

Chapter

4

Applications of Geographical Information Systems in Seed Conservation



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Summary

The use of Geographic Information Systems (GIS) in seed conservation has enormous potential. This paper examines the use of spatial technology (both GIS and remote sensing) in the context of seed conservation planning. It explores three major areas to which GIS technology can be applied, with practical and visual examples. These three applications are: targeting species and habitats for seed collecting, facilitation of collecting and of reintroduction of species. The current limitations to the accessibility of this technology for seed conservation are discussed.

Introduction

Geographical Information System technology has enormous potential in seed conservation, particularly in targeting collecting needs and in identifying what, where and when to collect. Electronic specimen databases, which include locality information, when combined with other electronic data, such as Red Data Lists (threatened species), Floras (endemics), specialist databases (e.g., RBG Kew's Survey of Economic Plants from Arid and Semi-Arid Lands), and geographical data (e.g., protected area coverage) allow development of prioritisation procedures for the targeting of taxa for collection and conservation. Information on habitats is increasingly based on remote sensing data such as aerial photographs and satellite imagery, from which extent and condition of vegetation can be measured through time. This approach has been widely used, for example, to chart the loss of rain forest (e.g., Green and Sussman, 1990; Mendoza and Dirzo, 1999) and the advance of desertification (Olsson, 1985), but has also recently been applied to the identification of habitats in which *ex situ* conservation effort would be useful and appropriate (see <http://www.rbgekew.org.uk/gis/projects/Zambia/index.html>).

GIS technology can also be extremely useful in expedition planning. For example, data on seeding periods can be taken from specimen databases, and combined with information on climate, terrain, infrastructure and accessibility to help plan an expedition. Furthermore, environmental data can be used to predict where a species is most likely to be found, or where a range of taxa might occur. Furthermore, GIS technology can be used in the field, with geographical positioning systems (GPS), to capture data, and to supply interactive maps and information to the user. The use of electronic gazetteers and other routines can reduce the amount of work involved in databasing and georeferencing historic specimens.

Finally, GIS technology is increasingly being used for predictive purposes in species re-introductions. Historical information from specimen labels, combined with up-to-date environmental data, can be used to identify the range of environmental conditions in which plants grow, and thereby understand the ecological requirements of different species. The relevant environmental conditions can then be used to delimit areas of high survival probability, and where more detailed ground work should be carried out prior to re-introduction (Sawkins, 1999).

Methods and Examples

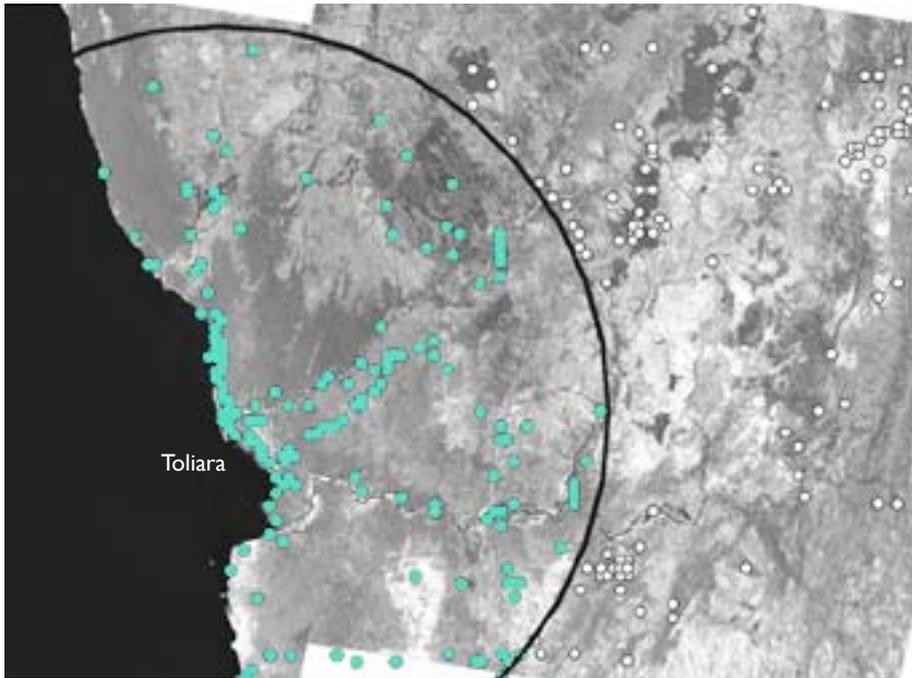
1. Targeting Species and Habitats for Seed Collecting

The example in Figure 4.1 uses a substantial specimen database of legumes from south western Madagascar. The database has been queried and the GIS has identified all species occurring within a 100 km radius of the selected town. The species highlighted by shading in the list are endemic to the region selected (the 100 km radius circle). The database also shows the number of collections already made of each species in this region. This gives a relative measure of species rarity. Furthermore, from the map, it is possible to see if the species is protected in any way (e.g., occurring within a reserve). The background image is radar data from 1996, which gives an indication of the intactness of larger stands of vegetation.

The example in Figure 4.2 shows Itigi thicket around Lake Mweru Wantipa in Northern Zambia. Itigi thicket is a woody deciduous vegetation type with high plant diversity and endemism (White, 1983). Several satellite images have been used to show the extent of thicket in the years 1984, 1990 and 1999. By calculating the rate of deforestation it is predicted that this area of thicket will be completely lost in 13 to 19 years time. Clearly, this habitat is seriously endangered in this area and is therefore a high priority for *ex situ* conservation.

Figure 4.1

A GIS using a specimen database of legumes from south western Madagascar. The database has been queried and the GIS has identified the species occurring within a 100 km radius of the main town. The species highlighted by shading in the list are endemic to the region selected. The database also shows the number of collections of each species in this region, which gives a measure of species rarity. In addition, from the map it is possible to see if the species is protected in any way (e.g., occurring within a reserve). The background image is radar data from 1996, and the selected region is ringed; collections within this region are light coloured dots.



Species	Count	Total	Percentage
<i>Crotalaria poissonii</i>	12□	12□	100.0
<i>Dalbergia xerophila</i>	7	7	100.0
<i>Indigofera mauroundavensis</i>	16□	16□	100.0
<i>Indigofera pseudoparula</i>	2	2	100.0
<i>Sophora inhambanensis</i>	1	1	100.0
<i>Vaughania humbertiana</i>	7	7	100.0
<i>Vaughania mahafalensis</i>	21□	22□	95.5
<i>Ormocarpopsis tulearensis</i>	11□	12□	91.7
<i>Dicraeopetalum mahafaliensis</i>	32□	36□	88.9
<i>Mundulea micrantha</i>	23□	27□	85.2
<i>Tephrosia bibracteolata</i>	16□	19□	84.2
<i>Indigofera trita</i>	17□	22□	77.3
<i>Indigofera praticola</i>	6	8	75.0
<i>Crotalaria humbertiana</i>	8	11□	72.7
<i>Vaughania depauperata</i>	19□	28□	67.9
<i>Zornia capensis</i>	2	3	66.7
<i>Tephrosia pungens</i>	30□	48□	62.5
<i>Otoptera madagascariensis</i>	15□	25□	60.0
<i>Indigofera peltieri</i>	2	4	50.0
<i>Tephrosia subtriflora</i>	1	2	50.0
<i>Pongamiopsis pervilleana</i>	47□	109□	43.1
<i>Chadsia grevei</i>	44□	104□	42.3
<i>Crotalaria edmundi-bakeri</i>	5	12□	41.7
<i>Crotalaria anomala</i>	2	5	40.0
<i>Dolichos fangitsa</i>	16□	41□	39.0
<i>Tephrosia alba</i>	5	13□	38.5
<i>Crotalaria decaryana</i>	12□	33□	36.4
<i>Rhynchosia sublobata</i>	9	25□	36.0
<i>Indigofera diversifolia</i>	6	17□	35.3

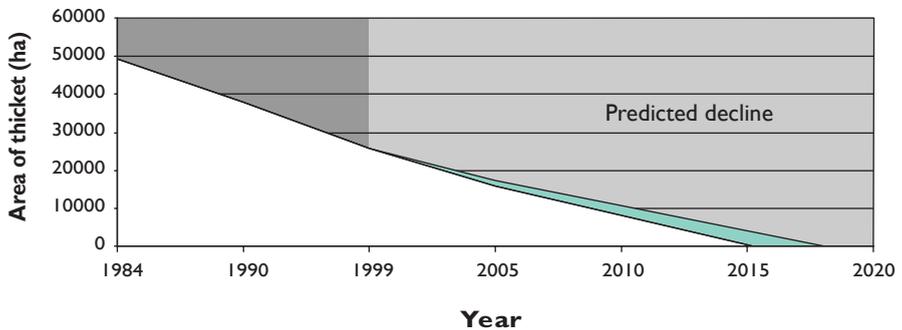
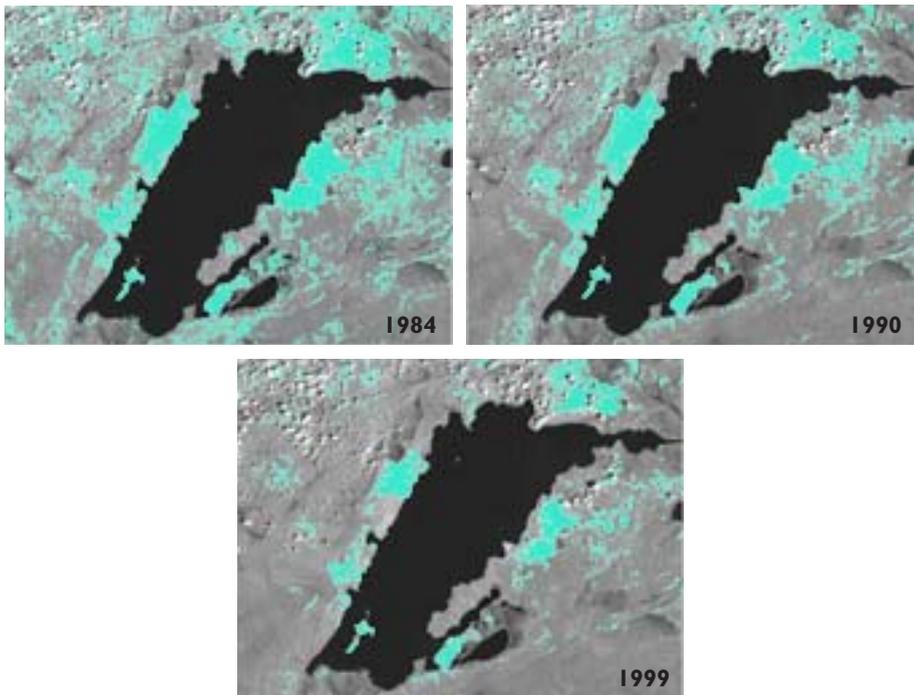


Figure 4.2 Itigi thicket around Lake Mweru Wantipa in Northern Zambia. Several satellite images have been used to show the extent of thicket in the years 1984, 1990 and 1999. By calculating the rate of vegetation reduction it is possible to estimate that this area of thicket will be completely lost in 13 to 19 years. This area is seriously endangered and is therefore a high priority for targeting collections.

Predictive Mapping for Expedition Planning or Species Re-introductions

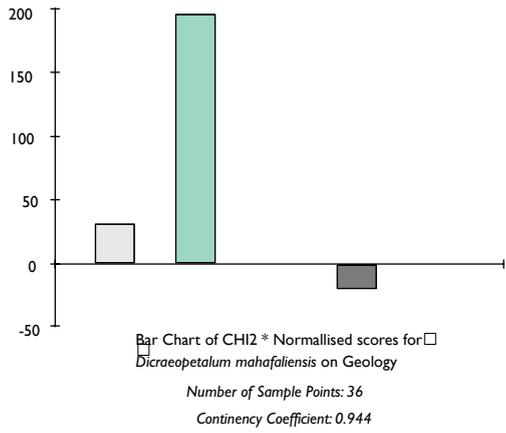
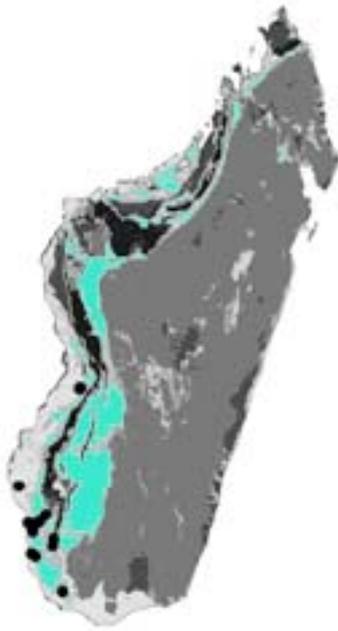
The example in Figure 4.3 shows how, using historical specimen information combined with up-to-date environmental data, it is possible to identify the range of environmental conditions occupied by a particular species (Du Puy and Moat, 1998). This may be useful for planning an expedition to look for a species of interest, or for reintroducing a species to the wild. *Dicraeopetalum mahafaliense* (M. Pelt.) Yakovlev is a species of legume occurring in Madagascar. When collection localities are plotted on a geological map (Figure 4.3A), a strong preference for limestone is indicated. For another legume species, *Alistilus jumellei* (R. Vig.) Verdc., elevation (DEM), geology, mean yearly temperature, phytogeographic zones, clear sky radiation and satellite imagery are combined to create a predictive distribution image for this species (Figure 4.3B). Such predictive maps have been produced for a number of papilionoid legume species. These maps not only show the potential distribution of species, but may also indicate where a species is likely to survive if re-introduced into the wild.

Discussion and Conclusions

The potential value of GIS analysis to conservation efforts has been shown in the preceding section of this paper. The most frequently encountered obstacle to the use of GIS technology in *ex situ* conservation planning is lack of data. This is particularly the case with species distribution information. Most species (taxon) databases do not include sufficiently accurate locality data to enable a collector to locate that species in the field. Specimen databases tend to include more precise locality information, but these are lacking for most species. Where they do exist, this information is often from historic specimens, which may no longer occur within the original collection site. This same lack of detail is often a feature of the available geographical information. It is rare to encounter digital vegetation maps at a sufficiently detailed scale, for example, to assign a single specimen or species to a particular habitat with confidence. In many cases, the information exists, but in a currently inaccessible form – on specimen sheets in herbarium cupboards, or on paper maps. In these cases, resources are needed to transform the data into a format applicable to this kind of technology. A related problem, which adds to the expense of transforming data into a useful form, is the diversity of software platforms, formats and data quality that currently exists. The application of data standards is particularly important to ensure database compatibility and consistency of data quality.

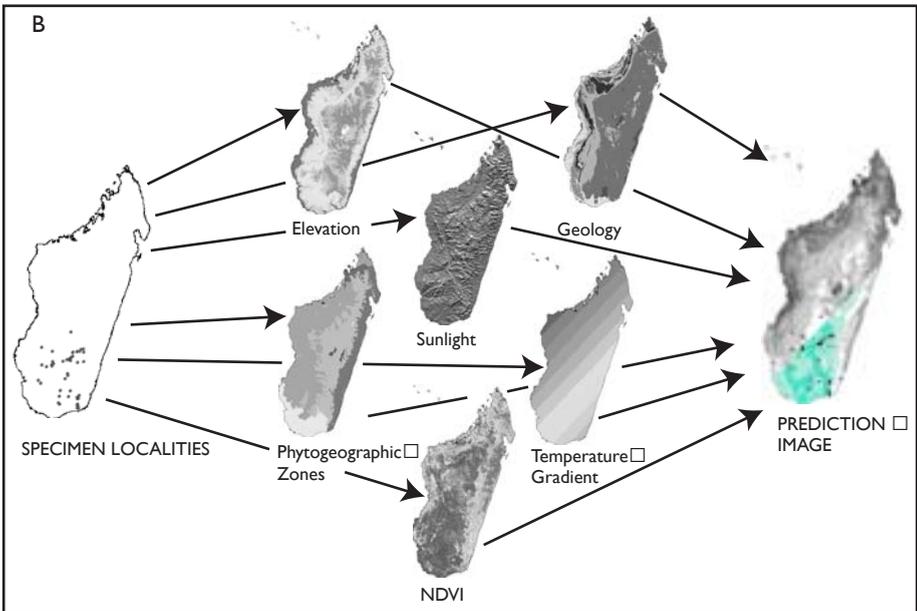
Up till now the considerable expense associated with establishing a GIS facility (hardware and software, training of operators, and data acquisition and

A



- Alluvial & Lake Deposits
- Unconsolidated Sands
- Mangrove Swamp
- Tertiary Limestones + Marls & Chalks
- Sandstones
- Mesozoic Limestones + Marls (Inc. "Tsingy")
- Lavas
- Basement Rocks (Metamorphic & Igneous)
- Ultrabasics
- Quartzites
- Marbles
- Collections

B



transformation) has usually been prohibitive, particularly in developing countries. However, software and hardware is getting cheaper, and information is increasingly available (many datasets can be downloaded from the internet free of charge). In addition, data standards are being applied more widely, resulting in fewer compatibility problems.

For plant conservationists, perhaps the greatest constraint to meaningful analysis remains the lack of relevant, good quality data in any form. The total number of plants assessed for the 2000 IUCN Red List only constitutes 2.3% of known species (Willis *et al.*, 2002, in press), and up to date, detailed vegetation maps exist for very few areas of conservation interest. It is therefore worth bearing in mind that although GIS applications to *ex situ* conservation can be useful, they are only as good as the data on which they are based.

References

- Du Puy, D. and Moat, J. (1998). Vegetation mapping and classification in Madagascar (using GIS): implications and recommendations for the conservation of biodiversity, pp. 97–117. In: C.R. Huxley, J.M. Lock and D.F. Cutler (eds). *Chorology, taxonomy and ecology of the Floras of Africa and Madagascar*. Royal Botanic Gardens, Kew, UK.
- Green, G.M. and Sussman, R.W. (1990). Deforestation history of the eastern rainforests of Madagascar from satellite images. *Science* **248**: 212–215.
- Mendoza, E. and Dirzo, R. (1999). Deforestation in Lacandonia (southeast Mexico): evidence for the declaration of the northernmost tropical hot-spot. *Biodiversity and Conservation* **8**: 1621–1641.
- Olsson, L. (1985). An integrated study of desertification: application of remote sensing, GIS and spatial models in semi-arid Sudan. University of Lund Sweden, Dept. of Geography, Lund, Sweden.
- Sawkins, M. (1999). *Geographic and genetic studies of Stylosanthes species*. PhD. University of Birmingham, Birmingham, UK.
- White, F. (1983). *The Vegetation of Africa, Natural Resources Research No. 20. A descriptive memoir to accompany UNESCO/AETFAT/UNSO vegetation map of Africa*. UNESCO, Paris, France.
- Willis, F., Moat, J. and Paton, A. (2002) in press. Defining a role for herbarium data in red list assessments: A case study applying *Plectranthus* from East and Southern Tropical Africa. *Biodiversity and Conservation*.

Figure 4.3 Figure 4.3A shows the distribution of *Dicraeopetalum mahafaliense*, a species of legume occurring in Madagascar (localities are the black dots), that when plotted on a geology map, shows a strong preference for limestone. Figure 4.3B creates a predictive distribution image for another legume species, *Alistilus jumellei*, using elevation (DEM), geology, mean yearly temperature, phytogeographic zones, clear sky radiation and satellite imagery.

