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# A Multimedia Data Bank System for Taiwan's Wildlife and Fishery Resources

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## ABSTRACT

*The need to manage natural resources in the framework of sustainable development is high in Taiwan. It is important for resource management agencies in planning resource utilization to incorporate all possible information of an ecosystem. In the past, wildlife resources in Taiwan are neglected in this process because of the scarcity of available researches. Effective use of information is therefore the essential part of decision making process at all levels. Recently, information on Taiwan's wildlife resources is accumulating but scattered. A computerized system is necessary to summarize these data and to support the decision-making process. We propose a conceptual framework using a personal computer to build a multimedia data bank system on Taiwan's wildlife and fishery resources. The software system will be implemented under Microsoft Windows using C++ language and the multimedia development kit. Mammals, birds, reptiles, amphibians, and freshwater fishes will be selected. Each species will be treated as an entry unit and data on its taxonomy, ecology, population, habitat requirements, and distribution will be recorded. Pictures such as diagnosis characteristics, field habitat, and spatial distribution will be included through scanned or camera-captured images and/or a geographic information system (GIS). Calls of wildlife species will be transferred from a tape to a sonagraph and incorporated into the system. The system will allow users to store and update available information, to query existing record, and to display the information on the screen and to produce hard copies. This system has a built-in spatial information system that allows the user to conduct spatial analyses of an animal's distribution or overlay analysis with existing environmental data, such as elevation, vegetation map and land-use patterns. It can also directly communicate with GIS packages, such as ARC/INFO, for further GIS-type analyses. This multimedia wildlife data bank system will serve many useful functions. It can be used as a decision support system in environmental impact analysis in determining the potential impact of a major utility construction. The animal distribution maps can serve as a basic guideline for determining possible natural reserve. Conservation policy maker can use it in resource utilization planning. The multimedia system is the current trend of information display which makes it an ideal tool for environmental education. It is also a fundamental tool to integrate the existing data to support the proposed National Land Information System.*

## INTRODUCTION

Concern for the need to manage natural resources in the framework of sustainable development is high in Taiwan (Botkin, 1986). Accurate information is the first step for an effective action. The more widely shared the information, the more likely that individuals and institutions will agree on the definition of problems and solutions. Effective use of information is therefore the essential part of decision-making process at all levels.

It is important for resource management agencies in planning resource utilization to incorporate all possible information of an ecosystem. In the past, wildlife resources in Taiwan were neglected in the decision process of major construction plan partly because of the lack of available information. Fifteen years ago, wildlife ecological study was a relatively new field in Taiwan. Taxonomic information of Taiwan's wildlife, especially vertebrate, was incomplete because virtually few studies have been conducted. The only data available were collected by either Japanese or foreigner. As a result of the scarcity of information and the economic-oriented decision-making process, many important habitats for wildlife species were destroyed or became fragmented. The consequence is that many of our precious species have become rare, endangered, or even extinct in the field. Large mammals (Formosan macaque, Formosan black bear, Formosan sika deer, Formosan clouded leopard, and Formosan serow, to name a few), birds (Mikado pheasant and Swinhoe's pheasant), amphibian (Formosan salamander), and freshwater fish (Formosan land-locked salmon) are declared as rare or endangered species in Taiwan.

Recently, information on Taiwan's wildlife resources is accumulating but scattered. A computerized system is necessary to summarize these data and to support the decision-making process. While the database system for vegetation survey and plant information was already developed (Hsieh, 1991), no well designed zoological database has been implemented. Our objectives in this paper are to describe a conceptual framework using a personal computer to build a multimedia data bank system for Taiwan's wildlife resources, and to discuss its potential uses in resources planning, environmental impact analysis, landscape ecology studies, and environmental education.

## NEEDS FOR AN ENVIRONMENTAL RESOURCE INFORMATION SYSTEM

Taiwan possesses diverse types of wildlife habitat though being 35,570 square kilometers in area. With its close relationships to other geographical localities, combined with a tall range of mountains, these environments support highly diverse ranges of wildlife species (Table 1). Many of them are endemic.

During the last decade, environmental conservation has become a strong movement and people begin to express concern for environmental health and realize the importance of wildlife as an indicator of environmental quality. As a result of the effort from all of our society, ecological awareness has been improved. The central government has already designated five national parks and 15 natural preserves and a wildlife sanctuary. Several laws related to the preservation of our natural beauty have been passed and enforced.

Many agencies are funding wildlife researches. Researches on wildlife ecology were financially supported by the Council of Agriculture, National Park Agencies, National Science Council, Bureau of Tourist and Recreation, Tai Power Company, and even some private companies. Wildlife information was accumulated rapidly. Data on the distribution and ecology of wildlife species are available for many parts of Taiwan.

There is an urgent need for information systems capable of effectively supporting environmental decision-making by all levels of government in Taiwan (Ride, 1992). The decision-makers require ready availability of knowledge bases and databases of many types of data, an ability to analyze data and to present information flexibly and ease-of-use (Slater and Noble, 1991). Similar requirements also appear within the private sector in natural resource-based or related industries. Environmental educators demand a product for better teaching the subject of Taiwan's wildlife and fishery

Internationally, global change, biological diversity, and sustainable ecological systems are the three research priorities proposed by the Ecological Society of America (Lubchenco et al., 1991). A sound information system to integrate all the available biological information is the first step to support this research agenda.

## SYSTEM SPECIFICATIONS

Availability of information does not mean just carrying out survey and publishing results. The information must be used. This may involve creating an integrated data bank system that can tap into

available information, that summarizes the existing data and that presents it to planners and decision-makers in useful forms.

Informed decisions about environmental management requires a sound understanding of the distribution and status of natural resources. Many kinds of wildlife information are required to support the decision-making process. A major effort is required to: (1) document the wealth of Taiwan's wildlife species, including mammals, birds, reptiles, amphibian, and freshwater fish, and (2) provide a bridge that link wildlife information and planning activity.

Under this horizon, the purposes of our multimedia wildlife data bank system are (1) to bridge the gaps among available research, decision making and environmental education (Figure 1), (2) to provide a decision support system for decision-maker in planing natural resources management, and (3) to aid environmental educators in better communicating the wildlife subject. To better present the wildlife materials which are sometimes dull if they are displayed in text mode, we use multimedia approach, including pictures of wildlife, habitat, and identification aid, descriptive text of taxonomy and ecology, and calls (sound).

New technology makes data management more productive and more accessible than ever. The developments of microcomputer, geographic information system (GIS) and remote sensing contribute to the making of our system. Recent advances in computer technology have made it possible to store and analyze large volume of data on relatively inexpensive microcomputers. GIS and remote sensing have a rapid development and their applications to ecological studies have become popular as the usage cost is greatly reduced (Roughgarden et al., 1991). With the advances of data collection sensors, remote sensing from all platforms now provides users various type of spatial images with several spatial resolutions simultaneously at relatively low cost (Wickland, 1991). A GIS is a computer hardware and software system that can incorporate spatial data (Scott et al., 1987). A GIS can be used to store point, line, and polygon data of two dimensional space and is the necessary tool to update, retrieve, display, and analyze spatial data (Haslett, 1990). These new technology combined with the data bank system can make it easier to determine which species and communities are currently protected and to identify alternative conservation strategies to achieve various levels of protection of other areas of high biological diversity.

To better serve the diverse audience, the data bank system will be in both Chinese and English. The English version system can be used by international researches interested in almost every aspect of wildlife ecology in Taiwan, such as bird migration, global changes, and distribution, while the Chinese one can be a tool in researches, decision-making, and environmental education.

One of the most important feature of the data bank system is the build-in spatial information system, which is similar to a GIS. Wildlife and fish information must be comparable to that of other resources if it is to receive equitable consideration (Clark et al., 1984). Wildlife and fish depend on land and water bases for habitat and must compete with other land uses, such as crop production, energy development, urban expansion, timber production, and recreation. Tradeoffs and interactions among resources produced from a fixed land and water base cannot be assessed by examining the component resources as isolated entities.

Final output of the data bank system include a screen display of available information on a given species. The information can be dumped to a printer, such as HP paint-jet series or color printer. Summary statistics as how many species in a given area and what is the distribution of a particular species can be searched and displayed. Animal distribution map can be overlaid with the provided map to show the distribution characteristics.

The database structure is intended to be compatible with existing wildlife database (or at least can read those data) and world standard such as those in the Red Data Books for data exchange purpose.

## SYSTEM IMPLEMENTATION

To implement the multimedia wildlife data bank system, the first task is to choose a computer platform. Costs, performance, popularity and ease of use are the major factors considered. After conducting several comparisons, we found that the IBM personal computer or its compatible, equipped

with Microsoft Windows, is the only logical choice. A Sun workstation or a Macintosh would be to expensive to invest.

Thus, the hardware for the system are a IBM-PC or compatible with at least 4 megabytes RAM, a 200-megabyte hard disk, a super VGA graphic card and a color monitor, a sound control card, a speaker, and a CD-ROM player. In terms of software, we need MS-DOS, Microsoft Windows (version 3.1) that runs on top of MS-DOS, and, of course, the data bank program written by us. A complete system, including hardware and software components, costs no more than US $4,000 dollars in Taiwan.

The data bank program itself will be written using an object-oriented programming language such as Borland C++ or Microsoft C++ and its development kit. To make the program easy to use, the program will be run under Microsoft Windows to take advantage of its graphical user interface and user-friendly environment. Menu selection is displayed and commands can be assessed through a mouse with pull-down menus. Specific items can be checked through a dialog box interface.

The data bank system can be used to input almost every aspect of a species' record which allows its use in a hierarchical levels of study, i.e., genetic, species-population, community-ecosystem, and regional landscape (Noss, 1990). Information on an animal's genetic characteristics, such as those from electrophoresis, karyotypic analysis, or DNA sequence, can be stored into the system as either graphical or descriptive data.

Census (observations, counts, captures, signs, and radio-tracking) data and species-habitat association can be recorded. Species' habitat preference can be stored as pictures. When the animal's distribution map is combined with the built-in geographical and environmental data within the content of a GIS, one can look at the questions pertaining to community-ecosystem and regional landscape.

Each record in the data bank represents an animal's life history information. We modified the basic data field of the species database (McNeely et al., 1990) of the World Conservation Monitoring Centre (WCMC) to fit our specific situation. Table 2 shows the modified basic data fields on wildlife species in the data bank system. Graphical data include animal pictures taken in their natural habitat, identification aid, and habitat.

The system shall have data input, update, search and retrieve capacities, and can display the results graphically on screen, hard copy, or both. It can also play back the animal's call. To arrange the data in specific order, we provide a sorting function. To find a specific species, we supply the query function. To find out how many species occur in an area within its 10 km ranges, we provide a spatial query that users just have to move the mouse to a build-in Taiwan map, supplied by Council of Agriculture, digitized in vector form and transferred to raster format, and double click the mouse, all the species information will be displayed and summary statistics, i.e., species richness and diversity indices, will be calculated and displayed. To produce a distribution map based on the incomplete survey data, we also use gap analysis (Scott et al., 1987, 1990) or Geostatistics algorithms, such as kriging or corking approaches (Isaaks and Srivastava, 1989; Cressie, 1991), to estimate the missing points where survey was not covered.

To incorporate large volumes of spatial data from remote sensing sources, environmental data, and animal distribution map, we choose a base map with a 1:100,000 scale. All data will be spatially registered according to the standard UTM system and in raster format with a grid cell size of about 70 by 70 m, the cell size of a Landsat multispectral scanner (MSS) images. To be accurate and to prevent error propagation, we require the animal distribution data be recorded through a global positioning system (GPS) with residual mean squares not exceeding 30 m.

A typical spatial information system should include basic information such as parameters of terrain and climate, ecological regions, and land resource information. Table 3 lists the geographic and environmental data layers that will be included in the data bank system. The spatial information system can have the capacities to overlay two maps, to locate impact area and the distribution of an endangered species, to identify areas where human development should not be permitted or should be permitted for development under strict monitoring program.

We will build a literature management subsystem for Taiwan's wildlife species in the data bank. Literature pertaining to the wildlife species will be included in the system. When an animal was queried,

the reference information of the species will be retrieved and displayed in a specified format and can be downloaded to a computer file for including in a paper. It can also used as an independent literature searching utility. All the necessary keywords will be built and are available to users for searching through the use of interacting dialog boxes.

## APPLICATIONS

The data bank system is an ideal decision support tool in evaluating the impact of a major utility construction plan to wildlife and ultimately to the environmental quality. Habitat fragmentation is the universal mode of habitat disturbance accompanying extensive land-use characteristic of a growing society (Harris, 1984; Temple and Wilcox, 1986; Rolstad, 1991). As the human constructions spread outward, continuous landscape becomes fragmented by a network of these developed lands. This, in turn, affects the wildlife species that depend on a continuous habitat (Saunders et al., 1991). With the help of the system, a decision-maker can easily find which species are influenced and which action affects the animals live within them, thus, can determine the potential impact of the construction (Westman, 1985). For a detailed analysis using GIS, the animal distribution maps and necessary environmental and geographic data can be transferred to a computer file and entered into a GIS for further quantitative modeling analyses.

The animal distribution maps can be used as a guideline for determining possible reserve areas and their potential boundaries (Scott et al., 1987, 1990). With overlay analysis, one can easily find how the wildlife species are geographically distributed in Taiwan and which areas are best suitable for wildlife (Joyce and Flather, 1989). For example, in designing the reserves for the Formosan macaque (*Macaca cyclopis*), a decision maker can use the system to generate a distribution map for macaque. From which he can gain a clue on where the reserves should be established and how these reserves should be spatially sited to provide landscape corridors among these reserves.

The built-in spatial information system provides a method to use multifaceted gap analysis (Scott et al., 1987, 1990) in predicting the animal distribution range. It is impossible for the researchers to survey all the potential habitats of an animal species. One way to overcome this problem is to use vegetation type map, combined with other possible factors, as a potential predictor for the animal's range, a probability of occurrence can be derived and a map depicting species richness can be generated. Subsequent fieldwork to verify the prediction can then be done in those uncovered areas.

Questions related to conservation and Biogeography, such as biodiversity in a given area, relation of species distribution and landscape pattern, genetic variation among various sub-populations of a given species distributed in the island, how and where can one invest conservation effort, etc., can all be answered through the system. For example, the species distribution map, matched with elevation, vegetation, climate map, and other geographic or environmental data, can be used to assess the species' preference in habitat selection which provides an opportunity to look at the distribution of these species and its associated landscape pattern (Harding., 1991).

The data bank system can support the global changes study by establishing the wildlife baseline data in local areas (Lubchenco et al., 1991; McNeely et al., 1990) . It has the capacities to show the wildlife habitat characteristic of an area and to indicate the trend of landscape changes through the changes of wildlife distributions (Joyce and Flather, 1989). The data bank system can be easily incorporated into the proposed National Land Information System. This system will also facilitate data sharing among researchers.

A multimedia system is the current trend for public communication. Our system should provide an ideal tool for environmental education since it can attract user's attention easily with its graphical approach and achieve the education goal quickly. Learning curve can be shorten. Anyone who is aware of operating a computer should be able to use it without too much difficulty. A spectrum of users at various levels can be identified: school students, local governmental workers who are in the front line of conservation, and interested natural lovers who visit national park, wildlife sanctuary, and natural reserves.

## CONCLUSION

Decision-making on environmental issues has been severely inhibited in the past by deficiencies in the extent of available information. In this paper, we propose a conceptual framework to design a computerized multimedia data bank system to integrate scattered wildlife information in Taiwan. In this system we will build species database that is to be combined with a spatial information system to look at questions such as what spatial landscape attributes are most ecologically significant in determining animal distribution pattern. We emphasize that this wildlife data bank system should be a distributed database and everyone can gain access to the data to make the most out of it. A decision-maker can use this system to draw on all available data and information, and carry what-if types of analyses on the potential effect of a specific action, such as construction plan, on wildlife habitat and distribution. A student, who wants to know all the species in a given area or the ecology, distribution, and habitat preference of a particular species in Taiwan, can use this system. We believe that the multimedia approach is a better approach than simply text-oriented description in catching the attention and conveying better conservation message. In summary, the multimedia data bank system for Taiwan's wildlife and fishery resources is a geographic approach to protecting future biological diversity. It is a solution to satisfying the needs at various levels.

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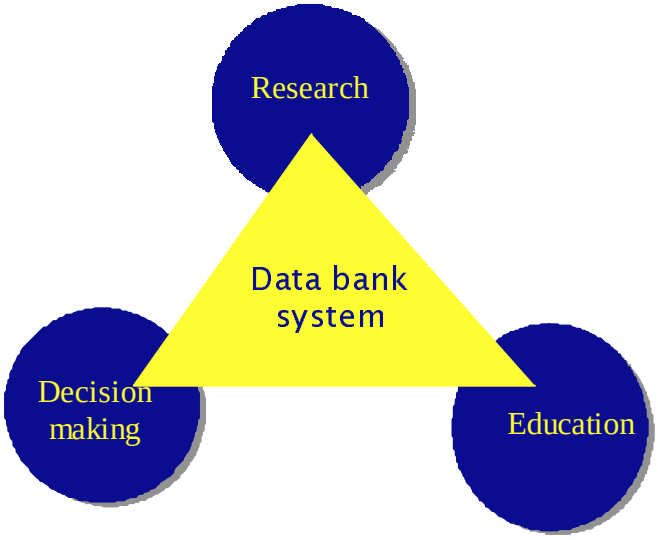


**Figure 1**. The goal of the multimedia wildlife data bank system is to bridge the gap among available researches, decision making process, and environmental education.

**Table 1**. Terrestrial vertebrate species in Taiwan (from Patel and Lin, 1989)

| Fauna | Number of species | Number of endemic species |
|---|---|---|
| Mammal | *61* | 12 |
| Bird | *>400* | 16 |
| Reptile | *92* | 19 |
| Amphibian | *30* | 8 |
| Freshwater fish | *140* | 17 |

**Table 2**. Basic data fields on wildlife species in the multimedia data bank system. Modified from the database in the Red Data Books.

| Data Field |
|---|
| Higher taxonomic name (family) |
| Scientific name (genus, species) |
| Common name in both Chinese and English |
| Morphological data (body weight, body length, tail length, and other measures) |
| Identification aid |
| Genetic characteristics |
| Basic habitat requirements |
| World IUCN conservation category |
| Population status (dependent on data availability) |
| Threats to survival |
| Distribution (capture or observation record) |
| Ecology (Food and habitat preference) |
| Reproduction |
| Conservation measures taken |
| Conservation measures proposed |
| Literature for further reference |
| Call (Amphibian, mammal and bird only) |

**Table 3**. Geographic and environmental data layers that will be built into the data bank system. All the spatial data will have resolution at 1:100,000.

| GIS data layer | Data source |
|---|---|
| Political boundary | Ministry of Interior |
| Elevation | Digital elevation model (DEM) |
| Slope | Calculated from DEM |
| Aspect | Calculated from DEM |
| Soil map | Council of Agriculture |
| Mineral distribution | Council of Agriculture |
| Climate zone | Council of Agriculture |
| Temperature contour | Council of Agriculture |
| Precipitation | Council of Agriculture |
| Land-use pattern | Ministry of Interior |
| Trend of land-use changes | Change detection from land-use maps |
| Levels of hazard | Ministry of Interior |
| Stream distribution | Council of Agriculture |
| Transportation system | Ministry of Communication |
| Existing protected areas | Council of Agriculture |
| Forest type map | Council of Agriculture |
| Vegetation distribution | Council of Agriculture |