IMPLEMENTATION OF REMOTE SENSING FOR ECOSYSTEM MANAGEMENT – RECOMMENDATIONS

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ABSTRACT

The Interregional Ecosystem Management Coordination Group (IREMCG) has sponsored a consolidated procurement of satellite imagery for the lower 48 states. This data set consists of: Advanced Very High Resolution Radiometer (AVHRR) biweekly composites, Landsat Multispectral Scanner (MSS) triplicates, and Landsat Thematic Mapper (TM) scenes. This multi-resolution and multi-temporal satellite imagery set was acquired to assist in field implementation of remote sensing to support ecosystem management. Guidelines and recommendations are needed to utilize the remotely sensed data properly.

This paper offers recommendations for vertical and horizontal integration of geospatial information, derived from remotely sensed data, with GIS Core Data layers. It also proposes ways to develop consistent products, lists skills and training requirements, and identifies the need for a spatial data clearinghouse. The goal of these recommendations are to facilitate data sharing and distribution, reduce duplication of effort, and promote consistent GIS Core Data development.
INTRODUCTION

Remotely sensed imagery is an important source of current and repeatable information about the location, quantity, and quality of land cover. Remote sensing also establishes a base from which to monitor changes over time. The IREMCG sponsored a consolidated procurement of satellite imagery for the lower 48 states. The procurement included AVHRR biweekly composites (1:1,000,000 scale), Landsat Multispectral Scanner (MSS) triplicates (1:250,000 scale), and Landsat Thematic Mapper (TM) data (1:100,000 scale). These multi-resolution and multi-temporal satellite images will assist in field implementation of remote sensing to support ecosystem management, especially in relation to Large Area Assessments and Forest Plan Revisions.

Guidelines and recommendations are needed to utilize satellite imagery properly. This paper offers recommendations to assist with vertical and horizontal integration of geospatial information derived from remote sensing and to facilitate the flow of information among Large Area Assessments, Forest Plan Revisions, and individual projects. These guidelines and recommendations are based on governmentwide federal standards for content and accuracy of geospatial data established by the Federal Geographic Data Committee (FGDC).

RECOMMENDATIONS

Remote sensing analysis techniques, methods, and concepts vary according to objectives, data type, acquisition date, analyst skills, and local environmental conditions. Consequently, establishing a comprehensive set of agencywide standards for all remote sensing projects at all ecological levels is impractical. These recommendations are meant to:

- Facilitate data sharing;
- Reduce duplication of effort;
- Promote technology transfer; and
- Aid ecosystem management with remote sensing technology.

The recommendations are not intended to limit the way Forest Service remote sensing projects are designed or implemented. Some plans or projects may require a more detailed classification scheme to meet specific objectives. Projects should be designed so that derived products can be cross-referenced to the recommended attributes described in this paper.
Non-vegetative land cover classes

Recommendation The predicted land cover attributes listed in Table 1 will provide the framework for consistent development of products from remotely sensed data. Portions of the USGS Land Use/Land Cover Classification System will be employed to describe non-vegetative classes.

The USGS Land Use/Land Cover classification system was designed specifically for satellite imagery classifications (Anderson et al., 1976). The non-vegetative labels from Level I or II should be employed to identify features such as roads, ice fields, urban areas, etc. As shown in Table 1, Level I labels should be used with AVHRR classifications. Level II labels can be used with higher resolution data (i.e., MSS, TM, or aerial photos). Determining Level I and II labels may require incorporating ancillary data.

Vegetative land cover classes

Recommendation Vegetative land cover classes will be defined by four attributes: canopy structure, tree size class, percent crown closure, and vegetation composition.

Four attributes will be used to define vegetative land cover classes. However, not all four can be derived from each remotely sensed data type listed in Table 1. Individual project objectives and design will determine which attributes are compiled and their level of detail. Conversely, some projects may find it necessary to gather data that goes beyond the four standard vegetation attributes. In this instance, these derived products should be cross-referenced to the recommended attributes to facilitate vertical and horizontal data integration.

Canopy structure Two labels, single and multi-story, will be employed to describe canopy structure. A single story canopy is smooth textured, often a sign of a homogenous, even-aged forest. A multi-story canopy has a dominant overstory and understory, this is frequently considered a multi-age forest.
Table 1. Predicted land cover attributes derived from the integration of remotely sensed data, geospatial databases, field data collections, and ecological modeling procedures.

<table>
<thead>
<tr>
<th>Non-vegetative Land Cover Classes</th>
<th>AVHRR</th>
<th>MSS</th>
<th>TM</th>
<th>SPOT</th>
<th>Aerial Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) USGS LU/LC&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Level I</td>
<td>Level II</td>
<td>Level II</td>
<td>Level II</td>
<td>Level II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetative Land Cover Classes</th>
<th>AVHRR</th>
<th>MSS</th>
<th>TM</th>
<th>SPOT</th>
<th>Aerial Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) CANOPY STRUCTURE</td>
<td>N/A</td>
<td>N/A</td>
<td>Single/ Multi</td>
<td>Single/ Multi</td>
<td>Single/ Multi</td>
</tr>
<tr>
<td>2) TREE SIZE CLASS</td>
<td>N/A</td>
<td>N/A</td>
<td>Generic&lt;sub&gt;5,6&lt;/sub&gt;</td>
<td>Generic&lt;sub&gt;6&lt;/sub&gt;</td>
<td>Generic&lt;sub&gt;6&lt;/sub&gt;</td>
</tr>
<tr>
<td>3) PERCENT CROWN CLOSURE</td>
<td>N/A</td>
<td>30%</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>4) VEGETATION COMPOSITION</td>
<td>NVCS</td>
<td>NVCS</td>
<td>NVCS</td>
<td>NVCS</td>
<td>NVCS</td>
</tr>
</tbody>
</table>

<sup>1</sup> Small-scale aerial photos < 1:40,000.
<sup>2</sup> Mid-scale aerial photos 1:40,000 - 1:15,000.
<sup>3</sup> Large-scale aerial photos > 1:15,000.
<sup>4</sup> USGS Land Use/Land Cover Classification System (Anderson et al., 1976).
<sup>5</sup> Generic breaks 0-8.9, 9.0-19.9, 20.0+ inches.
<sup>6</sup> May require substantial field data.
<sup>7</sup> Requires the integration of ancillary data.
**Tree Size Class**  The recommended tree size class divisions are listed in Table 2. These divisions were determined from tree size class guidelines by Forest Service region. Tree size class predictions require the incorporation of field data and GIS Core Data.

<table>
<thead>
<tr>
<th>Tree Diameter (inches)</th>
<th>Tree Size Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 8.9</td>
<td>Seed/Sap/Pole</td>
</tr>
<tr>
<td>9.0-19.9</td>
<td>Small</td>
</tr>
<tr>
<td>&gt; 20.0</td>
<td>Medium/Large</td>
</tr>
</tbody>
</table>

**Percent Crown Closure**  The percent crown closure divisions depend on the remotely sensed data type (Table 1). Ten percent divisions are possible with finer spatial resolution data (e.g., mid- and large-scale aerial photos, Landsat TM, and SPOT). As with the other vegetation attributes, determining percent crown closure divisions requires incorporating GIS Core Data and field samples.

**Vegetation Composition**  The National Vegetation Classification System (NVCS) as defined by the FGDC Vegetation Subcommittee is recommended for describing vegetation composition. Adopting this system will improve horizontal and vertical data integration and promote inter-agency information sharing. Using the NVCS ensures compliance with Executive Order 12906, which established the National Spatial Data Infrastructure (NDSI) to foster more efficient use, management, and production of geospatial data by federal, state, local, and tribal governments.

GIS Core Data is vital in NVCS class labeling. Vegetation composition attributes may be more detailed; however, a cross-reference to the NVCS is required to promote data sharing. A full description of the NVCS is found on the FGDC Vegetation Subcommittee web page at www.fgdc.gov.

**Metadata**

**Recommendation**  Use the “Content Standard for Digital Geospatial Metadata” developed by the FGDC for documenting and archiving geospatial data.

The FGDC developed a common set of terminology and definitions called “Content Standard for Digital Geospatial Metadata” for the documentation of digital geospatial data. Metadata are simply data about data. The primary functions of metadata are:

- To maintain an organization’s internal investment in geospatial data.
• To provide information about an organization’s data holdings to catalogues, clearinghouses, and brokerages.
• To provide information needed to process and interpret data transferred from an external source (Federal Geographic Data Committee, 1997).

The Metadata Standard is a hierarchy of data and compound elements that defines the information necessary to document a set of digital geospatial data. Properly documented metadata allows a user to determine:
• The availability of data sets for a geographic location;
• The fitness of a data set to meet a specific need;
• How to access the desired data set; and
• How to process and use a specific data set.

The Metadata Standard has been adopted by numerous federal, state, and local agencies; private companies; and other groups. This standard should be implemented to facilitate data sharing and reduce duplication of effort. For further information on the Metadata Standard and other FGDC activities, visit the FGDC home page at www.fgdc.gov.

Clearinghouse

Recommendation Establish a clearinghouse within the existing Forest Service Intranet for collecting and disseminating remote sensing data, products, and reports.

Establishing a remote sensing clearinghouse complies with Executive Order 12906 and would tie to other clearinghouses within the agency. A web browser could query a clearinghouse database for existing remote sensing products. The clearinghouse would only retain the metadata and a thumbnail graphic of the image or product. The actual geospatial data sets would reside on a server at the local or regional level where they were produced. Should users require the entire data set, hypertext linkages would permit them to download it directly.

The clearinghouse should also include a forum for technology transfer and exchange of ideas about remote sensing. Users should be able to access project summaries, review current Forest Service remote sensing literature, and post questions or tips for other analysts. The Remote Sensing Applications Center (RSAC) produces “Remote Sensing Tips,” which describe completed demonstration projects. These executive summaries include color graphics and are well suited for reproduction on the Forest Service Intranet.
Training

**Recommendation.** A "core competency" requirement for remote sensing awareness and implementation should be determined for all natural resource staff and line management. Ensure, through individual development plans, that personnel receive training to meet these requirements.

Upgrades to the Forest Service IBM computer system include image processing and GIS software. Each region, forest, district, and research unit will have the capability to create and manipulate data sets to meet its needs. A general understanding and appreciation of digital remotely sensed data, analysis procedures, and results are necessary for effective internal and external communication. Requirements and training to meet those core competencies will differ for each employee. The required level of competency should permit communication and understanding among various staff members about projects in which they are involved. Resource specialists need not be experts in remote sensing, although they should be able to understand basic concepts, terminology, and application. Forest Supervisor offices should have enough staff expertise to specify and obtain the remote sensing services they need to manage resources at the National Forest level.

**Recommendation.** Design a training program to develop the skills of image analysts and GIS Core Data technical staff at the National Forest level. Identify opportunities to strengthen backgrounds, improve skills, and ensure that critical personnel receive training to meet requirements.

The Forest Service IBM system will provide GIS and image processing tools to support ecosystem management. However, skilled image analysts and GIS Core Data technicians are in short supply, especially at the forest and district level. Remote sensing cannot be learned simply by reading a manual and following a software tutorial. Support personnel must be familiar with remote sensing principles, aerial photo interpretation, database management, spatial modeling, GIS analysis, and have an understanding of ecological processes. A consistent servicewide training program is required to develop the technical skills to incorporate remote sensing for ecosystem management throughout the Forest Service.

Many remote sensing training opportunities are available within the Forest Service. Some are offered at regional and forest levels, while others occur at the national level. Many are listed in the Forest Service Corporate Training Office (CTO) National Training Catalog. The CTO coordinates the training courses, while actual instruction is provided by specialists in specific subject areas. RSAC also offers specialized remote sensing training courses. The eight courses in Table 3 were offered by RSAC in 1997. Arrangements for training
should be coordinated through regional geometronics leaders. Additional remote sensing training and technical support projects can be arranged through the Regional Geometronics Coordinators and RSAC.

Opportunities for training outside the Forest Service, such as classes at universities, conference workshops, inter-agency training, or sessions at private corporations, should be explored. Many colleges and universities have developed GIS and remote sensing programs within their natural resource departments. These programs teach relationships between GIS and academic fields of study such as forestry, rangeland management, wildlife ecology, and fisheries.

Technical support

**Recommendation** Establish a help desk (Intranet and telephone-based) to supply technical and application support for the Forest Service image processing system and GIS Core Data.

Technical support must be provided to utilize remote sensing and related geospatial technologies effectively within the Forest Service. The help desk would offer not only software technical assistance, but also assistance with image processing techniques and integrating remotely sensed data with other geospatial data layers. It will be a valuable resource for beginning image analysts and provide support for continued professional development.

The Intranet-based help desk will create a forum for disseminating information on current remote sensing activities within the Forest Service. Additionally, users will be able to find quick solutions to geospatial analysis problems for ecosystem management.
Table 3. Aerial photo and remote sensing courses currently offered by RSAC.

**Integrating Remote Sensing and GIS**
Basic concepts and processes to integrate remote sensing with GIS for resource applications emphasizing ecosystem management applications.

**Basic Aerial Photo Use**
Learn how to use existing aerial photos and prepare interpreted data for input to GIS. Includes principles of photo interpretation, photogrammetry, orienteering, cartography, and mapping.

**Advanced Aerial Photo Use**
A variety of courses are available for aerial photo users, including Non-standard Formats, Project Specific Photo Acquisition and Flight Planning, and Forest Health Protection Applications.

**Aerial Videography and Digital Camera Imagery for Resource Applications**
The basics needed to apply these technologies to resource applications. Covers equipment usage, CCD sensor and signal characteristics, video formats, resolution, natural color and color infrared (CIR) interpretation, camera (image) geometry, flight planning, and image analysis.

**Digital Image Processing**
The basics of digital image processing applied to satellite acquired information for field, technical, project manager, and GIS staff involved in resource data collection, database development, information display, and special purpose mapping.

**Global Positioning Systems (GPS) Applications**
Basic concepts and techniques for collecting spatial and attribute data on ground features using state of the art satellite geopositioning technology. The course stresses project planning and differential data correction methodologies.

**Cartography for GIS Users**
Basic cartographic skills for all GIS users, providing instruction in essential principles, skills, and tools of cartography. This course was developed jointly by the Geometronics Service Center (GSC) and RSAC.

**Photography For Cultural Resources Management Applications**
Covers a variety of photography acquisition, analysis, and derived product applications to cultural resources management, needs including aerial and ground photos and several other kinds of imagery.
SUMMARY

With the implementation of a servicewide IBM image processing system and GIS, and the increased availability of remotely sensed data, users at all levels within the Forest Service will be able to create and process geospatial data. That makes it essential to establish guidelines to promote the development of consistent products, facilitate data sharing, reduce duplication of effort, and aid ecosystem management. Analyzing and manipulating remotely sensed data consistently is crucial for vertical and horizontal integration of derived products with GIS Core Data.

REFERENCES
