GIS Design for *in situ* Conservation of Rare and Endangered Species

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Abstract: Two projects: Conservation and use of genetic resources of non-traditional crops, related wild species and wild species for food and agriculture; and Characterization and evaluation of diversity of wheat and their wild relatives and utilising in breeding involve research into rare and endangered species in the territory of Slovakia. In Slovakia, many threatened and rare plant species occur. In this group of plants, *Aegilops cylindrica* Host and *Arctous alpina* (L.) Nied are also listed. They are registered in the Red Data Book of Slovakia. To locate the occurrences of these species, we have used a GPS system. In this article, we illustrate using GIS (Geographic Information System) in plant conservation.

Keywords: *Aegilops*; *Arctous*; endangered species; GIS; *in situ*; rare species

GIS (Geographic Information System) is a system utilising both technologies and instruments which can make decision-making process easier. It follows from the name itself, as it is a system of information technology, containing some geographic characteristics. According to several authors (Guarino *et al.* 1995; Tuček 1998), GIS can be defined as an organized system of computer hardware, software, and geographic data (filled databases) designed for the effective acquisition, storage, processing, management, analysing, and display of all forms of geographic information.

GIS stands for Geographic Information System, and indicates a computer system oriented to geographic data processing presented through maps. Before the start of the computer era, all information of this type had been manually processed. The resulting maps showed the results of the mutual effects of several data sets. In case of the need to interconnect the data in yet another way, or to enter new data, the map had to be redrawn. This procedure is very time and money intensive.

Moreover, the modern human in the present computer era is used to getting large quantities of information in the shortest possible time. For these reasons, the GIS products are being used more and more for geographic data processing. These products enable the manipulation of geographic data and the presentation of results in digital or visual forms. The computer processing of geographic data of course does not mean the end of classical maps. Both forms of processing have their advantages and disadvantages (http://www.gis.sudolska.sk/).

The main parts of a GIS are as follows (Hauptvogel 2005):

– Data input, verification, and modification.
– Data maintenance, acquisition, and management.
– Manipulation of the data, data analysis, and output.

In a very simplified way, we can say that within a GIS one has the possibility to add collected informational data to various graphic objects into a digital map; and/or based on this data one can make one's own digital map, according to what is needed. Using a GIS, we can analyse and interpret various data which describes places, localities, and objects on the Earth's surface. These so-called geospaces can be divided into three territorial categories: large territorial or regional geospaces (territories of a state, region), local geospaces (cadastre or an area of enterprise), and micro geospaces (occurrence of an individual, a concrete locality).

The result is the geospatial information in the form of a map, visualisation, graph or other diagrammatic output. When designing and creating such a system, it is necessary to understand that the data (in our case the database formed on the basis of passport data) forms a substantial part of the system. For this reason, the structure of graphic and descriptive data must be designed very carefully, with an emphasis on their mutual relationship. In general, the general task of a GIS is to answer the question, 'What is in a given locality, or where is the locality with the desired characteristics'. It also can attempt to find changes in a locality over time, to investigate the spatial background (i.e. to determine the effect of a factor affecting a given population, and to answer the question, 'What happens if'?).

In the present rapidly developing technological world, GIS is one of the most dynamic and developing information technologies. Especially in recent years, it has become an integral part of the development of information systems in areas such as: environment, geology, geography, geophysics, geodesy, as well as banking, marketing, human demographic research, medicine, and biology. It is also used in the area of plant genetic resources, in either local or the worldwide level where, GIS starts to influence the mapping and surveying of plant genetic resources, the production of phytogeographic maps, and the analysis of populations of particular species in a given locality (http://www.esri.com/).

Geographic data in a GIS can be organized into two basic data, specifically by the vector or raster model. These representations are reflective of the different possibilities of processing, storage, analysis, and presentation of the data.

The vector data model reflects real objects. They can be divided into three basic types of elements in space in a selected coordinate system.

– Points, or point element – characterized by coordinates in space (tree, plant).
– Line, or line element – organized set of coordinates in a sequence (stream, contours).
– Polygons, or area element – closed pattern, whose perimeter is created by the set of organized coordinates (settlement, forest, area). The term topology for this data model is typically defined as the relationships between mutual objects (neighbouring, crossing).

A raster data model is characterised by a set of points of the same size, regularly arranged in rows and columns, similar to any other image in a computer. The precision of a given model is determined by the size of a point, which has a given characteristic colour.

The basis of each GIS is a digital map created by many attributes. For spatial phenomena, dividing into thematic areas (layers) is typical. Each writable theme is defined as a set of elements of a given type, with a common attribute (forests, settlemets, streams, hills). For vector and raster data, it is typical to arrange the information into geographic layers (coverages). One can imagine these layers as transparent thematic layers overlaying one another. The user decides which layers he wants to work with, which layers will be displayed, and which not. Such a system offers not only the classical possibilities of questions answered using a database, but also graphics on vector and raster themes.

A GIS offers the ability of geographic modelling and analysis for completely new themes, created on the basis of combined selections from the original graphical layers. In a GIS, there are contained a set of user tools for working with vector and raster data, which further enable the processing and analysis of the data in detail and in different ways; using different methods. An integral part of the work with a map is also a transparent presentation of the processed data. A geographic information system has the ability to integrate sources from various areas of interest, and it therefore becomes an effective and rational instrument for administrative actions in a given administration unit; at the same time an impulse for further management (http://www.lesy.sk/).

MATERIAL AND METHODS

During the monitoring and collecting of diaspore, we have collected other passport data, together with samples of plant genetic resources. These were processed as a database in the form of tables. The Microsoft Excel program was used; the sets of data and passport data was stored in .xls format and then exported in .dbf format (because this format was suitable for our needs).

The passport portion of the database was processed according to the following collected data:

ACRONYM – acronym of collecting expedition, COLL_DATE – date of collecting, LOCALITY_N – serial number of locality, ACCESSION – serial number of sample, GENUS – botanical name of genus, CROP_CODE – code of crop, MATERIAL – type of collected material (seeds or vegetative parts), LOCALITY – name of locality or data of grower, HABITAT – place of occurrence (description of locality), EXPOSITION – exposition in terrain, SLOPE – slope, LATITUDE – latitude, LONGITUDE – longitude, ALTITUDE – altitude, HOLDER – holder of sample, NOTICE – notes.

Based on the results processed this way we can ask questions for the GIS to answer:

– What is on this locality?
– Where are the localities with the desired characteristics?
– What has been changed since …?
– What spatial background exists?
– What happens if …?

The geographical position of localities were recorded by means of GPS (Global Position System) from the Garmin Company GPS60CS, with an accuracy of 5 to 10 m. Processing of phytogeographic thematic maps, and layers on the basis of the databases created, was accomplished using ArcGIS 9.1 software from the ESRI Company. We have used the digitally processed maps from ESRI, especially European global maps.

RESULTS

Within the monitoring and collecting of plant data, and using the methodogy of geographic information systems, we processed the data of selected rare and endangered species from monitoring in the Slovak Republic. The monitoring was focused on *Aegilops cylindrica* Host (Figure 1) and *Arctous alpina* (L.) Nied.

Aegilops cylindrica Host, jointed goatgrass, *Poaceae* family is a critically endangered species, according to the IUCN category. Jointed goatgrass is a submediterranean and subcontinental species with a Euro-Asian distribution. The centre of occurrence is in South-Eastern Europe and Asia Minor. In Slovakia, it grows on anthropogenic biotops,

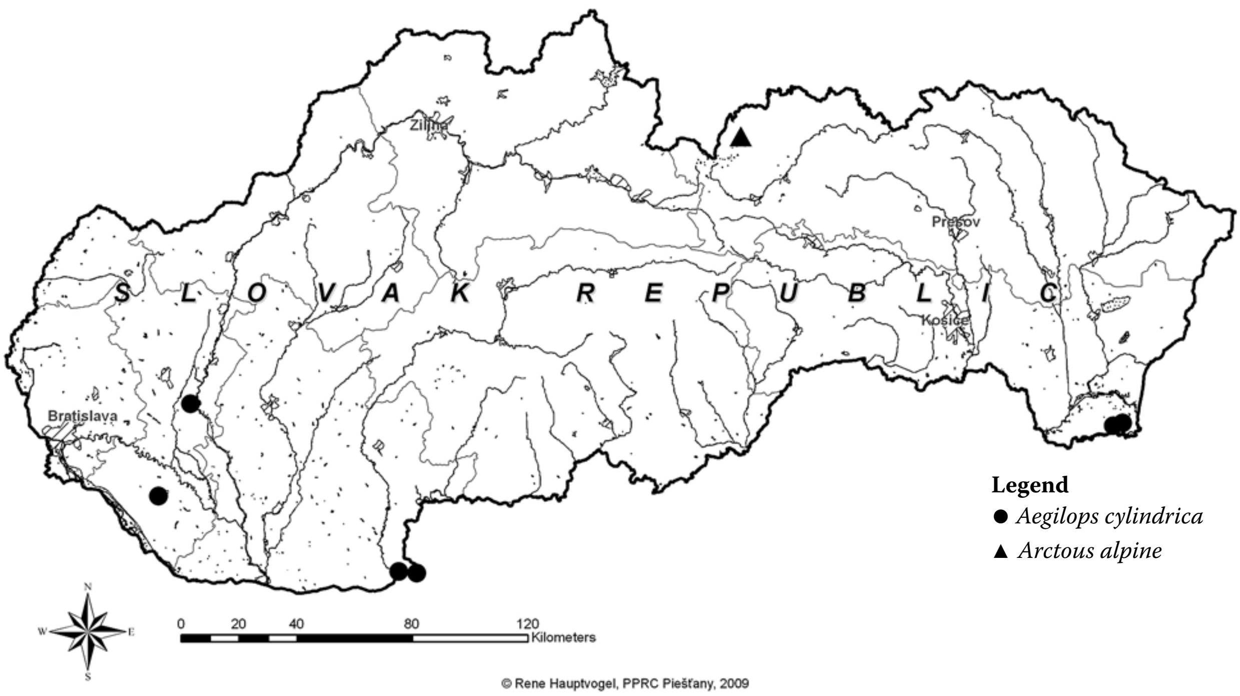

Figure 1. Distribution map of *Aegilops cylindrica* Host and *Arctous alpina* (L.) Nied. in Slovakia

and is also known in some localities (Kamenica n/Hronom, Chľaba, Dunajská Streda, Sereď, Čierna n/Tisou, and Dobrá). From the ecological point of view, jointed goatgrass is bound to warm, dry, light, loamy-sandy soils. It is a terophyt with caroypsis overwintering or germinating in autumn. Spikes decompose at the beginning of summer. The seeds require vernalisation for more than eight weeks. The crop does not tolerate shadow or treading upon, although it can also occur in cereals as a weed. It is a thermophilic plant, occurring in Slovakia on the margins of its natural distribution. Jointed goatgrass is endangered, especially by its occurrences on anthropogenic sites close to transportation and vineyards. According to the Red Data Book of endangered and rare plant and animal species in the SR and CR, it is recommended to make a collection of seeds or live plants (Čeřovský *et al.* 1999). At present, this is the subject of genetic and breeding research at leading scientific and research institutes involved in the study of wheat evolution and hybridization.

Arctous alpina (L.) Nied., alpine bearberry, *Ericaceae* family, is according to the IUCN in the category of critically endangered and rare species (syn. *Arbutus alpina* L., *Arctostaphylos alpina* (L.) Spreng., and *Uva-ursi alpina* (L.) A. Gray). In Slovakia, alpine bearberry is a critically endangered and very rare species. In the Carpathian flora it forms an important glacial relict. It occurs in the arctic area of Euro-Asia and North America, and also extends to Scotland, Scandinavia, northern Russia, Altay, Tien Shan, Japan, and the mountains of North America. In Europe, alpine bearberry occurs in the Pyrenees, Alps, and Dinaride Mountains. In Slovakia it occurs only in the Belian Tatras. It grows on rocks with a thin humus layer, on wet Alpine slopes, stony slopes, and on places with higher and longer lasting snow cover than normal (Čeřovský *et al.* 1999). Alpine bearberry is a small bush (chamaephyt), which creates carpet-like stands. The leaves are herbaceous, the flowers small and inconspicuous, the seeds are distributed by birds, and have significant seed rest. The plant forms colonies that are carpet stemlets and sprigs. The threat to it rests in its rareness and the small populations of this plant. It occurs in the strictly protected area of the Belian Tatras, and therefore, using this form of territorial protection, its continuing occurrence should be ensured in this territory (Štrba 2005).

CONCLUSION

The knowledge obtained and the results can be used in studies of the effects of various factors and stresses in relation to biological diversity, on the updating of the state of biological diversity of cultural plants in the Slovak Republic (as well as in Slovenia), as well as on promotional activities targeting problems of the environment, agriculture, and other areas of concern.

This information can also be used by the:

– Ministries (e.g. Ministry of Agriculture SR, Ministry of Environment SR, etc.).
– Institutions dealing with nature and landscape protection.
– Institutions dealing with territorial planning.
– Scientific institutions.
– Other non-governmental organizations.

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