1-1-1981

Remote Sensing: Its Role in Meeting Information Needs

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Reprinted from

Seventh International Symposium

Machine Processing of

Remotely Sensed Data

with special emphasis on

Range, Forest and Wetlands Assessment

June 23 - 26, 1981

Proceedings

Purdue University
The Laboratory for Applications of Remote Sensing
West Lafayette, Indiana 47907 USA

REMOTE SENSING: ITS ROLE IN MEETING INFORMATION NEEDS

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I. ABSTRACT

The Resources Planning Act, as amended by the National Forest Management Act, the Resources Conservation Act, and the Federal Land Policy and Management Act, all require periodic assessments and appraisals of the renewable resource situation and the development of action plans to accomplish efficient and effective resource management. These assessments and appraisals occur at 5-10 year intervals. They require continuous updating of the renewable resource situations obtained through inventory of which remote sensing must play a significant role.

Generally, information requirements for renewable resource assessments include: (1) area, extent, geographic location, and structure of vegetation types; (2) ecological successional stages of the vegetation types keyed to potential natural vegetation; (3) kind of substrate of the vegetation types in relation to soils and topography to assist in evaluation of resource management options; (4) kinds, amounts, extent, and duration of water bodies, i.e. size of lakes, streams, rivers, and ponds; duration of flow including peak flows; and water quality for commercial, industrial, and recreational activities; and (5) faunal populations.

Information needs may be further categorized as to measured, observed, calculated, or assigned. Measurements include mapping and actual measurements of information items such as tree height, shrub cover, lake area, or vegetation type area. Observed items are the presence or absence of something such as structures or landslides. Both measured and observed items are amenable to remote sensing. Calculated items include such determinations as timber volume and grazing capacity toward which measurements contribute. Assigned information needs include such items as land ownership, political boundaries, management areas. Assigned information must be obtained from sources other than remote sensing.

II. INTRODUCTION

The Resources Planning Act (PL 93-378), as amended by the National Forest Management Act (PL 94-588), the Resources Conservation Act (PL 95-192), and the Federal Land Policy and Management Act (PL 94-597) all require periodic (5 to 10 years) assessments, appraisals, and development of programs for the Nation's renewable natural resources. The Resources Planning Act (RPA) is constrained to dealing with the Nation's forest and rangeland base and more specifically requires assessments for range, timber, fish and wildlife, recreation and water. The assessments are used by the Forest Service for program planning of management and administration of lands under the National Forest System, identifying research needs and priorities, and cooperative assistance of state and private forestry. The Resources Conservation Act (RCA) requires appraisals specifically of the Nation's soil, water and related resources including agricultural needs and nonfederal forests and rangelands. The Federal Land Policy and Management Act (FLPMA) is the Bureau of Land Management's "Organic Act" and requires, among other things, periodic inventories of renewable natural resources for quantities, conditions, and trends to be used for renewable resource planning of the lands under their jurisdiction.

The above legislation requires coordination and cooperation among resource agencies, states, and the public to prepare comprehensive periodic assessments and appraisals of the Nation's resource situation. The data and information from the assessments provides a basis to decision makers to allocate resources in the most efficient and effective way to meet society needs and demands within the ecological and economic limits of the land and water base.

Assessment needs, supported by inventory, reinventory, and land classification, require information on <u>what</u> the resources are, <u>where</u> they are, <u>how much</u> is there, and <u>what</u> are their conditions. All of the resource systems, i.e., timber, range, wildlife and fish habitat, are functional and product oriented. However, there are basic resource elements -- vegetation, soil, and water -- common across all resource systems which lends credence to developing multi-resource inventory systems. Because of the large area coverage, rapid data acquisition and established and emerging interpretation techniques, remote sensing will continue to play an increasingly vital role in assisting the development of factual and reliable renewable resource assessments.

III. INFORMATION NEEDS

It is doubtful that there will ever be a complete consensus on what all data elements and information items are required to assess the state of the resource situation. This should be expected since changing political issues, resource management objectives, or required and expected tradeoffs within and among resource management objectives will affect the information requirements for assessments of the renewable natural resource situation. However, there is a wide spectrum of information needs, especially basic data elements, that will likely be consistently required. These can be grouped into five general categories: (1) area, extent, geographic location, and structure of vegetation, (2) ecological successional stages of vegetation type keyed to potential natural vegetation, (3) substrate of the vegetation including kind of soil, topography, and other physiographic features of the land, (4) water elements including kinds, amounts, extent, and duration of water bodies, and (5) faunal populations.

A. VEGETATION AREA, EXTENT, GEOGRAPHIC LOCATION, AND STRUCTURE

Classification of vegetation, the determination of vegetation types, is a first requirement for information on vegetation. Classification serves two basic purposes; (1) to provide stratification for sampling various resource parameters, and (2) to provide location data and information for efficient and effective application of resource management programs. Stratification improves sampling efficiency. Location specifics provides opportunities to select areas most suitable for specific resource program alternatives.

Two kinds of classifications are needed; (1) natural, or primary, which are based on fundamental ecological principals, and (2) technical, or secondary, which are based on specific product output.

Natural classifications are made without predetermined notions for specific uses; i.e., range livestock grazing or timber production. They are classifications made in relation to ecological considerations to define and describe plant communities, preferably in a hierarchical order. The characters and character states of a natural classification are based on primary properties to define and discriminate differences between plant communities based on ecological similarities and differences. The characters and character states are selected for permanency and will generally include kinds of information needed for resource assessments. The need for this kind of information is exemplified by legal requirements to ascertain potential plant community systems to evaluate trends and changes in community systems to assist in land management planning. A classification system to meet these requirements has been presented by Driscoll et al.[1]

Technical classifications are based on preconceived notions of resource use and product output. The characters and character states used for class discrimination are based on transient properties which change according to economic and social requirements. For example, a criterion for commercial forest land is its ability to produce more than 20 cubic feet per acre per year of industrial wood in natural stands. This criterion could change depending on demands for wood products and consequently is a transient descripter that could result in incompatible data bases and double counting of portions of the land base.

Both classifications are needed. The first establishes the base line from which to evaluate situation changes in the resource base. The second establishes the current situation in relation to economic and social demands.

Area statistics refer to that simply; the determination of how much is there of a particular plant community type. Extent and geographic location are determinations of contiguous size and location of plant communities. They also must consider juxtaposition to provide values on large and small area diversity. This kind of information is required, especially for assessments of wildlife and recreational situations.

Structure of vegetation is of prime importance for resource assessments. Structure refers to the three-dimensional picture of vegetation, i.e., length, width, and depth. For example, in a forest or any other plant community, we must know what kinds of vegetation constitute the various layers -- trees, shrubs, grasses and in some cases, mosses and other very low growing vegetation -- to provide a measure of within-community diversity. This kind of information is important for assessing wildlife habitat and assisting in evaluating management options for range livestock grazing or timbering. In the forest, it makes a difference in management treatments whether or not sprouting or nonsprouting vegetation is in the understory.

Periodicity of vegetation, especially herbaceous and shrubby vegetation, is a part of vegetation structure. This kind of information is needed, particularly for assessing the range and wildlife situation. In this case, periodicity refers to the within and between seasonal productivity. Productivity of herbaceous and shrubby vegetation is required to allocate range livestock grazing and to establish the amount of allowable controlled grazing in relation to other resource use requirements. In long range planning, production periodicity of wood fiber is required for renewable resource assessments. Production of wood fiber provides estimates on the amount of wood available for industrial use. In addition, it is becoming increasingly important to obtain information on total wood fiber production to determine the amount and availability of fuel wood.

B. ECOLOGICAL SUCCESSIONAL STAGES

Ecological successional stages refers to the successional pattern of plant communities. In this case, these stages refer to the secondary successional process of plant communities caused by timbering, grazing, and other disturbances to the community system.

The identification and distribution of ecological successional (seral) stages linked to potential natural (climax) communities is required for resource assessments, for land management planning, and for monitoring the effects of land management actions. In current inventory practices, seral stages refer to ecological range condition classes and timber stand size and condition classes. These seral stages are inventoried and provide the knowledge required of the existing situation. Information on area, extent, location, and structure of the seral stages linked to information about potential natural vegetation, or at least near potential natural vegetation, provides the knowledge required for management decisions.

For example, the existing (seral) community may be a grass-shrub complex within a grassland climax potential. Evaluation of management alternatives may result in a decision to "hold" the existing community in its present seral stage for combined wildlife-livestock-water production, use, and protection. Or, local and national issues may favor managing for livestock grazing or maintenance and improvement of wildlife habitats. Decisions can be made to manipulate the present community to address the issues and meet management goals. This is accomplished by having knowledge of the potential natural vegetation and the identification of the position of the existing seral community in relation to its successional status.

C. SUBSTRATE

Substrate refers to the abiotic or physical features of the landscape. Specifically, this includes kinds of soil and topography. Information needs on kinds of soil should be obvious. When linked to vegetation, it provides additional information required to establish inherent biological potential of vegetation. Information on soils provides needed data for assessing probabilities of success on revegetation projects. Certain kinds of soils data are required for engineering purposes such as road construction for timbering. The specific kinds of soils data required depends on the level of activity. For local project planning, complete classification to Soil Series with profile characteristics are needed. For regional or national level assessments and planning, generalized information on Soil Families may be all that is necessary. This would provide information, through nation- and region-wide assessments, on specific locations to most efficiently and effectively implement management programs.

Information on topography - slope aspect, slope steepness, and elevation - is an important element required for resources assessments, especially at the local level. The configuration of the landscape plays an important role on how the landscape will be managed. For example, steepness, aspect, and elevation are requirements for defining management alternatives in regard to timbering, domestic livestock grazing, potential recreational activities, and interactions among those uses.

D. WATER

Information on water is required in terms of kinds (lakes, ponds, and streams), area of impounded water bodies, and length and width dimensions of streams. Water quality and quantity data are required for resource assessments to establish action plans on how the water will be used in relation to industrial, commercial, agricultural, and recreational activities.

E. FAUNA

Information is required on kinds, numbers, and distribution of faunal populations. At the national level for resource assessments, it is unrealistic to include all individual species of wildlife and fish and their habitats because of the magnitude of the numbers. However, and by law, information is required on threatened and endangered wildlife and fish species populations and habitat requirements. Information on key or featured species populations and habitat requirements are needed for regional and especially local land management planning and monitoring.

F. OTHER

In addition to the above, secondary information requirements for renewable natural resource assessments include: (1) location and extent of commercial, industrial, and residential developments and estimates of pressures on the resource base caused by changes in these developments, (2) land ownership including private lands and those administered by different agencies, (3) land and resource management planning goals, (4) relative and economic values of different resource systems; i.e,, recreation, timber, wildlife and fish, and others, to calculate and interpret interactive resource systems relationships, and (5) location and extent of special areas such as natural heritage sites and critical habitat for threatened and endangered wildlife and fish or plant species.

The above is not an exhaustive list of information needs for resource assessments. It does include essential elements as are currently understood. Others will be needed as new issues are identified and answers are required for renewable natural resource assessments. Hoekstra et al. dealt in more depth with national level information needs and analysis procedures for national assessments.[2]

IV. REMOTE SENSING AND THE INFORMATION NEEDS

Information and data contributing toward resource assessments are measured, observed, calculated, or assigned. Measurements include mapping and actual measurements of information items such as tree height, shrub cover, lake area, or vegetation community area. Observed items include the presence or absence of things such as landslides or structures. Both measured and observed items are amenable to remote sensing. Calculated items include determinations of values such as timber volume and livestock grazing capacity. These items are not directly obtainable from remote sensed data but measurements from the data contribute toward the calculations. Assigned information includes such items as land ownership, political boundaries, and management areas. Assigned information must be obtained from sources other than remote sensing.

Aldrich recently completed a comprehensive state-of-the-art review on use of current remote sensing technology, applications, and costs for wildland resource inventory and management.[3] Included were discussions on data collection, interpretation, and processing of information obtained by photographic and nonphotographic sensors for classification and mapping, interpretation for specific applications, measurements of resource parameters, and observations and count occurrences.

Remote sensing provides either direct or indirect contributions to the information needs and requirements previously discussed. There are some items remote sensing cannot provide: (1) land ownership, (2) economic and social values of resource systems, (3) estimates of potential natural vegetation except in areas known to have little or no impact by human activities, (4) specific subsurface soil profile characteristics required to characterize soil taxonomic units or to assess the probabilities of success of engineering activities including road building and revegetation projects, (5) certain features of water quality and quantity, (6) populations of most fauna, and (7) faunal habitat requirements. There are others. Participants of this symposium should be aware of the direct and indirect contributions of remote sensing to required information needs.

However, herein lies a problem. In the majority of instances, most modern remote sensing technology has been developed to a stage of full evaluation. This important process must be carried through to implementation for operational procedures. The remote sensing applications for inventory and monitoring is lacking in many instances and lagging in others. Full scientific evaluation to determine repeatability or artifactual achievements need to be rigorously pursued.

There are a few remote sensing techniques that have been implemented. Aside from some routine applications of aerial photographs, some of these are use of thermal imagery for fire detection, Landsat imagery for certain mapping and monitoring requirements, and color and color infrared films for forest insect and disease detection and monitoring. We need to go further. There are applications on the verge of implementation. We need to spend more time on defining how these can assist in resource inventories for resource assessments to make them fully operational.

We have come a long way since the Gemini, Apollo, Landsat, and Skylab programs. Techniques have been developed. They are close to implementation but have not yet been fully accepted. The techniques on use of current and emerging remote sensing technology will be the eventual winners to assist in accomplishing the requirements for resource assessments.

We need to maintain the balance between visionary illusions on remote sensing technology, which will become realities with continuing research, and implementing operational or near operational procedures. These procedures need to be placed into the hand of practitioners to get extremely important jobs completed efficiently and effectively.

V. SUMMARY

Recent legislation requires assessments of the Nation's renewable resource situation at periodic 5 to 10 year intervals. Assessments require inventories of the renewable natural resources and monitoring certain parts of those resources. Information requirements include: (1) area, extent, location, and structure of vegetation including classification, (2) ecological successional stages of vegetation, (3) kinds of soils and topography, (4) kinds, amounts, extent, and duration of water bodies, and (5) faunal populations.

Remote sensing can provide direct and indirect information to most information needs. Some information such as land ownership and subsurface soil characteristics, cannot currently be obtained through remote sensing.

Application of remote sensing technology to supply data and information for resource assessments must be intensified. Scientific evaluation for implementation of remote sensing technology into operational renewable resource inventory procedures must be rigorously pursued.

VI. REFERENCES

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VII. AUTHOR BIOGRAPHICAL DATA

Dr. Richard S. Driscoll is currently Program Manager for the Forest Service, Rocky Mountain Forest and Range Experiment Station, Resources Evaluation Techniques Research and Development Program. The Program is nationwide in scope and is responsible for maintaining and improving renewable resource inventory and analysis techniques. Within the Program are four research projects: (1) remote sensing for resource inventories and land management planning, (2) multiresource inventory techniques, (3) land classification, and (4) resource analysis techniques.

Prior to his current assignment, Dr. Driscoll was Project Leader of a team of scientists working on remote sensing for resource inventories with special reference to ecological land classification and livestock range and wildlife habitat. During that time, he worked closely with the NASA Earth Resources Program, including the Apollo, Landsat, and Skylab Programs evaluating the use and effectiveness of multiscale/multiemulsion aerial and space photography and multispectral imagery for renewable resource inventories.

Dr. Driscoll obtained his Bachelors and Masters Degrees in Range Management from Colorado State University and his Doctorate in Ecology from Oregon State University.