

Escaping the Black Box: A Flexible Tool For Spatial Management of Your Sample Population

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Abstract

Too often, natural resources field data is collected, only to languish within a black-box DBMS application. Many of these black-box applications are driven by the details of field observations, not by the objectives of the overall resource management program. This can result in data loss and incomplete analyses that do not meet program needs.

This paper discusses an Arc/GIS-based tool that allows users to spatially define and stratify a sampling population, and to create, define, and manage protocols as they are used in practice. The National Park Service, working with Spatial Dynamics, has developed the Fire Ecology Assessment Tool (FEAT), a DBMS built around the objectives of the fire ecology program. This flexible tool supports data filtering and summary and streamlines export to statistical packages. FEAT can also perform common calculations like cover and basal area. The tool can and has been adapted to several biological monitoring programs.

Introduction

Many sampling applications in use have unrealized geographic potential. Data is continually collected for the purpose of detecting change or characterizing the landscape in some way. However, users often do not fully understand the connection between their data and the landscape, because they are limited by a tabular environment. These datasets often sit on the shelf untapped because systems support only the analysis that was peculiar to the data collection process. There is a need in monitoring programs for applications that are more flexible in the field protocols and methods they support, in the types of analyses they support, and above all, in their connectedness to the landscape throughout the lifecycle of the monitoring program.

The National Park Service (NPS) has developed and is using a Fire Ecology Assessment Tool (FEAT), which builds geography into the process from the start. Although the NPS Fire Ecology Monitoring Program developed FEAT to support fire effects monitoring, the tool is not limited to this application. It can also be used for other natural resource applications, ranging from vegetation monitoring to wildlife monitoring.

FEAT is an integrated tabular and spatial information system that supports data management and analysis for immediate and long-term monitoring and reporting. It is an integration of ArcView (9.1) and Microsoft SQL Server 2000 Desktop Engine. FEAT is designed to use PDAs for field data collection. An interactive Protocol Builder, which supports creation of new protocol database tables and data collection screens, is also incorporated into FEAT.

Although FEAT is primarily a tabular application, the GIS component enters into the process at key points without being obtrusive and without dominating the system. The application is modular, so that users who will not use the GIS component do not need to install any GIS software. This paper highlights how the GIS component fits into the overall sampling process.

Sampling strategy

The first step addressed by FEAT in developing a vegetation monitoring program is to establish a sampling strategy. Available resources must be evaluated in the context of the geography. Although biologists and fire ecologists have an understanding of the distribution of their sampling populations across the landscape, a set of GIS tools can help to sharpen that understanding and aid in arriving at a realistic strategy. FEAT provides an intuitive way to stratify remote sensing data with additional inputs from vector layers.

The GIS component of FEAT is reached through a toolbar in ArcMap. The fire ecologist is expected to seek the help of an agency GIS specialist in identifying appropriate GIS layers and setting up a map document in which to work. The toolbar includes a tool to stratify the landscape by overlaying raster layers. This tool is a simple map calculator that targets the types of overlays that are appropriate in describing a subset of the study area that meets a set of criteria.

The stratification tool accepts parameters of two types: a range of values from a continuous dataset like elevation, and discrete values from a coded dataset like vegetation type. In the

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example below, criteria are supplied for a normalized burn ratio layer (a remote sensing product) to include values above 300 and for a vegetation layer to include the ponderosa or shrub land general cover. The ecologist in this example is requesting all the terrain for which the normalized burn ratio is above 300 within the ponderosa or shrub land general vegetation types.

Make a Monitoring Unit

☐ Existing ☐ New

Objective: DNEB over 300, PSPD, shrb

Description: DNEB over 300, HPD, shrb

Comment: DNEB over 300 Ponderosa and shrubland

Choose Layer and Field

Raster Layer

- Burn Units Grid
- WCA Facilities Grid
- Facility Distance Grid
- Facility Proximity Grid
- General Vegetation **Selected**
- Elevation Feet
- Slope Degree
- Topography Hill Shade
- WCA Area of Interest

Fields

- Value
- Count
- Geocode
- G_cover **Selected**

Grid type: Integer
Field type: Text

Include a Value Range for Layer

Min: [Dropdown] Max: [Dropdown] [Add] [Remove]

Layer	Field	Min	Max
Normalized Burn	Value	300	None

Include Discrete Values for Layer

Value: [Dropdown] [Add] [Remove]

Remove val: [Dropdown]

Layer	Field	Value
General Vegetation	G_cover	Ponderosa, Shrubland

[Cancel] [Execute]

Figure 1. Specifying parameters to stratify the landscape

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The resulting stratification is saved as a record in the database with an associated raster layer, which is displayed in the map.

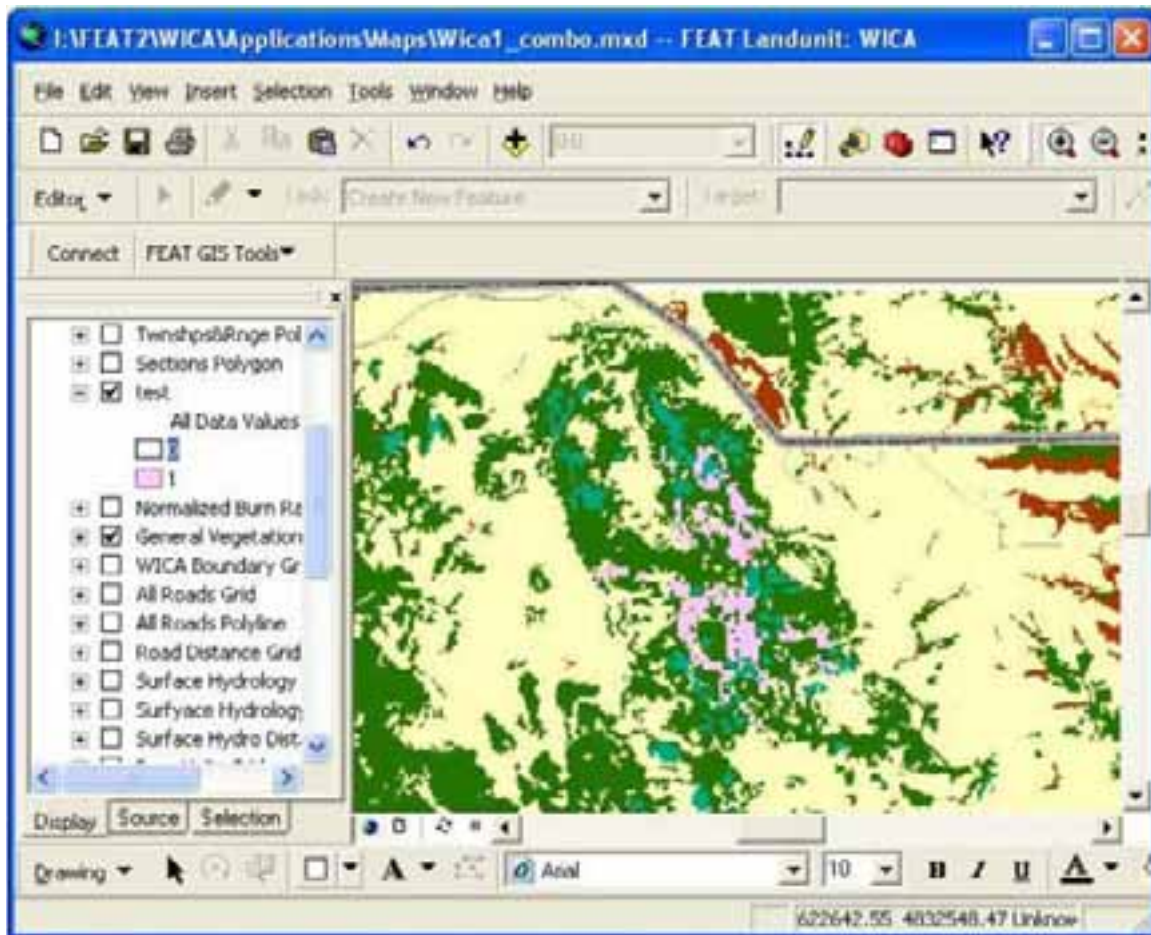


Figure 2. Landscape stratification displayed in ArcMap

Vegetation monitoring often requires a fine-tuned stratification of the landscape for statistically valid sampling to occur. The ecologist will have an idea of where the target sample population is and how it can be sampled, but pilot sampling will often reveal problems with the initial stratification. The ecologist can start with a broad stratification to conduct pilot sampling and then refine the stratification based on the outcome of the pilot sampling.

Understanding the landscape is part of evaluating the available resources when beginning a sampling strategy. Costs associated with travel distances and terrain challenges are more easily understood in the context of a GIS. When stratifying the landscape, the ecologist can specify parameters like minimum and maximum distances from roads, and maximum slope. Although these parameters may degrade the extent to which the samples represent the sample population, they can enable a reasonable level of sampling when resources are limited.

Development of protocols and methods

The FEAT Protocol Manager module supports development of new protocols and sampling methods. Data collection forms, as well as data analysis components, can accommodate the new methods without any reprogramming. The Protocol Manager modifies the database schema to store data for new methods.

FEAT is not built around a set of methods, but is designed as a framework to support any sampling method. In the example below, a density method has been created with species, tally, and sub-belt fields. The Protocol Manager also supports creation of coded value fields, such as damage codes. The ability to allow the ecologist to create new methods is key to creating a flexible application that can grow with the sampling program.

The screenshot shows the 'Method Builder' window. Under 'Method Information', the 'Name' is 'Density', 'Unit System' is 'Metric', and 'Method Shape' is 'Belt'. The 'Method Properties' section has tabs for 'Attributes', 'Organizations', 'Description', 'References', and 'Version History'. The 'Attributes' tab is active, showing a table with columns: Field Name, Caption, Unit, Order, Rolldown, Precision, and Del. The table contains four rows: 'SP_GUID' (Species, Line, 1), 'SP_Code' (Species, Cod, 2), 'Tally' (Tally, Cou, 4), and 'subBelt' (Sub Bel, Cou, 5). To the right of the table are 'Move UP' and 'Move Down' buttons. On the far right of the window are 'Save & Close', 'Save', and 'Cancel' buttons.

Field Name	Caption	Unit	Order	Rolldown	Precision	Del
SP_GUID	Species	Line	1	<input type="checkbox"/>		
SP_Code	Species	Cod	2	<input type="checkbox"/>		
Tally	Tally	Cou	4	<input type="checkbox"/>		
subBelt	Sub Bel	Cou	5	<input type="checkbox"/>		

Figure 3. Building a new method

Sampling setup

Sampling setup is driven by the landscape stratification. Researchers have a variety of methods for randomly or regularly distributing samples. A variety of GIS tools is available to locate random or regular points within a raster layer. The ecologist may use any method to create points and import them into FEAT as candidate sampling plots. FEAT also provides a simple random point generation tool that will locate points within stratification and within a polygon layer. This tool will capture point and neighbor values from another layer, which will provide more detail about the candidate point before the site is visited – for example, the normalized burn ratio.

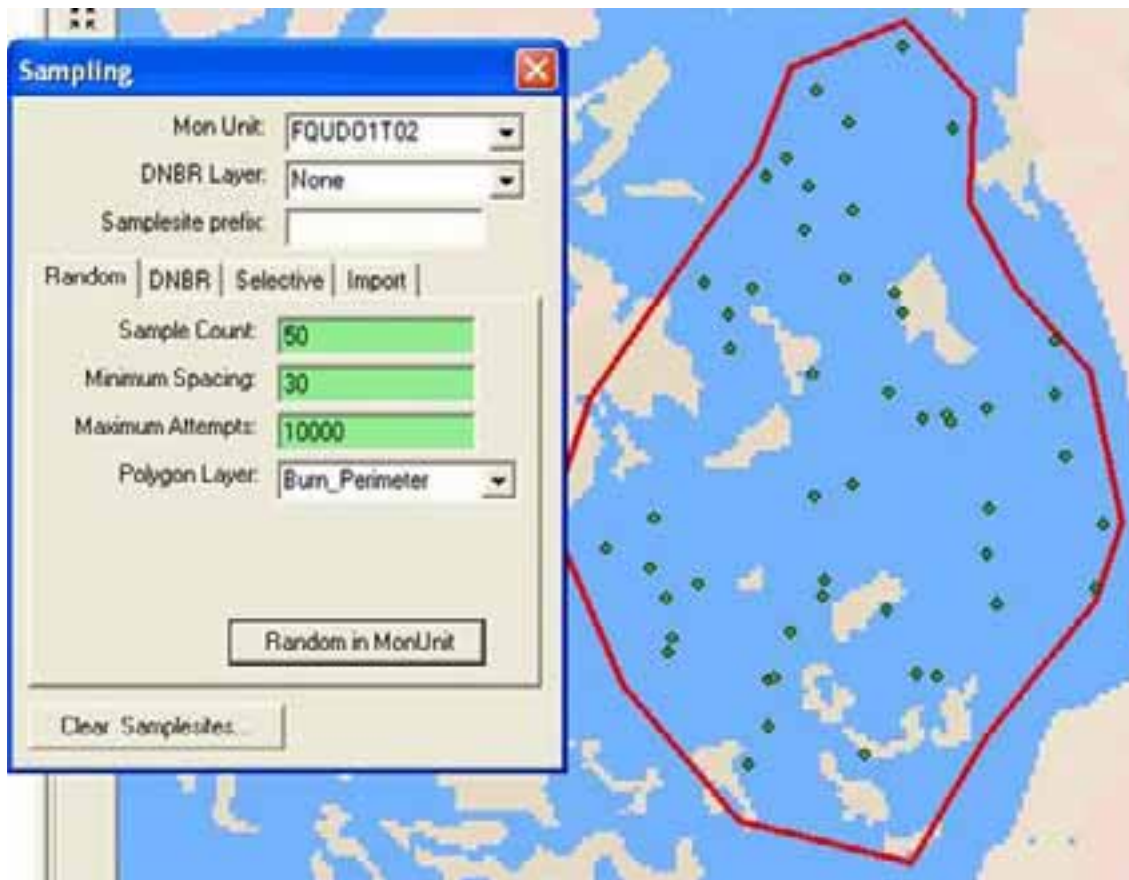


Figure 4. Generating random points

Stratified samples

Sometimes there is a need to generate stratified samples, for which an equal number of samples is chosen for specific intervals across a spectrum. For example, the normalized burn ratio (dNBR) raster layer is broken into four severity classes. FEAT provides a tool to preview each of these ranges on the map by adjusting the legend of the dNBR layer. The tool has slider bars to control the upper and lower cutoffs. The example below shows one way to use this tool to determine severity class thresholds. This method is based on the Landscape Assessment documentation (Key & Benson). In the example, the user is previewing the range between 650 and 1081. The red polygon is a burn perimeter, and the green is the portion of the dNBR layer that falls within those values.

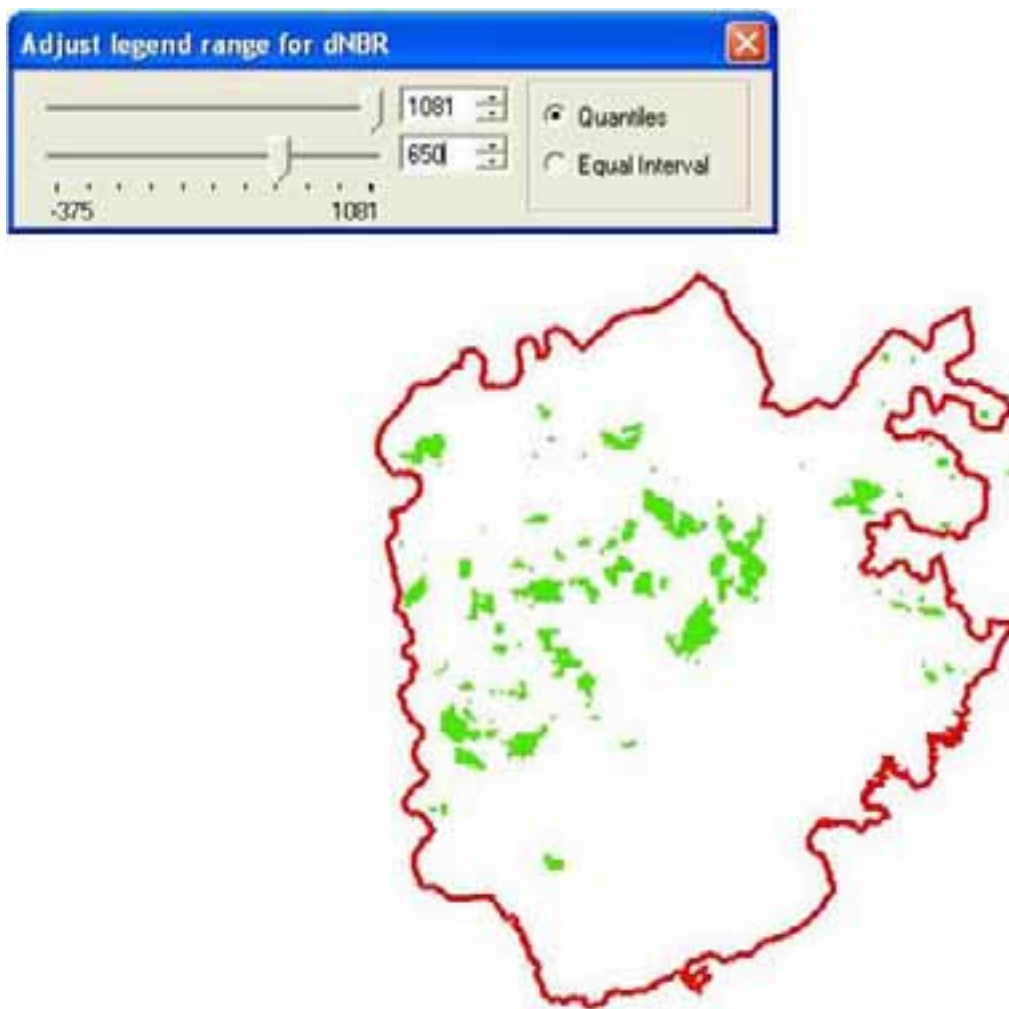


Figure 5. Previewing a severity class

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After the ranges are identified, the sampling tool is used to generate random points within each of these ranges. In the example below, 20 points have been generated for the "low" severity class of dNBR between 25 and 225. The minimum sample point spacing has been set to 50 meters.



Figure 6. Generating stratified samples for a severity class

Data collection

Data collection for monitoring programs of this type is not spatially intensive, because a significant amount of time is spent at each location. For this reason, the data collection component of FEAT is a purely tabular database input interface. Data collection allows flexibility because the methods created in the Protocol Manager, as discussed above, are available in the data collection forms on the desktop and on the PDA.

These input forms respond to the database schema for the current method and generate the appropriate controls on the fly, so that the user is presented with an appropriate input environment. In this example, the PDA is ready to accept a record for a point transect vegetation method. Both point and tape fields can be used to record the position of the point on the transect. There are several controls to aid the user in entering the correct species code. The method is configured to include an "Auto Increment" button as one of the controls that appears at run time. This button will advance the numbers to the next point on the transect.

The screenshot shows a PDA screen with a data collection form. At the top, it says 'Protocol Data' and 'B:FLOTHID09:01 : tranq4_01 Post (POINT TRANSECT): TEST1 - Ju'. Below this, there are input fields for 'Point : 1', 'Tape (m) : 0.3', 'Order : 1', and 'Height (m) : +1'. There is an 'Auto Increment' button. Below these is a 'Species Selection' section with a 'Species :' dropdown, a 'Match:' field, '# of Common: 5', 'Common:' dropdown, 'Use LF:' field, 'Lifeform: No Filter' dropdown, and a 'Live : ☒' checkbox. At the bottom, there are buttons for 'Setup', 'Data', 'View Data', and 'CBI Sum'. The bottom bar has 'Edit', 'Save', 'Delete', and 'Cancel' buttons.

Figure 7. PDA data collection form with on-the-fly controls

Analysis

During analysis, the GIS component comes into play again. Existing data can be used in new ways by creating new stratifications. As the data matures and as fire history changes the landscape, it will become evident that plots that were established independently become connected. Sample locations are displayed in ArcMap as a live layer from the database. FEAT provides a tool to select plots that fall into a new stratification and to then save a query in the database to include those plots in any analysis.



Figure 8. Spatially selecting plots within a terrain strata

FEAT provides a flexible interface for constructing ad hoc queries on the data for any sampling method. Users can specify criteria for filtering and grouping records and can classify values from a numeric field. Users can cross-tabulate results for input into a statistics package. For example, each species code can become a column heading in a new query. Queries can be saved in SQL Server as views and can be further modified directly through the DBMS. Query results can be exported to Excel and other formats.

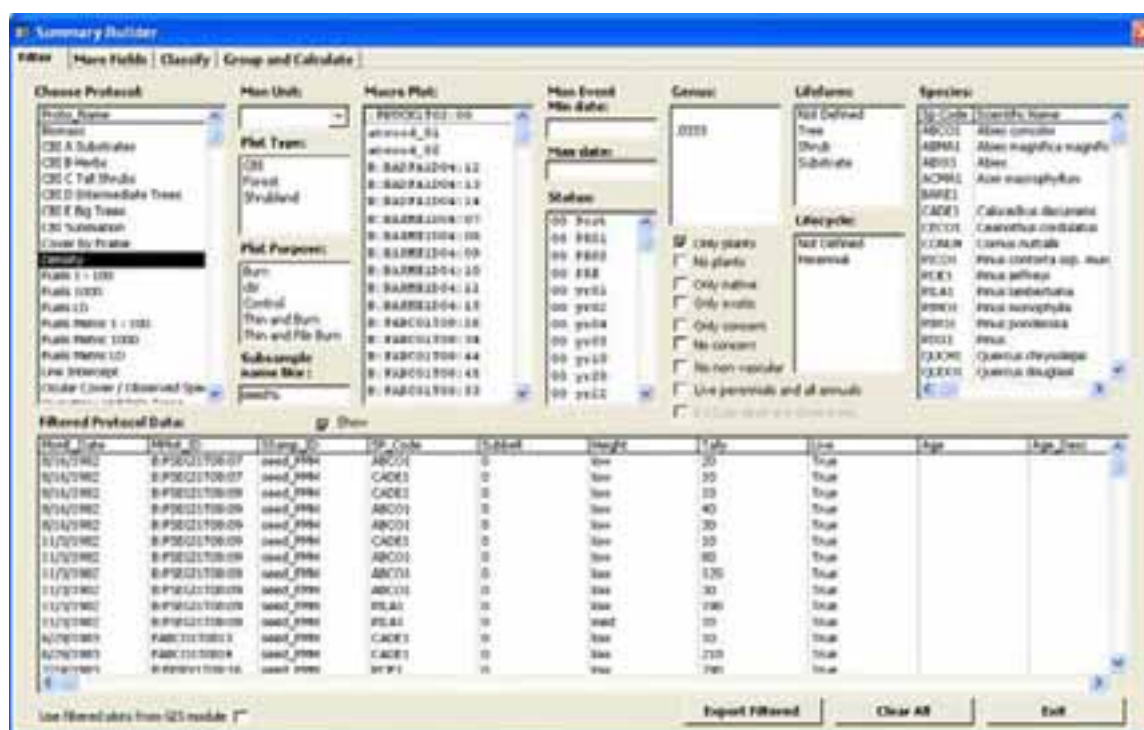


Figure 9. Ad hoc query builder

The future

At this time, FEAT is being integrated with FIREMON, a fire ecology monitoring application developed by the Forest Service, as an inter-agency effort. Although the integration will not offer significant change in the use of GIS, there is great potential for advancement. As the user communities for these two applications come together, we hope that best practices in the use of GIS in fire ecology monitoring will mature to the point that these practices can be incorporated into future versions. Because the GIS component is a toolbar in ArcMap, the users will have full control of their GIS and will have freedom to explore.

Areas in which we anticipate improvements include more vector inputs to stratification and the ability to preview the resulting overlay as parameters take shape. There is a need in sample selection to preview as many as four severity classes at once when generating stratified sampling. There is great potential to display analysis results with a variety of symbology on the map. Plot photos could be displayed on the map via a pop-up frame or pop-up menu. The data collection application on the PDA could integrate with a GPS unit to capture the location of new sample plots and to verify the correct location of existing sampling plots.

Conclusion

In order to escape the black box mentality of monitoring programs, systems must be adaptable to new sampling methods, responding to changes in monitoring objectives and resources. Systems may give users canned outputs where these are appropriate, but must also give users direct access to the data in a flexible query and export interface.

GIS can and should play a key role in monitoring programs without dominating the application. Modular program design is important, so that not all computers used in a monitoring program would require GIS software. Only lead monitors and ecologists need to become GIS-savvy, allowing field personnel to continue to use a simple tabular data collection interface. The use of GIS functions in the application should be optional, since many sampling and monitoring programs are not yet ready to take on the overhead of running a GIS.

References

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