Forestry Data Model

Data Model Workgroup June 2000

Forestry Spatial Interest Group

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INTRODUCTION

WHY INITIATE A DATA MODEL WORKGROUP?

Forestry Users attending the 1999 ESRI Users Conference discussed presentations of Arc 8.0 and the geodatabase technology. During those meetings, users expressed interest in forestry examples using the geodatabase model. Most forestry organizations have invested in the coverage data model and it has been very successful. Because of that existing investment, several questions surfaced: How does my organization make the transition? When should we make the transition? How well are natural resource requirements met in the geodatabase structure now? What can we do as a group to understand the technology and identify requirements? What are the potential benefits?

The Data Model Workgroup was formed to help address these questions as a concerted effort for the ESRI user community in forest management organizations. The ESRI Olympia Office hosted the first meeting at their facility in May to begin the design process. This report documents the discussions and preliminary design efforts.

WHAT WILL HAPPEN WITH THIS WHITE PAPER?

This document is an initial draft of data model concepts to support forest management. In this context, it is a preliminary report to further discussion and understanding of the new technology.

The Data Model Workgroup will distribute the White Paper for comment and discussion to the following people:

- Members of the FSIG Data Model Workgroup, including those members unable to attend the first meeting.
- ESRI Software Development Staff
- General FSIG membership (following modifications based on discussions with ESRI staff).

OBJECTIVE

ArcInfo 8.0 has introduced an object-oriented technology to support a new data model for geographic information. Geodatabase Data Access Objects, a subset of ArcObjects, provide the software framework for GIS database implementation. The ESRI software engineers have applied component object model standards to implement this framework. Through the ESRI software development process, engineers created a core set of software objects with properties and behaviors. The object model diagrams document the software design patterns implemented to construct the new ArcInfo. In object engineering terminology, the patterns represent the software classes, their properties, the encapsulated functions (behaviors), and the association between the classes. In an operational geodatabase, the long-term properties of interest associated with the objects need to be retained (need to persist). The software architecture stores these properties in commercial relational database management systems. Geodatabase data access objects in aggregate provide a framework[1] to store, retrieve, manipulate, and modify the values of object properties. These objects are new tools available to the GIS application architect.

From a user perspective, an application design is a decision process. In the older technology of coverages and map libraries, design options included tile structure, coverage type, and content of feature attribute tables. The geodatabase structure also supports construction of alternative data models with the framework defined by the core software. Design is a process to decide between data structure options.

The results of the design decisions for an application are communicated through data model diagrams specific to the problem. In this report, the diagrams are referred to as application design patterns, using the framework provided by ArcObjects. This term reinforces the fact that the applications work within the database structure of the geodatabase.

In addition to the benefit of communication, the data model diagrams created by CASE tools[2] also provide the mechanism to create a database schema in a relational database management system. The unified modeling language (UML) is an industry standard to support this process. One product of the workgroup will be an example schema designed for forest management.

The objectives of the FSIG Data Model Workgroup are:

- Design an example geodatabase for forest management.
- Document the example in a data model diagram (application design pattern).
- Implement a physical representation of the model as a prototype created within a personnel geodatabase.
- Populate the geodatabase with data from an operational system.
- Produce supporting documentation.
- Encourage FSIG members to critique the prototype and identify needed modifications.

The White Paper publication, and subsequent review, is a preliminary step in the development of the forest data model prototype.

[1] Persistence framework
[2] CASE: computer assisted software engineering

APPLICATION DESIGN OPTIONS

The decisions addressed by an application design for a geodatabase are identified in Table 1.

• Table 1: Application Design Decisions

Functions	What functions of the organization will be supported by the system?
Geodatabase	One or many geodatabases?
Entities	What entities will represent the operations of the organization?
Features	Which entities are features (spatial objects)?
	What is the spatial type of those features?
	How will the features be represented in ArcInfo?
	Is the feature an independent class or part of a dataset?
	What are the fields and their data types?
	Do the features have primary keys?
	Do the features have subtypes?
Spatial Reference	What is the spatial domain (coordinate minimum, maximum, elevation range, measure range)?
Objects	What objects are defined (non-spatial)?
	Does an object have a primary key? Subtypes?
	What fields are included? What are the data types?
	Is there an embedded foreign key?
Relationships	What objects are related?
	What is the type of relationship: simple, aggregation, composition, spatial?
	Cardinality of the relationship?
	Are there attributes for the relationship?
Custom Objects	Are custom objects required to capture behavior or relationships?

PROCESS

The Data Model Workgroup is approaching the design as an iterative process, one of successive refinement. In this context, the preliminary design focused on a specific organization context as a starting point – an industrial forest management organization with financial and land stewardship objectives. The design process incorporates the steps identified as follows:

ANALYSIS

Identify ***Forest Management Functions & Decisions*** - What is the scope of functions to be supported by the data model? What types of decisions are involved? Are there priorities for the functional areas?
Describe ***Forest Resource Geography*** - What are the essential entities (features and objects) managed by the resource functions? What are the associations between the objects? What are the unusual data characteristics that lead to distinct data model patterns for forest objects (compared to other applications)?

DESIGN

Design a ***Logical Data Model, Forest Patterns*** - What is a conceptual data model, independent of implementation details?
Design the ***Physical Implementation*** - How can the logical model be implemented in current geodatabase structure?
Implement a ***Prototype*** in a personal geodatabase structure. Distribute a white paper and the personal geodatabase schema for evaluation.
Revise and refine the model.

FOREST MANAGEMENT FUNCTIONS AND DECISIONS

Functions and decisions depend upon the management purpose of the organization. Whether an organization is a government agency or a corporation (privately held or publicly owned) will influence objectives, functions and the criteria for decisions. GIS implementations will vary due to differences in organizational context.

A forest products company is the organization context for the initial data model. The functions for this organization can be viewed as a production chain, with management constraints of space, time and resources (Figure 1). A company manages the forest resource as a business, with an emphasis on the efficient production of timber. Log sales (the upper right portion of the figure) generates the majority of the revenue for the business. Annual harvest and production levels are constrained by limiting factors within each of the resource functions. Over long periods of time (i.e., rotations for individual stands), land is acquired, trees grow, engineers design and construct roads, stands are harvested, logs are delivered to customer destinations, and customers pay for the delivered product. The arrows between ovals are increments of time; if these arrows were drawn to scale (with respect to time), the length would vary from months in the upper portion of the figure, to decades for the management of growing stock

• Figure 1: Production Functions of an Industrial Forest Management Organization

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Within this context, managers address three different types of decisions: operations, investment, and land stewardship.

1. Operations decisions: concerned with managing production costs within a 1-5 year period, i.e. the operating expense to harvest a stand and deliver the logs to a destination.

2. Investment decisions: address the economic tradeoffs of investing in growing stock. Investments in growing stock include silvicultural activities and deferral of harvest activity. Harvest is a divestment of the growing stock. The growing stock level determines future growth (shown in the figure with a recursive arrow).

3. Stewardship decisions: consider the ecosystem services that enable forests to grow. These services, although outside the pricing mechanism of a market, are invaluable to the management of the resource.

The analysis identified map features that support the resource functions. In addition to the supporting map features, the spatial measurements (area, length, distance) and associations were identified. The features, spatial measurements and associations address the question: What is so spatial about forest management? The features were grouped in categories described below.

LOG PRODUCTION

Markets for log sales are geographic by definition. A market is a product price at a specific location and time. Hauling costs from the stand to the mill or landing location impact influence market areas for logs. Distance is required to estimate costs, using two units of measure: road miles and round trip travel time between the source and the destination. The source in this resource function is the stand and the destination is the landing.

Operational planning for log production requires information on the appropriate equipment for the site. Slope, soil conditions, and stand structure contribute to the equipment allocation decision.

ACCESS MANAGEMENT

Log production requires road access and the maintenance of roads. A road inventory relies on location (absolute coordinates and relative location to specific locations) as well as the road length. Road assessments use length and potential sediment per mile to estimate total sediment contribution in the watershed by each of the roads.

GROWING STOCK MANAGEMENT

The timber resource is a valuable asset of a forest management organization. Inventory procedures include methods to sample forest stands. Expansion factors for the statistical estimators are determined from the area defined by the inventory unit. Accurate area estimation is essential in an in-place inventory system.

Site productivity influences future growth of the stand and growth has a significant influence on management plans. Physical site characteristics are one source to estimate forest productivity: relevant variables include geologic parent material, elevation, slope, aspect, and average annual precipitation.

Harvest activity creates a requirement for effective forest regeneration. Matching an appropriate seed source with the site conditions can improve the chances of plantation survival. Locations of seed source trees, combined with spatial rules for their distribution, define geographic zones of seed suitability.

LAND RECORDS

Land records identify the ownership of parcels within which inventory and management units are established.

SURVEYING AND MAPPING

Features in this category provide reference for timber stand delineation. These features are also necessary for base maps of the operating area.

STEWARDSHIP

Growing stock inventories are commodity-oriented surveys that measure existing vegetation. Other relatively stable characteristics that can describe the ecological structure of the forest are important. An ecological land classification combines multiple types of geographic data to characterize: solar exposure (derived form topography), soil nutrients, soil moisture, and potential natural vegetation. Management guidelines associated with the derived land classes can match a treatment regime with the site and landscape conditions.

The Appendix includes a list of example map features in each of the resource function categories.

FOREST PATTERNS

PACKAGE OVERVIEW

The application design partitions the data model into subsets (packages in UML terminology). The figure below contains an overview of the model with dependencies (shown as arrows between the packages). The features within each package comprise a feature dataset in the geodatabase. The dependencies shown between the feature datasets indicate an order of precedence for database implementation. The Growing Stock Package is the central hub of the data model. In order to delineate the growing stock management units within that package of the model, land records are required. The surveying and mapping package includes source features needed to produce land parcels.

Log Production depends upon inventory information from Growing Stock. This management function also requires the roads from Access Management to determine hauling distance between stands and the customer destination.

The Access Management and Growing Stock models are dependent upon Stewardship features to assess the appropriate activities given the ecological structure and function of the landscape.

PATTERNS

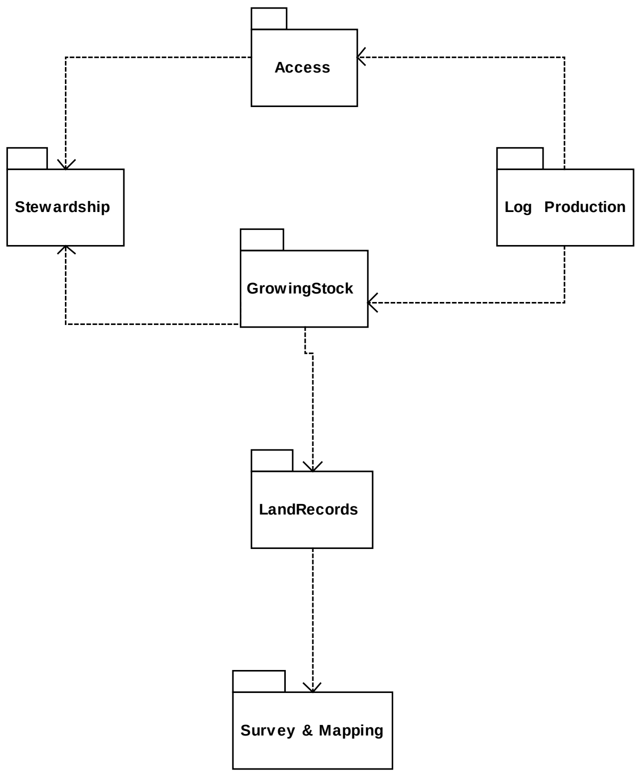
In the world of object oriented software engineering, an understanding of patterns benefits the design of an application. Resource management professionals work with patterns in forested landscapes throughout the year. In this context, patterns reflect the spatial variation of a resource of interest. A geographic database represents these patterns as one of several spatial types: point, line, polygon, surface, or raster.

For the software engineer, however, a pattern assumes a different meaning. Object oriented design is a method to assign responsibility to software classes. Which class should perform the function specified by the requirements analysis? UML notation is both a method to communicate the pattern implemented, and a software technology to assist with the implementation.

> I could tell you how to make a dress by specifying the route of a scissors through a piece of cloth in terms of angles and lengths of cut.
>
> Or, I could give you a pattern. Reading the specification, you would have no idea what was being built or if you had built the right thing when you were finished.

The pattern foreshadows the product: it is the rule for making the thing, but it is also, in many respects, the thing itself.[3]

Application Design Pattern Overview

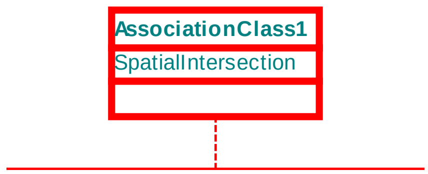


[3] Software Patterns, Jim Coplien

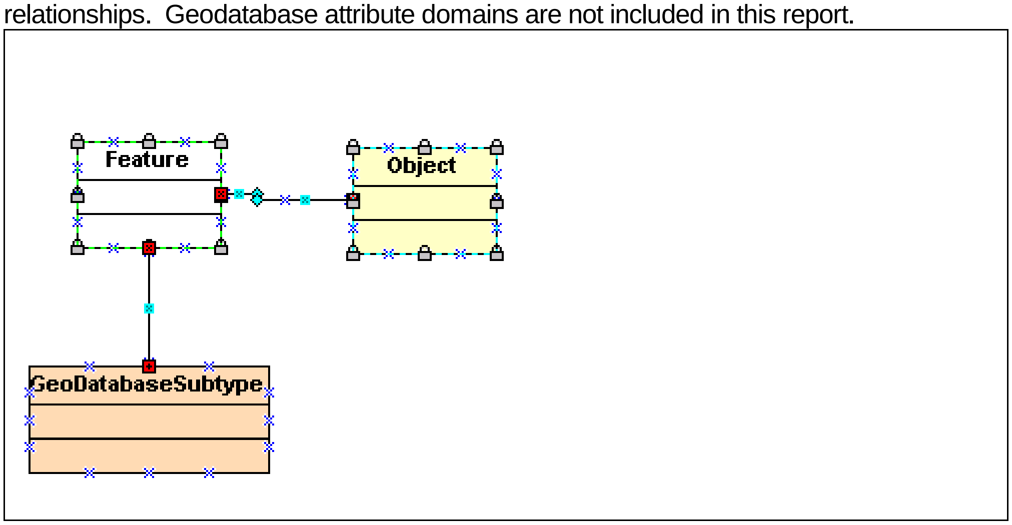
Each of the packages in the data model contains a pattern that identifies the 'thing' we expect to make. The pattern foreshadows the geodatabase. The Data Model Workgroup anticipates that a catalog or knowledge base of patterns will be developed over time that solve database management and application problems within forest management GIS applications.

NOTATION

The design process used standard CASE tools to create data model diagrams. Case diagrams show associations between objects, but are limited for GIS applications because spatial associations are not explicit. Forest Patterns often involve database objects derived from topological operations between features. The topological operations populate object tables in the data model. The lifetime of the object expires when either of the source features change. UML does not directly support a notation to implement these spatial associations. In other words, a spatial UML does not exist. In order to communicate the spatial associations in this report, the diagrams incorporate the UML notation for an 'association with attributes'. An attribute assigned to the association identifies the type of spatial relationship. The appropriate method to implement these spatial associations in the geodatabase needs further discussion.



The forest pattern diagrams distinguish between geodatabase features, objects, and their subtypes, using the color codes shown below. Standard UML symbols for associations imply geodatabase relationships. Geodatabase attribute domains are not included in this report.



PLANIMETRY

DEFER EXPLANATION FOR NOW.

LAND RECORDS

FEATURES

Parcels

Legal parcels are the primary feature class of interest. Surveys provide the data source for parcel delineation. For those geographic regions covered by a public land survey system, the data structure incorporates a nested hierarchy of polygons. The hierarchy uniquely identifies individual parcels within survey sections that reside within townships.

Tax Parcels

Local governments appraise land parcels for tax purposes. These features are aggregates of the individual ownership parcels.

OBJECTS

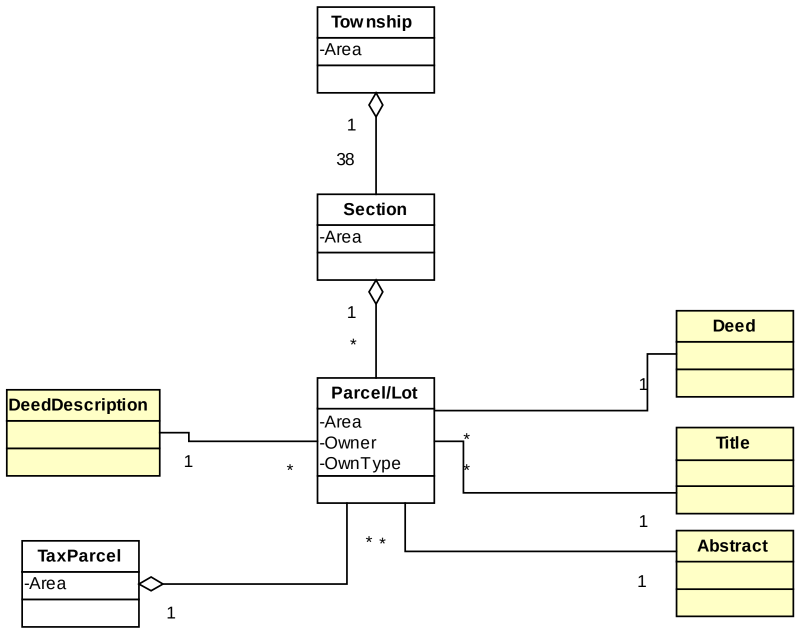
Legal Documents

Legal instruments convey parcel ownership transactions. These documents (scanned) are included in the land records pattern as objects associated with the parcel: deed, title, and abstract of title. An ownership transaction can cover multiple parcels (multiplicity is one-to-many).

In addition to the scanned documents, a text description object facilitates queries based on attributes of the ownership transaction.

The Land Parcel Workgroup will address the requirements for this topic in more detail. The design pattern is included here to reinforce the importance of land survey in a forest management domain.

Application Design Pattern: Land Records



GROWING STOCK

The growing stock model is the central feature dataset of importance for forest patterns. The pattern for the application model in forestry will vary depending upon organizational factors. In particular, the definition of forest inventory and management units will influence the design. In addition, the regulatory environment will determine differences between implementations. For simplicity, the pattern described in this report will follow an in-place inventory, stand management definition through all packages. A subsequent section, however, describes an alternative pattern for the growing stock component of the model.

Three temporal perspectives are relevant in the growing stock data model: the current conditions as described by recent inventories, past activities or stand history of silvicultural and harvest treatments, and future activities planned for the stand.

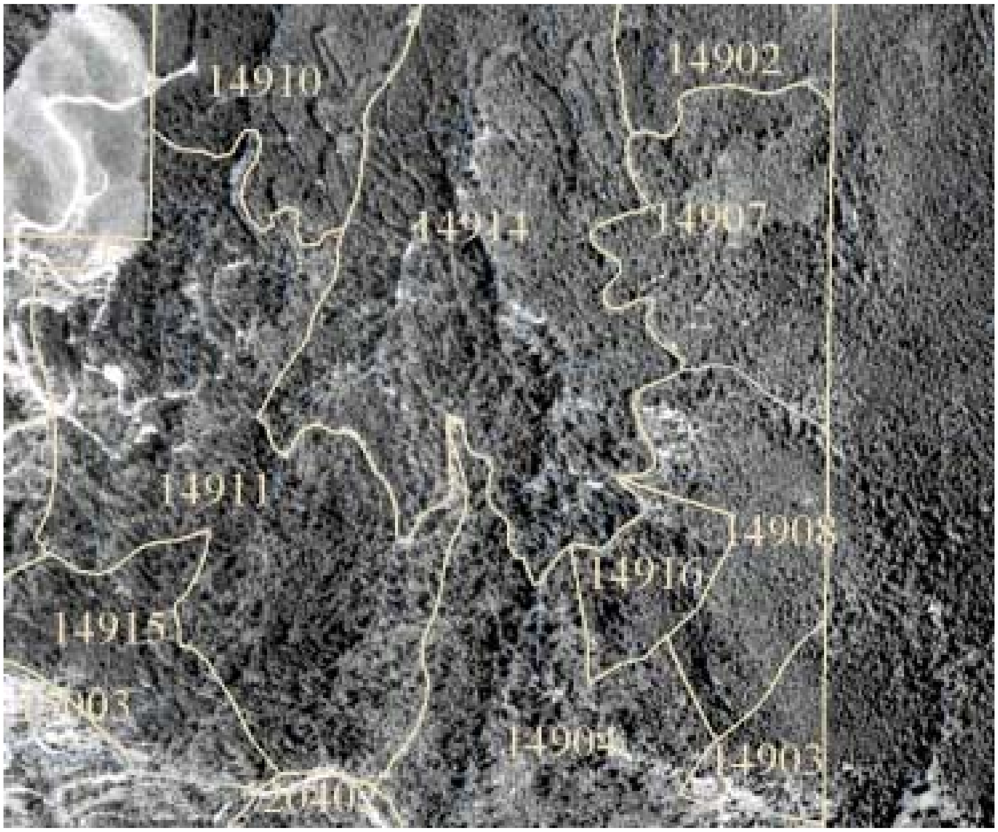
FEATURES

Stand

Three stand delineation objectives for this example is:

1. Sampling unit for the in-place inventory.
2. A single next treatment for the stand.
3. Field personnel are able to identify the feature on the ground.

This polygon feature class is the source for area (acres) that is the expansion factor applied to average area estimates produced from field surveys (see example stand delineation below).



• Figure 2 Example Stand Delineation

Activity

Activities reflect investment decisions that affect the growing stock. These investment projects do not always coincide with stands. Fertilization projects, for example, may include multiple adjacent stands. Thinning activities frequently cover a sub area of the stand. The area of these polygon features is important information to evaluate project costs on a unit area basis. For these reasons, the data model includes activities as a feature class distinct from stands but within the same feature dataset.

Note also that geodatabase subtypes further classify the activities. [4]

Administrative Hierarchy

Resource organizations with large land ownership typically administer the land within a hierarchy of management units. The units are polygon features, within a nested hierarchy. In other words, the resource geographer completely delineates the land area at the lowest common denominator (highest spatial resolution). This approach works well with a data structure that supports planar topologies.

[4] Depending upon future software development direction, this approach may be sub optimal. When planar topology is implemented in a future software release, an alternative structure should be evaluated.

Seed Tree

The annual cone collection work records point locations of seed trees. The seeds from these trees are the source for future seedlings to regenerate the stands. The locations are important to determine suitability of the seedlings on varying site conditions.

The seed tree also has a role to play in tracking plantation performance.

OBJECTS

Several descriptor objects characterize the current condition of the stand: growing stock volume and cruise status are two basic ones.

Growing Stock

The growing stock object describes stand structure and composition. Attribute values in this table describe species composition and stand structure. The association between stand and growing stock is a multiplicity of one-to-many.

Cruise Status

The source for the stand structure and composition description is a cruise. The cruise status object identifies information about the field procedures: two example properties are date of the field sample and the design selected by the field forester.

Planned Activities

This object describes the future treatments for the stand. It is an object associated with the stand, not a distinct map feature. The subtypes Harvest, Silviculture and Other further characterize the planned activities. The category named ‘other’ facilitates activity scheduling for tasks that may not directly affect the growing stock in the stand (e.g., reconnaissance, running property lines).

Seed Inventory

The seed inventory object assists in planning greenhouse production based on forecasted harvest activities. The association between stands and the seed inventory is a seedling request, or order, directed to the greenhouse.

Growth

Growth is a descriptor object that contains the predicted growth of the stand for a near-term planning period.

SPATIAL ASSOCIATIONS

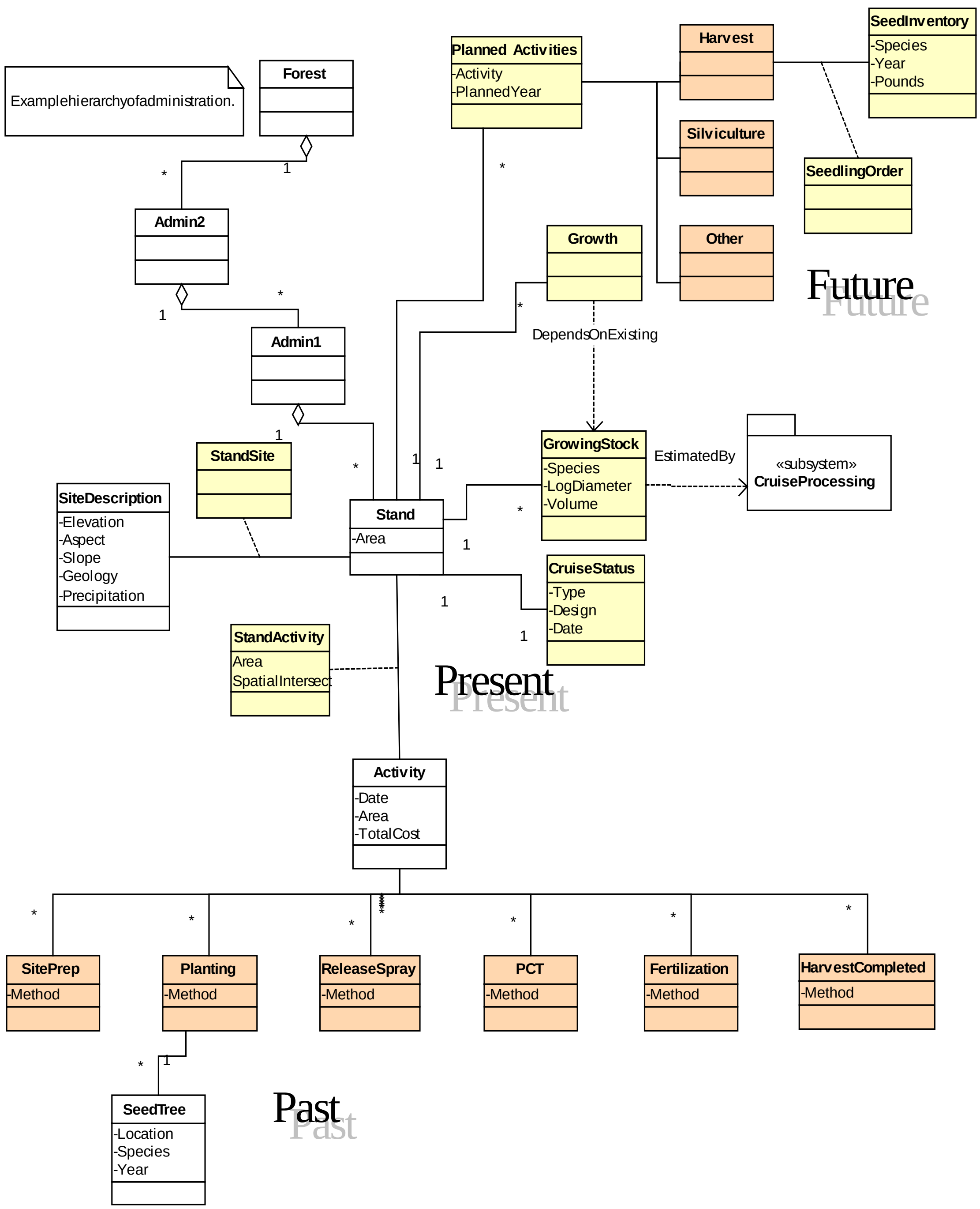
Stand and Physical Site

A spatial association between the stand and site description information allows the further description of the stand by physical factors influencing site productivity. Spatial associations derive these characteristics of the stand from other map features (i.e., the data are not assigned by field personnel). A physical site model predicts productivity from these variables.

Stand and Historical Activity

The historical activities have a spatial association with the current stand features (intersection). The association documents the investments in the stand by creating an object that tracks acres by treatment.

Application Design Pattern: Manage Growing Stock



ACCESS MANAGEMENT

FEATURES

Road Subtypes

The road features are complex edges in a geometric network. Geodatabase subtypes discriminate between four classes of roads: primary, secondary, abandoned roads and obliterated roads. Additional attributes describe road surface material, access status (controlled access or open), and any planned change in road class (planned construction, obliteration, or abandonment). This feature and the road barriers are components of a road inventory.

Barriers

Restricted access is necessary to minimize damage to road infrastructure and adjacent streams. Barriers are simple junctions connected geometrically by location to the road edges.

Road Assessment

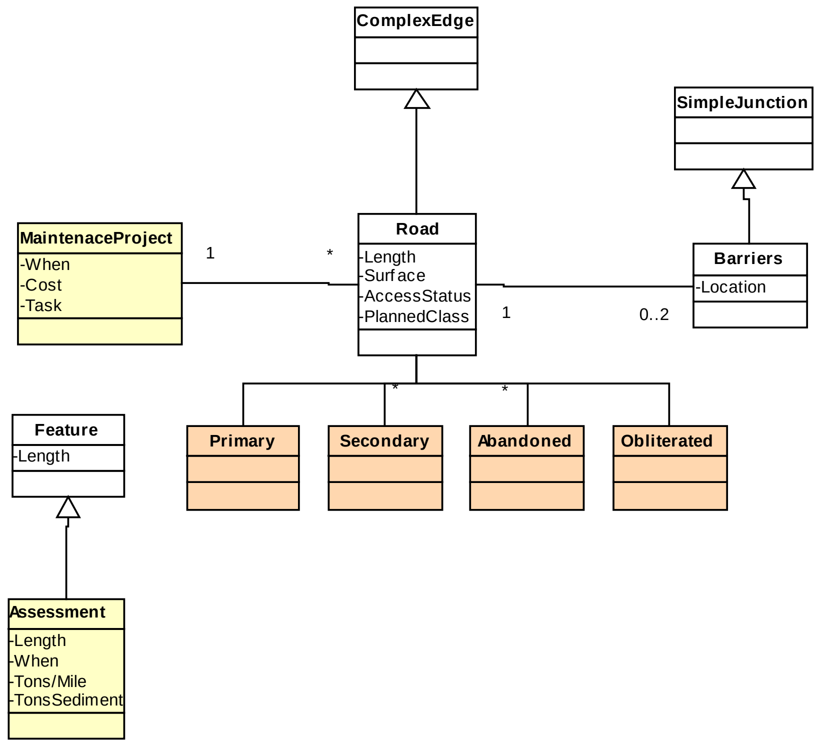
Annual road assessments collect data to determine general condition and maintenance issues. Field survey crews collect the coordinates and descriptive attributes for this feature with a global positioning system receiver. Field crews repeat the assessment periodically to monitor progress on problem conditions. A model estimates sediment contribution in units of tons per mile. Total road length expands this average to the total sediment contributed by the road feature.

OBJECTS

Maintenance/Budget

The road inventory and assessment work contributes background information for an annual maintenance budget. This object defines the work to be completed, the cost, and the budget year. The object is also a record of completed maintenance. Road engineers plan maintenance on segments of the road feature.

Application Design Pattern: Access Management



LOG PRODUCTION

FEATURES

Stand/Timber Sale

The log production design pattern depends upon the stand feature from the growing stock package.

Subtypes

Two subtypes of the stand are involved in log production: stands located on legal parcels owned by the organization, and purchased timber sales. Both subtypes have associations with subsequent business rules to process delivered logs.

Road Network

The entire road network is a feature dataset in the log production pattern.

Landing

Landings are facilities that receive harvested timber. The spatial type of the feature is a point location.

OBJECTS

Advertised Volume

This object modifies total volume to an estimate of deliverable volume. The object named Advertised Volume further describes this volume.

Log Products

Market prices vary depending upon the species, diameter and grade of the logs. This object defines the entire set of log products, and the current prices for them.

Contractor

Contractors harvest stands and receive payment based on the volume delivered to landings.

Contract

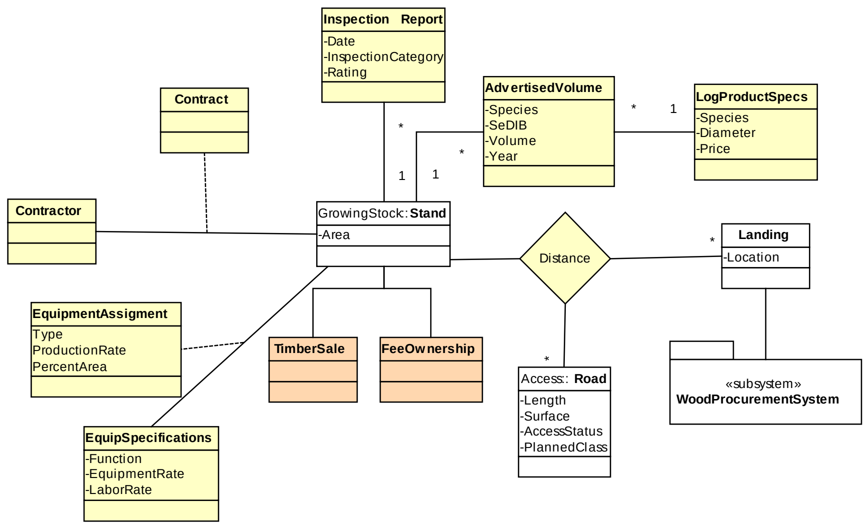
Contract supervisors negotiate costs for logging services based on stand conditions, allocated equipment production rates and the hauling distance from stand to landing. More than one contractor may provide the service for a single stand.

Equipment Fleet

This object is a catalog of the different types of logging equipment available, the daily equipment rate, the daily labor rate, and the overhead.

Equipment Assignment

Contract supervisors assign equipment to stands and estimate the production rate for each piece of equipment.



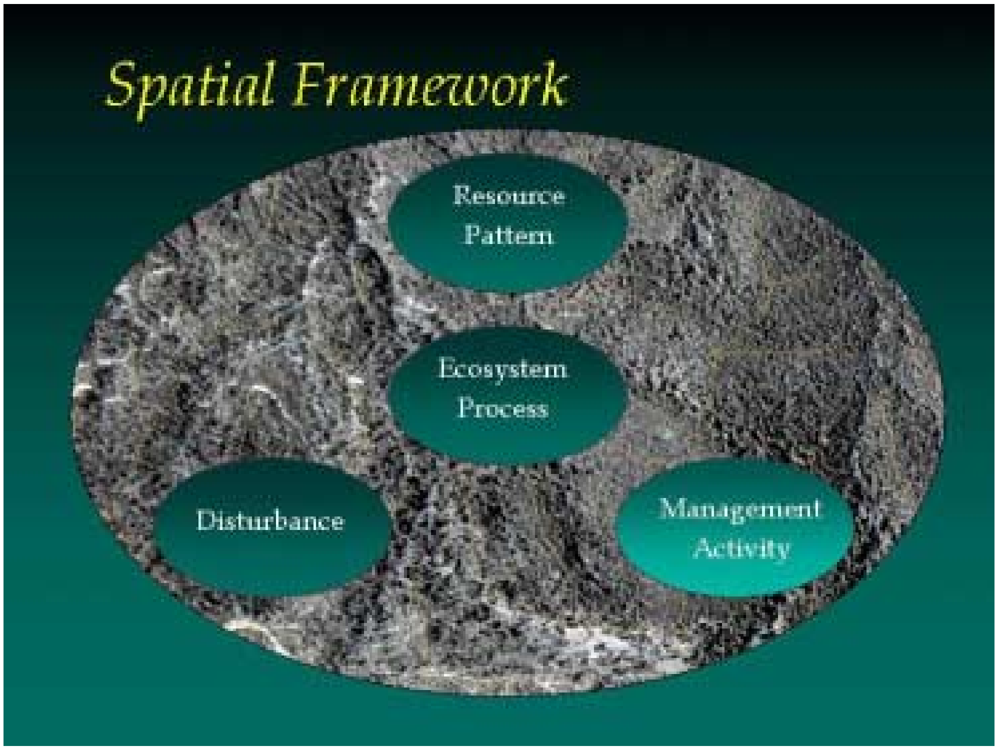
SPATIAL ASSOCIATIONS

Distance

The three features (stands/timber sales, road network and landings) have a spatial relationship that is a major component of the logging production pattern. The relationship is the distance across the road network from the stand to each feasible landing. Contractors can deliver log products to multiple landings. Markets (manufacturing demands and available inventory) for species, size and grade influence final destinations. Distance measures in units of travel time vary by road class and road surfacing.

STEWARDSHIP

Forest inventories in a business enterprise concentrate on the commodity-related characteristics of the stand. The structure (size classes) and composition (species) of the stand are important because of their economic value and growth potential. However, current vegetation is a relatively temporary condition, a snapshot in the dynamics of the forest development. Inventory specialists generally did not design these surveys to characterize the ecological structure and function of the forest. The spatial patterns and characteristics of forest stands are a reflection of past disturbance, management activity, and development stage.



• Figure 3 Components of Landscape Pattern

An ecological land classification describes the relatively stable land characteristics that are responsible for forest growth. An organization that understands the structure and function of their forest landscapes can benefit the long-term sustainability of their resource. The land class delineation captures the variability between sites in terms of four ecological functions: solar exposure for photosynthesis, soil nutrient cycles (nutrient availability), water cycles (soil moisture), and community dynamics (potential natural vegetation). Spatial features that support ecological functions include digital elevation models, geologic parent material, soils, annual precipitation, and vegetation habitat type. The goal is to improve resource management decisions by incorporating guidelines based on land classification.

FEATURES

Ecological Land Classification

The resource geographer represents the land classification as a nested hierarchy of polygon features. Researchers have suggested at least a three level system.

Regional climatic zones

Landscapes

Ecological management units

Stand

The stands (from the growing stock pattern) are an integral feature of the stewardship application pattern.

OBJECTS

Guidelines

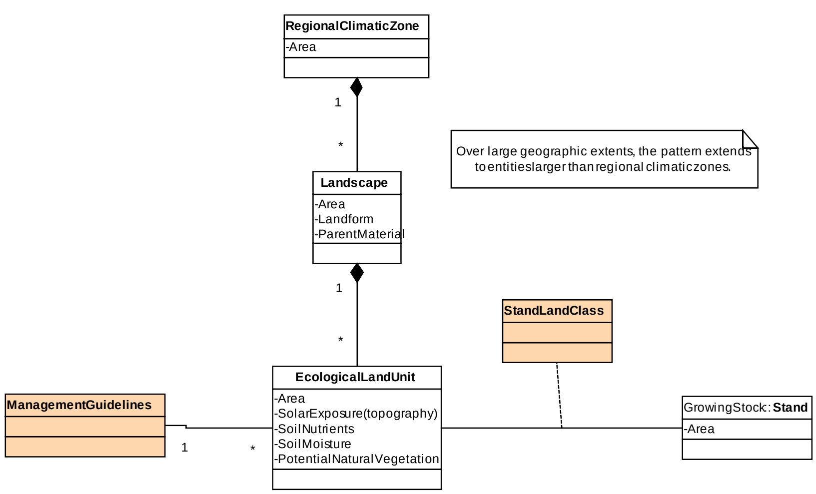
Knowing the land class is useful for management only if the land manager also has prescription guidelines for appropriate management activities. The land class provides the ecological framework to assess suitability of the stand for the intensity and frequency of activity. The object named Guidelines describes appropriate treatment regimes for the land class.

SPATIAL ASSOCIATIONS

Site Suitability

The spatial association between stand and the ecological land unit is a topological intersection. The result characterizes the stand by the percent area in the individual land classes. Combined with the Guideline object, this information describes suitable treatment regimes.

Application Design Pattern: Stewardship



GROWING STOCK ALTERNATIVE

The second example for the growing stock pattern uses a photo type based inventory rather than an in-place inventory. In addition, this example includes multiple administrative units that represent a hierarchy, but not one of spatially nested polygons.

This example reflects the permitting and licensing situation for an operation in a Canadian province.

FEATURES

Growing Stock Activity Unit

The activity unit is a feature class with subtypes for different categories of activities. The activities shown are a subset of the total possible activities. The features are aggregated through relationship classes to features defined for administrative and reporting purposes.

Harvest Unit

The harvest unit is a polygonal feature that may include several inventory units.

Inventory Unit

The inventory map feature is a polygon that contains relatively homogeneous timber. Approaches to defining these features vary. Vegetation classes of timber type, size, and density (derived from photo interpretation) are one method to delineate the features. The features collectively represent a stratification of the forest for sampling. Inventory plots sample the features; field crews do not sample all mapped units.

Planting Unit

Administrative or Reporting

A forest development plan (FDP) is an operational plan guided by the principles of integrated resource management (the consideration of timber and non-timber values), which details the logistics of timber development over a period of usually five years. There is a map product that is part of the FDP. This product represents an aggregate of cut blocks. Within an FDP, there may be multiple licenses. Each license contains several cutting permits. The cutting permits are, in turn, comprised of one to several cut blocks.

Within a cut block boundary, there are several internal boundaries specific to that cut block. Some examples of internal boundaries are Treatment Units, Harvest Units & Planting Units. At the cut block level the cut block boundary and some interior boundaries are used for Silviculture Prescription Maps. These maps give a detailed description of how the cut block will be harvested and treated post harvest.

A cut block boundary is comprised of an aggregate of interior units.

• Figure 4 Three Licenses within a Forest Development Plan

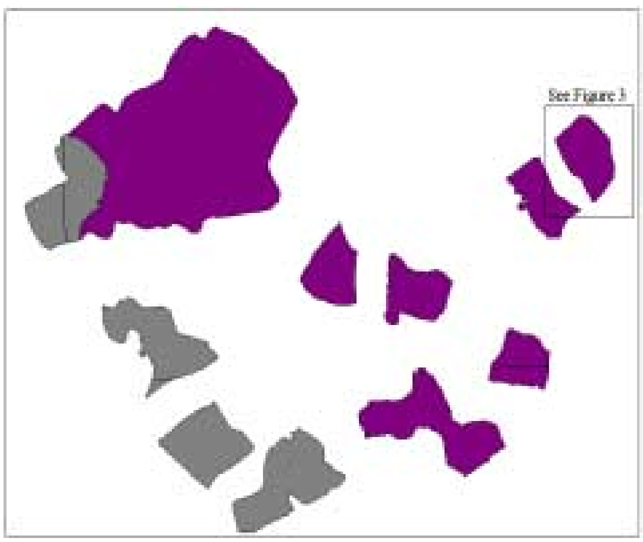


Figure 5 Two Cutting Permits Containing Multiple Cut Blocks

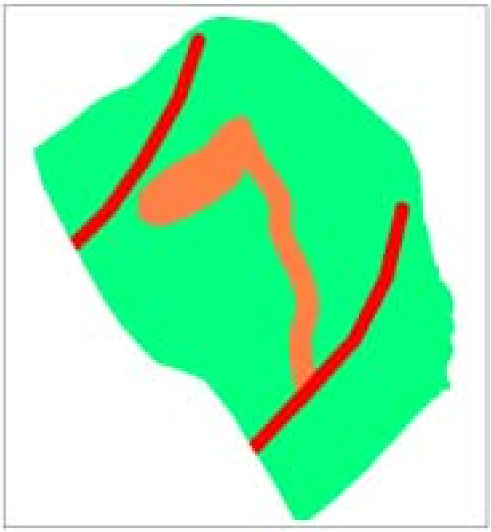


Figure 6 Cut Block with Interior Boundaries

OBJECTS

Growing Stock

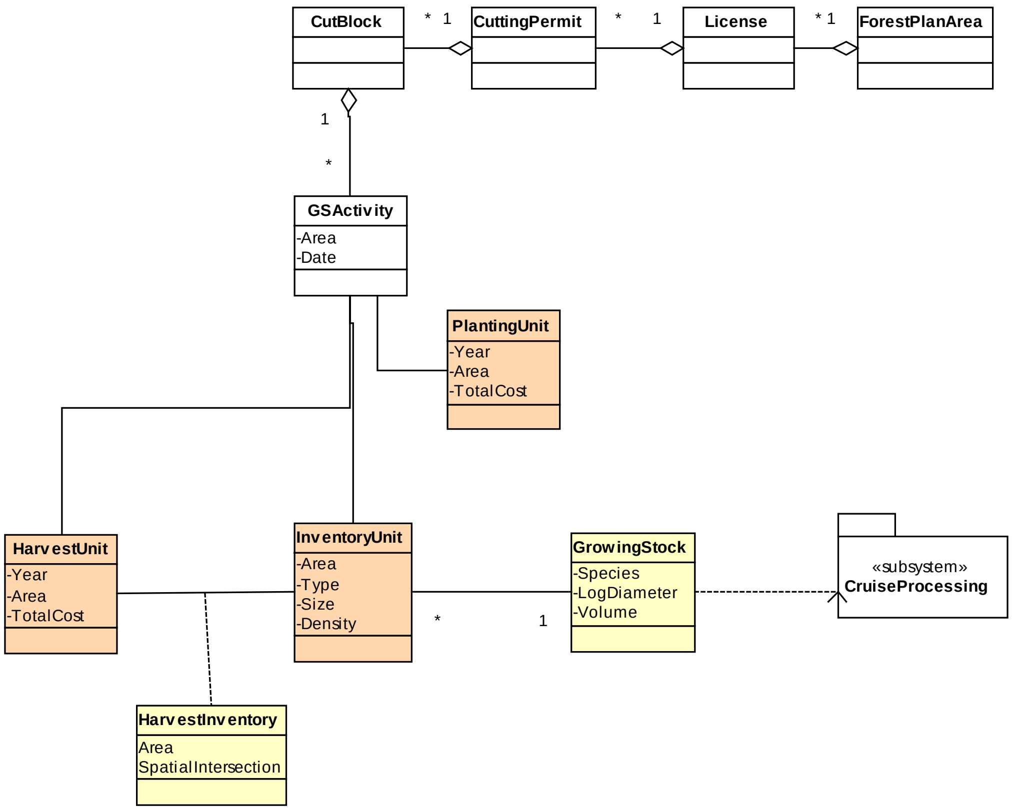
The sampling design provides estimates of the growing stock volume by the vegetation categories applied to define the inventory units.

SPATIAL ASSOCIATIONS

Harvest Inventory Unit

The harvest unit growing stock volume is derived from the inventory units that are contained within it. The spatial association is an intersection between the features, producing a table of land area by inventory unit with the harvest unit.

Application Design Pattern Growing Stock Alternative



APPENDIX

Resource Function	Category	Entities
Land Stewardship	*Water Quality*	Stream Segments
	Road Assessment	Road Segments
	Fisheries	Stream Segments
	Game Management	Game Unit
	Research/Monitoring	Plot or Transect
	Forest Health	Infested Sites
	Fire Control	Dip ponds
		Pump sources
	Ecosystem Function	*Landscape Structures*
		Mosaic
		Patches
		Corridors
		Ecological Land Class
Log Production	*Plan & Budget*	Administrative Units
		Landings / destinations
		Equipment
Growing Stock	*Inventory*	Stand
	Silviculture History	Project
	Harvest History	Cutting Blocks
	Regeneration	Seed Trees
		Greenhouse
	Productivity	Land Classes
Access Management	*Assessment*	Road segments
		Barriers / Gates
		Drainage Structures
	Permits, Easements	Road Segments
	Cost Share Agreements	Road segments
		Cost Share Area
	Road Inventory	Roads
Land Records	*Taxes*	Tax Parcels
	Leases	Grazing Allotments
		Mineral
		Other
	Permits	Parcels
	Ownership	Parcels
Surveying/Mapping	*Geology/Soils*	Map units
	Climate	Precipitation
	Planimetry	Survey Measures
		Survey Corners
		Utility Corridors
		Railroads
		Streams
		Rivers

Lakes
Watersheds
Ridges
Special Sites
Wetlands
Buildings
Control Points
Elevation
Aerial Photography