Geographic Information Systems (GIS) and its applications for *In Situ* Conservation

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GIS concepts
Geographic Information System (GIS)

Computer based system that allows to capture, store, manipulate, analyze, manage, and visualize all types of spatial information and associated attributes.
Geographic Information System (GIS)

GIS applications (such as DIVA-GIS) allow users to create combined queries (user-created searches), analyze spatial information, edit data in maps, and present the results in tables or maps.

GIS can relate unrelated information deriving from “real” physical locations by using location as the key index variable.

This key characteristic of GIS enables scientific inquiry and has many applications (Biology, ecology, environmental sciences, forest science, geology, engineering, transportation/logistics, archeology, geography, agriculture, urban planning, atmospheric sciences,…….)

GIS is much more than a tool to make nice maps for reports, it is a tool for spatial analysis!
Geographic Information System (GIS)

Development in recent years:
- Generalized access to GPS -> more georeferenced data
- Faster processors -> more complex analyses
- Growing amount of data and hard disk capacity -> use of more detailed maps and data (e.g. climate)
- General access to internet -> exchange of data and maps

GIS and Genetic Resources:
Answers to important questions can be obtained with the use of GIS:
- What is the conservation status of priority species?
- Where are the areas with highest diversity?
- How to formulate optimal in situ conservation strategies?
- Which accessions perform best where?
- Are there any significant gaps in current collections?
- How can diversity be used in climate change adaptation strategies?
- ...
GIS file formats
GIS file formats

A GIS file format is a standard of encoding geographical information into a file

- **Vector format**
- **Raster format**
GIS file formats

**Vector:** Different geographical features are expressed by different types of geometry

- **Points**
  Zero-dimensional points used for geographical features that can best be expressed by a single location (e.g. samples)

- **Lines**
  One-dimensional lines or polylines used for linear features such as rivers, roads, railroads, trails, and topographic lines.

- **Polygons**
  Two-dimensional polygons used for geographical features that cover a particular area, such as lakes, admin boundaries, ecological zones, protected areas etc.
GIS file formats

**Raster:** Consists of a matrix of cells (or pixels) organized in a grid where each cell contains a single value representing information. Raster files usually derive from digital aerial photographs, satellites images or scanned maps.

**Extent:** size of area  
**Resolution:** size of one cell

### Approximate size of Geographic Units (close to the equator)

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 seconds</td>
<td>1 km</td>
</tr>
<tr>
<td>2.5 minutes</td>
<td>5 km</td>
</tr>
<tr>
<td>5 minutes</td>
<td>9 km</td>
</tr>
<tr>
<td>10 minutes</td>
<td>18 km</td>
</tr>
<tr>
<td>1 degree</td>
<td>111 km</td>
</tr>
</tbody>
</table>
Georeferenced data
Geographic coordinates

Latitude and Longitude:

- Meridians (latitude) and parallels (longitude)
- Prime Meridian (Greenwich) and equator
- 180/360 degrees, 60 minutes, 60 seconds

Formats:

- **degrees, minutes and seconds + hemisphere**: DDºMM’S’S” : 12º20’15” S
- **decimal minutes**: DDºMM.MM.MMMM’ : -12º20.25’
- **decimal degrees**: DD.DDDD : -12.3375

Decimal degrees = [(Degrees (º) + Minutes (’) / 60 + Seconds (”) / 3600)] * H
H = 1 when the coordinate is in the Eastern (E) or Northern (N) Hemisphere
H = -1 when the coordinate is in the Western (W) or Southern (S) Hemisphere

Don’t Mix!

12º20’15” S ≠ -12.2015 (= 12º12’05” S)
-12.2015 ≠ 12.2015

Watch out for lists of coordinates with decimals always < .59
UTM Coordinates

UTM: Universal Transverse Mercator

- metric-based Cartesian grid
- 60 zones/projections (180 x 800 km)

Advantage: low distortion: easy to calculate distances
Disadvantage: small scale

17N 630084 4833438
Datum

How to represent earth as simple geometric volume (ellipsoid)

Datum: Definition of used ellipsoid (reference ellipsoid)

Check! Standard: WGS 84 (World Geodetic System)!
Projections

How to represent 3D as 2D

Map/projection properties:

- Area
- Shape
- Direction
- Distance

Distortions

Don’t worry!
Georeferencing points

Data collection
Possible data sources:

Maps

GPS

Gazetteers
Georeferenced points + attributes

Passport data
• Administrative data
• Detailed site description
• Coordinates!
• Status of sample
• Taxonomy etc.

Characterization data
• Morphologic properties (GxE)
• Molecular marker data
• Standards/comparability!
• Crop specific

Evaluation data
• Performance data
• GxE
Errors

Errors are unavoidable, how to deal with them?
Errors
Identification of atypical points
Errors

Errors are unavoidable, how to deal with them?

- Source data (field book)
- Information by collectors

Importance of proper documentation

Decision: Eliminate or correct?
Additional data sources
International data providers’ networks (established in 2001) that shares biodiversity data without any cost Plantae, Animalia, Fungi, Bacteria, Viruses (516,757,748 records) with coordinates: 448,781,964

Example:
Plant records in Mauritius
6,276 records
4,835 georeferenced sites (quality control!!!)

http://www.gbif.org/
CGIAR initiative to group all the information from crop genebanks
Mainly crops (important)
Accession level information (including characterization data)
2,802,770 accessions

Example:
Plant records in Mauritius
315 records
7 georeferenced sites
(quality control!!)

https://www.genesys-pgr.org/welcome
Bioversity Collecting Mission Database

Access to original passport data of germplasm samples collected around the world during Bioversity International supported missions

Plant records (220,000 records) with coordinates: 150,000

Example:
Plant records in Mauritius
47 records
47 georeferenced sites (quality control!)
Case studies
Distribution and richness/diversity

Highland Papayas (Vasconcellea spp.)

Species richness

Species diversity (Shannon)
Priority areas for in situ conservation

Highland Papayas (*Vasconcellea* spp.)

![Map showing priority areas for conservation](image)

- **1st priority**: Highland Papayas
- **2nd priority**: Additional species
- **3rd priority**: Species diversity
- **4th priority**: Additional species
Priority areas for in situ conservation

Cherimoya (Annona cherimola)

Allelic diversity

Additional alleles
Collection gap analysis

Highland Papayas (Vasconcellea spp.)

- Observed species richness
- Modeled species richness
- Potential collection gap
Targeted germplasm collection

Wild and rare chilli species (*Capsicum flexuosum*)
Threat analysis

Wild walnut (*Juglans regia*)

- Livestock grazing
- Landslides
- Climate change
- Human accessibility
- Combined threat
Conclusions

• Georeferenced data contain much unknown or hidden information

• Importance to georeference (and carry out quality control)

• The quality of the analysis depends much on the amount (and quality) of the data: importance to integrate data (at regional / global levels)

• GIS: be careful in the interpretation of results (there are always results!)

• How can we better integrate intraspecific diversity data into spatial analysis?
DIVA-GIS

GIS software developed by CIP, Bioversity, and Berkeley University with support from FAO, USDA, SINGER, BMZ, and SENASA.

Emphasis in mapping and spatial analysis of diversity

Tools to check/correct data

Works with vector (shp) and raster (grd) data

Includes climate data and runs the BIOCLIM and DOMAIN niche models

Includes a tutorial handbook with exercises to learn how to use it

All without costs !!

http://www.diva-gis.org
Thank you 😊

www.bioversityinternational.org