and resulted in conflicting information. There was little attempt to tie inventories between resource functions, administrative units, and planning levels. In addition, many inventories were designed for very short-term problems. Little consideration was given to long-term integrated development now required in our planning processes.

There are common data requirements for several of the inventories listed in **Table 1**. For example, all of the timber, range, and wildlife surveys require information on vegetation. In addition, recent laws required that the USDA Forest Service look at its resources in an integrated manner – that is to say, understanding the management of one resource would affect the sustainability of another. The agency could realize cost savings and meet its legal obligations by developing multipurpose or multiple resource inventories where attributes are measured once but used by many (**Figure 1**).

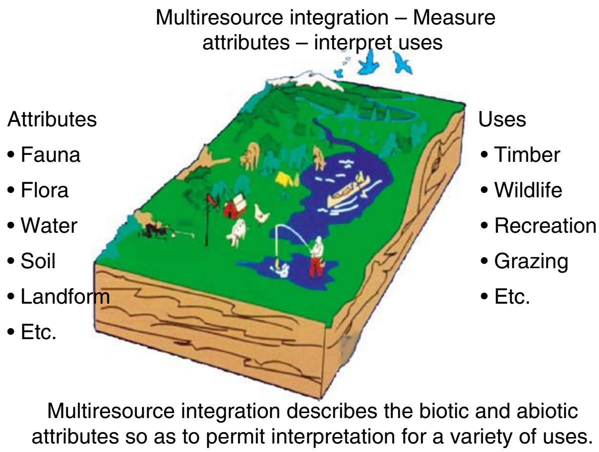

Figure 1 Measuring attributes and interpreting uses.

Table 1 Resource inventories conducted by the US Department of Agriculture Forest Service

Responsible staff	*Inventory subject*	*Major uses*
Forest research	State-wide forest survey	State survey reports, national and international assessments
Timber management	Forest-wide surveys	Forest planning
	Silvicultural examinations	Forest and project planning
	Timber cruises	Project planning
	Regeneration surveys	Project planning
Range management	Range analysis	National assessments, forest and project planning
	Noxious weed survey	National assessments, forest and project planning
Watershed and air management	Water-quality survey	National assessments, forest and project planning
	Air-quality survey	National assessments, forest and project planning
	Soil survey	National assessments, forest and project planning
Wildlife and fisheries management	Threatened and endangered species	National assessments, forest and project planning
	Wildlife and fish habitat survey	National assessments, forest and project planning
Recreation management	Cultural resource survey	National assessments, forest and project planning
	Recreation opportunity spectrum	National assessments, forest and project planning
	Visual management	National assessments, forest and project planning
Minerals and geology management	Common-variety minerals	National assessments, forest and project planning
Fire and aviation management	Fuels inventory	Forest and project planning
Forest pest management	Forest pest condition	Forest and project planning
Lands staff	Land status and utility corridors	National assessments, forest and project planning

Multipurpose Inventories

New concepts in resource management planning require periodic inventories that are free of political judgments and not conceived to support foregone conclusions about which lands will be used for what purpose.

Given today's funding, we cannot get the necessary information by each resource collecting data separately. We need to start collecting data so it can be used by other resource sectors. Multiresource inventory integration is a must.

If we are to avoid contradictory data and keep costs down, the same inventories we use at the local level should be used for national and global assessments. Multilevel inventory integration is needed as much as multiresource integration is needed.

As inventories are aggregated for national assessment, they must be compatible across states and provinces. This requires multilocation integration. Lastly, the success of our plans and programs needs to be monitored and evaluated. Temporal inventory integration has to be involved. Thus, multipurpose inventories may take on up to four forms of integration (**Figure 2**).

MRI Requirements

Successful multipurpose inventories depend upon the fundamentals of cooperation and coordination, standardization of terminology and techniques, objectivity in design, and control and responsibility. Without these, integration is not possible.

Cooperation and Coordination

The most important elements for successful inventory integration are cooperation and coordination – cooperation between data collectors and decision-makers so that inventories meet an organization's objectives and coordination among data collectors so that the required information is gathered most effectively. This may include cooperation between functional specialists, line officers, and research units.

Cooperation is needed to: (1) establish minimum requirements for meeting information needs irrespective of agency or organization; (2) establish inventory standards providing uniformity between data collectors; (3) provide minimum quality requirements against which inventories can be evaluated; (4) eliminate unnecessary duplication of data collection; and (5) increase utility of resulting information.

Coordination improves cost-effectiveness by eliminating redundant data collection and reporting and by incorporating alternative measuring and sampling techniques. Involving all interested parties clearly identifying intended uses, defining areas of responsibilities (particularly when inventories may be conducted by two or more individuals and agencies) and designing inventories that are multipurpose all improve efficiency.

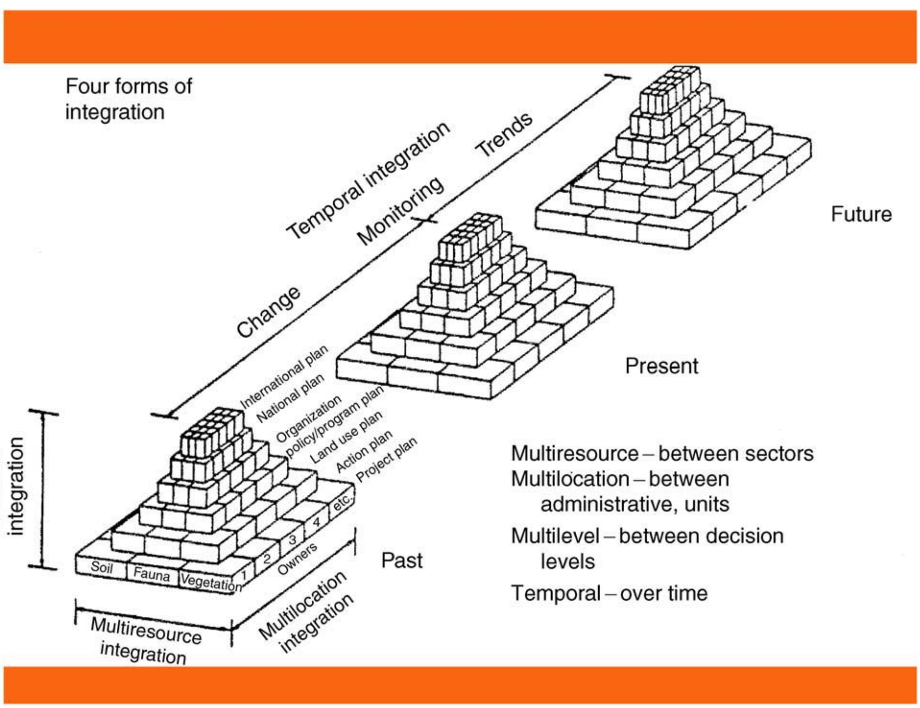

Figure 2 Four forms of integrated or multipurpose inventories: multiresource, multilocation, multilevel, and temporal.

Standardization

Standardization adds to the value of information, for information that becomes useful to more people and data can be compared and combined. Definitions, classifications, and measurement require standardization, but to encourage innovativeness, flexibility in how those standards are met should be allowed.

Objectivity

Objectivity in inventory designs is needed so that data from different sources can be scientifically compared and aggregated. Objectivity is maintained through the use of sound sampling strategies. The proper choice of sampling strategies involves minimizing bias, constructing a sample frame, and selecting a sampling technique.

- Implied in objectivity is that all locations or survey units be mutually exclusive (i.e., boundaries do not overlap) and data from all locations must be complete (i.e., all locations are accounted for).
- The inventory of each location must be based on complete enumeration or on a scientifically valid sample.
- Common definitions and standards must have been used or data collected in such a manner that they can be converted to common definitions and standards.
- The information produced from each inventory includes estimates of the mean (or total), the standard error of the mean (or total), and the probability level at which the standard error is calculated.

Control and Responsibility

Quality control provides the mechanisms for ensuring inventories are carried out according to specifications. Control includes assignments of responsibilities, choice of area bases, time frames, and data collection, compilation, and summary processes. Control should be established in an inventory plan and begun before the first field plot is established.

Responsibility Assignment of responsibility indicates who will do what, when, and how. Responsibility also includes assignment of authority to resolve any conflicts or questions that may arise in the course of the inventory. This authority should monitor the inventory work, make changes in inventory methodology, and ensure that users understand the processes and correctly apply the results.

Area control Decision-makers usually require area statistics as well as volume and production information. All those concerned with integrated inventories must utilize the same area control base from which to compute areas. Without an agreed-upon base, there would be no means of determining if areas are omitted or duplicated. The sum of the mapped and/or survey areas must equal the total area of interest.

Time frame In addition to utilizing a standard land base, inventories should also be within compatible time frames. If compatible time frames cannot be used, it is often necessary to update or 'grow' the inventory through simulation models, to make the data compatible. The models used, as well as the coefficients, may also become a form of control.

Data collection, compilation, and summary Measurements and observations should be made as objectively as possible. Detailed instructions should be provided for each step of the inventory from measurements to ensure uniformity. Checks should be made throughout the inventory to ensure procedures are being followed. The central authority should be available in case procedural questions arise. The more authority provided, the more compatible the multipurpose inventories become.

Advantages/Disadvantages of MRIs

The advantages of developing MRIs are that they:

- reduce overall costs of gathering data (US Forest Service table)
- provide more useable information for easier analysis of interactions
- get people talking and acting together
- eliminate confusion and duplication.

The disadvantages are that MRIs:

- are more costly than a single-purpose inventory as one is gathering more data
- require working with other people with different goals, agendas, and backgrounds
- require partnerships to share responsibilities, results, and credit
- require more time to determine information needs and to develop methods to collect the necessary data.

Information Needs Assessment (INA)

Decisions are often based in part on inventory summaries. To determine the kinds of summaries needed, we have to examine the kinds of decisions a large organization has to make. Then we need to look at the techniques and fundamentals available for designing inventories that can link these decisions together.

In planning for the management of its resources, a large federal agency can be involved at several decision levels, including international, national, agency, regional, forest, district, and compartment, and stand. Each level of decision has its own information needs, uses, and, requirements. Typical characteristics of various decision levels are given in **Table 1**.

You will note from **Table 1** that data collected at the local level are also needed at the national and international levels. **Table 2** shows the kinds of information needs at various levels of decisions.

The information required at a given decision level is usually more general and broadly based than the information required at lower levels. Users of the information also differ. Users of national-level information are usually more numerous and diverse than users of project-level information. At the same time, information needs change as an organization matures. When first created, an agency may have need for (and access to) only broad descriptive information about its resources. As management intensifies, more detailed information is needed and more information becomes available.

Integration between decision levels or multilevel integration is usually required to provide a continuous flow of information and management direction between the highest levels in the organization and the

Table 2 Typical decision level characteristics

Level	*Characteristics*
International	Goal: To develop international assistance programs or action plans to reverse the depletion of resources and degradation of the environment; foreign trade agreements to shift surplus to meet demands; or cooperative agreements to control pests and diseases or to address other catastrophic occurrences. Information sought includes the present state of the resources and the rate and pattern of change. An international group usually assembles data
National	Goal: To develop long-range federal policies and programs for public and private land-administrating organizations within a given country. National assessments often provide basic and relevant data on renewable resources held by all types of owners within a nation, appraising changes in supplies of resources and demands for them, the outlooks for the future, and possible alterations in these outlooks by changes in national program end policies. National assessments include descriptions of the present situation and estimated changes due to management, cultural influences, and natural or secondary factors. The data are usually assembled and compiled by a federal agency or an association dealing with a specific resource product. The primary users of the information are the executive branch, Congress, and regulatory agencies. Private industries also use long-range estimates of production and trends to develop their own strategies
Agency	Goal: To develop an overall strategy for the management of resources within the agency's jurisdiction; to define a policy; to express that policy as a set of regulations; and to carry out and execute the policy through the agency's program. The information required usually reflects current values and rates of change. Inventories conducted at this level may be considered as a prelude to the development of the resource. Inventories focus on the resource stock and the land's capability to produce on a sustained yield basis. The inventory units used in planning are usually based upon political or administrative boundaries. Broad management goals and objectives and financial plans for the organization are the eventual products
Region, forest, district	Goal: To develop long-term direction for each management or administrative unit (e.g., region, forest, district) within an organization. The resources and their condition and potential are described only in sufficient detail to direct the manager's attention to specific portions of the management unit for more intensive planning. Area, volume, and production estimates are usually tied to each unit. For timber planning, information sought includes areas by land class, soil-vegetation types, estimates of growing stock within the classes, and accessibility. The product is a management plan
Compartment and stand	Goal: To determine what, where, and when specific treatments are to take place. Decisions regarding timber sale locations and prescriptions for specific stands are examples. Inventories to assist the decision-maker often include maps of vegetation conditions by compartments and stands, description of vegetation and terrain within the units, and accessibility and relevant classification of the units with respect to the alternatives selected under the land use planning process. Data observed include vegetation factors, potential productivity, accessibility, and economic factors in order to determine specific management actions to take place within the treatment unit. The district usually conducts the inventories. The output is a functional action plan showing the treatment areas and indicating what is to be done when, where, and how. The plan is used for the day-to-day operations of the lowest-level field office

lowest levels. This ensures that the lowest units are carrying out the policies of the agency and that policies can consider the most recent data available. The differences in users, needs, and timing between decisions present special problems when trying to develop inventories to support multiple decisions.

Approaches for determining information needs There are two approaches generally used in determining information needs – a bottom–up and a top–down approach.

In the bottom–up approach, the information requirements are defined at the local level and accumulated upwards. The disadvantage is that the information identified may not include the information required at the top level of the organization.

With the top–down approach, information needs are defined at the highest echelons. At each subsequent decision level, more information is added to meet more local issues. A problem with this approach is that the people collecting the data at the project level feel burdened collecting information for which they do not feel a use.

If we assume that information needed at the top decision levels in an organization is needed at subsequently lower levels, the top–down approach is preferred.

To develop a workable information flow, decision-makers at all levels of the agency must be involved. Information needs and reporting formats must be identified at each planning level, starting at the highest or broadest level. This procedure establishes a minimum core of information and priorities required at all decision levels and ensures that the policies, regulations, and information needs of the organization are developed and fulfilled. The commitment to provide information from the lower levels will only be as strong as the field perceives the need for the information. Consequently, field units will be more cooperative in supplying information when they have been involved, and clearly understand why the information is needed and how it will be used to serve their needs.

Inventory design options There are two design options for meeting multipurpose information needs. The first option is to design a system in which the mapping and sampling is intense enough to meet the most demanding needs (i.e., at the compartment and stand decision levels). The second option is to conduct two or more inventories on the same piece of terrain but at times corresponding to different stages of development.

The first option has the advantage that one inventory would provide compatible information for all decision levels. However, because all lands may not be managed at the same intensity, this option can be costly if the production potential and management intensity of the lands are low.

Under the second option, a broad decision level is chosen as a base where the same detail of information is required across all lands. As with the first option, these inventories would be aggregated to provide more generalized information to the upper levels in the hierarchy and would provide defined survey areas for the lower echelons. Additional inventories for the more detailed planning levels would be conducted within those survey areas only when and where they are necessary, resulting in overall cost savings. Information from the broader inventory would be used to enhance, expand, and supplement the more intensive surveys.

Minimum data As a minimum and regardless of information source (imagery or ground observations) where possible measure, record and make available the following information:

- geographic coordinates of observation
- date of observation dominant
- vegetation type (life form as a minimum)
- height of dominant vegetation
- percent of canopy cover of dominant vegetation
- area classification surrounding point of observation to which observations apply.

This is the very minimum set of data that should be recorded for each plot or polygon in national vegetation inventory and mapping efforts. By using this information, one can resort the data to fit almost any international vegetation classification schemes, especially when used in a geographic information system with soils, climate, and topography data. In addition, these attributes can be used for developing classes, validation of classes, and for accuracy assessment.

Research Needs

Regardless of design used, data collection is still costly. The identification of indicators and development of models can reduce inventory costs.

Research on new products, uses, and cultivation of native vegetation is needed. As new products and uses are identified, new measuring and sampling techniques will need to be developed.

Production coefficients, linked to soil and climatic factors, need to be developed for existing and emerging uses. Without this information, we cannot develop resource management programs.

Statistical strategies for combining existing information also need to be strengthened. There is a wealth of data available, but how can we combine it, compare it, and disaggregate the information?

Finally, we need more research on integrated analyses to determine how changes in one resource will affect other sectors. For example, forest land is increasing in many parts of the developed world as agricultural lands are abandoned. Does this reduction of agricultural lands in the north increase deforestation in the developing world as lands are converted to agriculture?

Summary

Agencies such as the USDA Forest Service are taking an integrated approach to developing inventories. Inventories concentrate on measuring basic resource attributes in a manner that will permit multipurpose interpretations.

Cooperation and coordination, standardization, objectivity, and control and responsibility are fundamental in designing these inventories to ensure that the inventories can be summarized and used by decision-makers for a variety of purposes.

See also: **Biodiversity**: Biodiversity in Forests. **Inventory**: Forest Inventory and Monitoring. **Mensuration**: Forest Measurements. **Resource Assessment**: Forest Resources.

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Stand Inventories

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Introduction

Stand inventories are the classical way to build a management plan. The first step is the delineation of stands: useful for this are forest survey, aerial photography, or remote sensing technologies (*see* **Resource Assessment**: GIS and Remote Sensing). The second step is to collect information on each stand. This can be done by using inventory techniques (sampling techniques) or by using aerial photographs or remote sensing. In the future, a new approach could bring better results: airborne laser-scanning combined with high resolution satellite data, for example.

This article covers special stand inventory techniques based on considerations of precision and accuracy and tries to demonstrate the differences between stand inventories and forest inventories.

Historical Overview

The classical method to obtain data for a management plan is to use stand inventories. After the stands have been delineated, some information on each of them is collected. See **Table 1** for an actual example from the nineteenth century.