Ecogeographic Surveys and Data Analysis

N. Maxted, J. Magos Brehm, S. Kell + Colleagues
University of Birmingham, UK

SADC Crop Wild Relatives Regional training workshop
‘*In situ* conservation of CWR including diversity assessment techniques’
Le Meridien Ile Maurice, Mauritius 10th – 13th November 2014

Introduction

- Publications
  - Groom, Meffe & Carroll (2006) Chp 14
  - Castañeda Álvarez, N.P., Vincent, H.A., Kell, S.P., Eastwood, R.J. and Maxted, N. (2011) Ecogeographic surveys. In Guarino L, Ramanatha Rao V, Goldberg E (editors). Collecting Plant Genetic Diversity: Technical Guidelines. 2011 update. Bioversity International, Rome. Available online: http://cropgenebank.sgrp.cgiar.org/index.php?option=com_content&view=article&id=679

" Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity."

Article 8 - CBD (1992)

- Pandas in South America!
- PAs are established on "Land no one else wants"

Definition

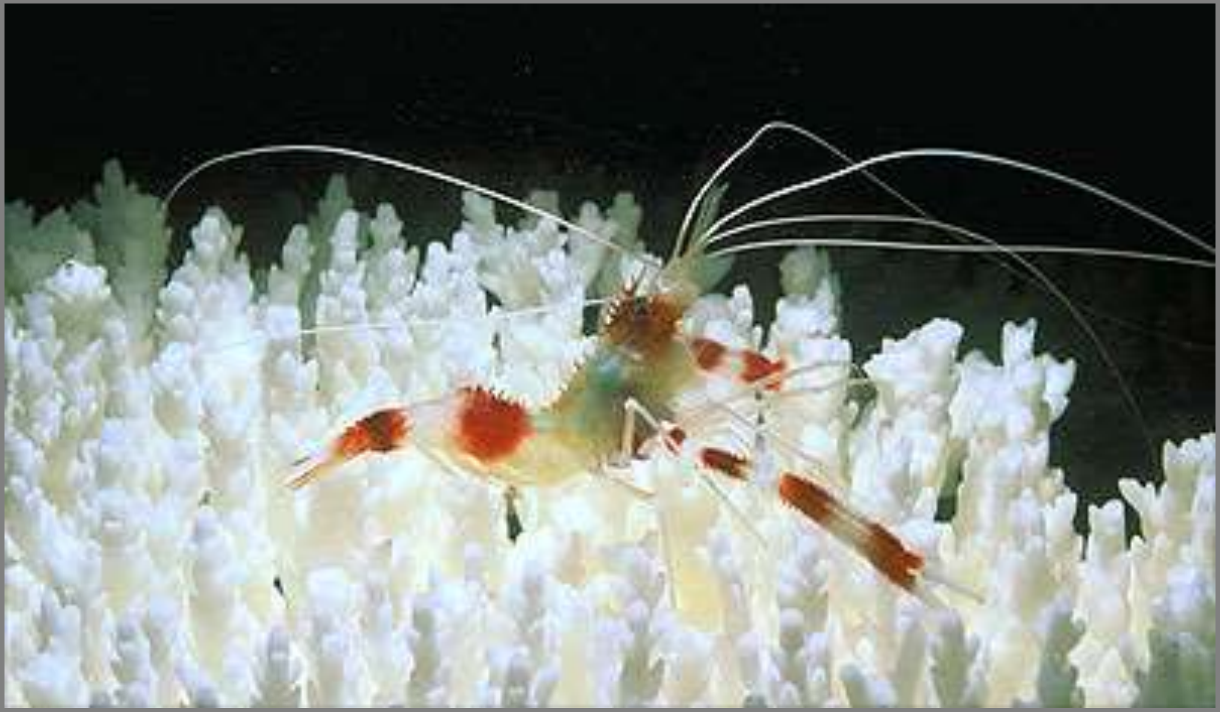
"An ecogeographic study is an ecological, geographical, taxonomic and genetic information gathering and synthesis process. The results are predictive and can be used to assist in the formulation of conservation priorities."

Castañeda Álvarez *et al.* (2013)

Now linked to Gap Analysis

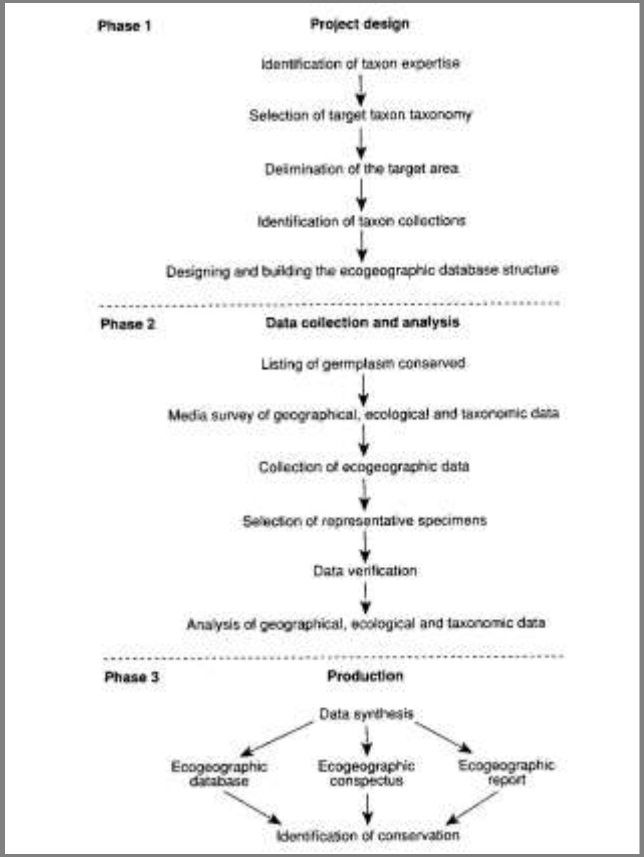
Survey or Study

- Study - novel data, more detailed data, more detailed analysis



- Survey - little fresh data, quick, routine

Ecogeographic Paradigm



PHASE 1

1.1 Project commissioning

- Commissioning Agency (IUCN, Planta Europa, London Zoo, Shamba Lodge)

- Breadth of Taxon and Geographical Coverage (linked to prioritisation)

- Commission statement

"An ecogeographic survey is commissioned for the genus *Vicia* L. in Turkey by the Aegean Agricultural Research Institute. The survey has the objective of identifying areas that contain novel genetic diversity not already conserved that could be utilised in selection or breeding programmes for the benefit of Turkish agriculture. The report should contain a detailed conservation strategy for the genus, including: collecting routes, timing and suitable local contacts. It should also attempt to identify those *Vicia* species of immediate and medium-term potential value to Turkish agriculture"

PHASE 1

1.2 Identification of taxon expertise

- Contact appropriate specialists:
  - Recent or authorative publications
  - Web search
  - Index Herbariorum (Holmgren *et al*., 1990)
  - IUCN Specialist Groups

PHASE 1
1.3 Selection of taxon taxonomy

- Classification
  - accepted taxa
  - taxon descriptions
  - synonymised lists
  - distributions
  - identification aids (keys, illustrations)
  - ecological preferences, bibliographies
  - critical taxonomic notes

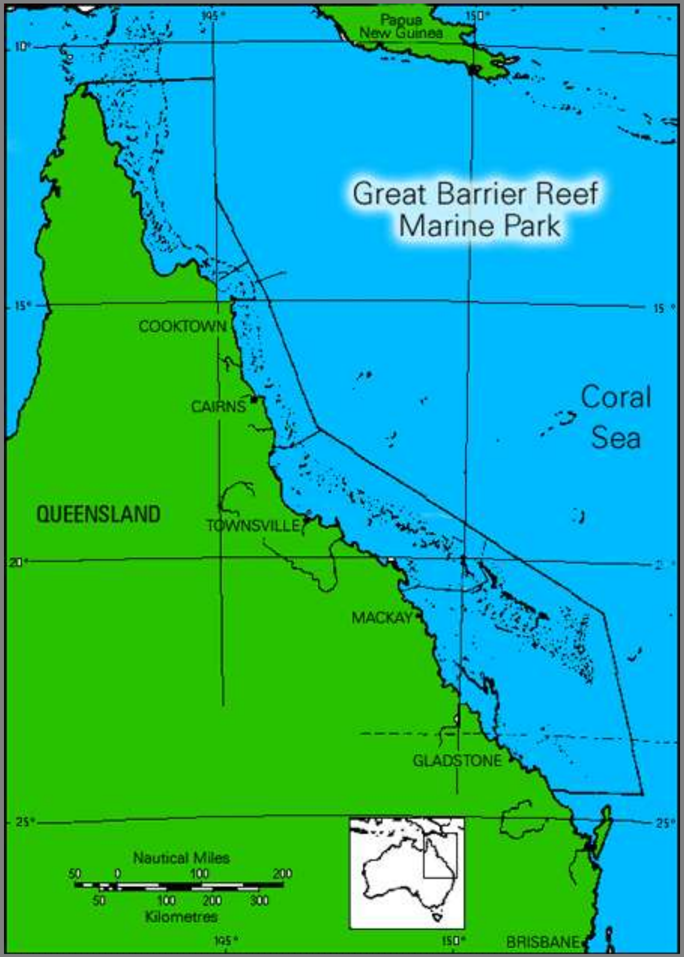
- Where and how to find

- Obscure groups

PHASE 1

1.4 Delimitation of the target area

- Set in commission statement - e.g. Turkey, Great Barrier Reef
- As wide as possible
- Problem of multiple studies
- Consult local Faunas and Floras to provide more information



PHASE 1

1.5 Identification of taxon collections

Museum, Wildlife park, gene bank and herbarium specimens

	Advantages	**Disadvantages**
Major inter-national	1. broad taxonomic coverage, possibly material used in the production of revisions and monographs 2. broad international geographical coverage, possibly material used in the production of local Faunas / Floras 3. skilled researchers available to provide general advice 4. appropriate taxonomic and geographical specialists 5. type material of target taxa 6. good biological library	1. predominance of old collections, making extraction of passport data more difficult and likely predictive value lower 2. geographical names associated with older collections sites may have changed more recently

PHASE 1

1.5 Identification of taxon collections

	Advantages	**Disadvantages**
Regional	1. good local regional coverage of target area 2. better documented material, as the collection is likely to have been more recently established 3. regional specialists present, who can assist in deciphering local geographical names	1. limited resources for collection maintenance 2. lack of target taxon specialists 3. limited biological library

Direct data input via web from Museum, Wildlife park, gene bank and herbarium e.g.

GBIF - www.gbif.org/

NBN Gateway - http://data.nbn.org.uk/

PHASE 1

1.6 Designing and building the ecogeographic database structure

- Paper or direct into database
  - Save time
  - Reduce errors
- Simple database structure
- Standardise data - Biodiversity Information Standards (TDWG) is an international not-for-profit group that develops standards and protocols for sharing biodiversity data.

  http://www.tdwg.org/

Sergey Shuvalov

PHASE 2

2.1 Review conservation status

- Why continue if sufficient already conserved?

- Check catalogues and databases

- Be careful when interpreting conservation status
  - Sample size and number
  - Lack passport data
  - Good sample of genetic diversity
  - Misidentification
  - Duplicates
  - Genetic diversity lost since original collection
    - unsuitable regeneration conditions
    - poor storage resulting in differential erosion
    - human errors through mislabelling samples
    - Present but unavailable

PHASE 2

2.2 Media survey of geographical, ecological and taxonomic data

- Literature: monographs, revisions, field guides, faunas, floras, gazetteers, articles, papers, soil, vegetation and climatic maps, atlases, etc.

- Other media: on-line databases, Science Citation Index, CD-ROM discs, videos, and other contemporary data storage media.
  - Global Biodiversity Information Facility (GBIF) (http://data.gbif.org)
  - National Geospatial-Intelligence Agency (NGA) (http://earth-info.nga.mil/gns/html)
  - Biogeomancer (http://bg.berkeley.edu)
  - Google Geocoding API (https://developers.google.com/maps/documentation/geocoding)

PHASE 2

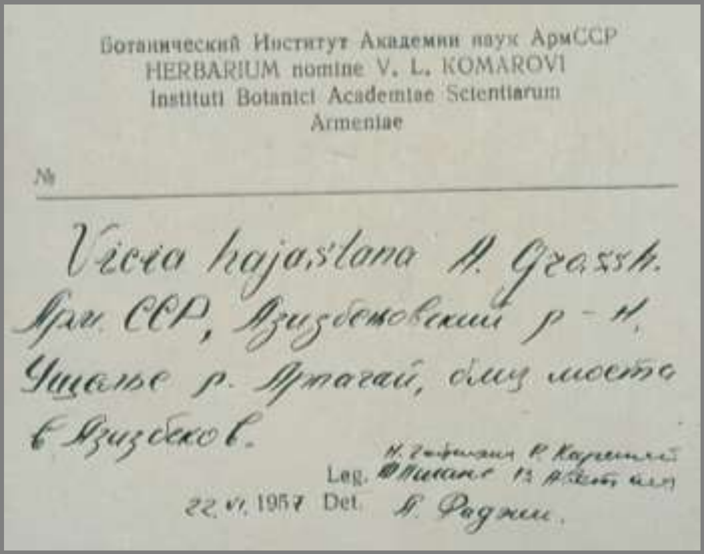
2.2 Media survey (Taxon Level)

- The data that might be obtained from the literature will include:
  - accepted taxon name*
  - locally used taxon name*
  - where in the target area the species is reported*
  - timing of local migration / flowering and fruiting*
  - habitat preference*
  - topographic preference*
  - soil preference*
  - geological preferences*
  - climate and micro-climatic preference*
  - breeding system employed*
  - genotypic and phenotypic variation (are local variants found, is this variation genetically or environmentally based?)
  - biotic interactions
  - archaeological evidence
  - ethnobotanical evidence
  - conservation status* (e.g. Red Data Book status)

PHASE 2

2.3 Collection of ecogeographic data (specimen level)

- Quality of data recorded
- Basic location, but poor ecological & behavioural data
- Hand written
- Foreign language
- Check identification
- Type of passport data collected



PHASE 2

2.3 Collection of ecogeographic data

- **Type of specimen passport data collected:**
  - Museum, herbarium, genebank or botanical garden where specimen is deposited*
  - collectors name and number
  - collection date* (to derive migration, flower and fruiting timing)
  - particular area of provenance*, latitude and longitude or even greater detail if possible
  - altitude*
  - soil type*
  - habitat type*
  - vegetation type*
  - site slope and aspect*
  - land use and/or agricultural practice*
  - biotic interactions
  - competitive ability*
  - vernacular names
  - uses

PHASE 2

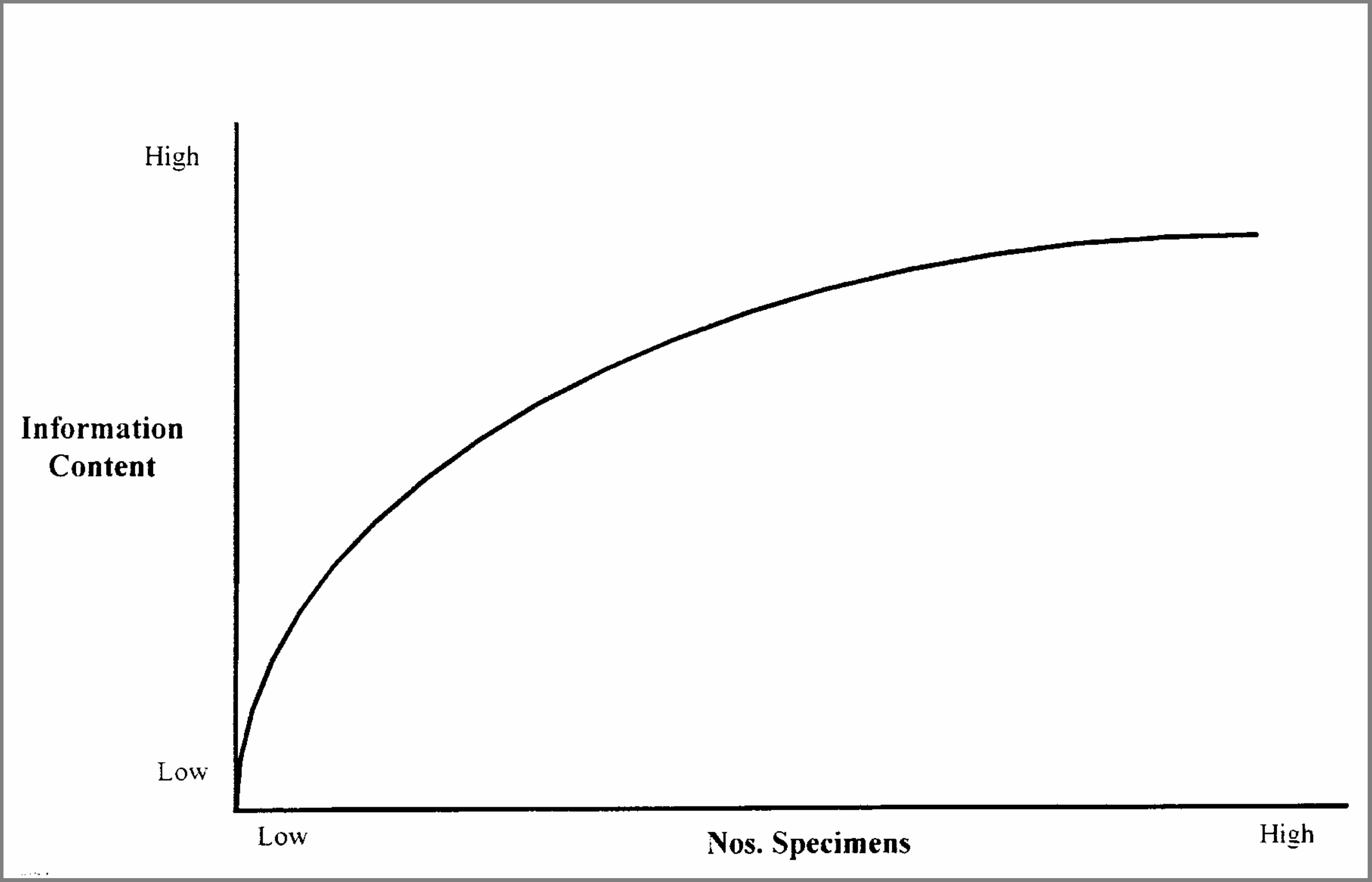
2.4 Selection of specimens

- Millions of specimens - limited resources = specimens are selected
- Select those with best provenance data - recently collected
- Select for breadth not duplication, new not old!
- Photograph specimens
- Data inference (e.g. Worldclim (www.worldclim.org)
- Geographical information systems (GIS)
- How many specimens?

PHASE 2

2.4 Selection of specimens

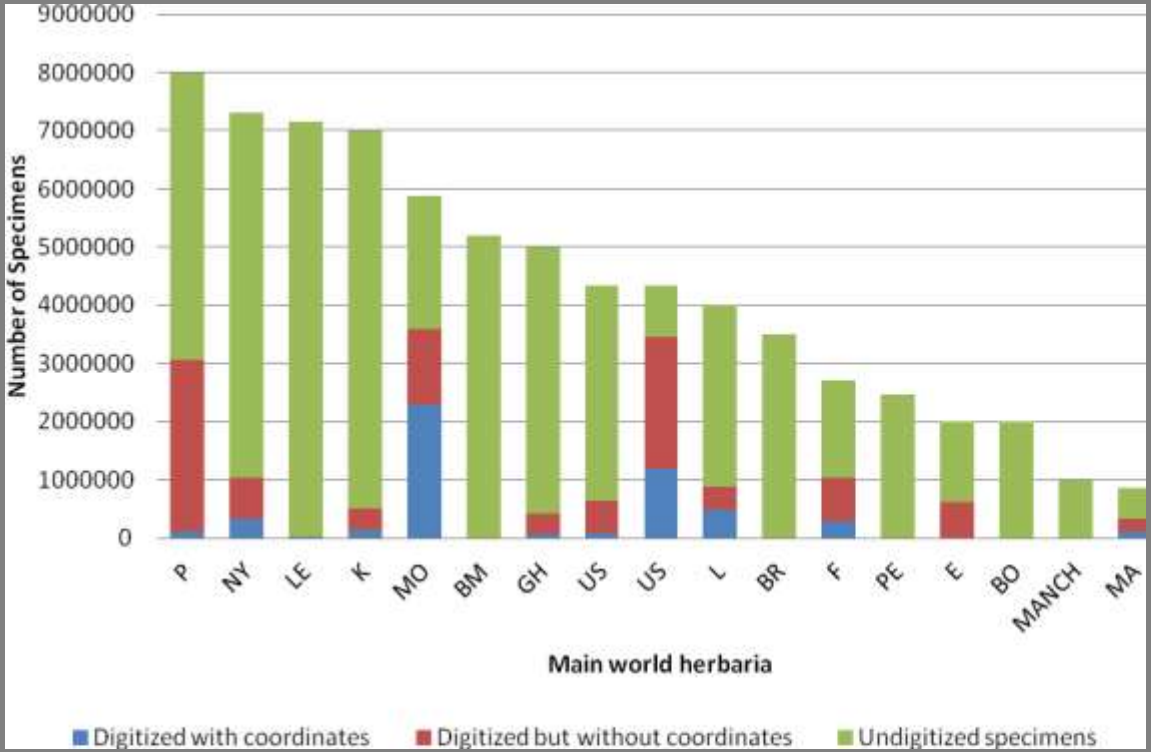
- How many specimens / accessions?



PHASE 2

2.4 Selection of specimens

- Data interpolation
  - Infer characteristics from location
    - Climate
    - Altitude
    - Soils
    - Habitat etc.



- Be pragmatic when interpolating

- Must know specimen provenance
  - www.nima.mil National Imagery and Mapping Agency

PHASE 2

2.5 Data verification

- Assess completeness of the data set
  - certain analyses not possible if it is incomplete

- Check for errors
  - typing errors
  - inconsistencies e.g. latitude/longitude
  - index
  - Map

Errors can be avoided with careful system design

- Note duplicates or bias

PHASE 2

2.5 Data verification

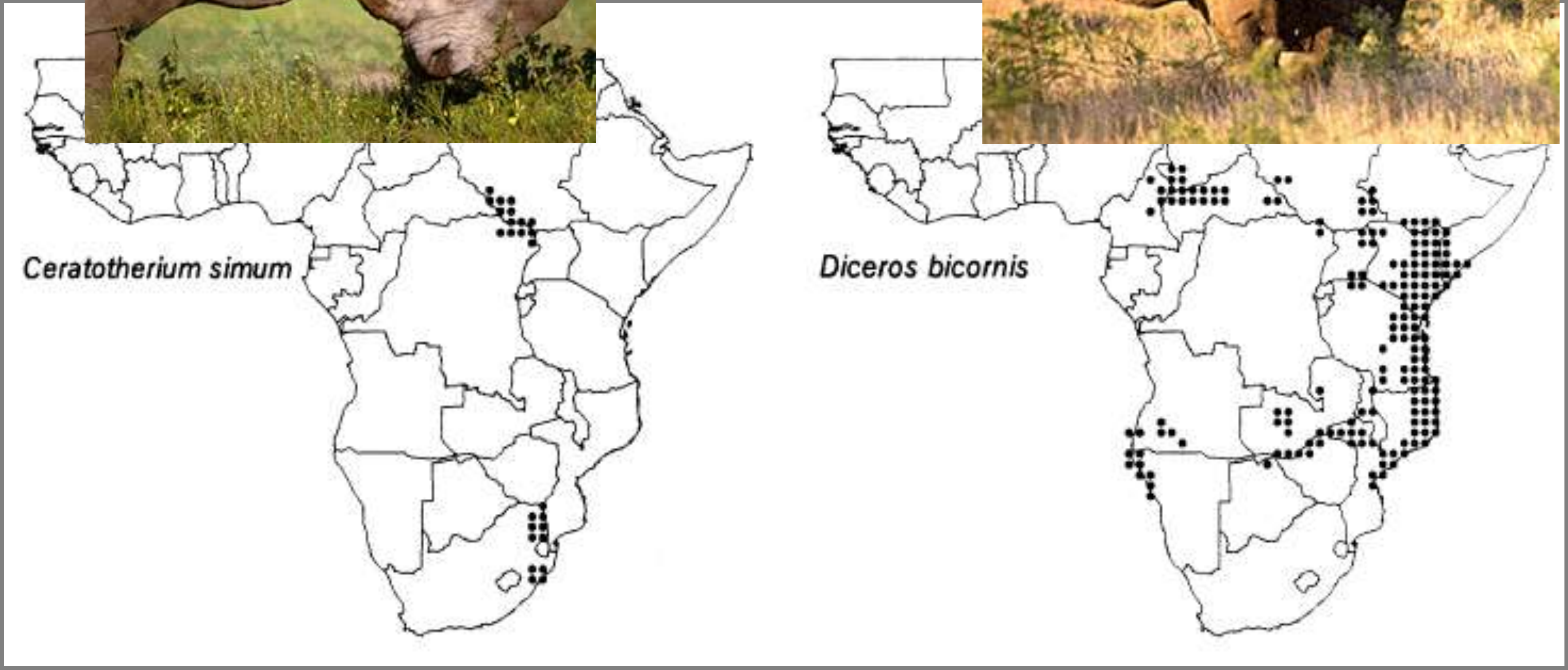
White

Data quality:

distribution

errors

Black



PHASE 2

2.6 Analysis of geographic, ecological and taxonomic data

- To help interpret geographic, ecological and taxonomic patterns

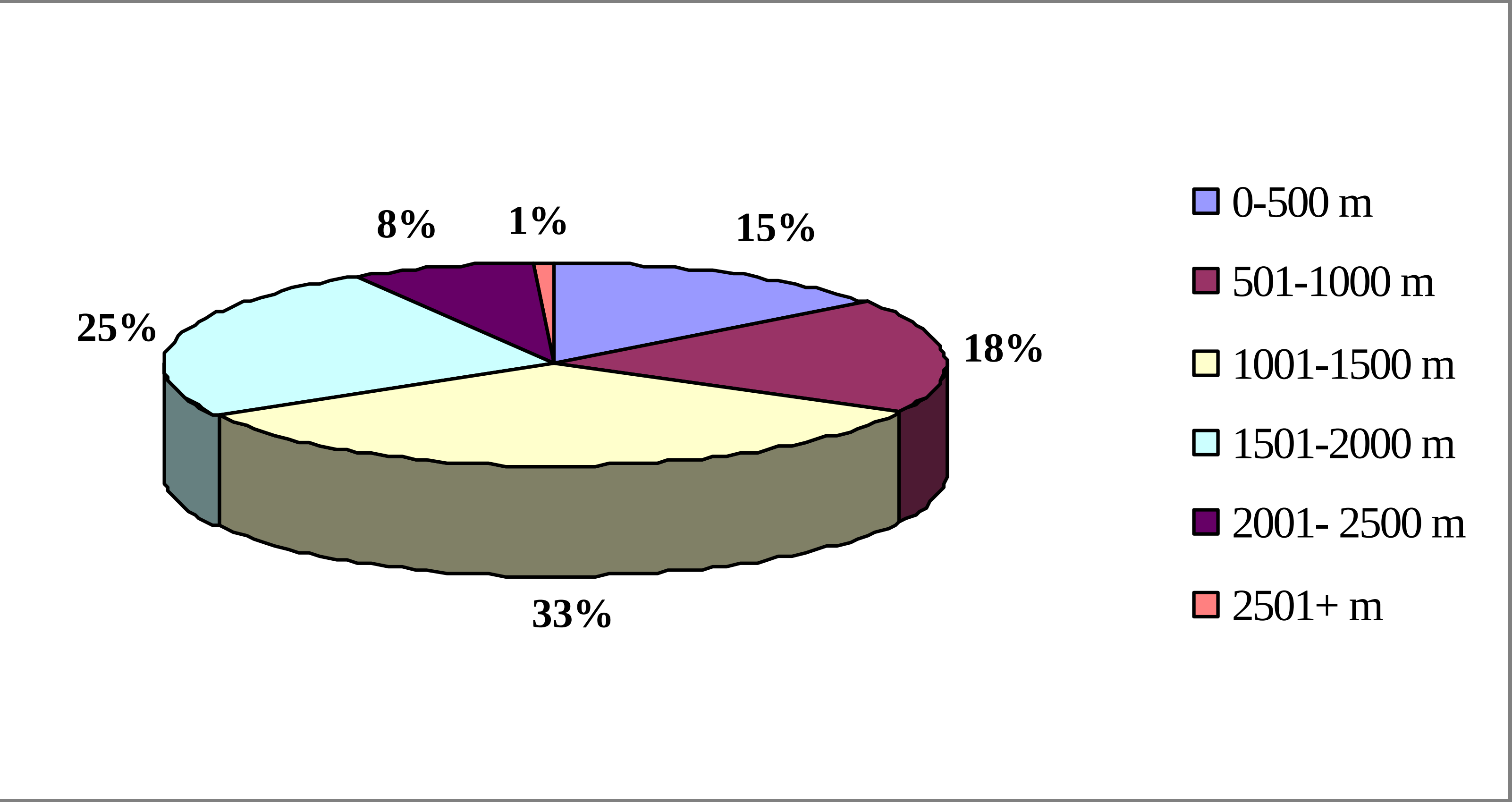
- Simple analysis
  - Pie charts
  - Tables
  - Graphs
  - Distribution maps
    - Enclosed line
    - Dot distribution
    - Enhanced dot distribution
    - Isopleath maps
  - Geographical information systems

- Multivariate analysis
  - Various cluster analysis and ordination techniques

PHASE 2

2.6 Analysis of ecogeographic data

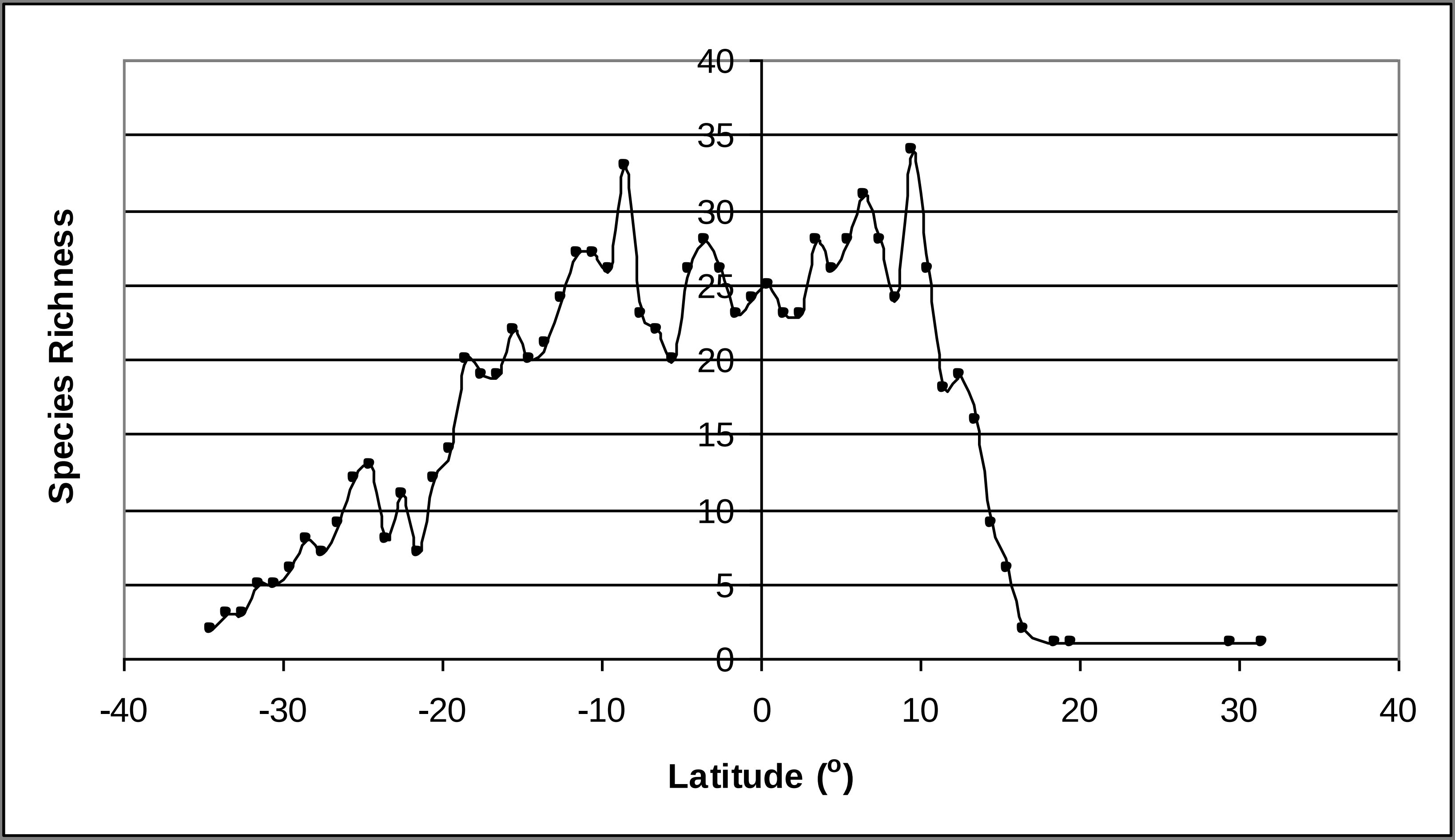
Proportion of all *Vigna* specimens collected at various altitudes in Africa



PHASE 2

2.6 Analysis of ecogeographic data

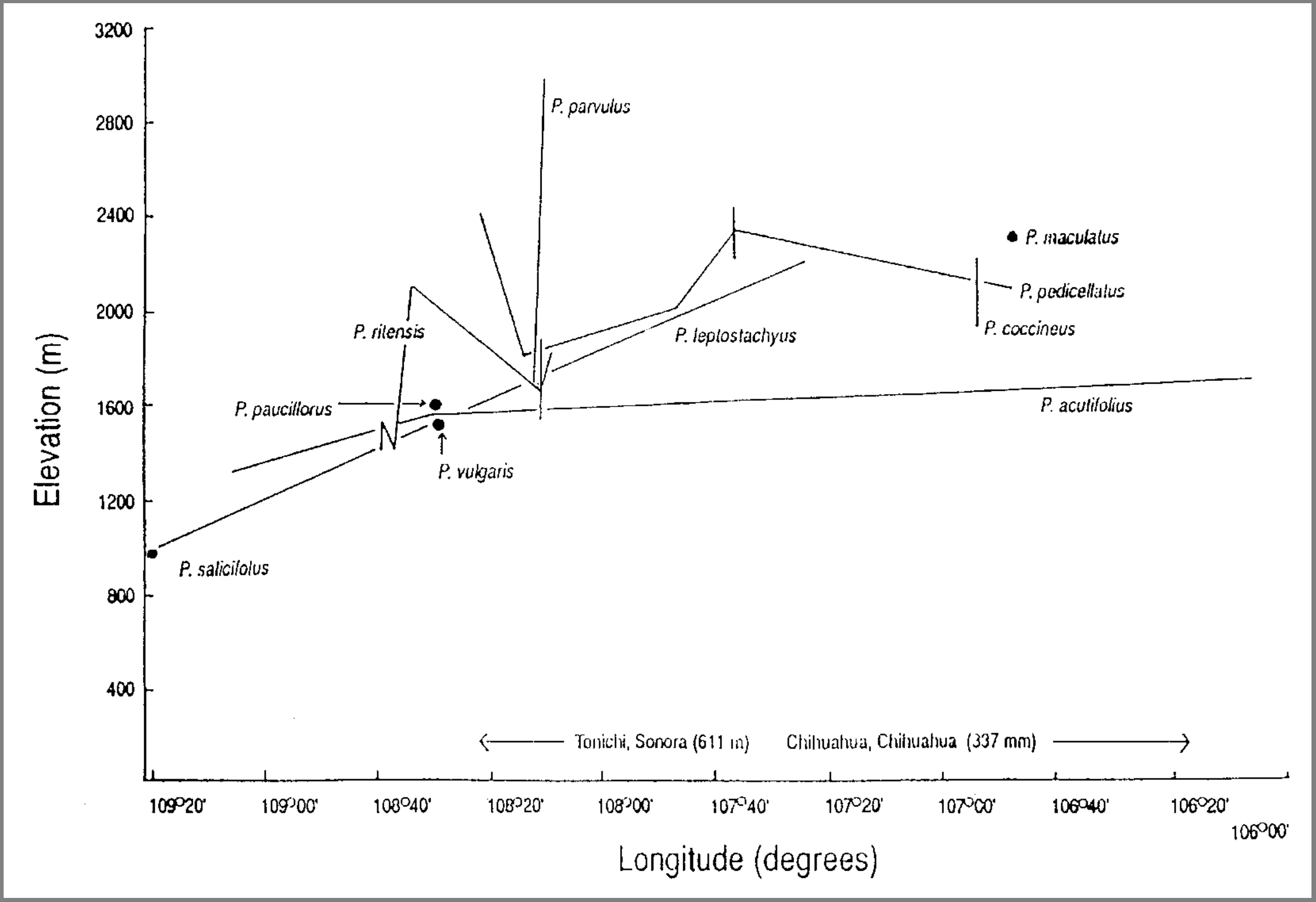
Number of *Vigna* species plotted against latitude



PHASE 2

2.6 Analysis of ecogeographic data

Plot of elevation against longitude for *Phaseolus* spp.



PHASE 2

2.6 Analysis of ecogeographic data

Enclosed line map for *V. juncea*

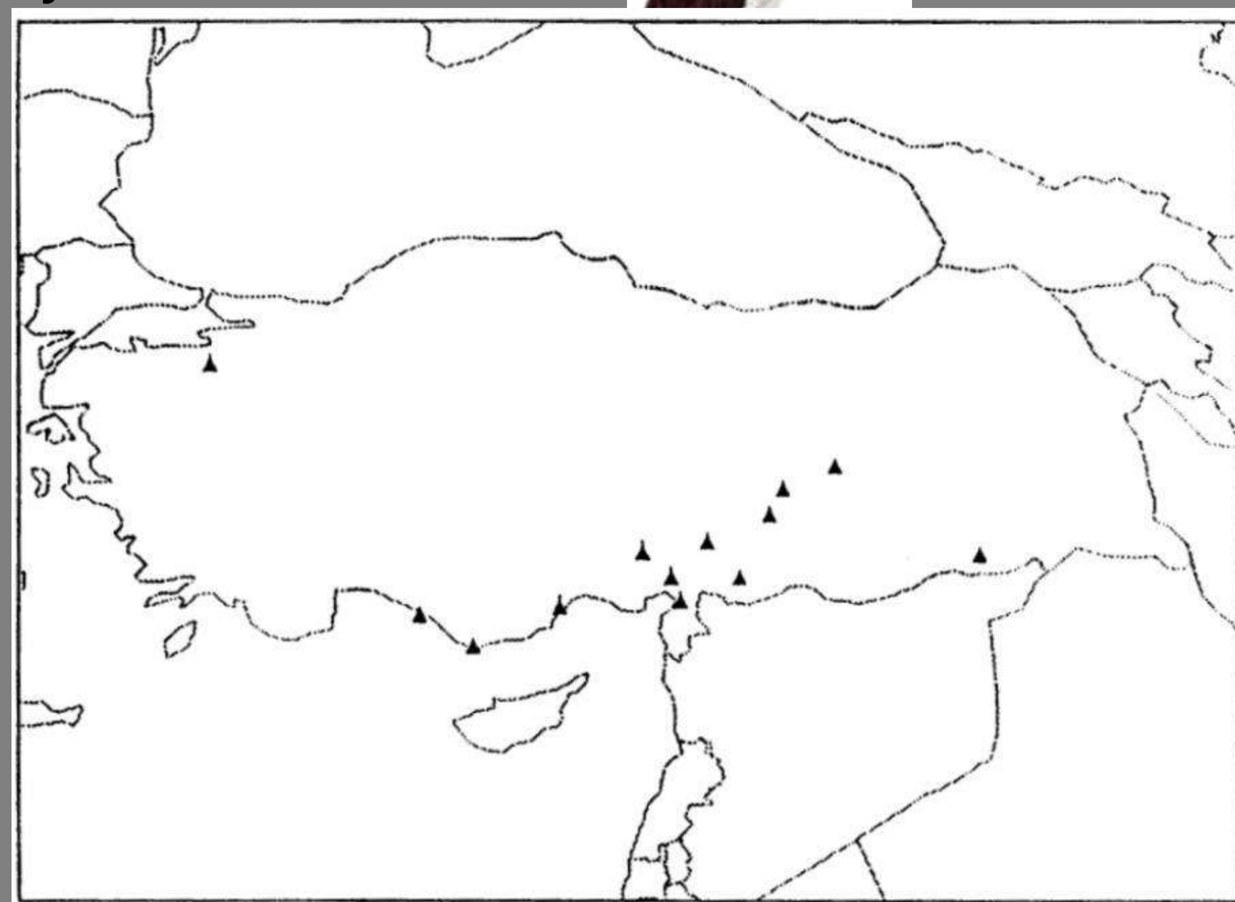
no indication of frequency
no local variation
problems with isolated occurrences

PHASE 2

2.6 Analysis of ecogeographic data

- Problem with enclosed line maps, e.g. *Vic*

  sericocarpa in Turkey

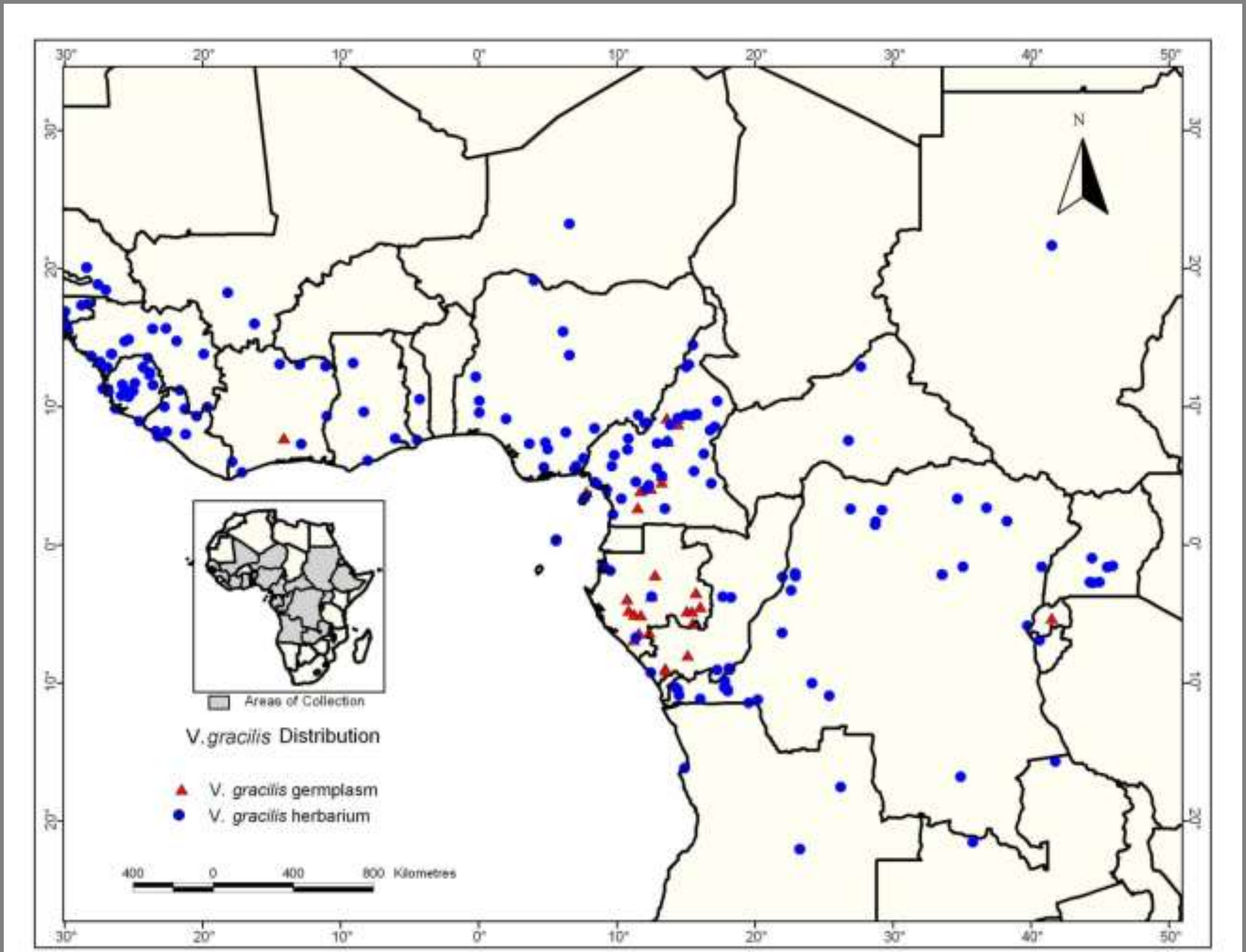


- Sampling error
- Bias (habitat & species – crane v thrush)

PHASE 2

2.6 Analysis of ecogeographic data

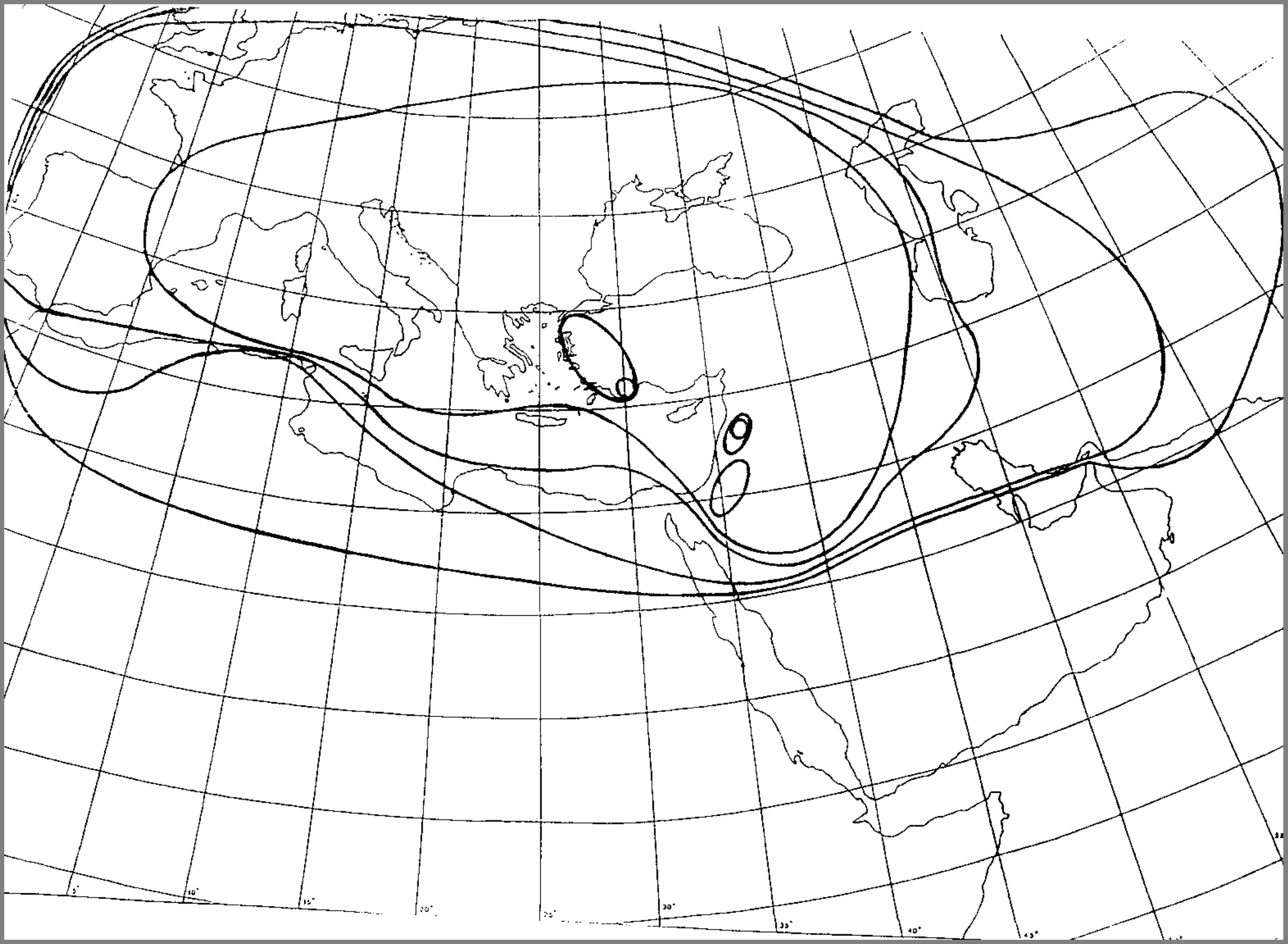
- Dot distribution map of *V. gracilis*



PHASE 2

2.6 Analysis of ecogeographic data

- **Isoflor map for *Vicia* Section *Hypechusa***



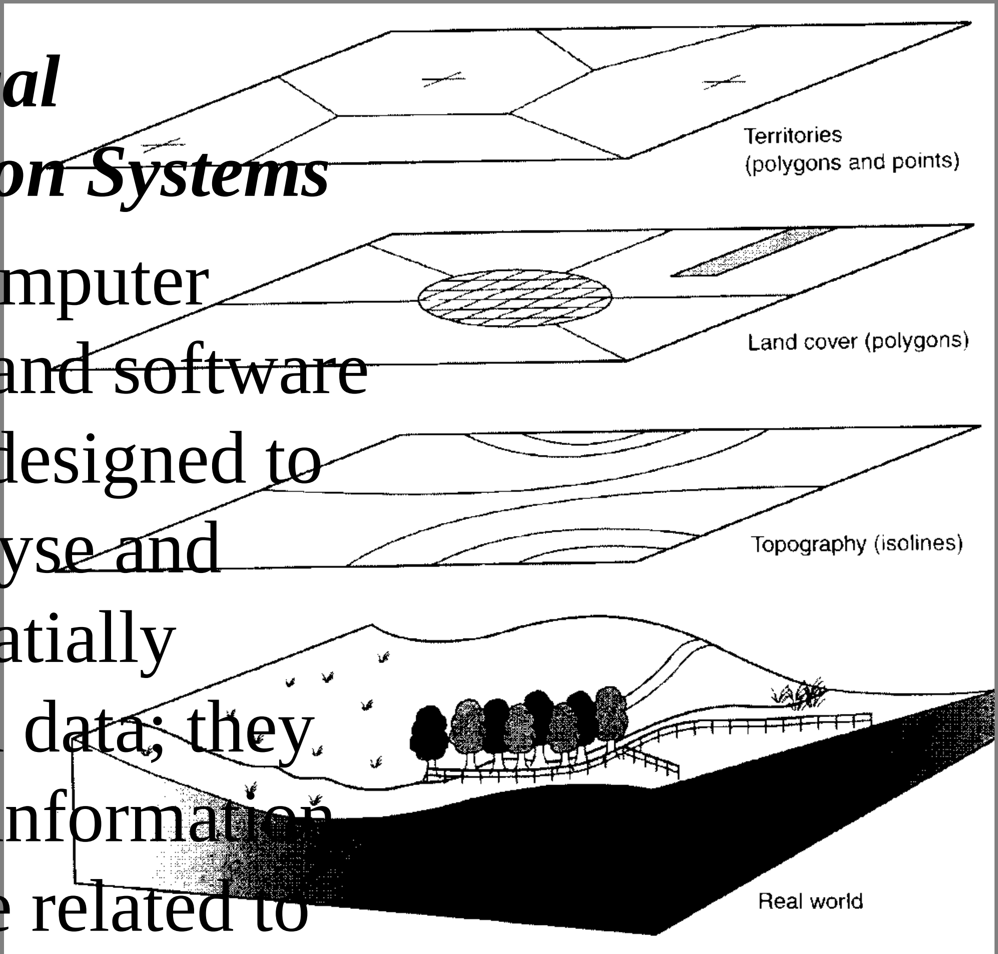
PHASE 2

2.6 Analysis of ecogeographic data

- More complex ecogeographic data
  - Multivariate analysis (Analyse more than one variable at a time)
    - cluster analysis
    - ordination techniques
  - Survey will usually permit only simple analysis
  - Study allow more sophisticated analysis
  - Geographical information systems (Species distribution modelling – SDM; Assessment of impact of climate change)

PHASE 2

2.6 Analysis of ecogeographic data



Geographical Information Systems

"GIS are computer hardware and software packages designed to store, analyse and display spatially referenced data; they deal with information that can be related to some form of map".

PHASE 2

2.6 Analysis of ecogeographic data

- Standard GIS capabilities, and their relevance in ecogeographic work, include:
  - **Geometric correction.** The scale, projection etc. of different maps may be changed
  - **Digital terrain model analysis.** The altitude contours on a topographical map may be used to produce maps of slope, aspect, inter-visibility, shaded relief etc.
  - **Interpolation.** Point data may be used to create isopleth (equal-value contour) maps,
  - **Overlay analysis.** Different maps of the same area may be combined to produce a new map.
  - **Proximity analysis.** Buffers may be generated around features such as wells, villages and roads to determine the accessibility of potential reserves.
  - **Computation of statistics.** Means, counts, lengths and areas may be calculated for different features.
  - **Location.** Entities having defined sets of attributes (for example, all specimens recorded from particular soil types) may be located.

PHASE 2

2.6 Analysis of ecogeographic data

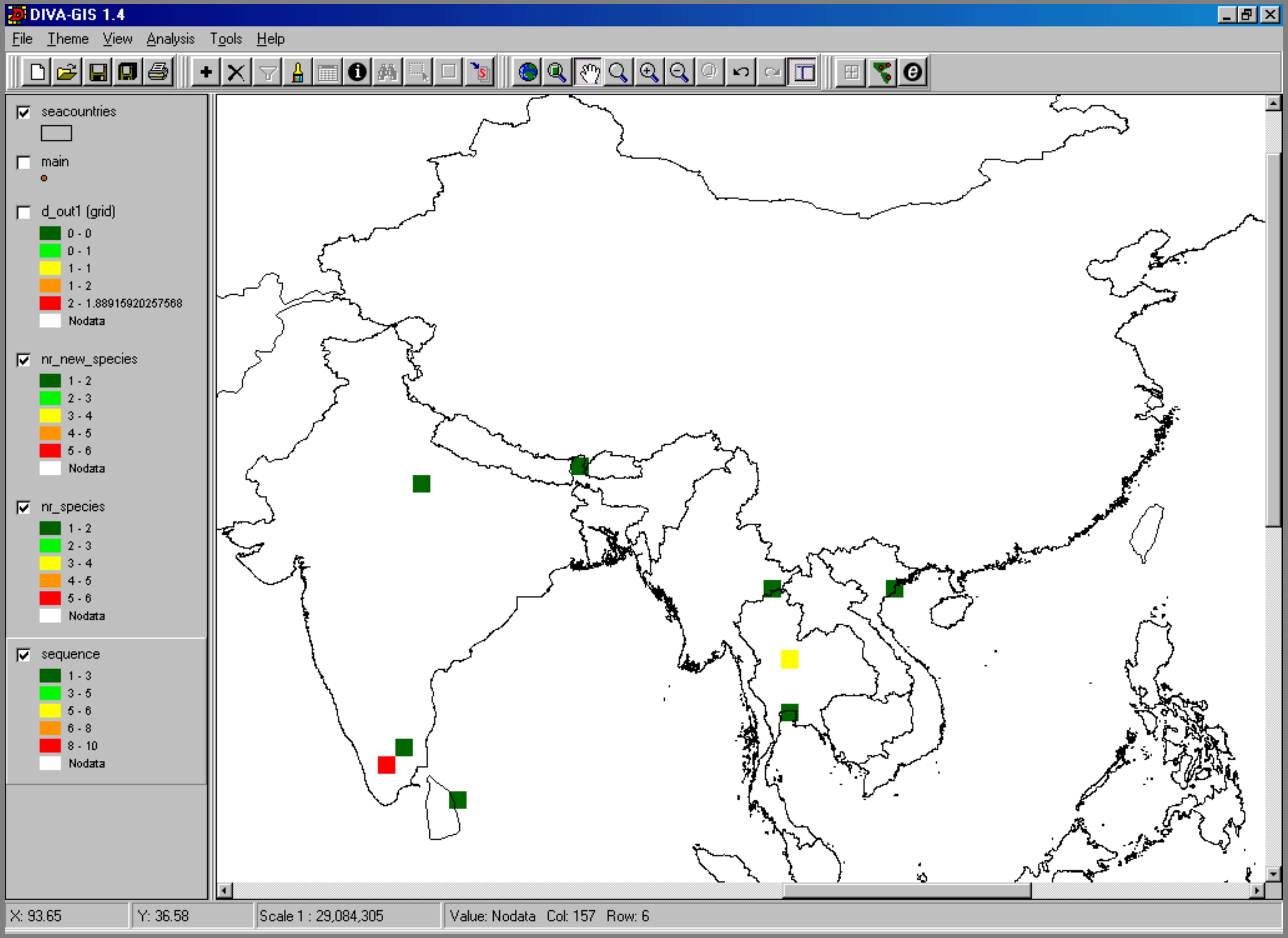
Examples of GIS packages

- **Predictive distribution**:
  - BIOCLIM (Nix, Busby and Hutchinson, 1986)
  - FloraMap (Jones and Gladkov, 1999)
    - uses interpolation surfaces to estimate mean climatic conditions at collection sites
- **High diversity areas**:
  - Diva (Hijmans, 2000) *FREE*
  - SID Spatial Intraspecific Diversity (Nelson *et al.* (1999)
- **Complementary areas / Under conserved areas**:
  - WORLDMAP (Williams, 1992)
    - combines taxonomic and geographical distribution data to assist the selection of priority areas for conservation
- **Threatened areas**:
  - MaxEnt (Smith, 2004) *FREE*

PHASE 2

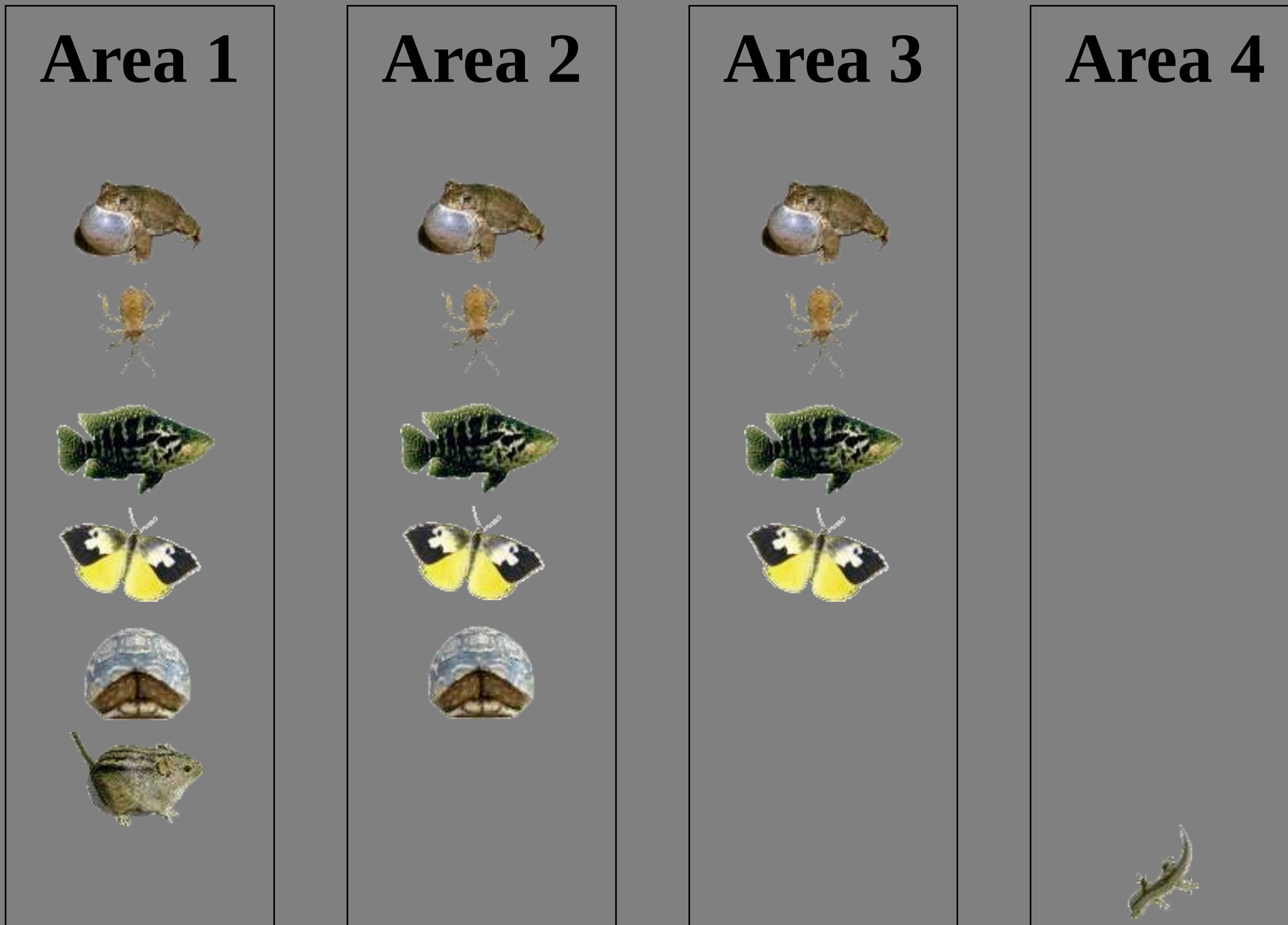
2.6 Analysis of ecogeographic data

Examples of GIS packages – DIVA Complementarity analysis



PHASE 2

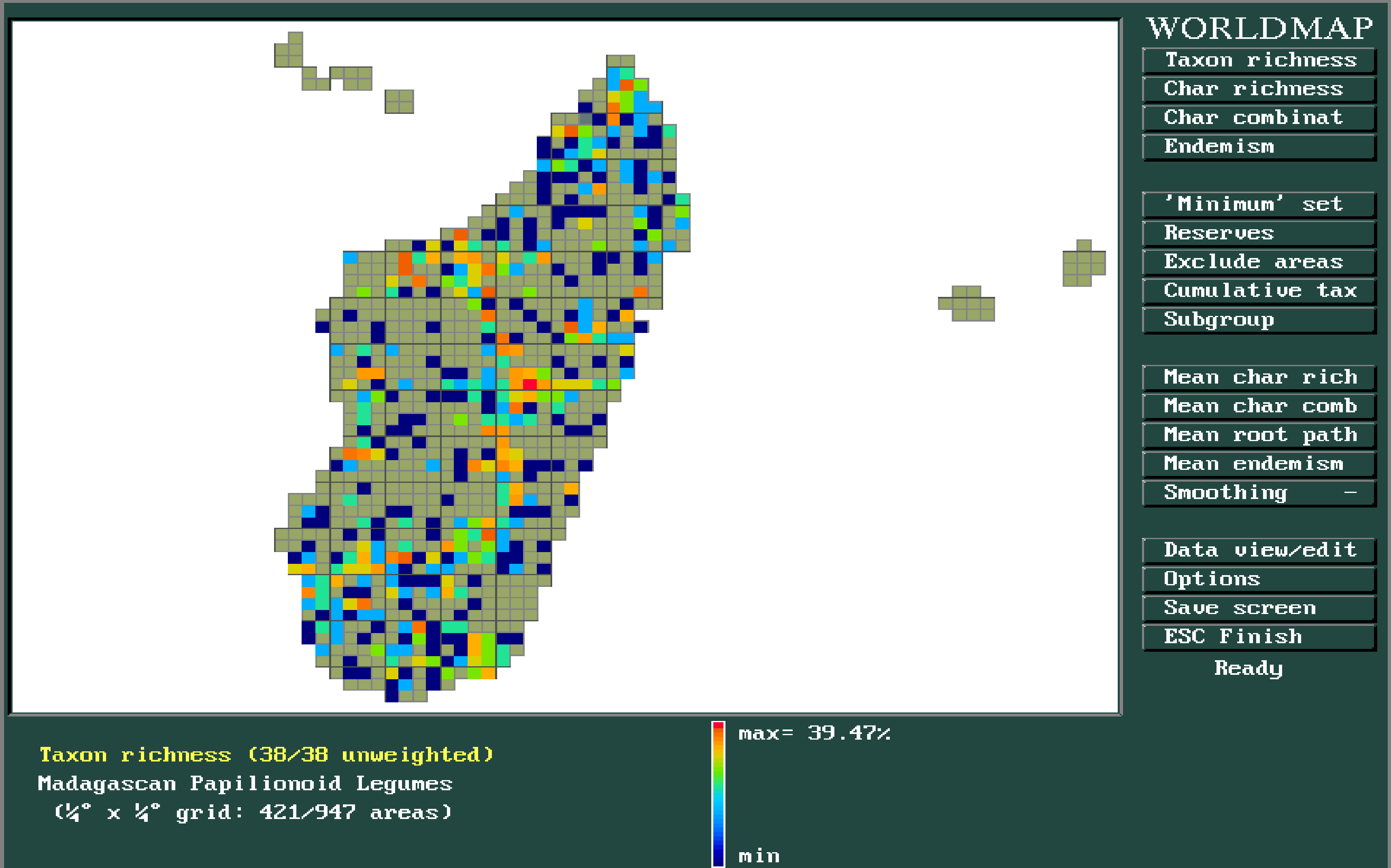
2.6 Analysis of ecogeographic data



PHASE 2

2.6 Analysis of ecogeographic data

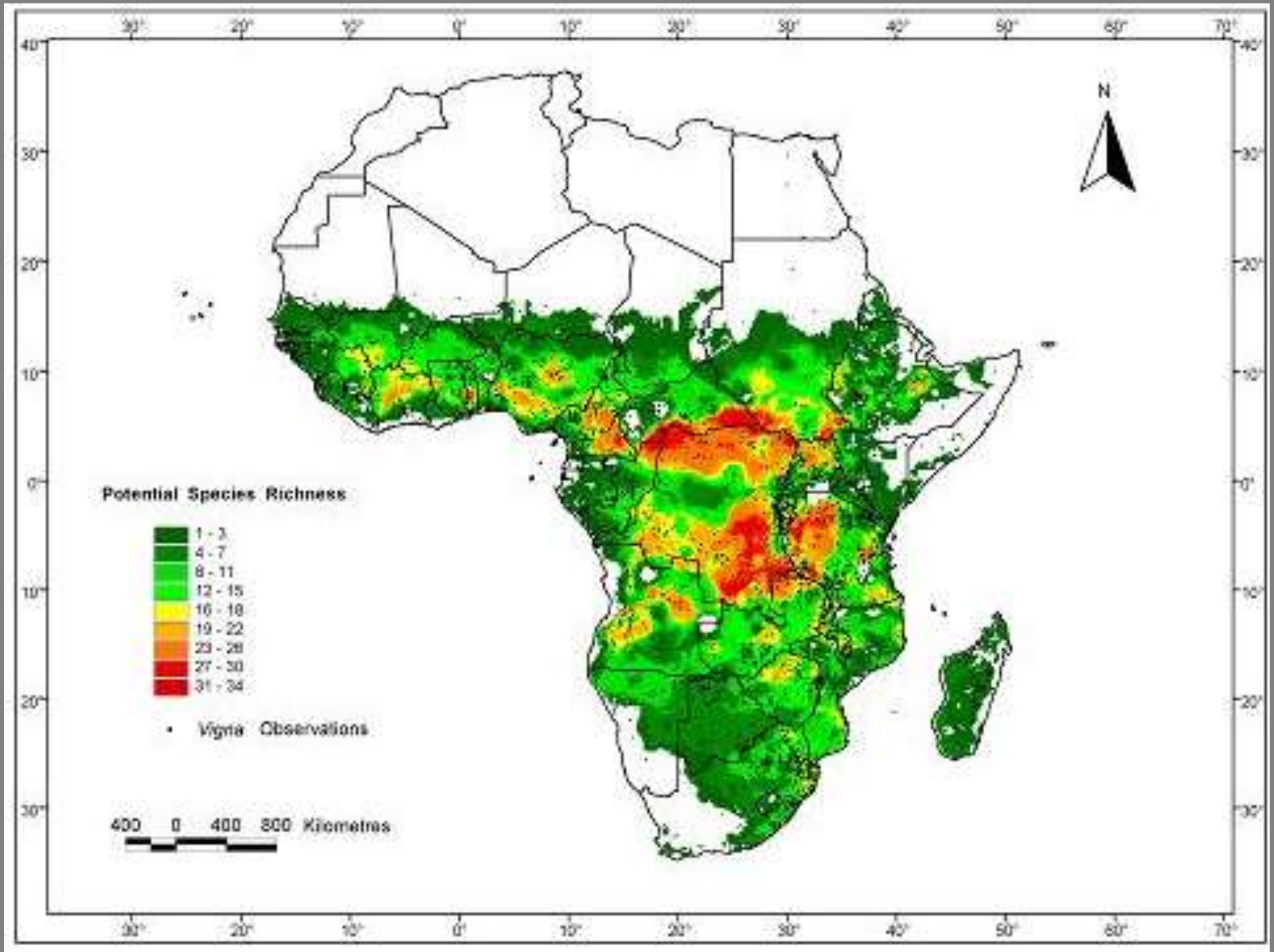
- Examples of GIS packages – WorldMap to identify taxon richness



PHASE 2

2.6 Analysis of ecogeographic data

- Examples of GIS packages – FloraMap Predicted distribution of species richness in *Vigna*



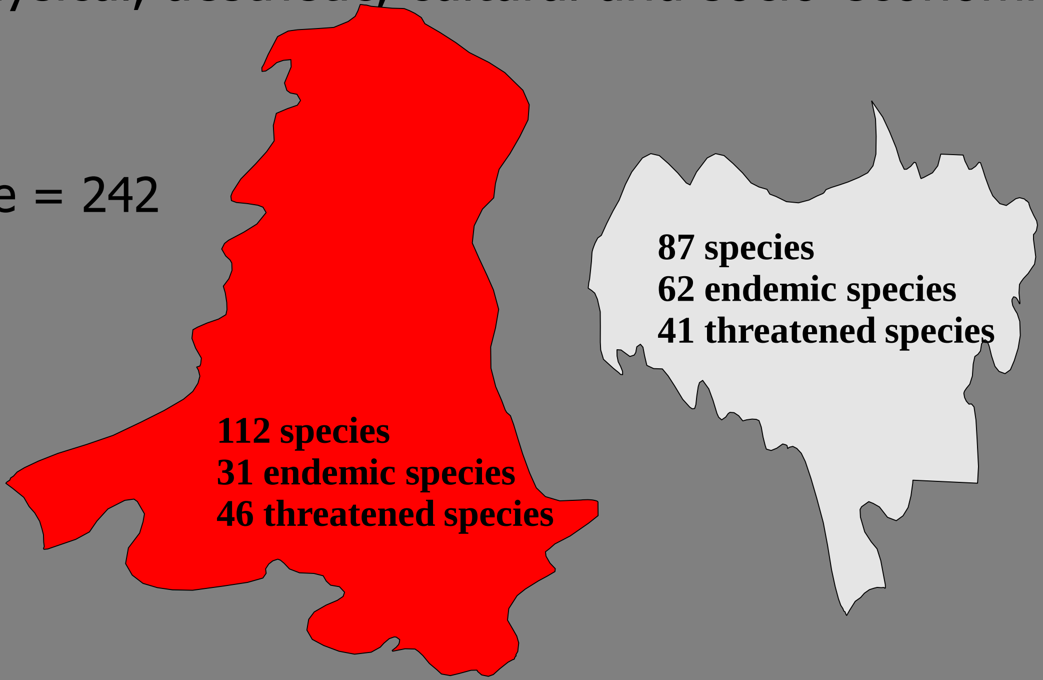
PHASE 2

2.6 Analysis of ecogeographic data

Comparative Scoring systems

Rigorous scoring systems have been developed based on data collected on the biodiversity value of an area. Such systems also often included data on a range of physical, aesthetic, cultural and socio-economic factors.

Score = 242



Score = 279

Score = (1.5 * Threatened sp. No.) + (2.4 * Endemic sp. No.)

Toward a Blueprint for Conservation in Africa

THOMAS BROOKS, ANDREW BALMFORD, NEIL BURGESS, JON FJELDSÅ, LOUIS A. HANSEN, JOSLIN MOORE, CARSTEN RAHBEK, AND PAUL WILLIAMS

In the last two decades, various quantitative techniques for assessing conservation priorities have been developed, based on data about the distribution of species (Reid 1998, Williams 1998, Margules and Pressey 2000). These methods have been applied extensively in temperate regions such as North America at both the state (Csuti et al. 1997) and national (Dobson et al. 1997) levels. However, biological diversity is concentrated in the tropics, and it is here that conservation faces the most pressing threats (Raven 1988). Furthermore, fine resolution data are often so scarce and local land-use patterns so diverse as to limit our ability to apply quantitative prioritization techniques at fine scales (Pimm and Lawton 1998). Hence, such techniques may be particularly appropriate for application in tropical areas and at continental scales. Until recently this application has been restricted to single families (Kershaw et al. 1994, 1995) or orders (Hacker et al. 1998), because continent-level species distribution data from the tropics are rarely compiled.

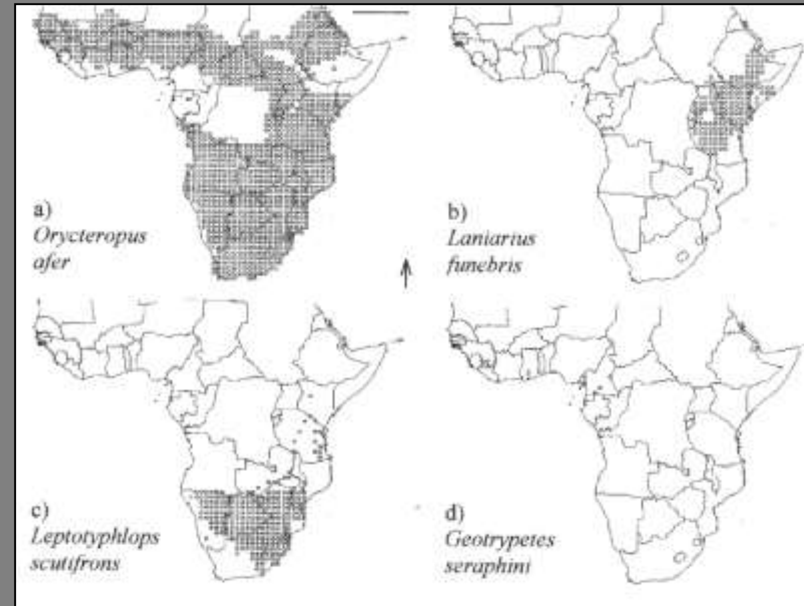
Recognizing this limitation, the Zoological Museum of the University of Copenhagen embarked on a program to compile continent-level data on the distributions of tropical species. Such data have allowed the use of quantitative conservation prioritization techniques for birds, for which data are better than for other taxa, in both South America and Africa (Burgess et al. 1997, de Klerk 1998, Fjeldså and Rahbek 1997, 1998, 1999). Simultaneously, the museum has compiled data from Africa for three other major taxa: mammals, snakes, and amphibians (Burgess et al. 1998). The Zoological Museum of the University of Copenhagen intends to publish these data as an atlas of African biodiversity.

A NEW DATABASE ON THE DISTRIBUTION OF VERTEBRATE SPECIES IN A TROPICAL CONTINENT ALLOWS NEW INSIGHTS INTO PRIORITIES FOR CONSERVATION ACROSS AFRICA

This article begins a series planned to extend these analyses across four major terrestrial taxa, for an entire tropical continent. For each taxon we first present an overview of patterns of species richness and narrow endemism across the continent. Second, we use these patterns to identify areas of high conservation priority that can most efficiently represent each group of species. Finally, we repeat the analysis for threatened species (Baillie and Groombridge 1996), the immediate priorities for conservation in Africa.

Numerous important issues remain to be addressed, and we conclude the article with a detailed discussion of them. In our ongoing research we are address four in particular. First is the question of surrogacy—how well do conservation priorities for one taxon represent other taxa? Second is the matter of incorporating socioeconomic variables into the analyses, both as pressure (e.g., human population) and as response (e.g., existing protected areas) variables—the need to do so is urgent. The third issue involves scale: We are using environmental models to increase the resolution of the databases to scales relevant to local (rather than continental) conser-

Thomas Brooks (e-mail: t.brooks@conservation.org) is a postdoctoral research associate in the Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark, and in the Conservation Biology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK; he is also the director of biodiversity analysis at the Center for Applied Biodiversity Science, Conservation International, 1919 M Street NW, Suite 600, Washington, DC 20036. Andrew Balmford is a lecturer in the Conservation Biology Group, Department of Zoology, University of Cambridge. Neil Burgess is the technical advisor to the Uluguru Mountains Biodiversity Conservation Project, Wildlife Conservation Society of Tanzania, Pamba House, PO Box 1668, Morogoro, Tanzania. Jon Fjeldså is a professor and the curator of birds, Louis A. Hansen a database manager, and Carsten Rahbek an associate professor in the Zoological Museum, University of Copenhagen. Joslin Moore is a postdoctoral research associate in the Zoological Museum, University of Copenhagen, and in the Conservation Biology Group, Department of Zoology, University of Cambridge. Paul Williams is a researcher in the Biogeography and Conservation Laboratory, Department of Entomology, Natural History Museum, Cromwell Road, London SW7 5BD, UK.



This paper uses a dataset that shows the distribution of 3882 vertebrate species in 1,957 1º grid squares in sub-Saharan Africa.

PHASE 3 PRODUCTION

3.1 Data Synthesis

- Adequacy of data, is it truly representative?
- Any geographical or ecological bias?
- Draw conclusions

Do you have the correct ingredient to make the soup?

PHASE 3

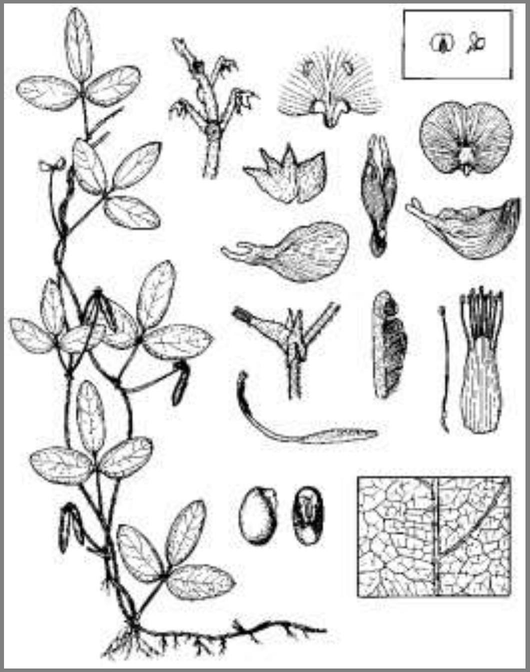
3.2 Ecogeographic products

- Database - raw data
- Conspectus - summary of data
- Report - discussion of project and draws conclusions

PHASE 3

3.2 Ecogeographic products

Conspectus:

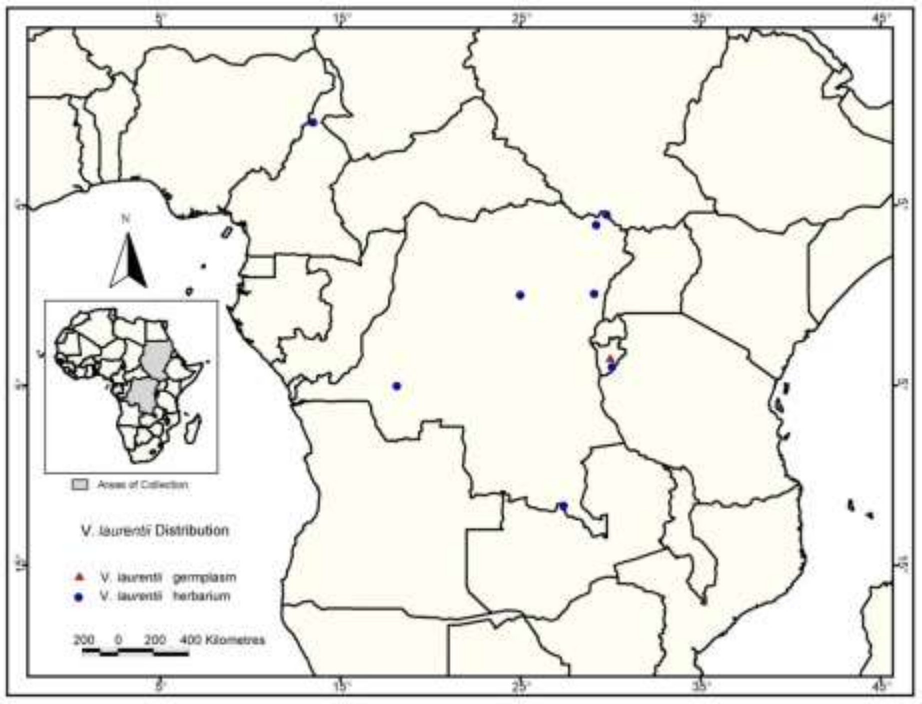


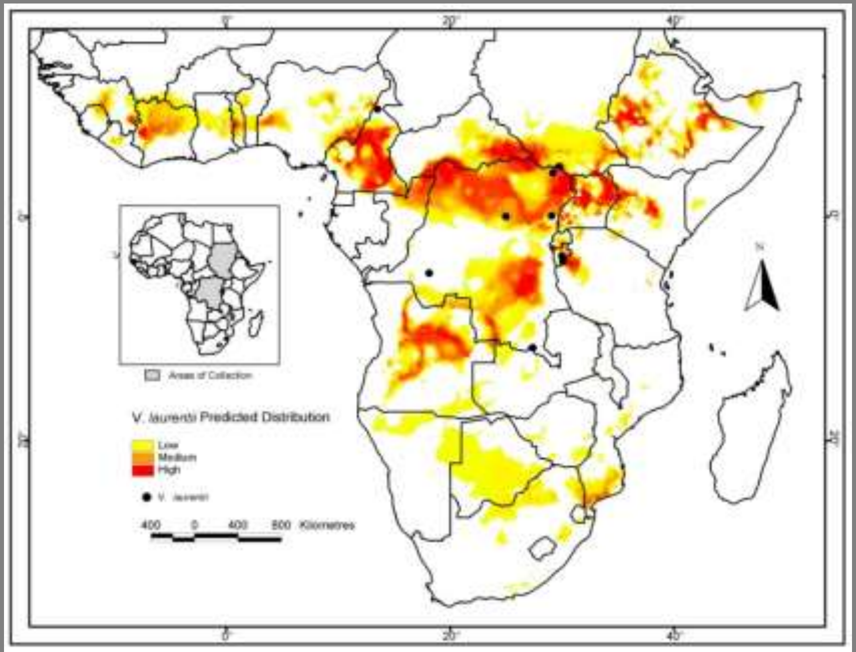
Vigna laurentii De Wild., Mission Laurent: 122 (1905).
Reference to a published description: CPV 170; FCBR 361.
Vernacular names: BUR: Umukaloko
Habit and life span: Climbing, perennial.
Flower colour: Blue or violet
Habitat: Savannah, river banks and on poor marshy soils.
Associated species: *Loudetia, Phragmites*.
Altitude: 340-1850m.
Distribution: CEAF: BUR, ZAI. WAF: CMN.
Phenology: September – December.
Uses: None known.
Taxon Vulnerability Assessment: = 5.4
Conservation Notes: *V. laurentii* is rare and restricted in terms of distribution, but it should be noted that it is restricted to countries that have in general been under-collected. The predicted distribution indicates a much wider distribution that has yet to be validated. It is inadequately represented in *ex situ* collections with only two germplasm samples from Burundi, which cannot hope to represent the full geographic range or genetic diversity of the species. The number of collections made over time is sporadic, and since the 1970s only one population has been sampled, which may indicate decline. There is need for further systematic collection throughout Burundi, Democratic Republic of the Congo and Cameroon.
IUCN Red List Category: Endangered.

PHASE 3

3.2 Ecogeographic products

Conspectus - Distribution and predicted distribution of *V. laurentii*





PHASE 3

3.2 Ecogeographic products

- Report
  - delimitation of the target taxon
  - classification of the target taxon
  - selection of representative specimens
  - choice of hardware and software
  - ecogeographic database file structures and inter-relationships
  - database content
  - target taxon ecology
  - target taxon biogeography

PHASE 3

3.2 Ecogeographic products

- Report
  - interesting taxonomic variants
  - current and potential uses of the target taxon
  - relationship between the cultivated species and their wild relatives
  - identification problems encountered
  - current *in situ* and *ex situ* conservation activities
  - genetic erosion threat facing the group
  - priorities and suggested strategy for future conservation of the target taxon

PHASE 3

3.3 Identification of conservation priorities

- Must conclude with a clear statement of the priorities e.g. which particular taxa to target from which areas, etc.

- Must conclude with a clear statement of the appropriate strategy e.g. which combination of *ex situ* collection, if collecting migratory individual or seed when is the collection window, where to establish a PA, etc.

- Practical aspects e.g. collecting route, timing of collection, which local counterparts to contact

- Further research requirements

Conclusions

- There is a requirement for more efficient, objective methods !
- Need to set scientific conservation in the context of biodiversity – conservation – utilisation paradigm.
- The collation and analysis of a taxon's geography, ecology, genetics and taxonomy permits the efficient formulation of conservation strategies.
- These methods can help us more effectively conserved genetic diversity and ensure the link to utilisation.
- Don’t forget the local communities !