# A GIS FOR THE MANAGEMENT OF THE LOW ALTITUDE EXPERIMENTAL STATION AT TAIWAN ENDEMIC SPECIES RESEARCH INSTITUTE

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## ABSTRACT

Taiwan Endemic Species Research Institute is a provincial government agency in charge of endemic species research and conservation in Taiwan. The Low Altitude Experimental Station was created in 1993 to perform on site experiments to pursue conservation of endemic species. The station covers an area of 384 ha. and was a national forest with elevation in the range of 700 meters to 1834 meters. A self- developed GIS was created at the very beginning accordingly. Remote sensing and global positioning systems were also integrated with a GIS. Ten application modules have been created in the last two years, namely, basic application module, animal and vegetation inventory module, zoning module, animal inquiry module, vegetation inquiry module, station management module, global positioning system module, three-dimensional terrain analysis module, terrain animation module, spatial interaction module. All experiments in the station can be treated in spatial context at a continuous basis. Real time monitoring for a given animal species is now possible because radio communication and GPS were integrated with a GIS. Zoning of experiment sites is now managed not only in two dimensions but also in three dimensions. In addition, they can be reviewed in a spatial interaction model for a given period of time. All functions provided by a commercial GIS package can not solve all management problems in the station. The whole process gave a new horizon to endemic species research and conservation experiments.

## 1. INTRODUCTION

Endemic species research in Taiwan is one of several approaches has been adopted to pursue conservation and environmental protection. Taiwan Endemic Species Research Institute is a quite new provincial government agency. There are three experimental stations to perform on site experiments at three different elevations to depict land forms of Taiwan. The Low Altitude Experimental Station was created in 1993. It covers an area about 384 hectares. It was a national forest with elevation in the range of 700 meters to 1834 meters. Management of the station is a task that has to deal with vegetation, animal, meteorology, insects, soil, geology, and day to day business. Field experiments are not confined to a particular site that they should be in quite different forms and shapes. All factors in the field have to be taken into consideration on a continuous basis and everything has to be treated in an interaction way. A self-developed geographic information system ( GIS ) was created at the very beginning. Remote sensing, global positioning system, and radio tracking were also integrated with the GIS. Data bases creation is performed to cover a wide variety of data types at the station. Application modules were developed to manage the station such that experiments at the station can be treated in a spatial context and in a continuous basis. Commercial GIS packages have not been used. All programs were written in C and C++ languages. Every function provided in the GIS is on a module by module basis to solve different types of problems encountered in a daily business and the field experiments. One professor is working as a consultant and provided all programs for the station. The station is giving prescriptions of a certain type of modules has to be developed. All GIS functions are running in Chinese mode. It can be categorized as a customized design GIS. Every thing and every function in the GIS is developed on request. This developed GIS can be termed as a special purposed program which is good for the management of the experimental station.

## 2. MATERIALS AND METHOD

### 2.1 Management of the Station

The major task at the Low Altitude Experimental Station is to perform on site experiments to ensure that endemic species can be conserved in a very good shape and in an ecological sense. Some endanger species have to bring into the station for further protection and studies. All environmental factors at the station have to be created in the databases. Every on site experiment at the station then can be monitored and analyzed closely and continuously. Management prescription has to adapt into its ecosystem. Spatial interaction has to be analyzed where it is possible. Day to day business other than experiments is also required to be managed in a GIS frame work. Thus, every thing at the station can be focused on the experiments to ensure that experiments at the station can be performed smoothly and efficiently.

### 2.2 A Self-developed Geographic Information System

A GIS developed at the station is not used for general purposes. It was followed a guideline that the developed GIS should provide functions to solve management problems encountered at the station as many as possible. User friendly is one of several key components that make a GIS successful. No commercial GIS packages have been used. Databases created by major brand names GIS can be reformatted and integrated into the existing databases for further analysis. All programs were written in C and C++ languages. Functions are provided module by module such that they can be configured in different ways to solve so many different types of managemant problems. Only personal computers and their peripherals were used. A work station version of GIS can be converted in a very short period of time when a work station is required in addition to personal computers. All functions are running in a Chinese mode and menu driven makes it easy to operate. Every technician at the experimental station can implement the GIS by themselves in couple hours of training.

### 2.3 Databases

All kinds of data has to be converted into digital form. Forest inventory at the station is the major database has been converted. They provide the station detail information on a subcompartment basis. However, more investigations have been conducted by the institute consisting of soil, vegetation, animal, and insect.Topographic data was digitized from four sheets of orthophoto maps at a scale of 1:5000. Contour lines at two meters intervals provide a very good material to generate slope maps and aspect maps. Solid model of the station was then generated based on the contour lines. Terrain animation of the station was also possible to perform and built into the databases. Field survey gave a very detail information of buildings, water pipeline, road system and facilities. An ecology system is changing all the time and their interaction has to be taken into consideration whenever an experiment is performed. The database creation is a continuous process and trying to depict their spatial interactions from the very beginning. Data types include maps, photos, tally sheets, voices, and computer animation. Every database has to be created in a relational type such that a GIS can implement it for further studies.

### 2.4 Application Modules

Application modules are the major components of the developed GIS which perform all kinds of functions to solve problems encountered in the management of the experimental station. There are ten application modules have been developed, namely, basic application module, animal and vegetation inventory module, zoning module, animal inquiry module, vegetation inquiry module, station management module, global positioning system module, three-dimensional terrain analysis module, terrain animation module, spatial interaction module.

#### 2.4.1 Basic Application Module

This module provides basic GIS functions such as overlay analysis, inquiry, display, input and output. Topographic maps, slope maps, aspect maps, forest inventory, upper growth, under growth, soil maps, buildings, and facilities can be extracted by mouse clicking. All kinds of data layers can be turned on or off, zoomed in or zoomed out by clicking a mouse. Every thing displayed on a color monitor can be sent to a laser printer. Inquiry of elevation of a particular contour is also a mouse clicking process. Detail information of a given subcompartment can be extracted from the databases to display on a color monitor right away without issuing any computer command. It is a process no more than moving a mouse and clicking a mouse.

#### 2.4.2 Animal and Vegetation Inventory Module

Inventory of animal and vegetation at the station is a continuous process. This module provides information relevant with animal and vegetation have been investigated at the station. Vegetation is categorized into upper growth and under growth, distinct and unique species. Animal is divided into several categories such as mammal, bird, insect, fish, amphibia, and reptile. Every species has their own description and image file for quick inquiry. They can be inquired by year, by species. This module provides input function for a new inventory, both animal and vegetation as well.

#### 2.4.3 Zoning Module

Zoning at the station is a very important issue. The zoning module provides very user friendly functions that one only draws boundary for a given site(ex. fig.1) on a color monitor. Then very detail information for that particular site will generate automatically on a color monitor for further analysis. All databases can be extracted right away. To decide a right place for a given type of experiment is not difficult at all if site requirement for a given species has been decided before hand.

#### 2.4.4 Animal Inquiry Module

This module provides an inquiry function of an existing animal database. Sorting and data entry are two major functions that provide typical database management functions. Animal can be inquired according to several different categories.

#### 2.4.5 Vegetation Inquiry Module

This module provides same functions as does by animal inquiry module. Inquiry can be issued not only by their names but also by their sites.

#### 2.4.6 Station Management Module

Research projects have been conducted at the station can be inquired in detail by the station management module. Meteorological data analysis and inquiry are the second components. Field patrolling and daily log are managed by this module. Buildings, road system, water supply system,

flat land parcel management, and some types of attributes management are all managed by the station management module.

### 2.4.7 Global Positioning System Module

A global positioning system module provides an integration between GPS and GIS. When a radio communication is connected with a GPS device and a computer, then automatically monitoring can be performed. Usually, a GPS device provides longitude and latitude of a particular target at a given time. Then these information either marked on a notebook or transmitted back to head office at the station by radio. One technician types these information into a personal computer based on what one heard in a radio. New information can input into the databases and information in the databases can be extracted right away on a color monitor for further analysis. This module now provides very precise location for a given type of trees or animal. Distribution of a given type of vegetation and animal is now can be described precisely where they are.

### 2.4.8 Three-dimensional Terrain Analysis Module

Three-dimensional terrain analysis of the station is a very good approach to review what they are on the ground. A solid model of the whole station was generated once then they can be reviewed on a color monitor with different view angles. It is an interaction process. One changes viewpoints and a solid model of the station changes accordingly. Zoning and vegetation cover types can be overlay on the solid model of the station(ex. fig.2). One technician can review them on a color monitor and changes viewpoints as he likes.

### 2.4.9 Terrain Animation Module

A solid model of the station provides a static view while terrain animaton provides moving sequence of several solid models. Usually, terrain animation has to be generated by special animation packages and it is a very tough job. However, this module provides a very easy way to generate terrain animation for every one. One only decides how many image frames to be generated and draws flight path on a color monitor by clicking a mouse. Then, a terrain animation file will be generated automatically and it is ready for display on a color monitor.

### 2.4.10 Spatial Interaction Module

Spatial interaction is quite common process in a given environment.This module implements three-dimensional terrain analysis module as its base module such that spatial distributions of the whole station can be overlay on a solid model for a given period of time. Once different season spatial patterns have been generated then, they can be displayed on a color monitor one by one. Spatial interaction of one particular type of species, such as timber stand, can be reviewed as their changes in sequence of week, month, season, and year.Changes among several species with their neighbors can be generated in spatial context as well as numerical context(ex. fig.3).

## 3. DISCUSSION

GIS implementation is usually a long time process if there is no databases. Most of time and expenses are consumed in the creation of databases. How to implement a GIS in an all English mode is another tough job to be overcome. This is the major difficulty that a GIS can not be utilized by a person who has very limited knowledge of English. Computer is the another reason that keeps person away from a GIS. At the Low Altitude Experimental Station, all this kinds of difficulty have been overcome. One knows Chinese then he can implement the GIS. It is very user friendly. This is not an all purpose GIS. However, it has solved a lot of management problems at the station. Management of the station is a job that should adapt into the ecosystem as well as what new demand has been asked by the general public. By no means, new application module should be developed accordingly. This GIS is now been reformatted for implementation at another experimental station.

## 4. CONCLUSION

Taiwan Endemic Research Institute is entitled to perform endemic research and conservation. The Low Altitude Experimental Station is one of the three field offices to perform on site experiments. In the last three years, a GIS for management of experimental station has been developed. All functions provided by the GIS are only prescribed by the experimental station such that a GIS is used for the management of the station. Ten application modules have been tested and implemented in the field as well as in the office. Databases has been created at the same time. It is very user friendly. The whole process gave a new horizon to endemic species research and conservation experiments.

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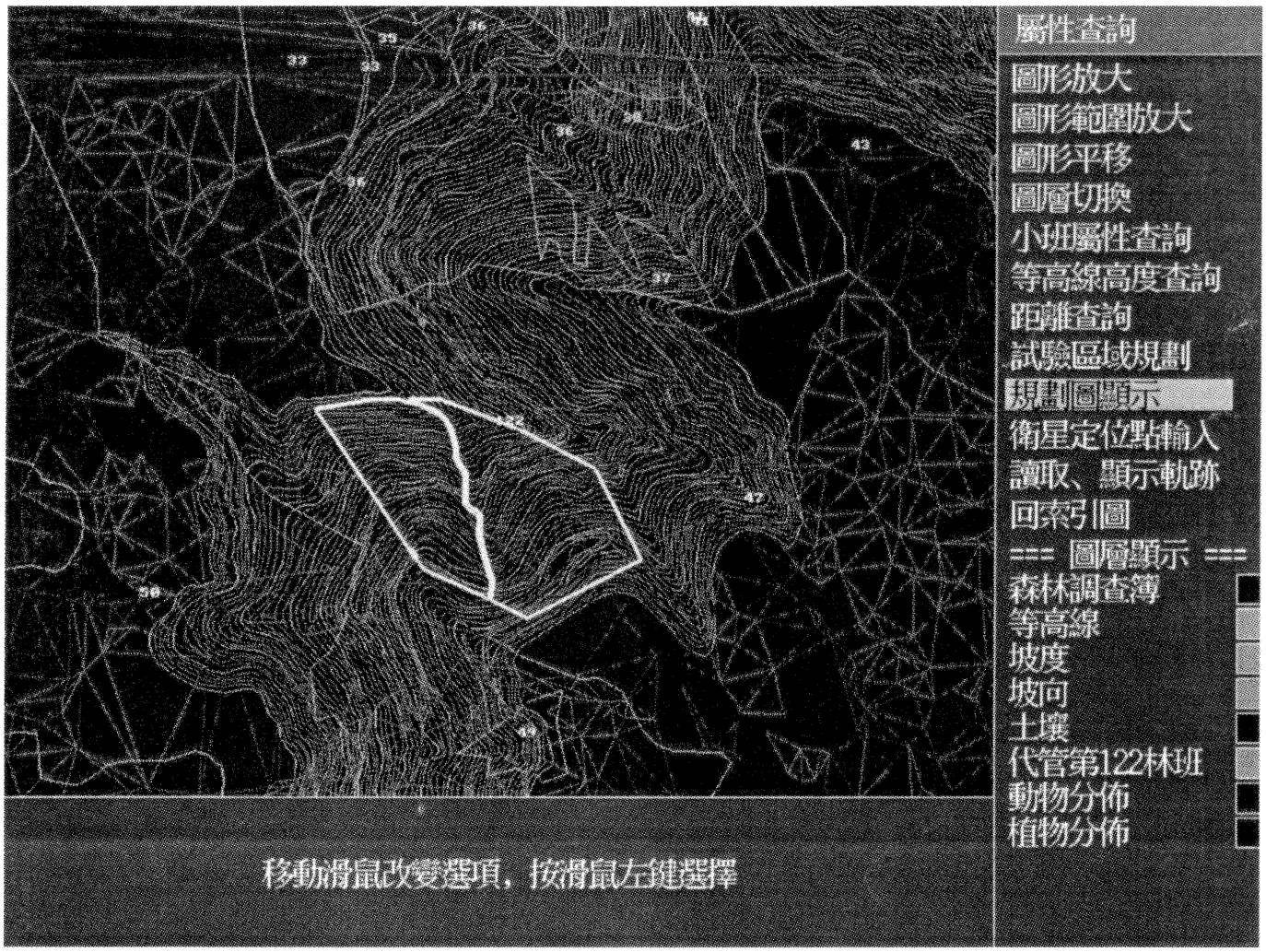


**Figure 1. Experimental site selection based on ecological and environmental constraints by a zoning module.**

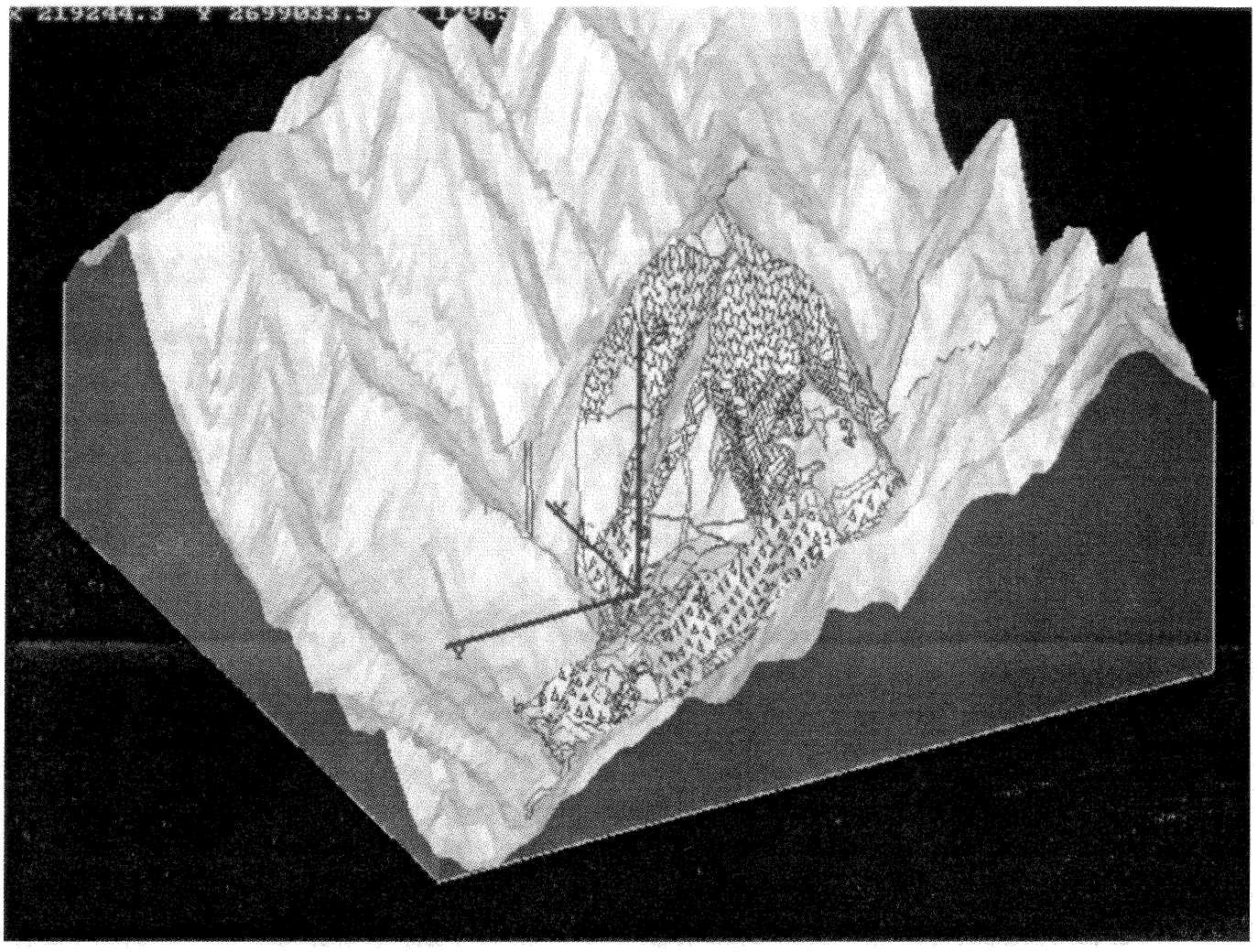

**Figure 2. Upper growth overlay on a solid model of the experimental station.**

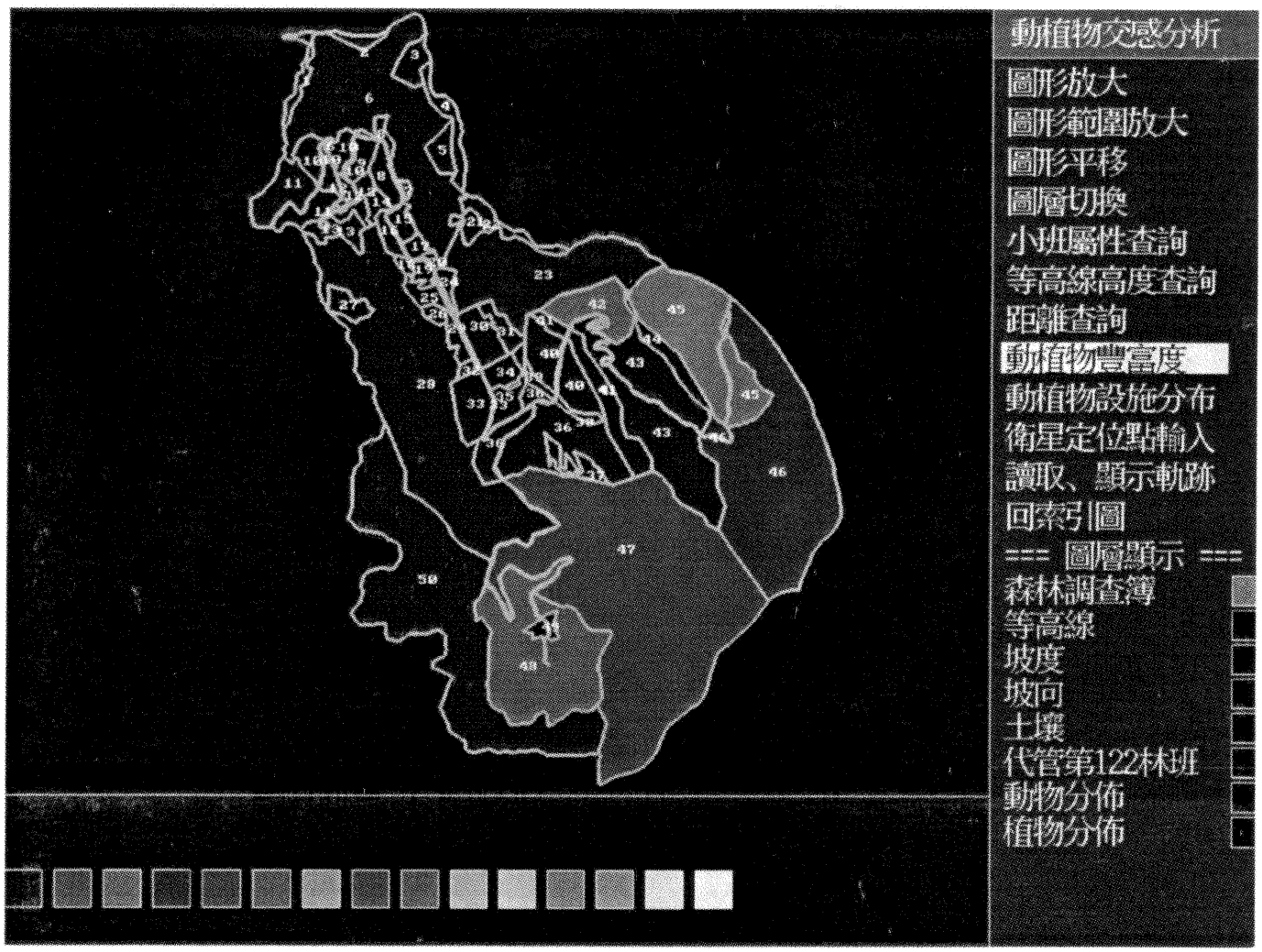


**Figure 3. Species richness distribution for a given period of time extracted from the existing databases.**