Title of Paper :

The "Last Great Wild Places": A Project Based Group Investigation

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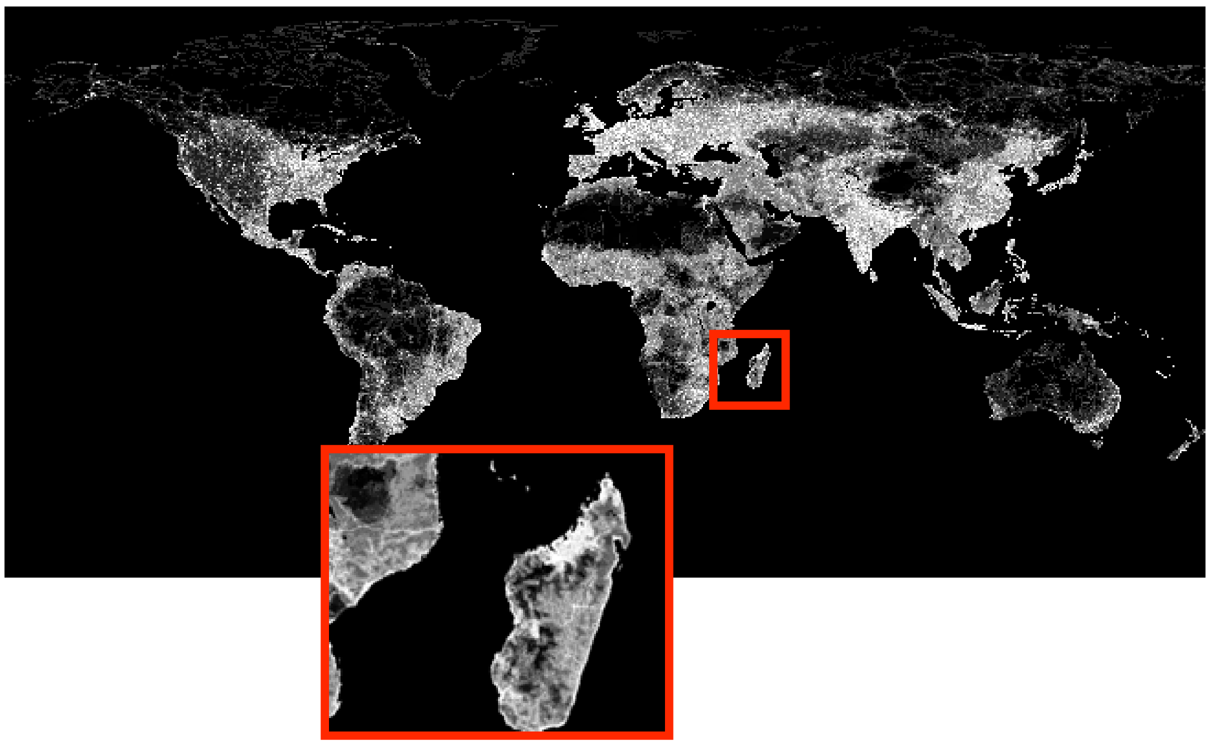

Whether we like it or not what we ***do*** *has direct implications on nature. Therefore our role as stewards of nature is real. (Sanderson et al, 2002)*

Authors' Names

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Abstract

Summary

Conservation efforts are often focused on two areas: (i) '**hotspots**'-–sites of unusual importance in terms of endemic species and overall richness that are in immediate threat (i.e., > 75% of habitat already altered) and (ii) **large wilderness areas** The United Nations Environmental Programme (UNEP) in collaboration with Wildlife Conservation Society (WCS) and World Wildlife Fund (WWF) has hired your team of researchers to evaluate human influence and determine the "last great wild places" in your assigned country…' This group investigation, adapted from Sanderson et al, (2002) Bioscience [52(10):891-904] paper: *"The human footprint and last of the Wild"*, makes an excellent learning experience by empowering students on the idea that what they are doing is very close to something that could be real, plausible and publishable.

June 2, 2005

Paper Body

Introduction

Conservation efforts are often focused on two areas: (i) '**hotspots**' and (ii) **large wilderness areas**. At a global level, the location of 'hotspots' and great wilderness areas have been identified by Conservation International (CI) (CI, 2005; Myers et al, 2000; Mittermeier et al, 1998). Yet, conservation actions often occur at national or regional levels, so identifying ***potential wilderness areas*** and ***measuring human impacts*** at these smaller geographic scales is also important for biodiversity conservation. Students participating in this Group Project Investigation will actually engage in determining these potential wilderness areas, for their assigned country, using Geographic Information Systems (GIS) technology. Moreover, students will make decisions based on their analyses to support their choice of areas for conservation and later during their final presentation they will defend their position in front of an active audience (the class and the teacher).

Development and objectives behind the group project investigation activity

This activity was developed by the authors, using Sanderson's et al (2002) paper about the human footprint as a baseline. In his paper Sanderson evaluated the impact of humans on the Globe's land surface by developing a HI-index (i.e., human impact index). This index is based on a series of proxies such as accessibility to areas, population density, and infrastructure development to determine areas that have high influence of humans (e.g., very accessible, high population density, and many buildings/ roads, etc) and those that have low influence. Areas with high values for HI index and, with high richness and endemism levels, could be seen as "hot spots" and areas with low influence could be related to large wilderness areas or pristine sites.

The main raison d'être behind the development of this activity was that: 1) the project could be related back to a real investigation where a publication was produced; 2) the activity lends itself to a healthy interaction between a decision-making situation (problem based), a collaborative work environment, and an inquiry approach; and 3) data were readily available, varied, and thus, facilitated a diverse classroom environment.

The Setting

Twenty students from a graduate program in Ecology, Evolution and Systematics program enrolled in the course: *Application of GIS in Biology* participated in this activity. Prior to this activity, students were exposed to the basic functions of ArcMap and its spatial analysis capabilities as part of the curriculum of the course.

Classes at graduate level are often very diverse. In our program students come with different level of technology expertise, different educational backgrounds, but most important different cultures. In this particular case when the project was implemented the class consisted of at least 20 students and in that cadre 10 different countries were represented. Hence the ability to draw data for different countries was crucial to make the learning experience more meaningful for the participants.

The time specified to finish the activity was 3 weeks. Students were given 3 hours of class time each week to meet and accomplish specific tasks within their projects. Most of the work, however, occurred outside classroom hours.

The teacher guided the students through this activity, but intervened only when major roadblocks were encountered. For example, a major roadblock could have been the lack of GIS knowledge, at the program level, to do additional spatial or statistical analyses for their projects. (Note: The exercise can be completed with skills already taught in the course, but some students designed solutions that required spatial analytical skills that they had not yet encountered or perhaps had not yet mastered.)

The Activity

Students were given a handout with the project specifications (Appendix 1.0) at the beginning of the first week of the 3 week implementation period. Then the objectives and specifics of the project were explained and the students were split into their groups. Groups were formed based on ability, and background of students. By the end of the three week period each group handed in three documents: 1) an ArcMap project, 2) a paper document, and 3) a PowerPoint presentation. Then they had 15 minutes to present their findings and defend their stance to the audience.

Please refer to the following appendices for actual documents and examples:

- Appendix 1.0: The handout.
- Appendix 2.0: An example, using Madagascar as a country of choice, of how a group might develop the ArcMap (or paper) document.
- Appendix 3.0: An example, using Madagascar as a country of choice, of how a group might develop the PowerPoint presentation.

High lights

This section has been developed to show examples of what we consider empowerment of learners. Through their comments and the steps they took after their exposure to the course, it is clear to us that something changed in them.

- Student comments: "*I liked the idea of working on something that has the potential to be published, especially after realizing that what we did is very similar to what Sanderson did in his paper. The difference is that we took a step further in a more localized way.(Student A)*"; "*It was great, it made the pieces fall into place* [referring to the fact that most of what was learnt before did not make much sense until this activity] (*Student B*)"
- Final Projects: Some students decided to make their final project for the course using the main idea behind human influence and the environment.
- Sharing their project with a larger community: Some students had the opportunity to present their work in a Poster session taking place in the local metropolitan Zoo.
- Thesis research: Some students decided to use the main idea behind the 'Last Great Wild Places' as the topic for their Master of Science thesis as a result of their exposure to this GIS exercise.

Future Paths & Potential for Growth

This group project investigation has great potential and flexibility. First of all it can be easily implemented at various level of the educational ladder that is from high school through graduate school. For example, it has the potential to be scaled down to a state level or even a county level to make it more meaningful to students living in counties of interest or states of interest. This is especially true for the United States, or any country, that has spatial data available at no cost. (e.g. Digital Chart of the World from PSU, Missouri Spatial Data Information Service http://msdisweb.missouri.edu). At the moment JPS is developing a version of this activity for Missouri. Secondly, as shown in the highlight section the activity could be scaled up to serve as a Master of Science thesis or other independent research endeavor, similar in nature to situations graduate students may encounter in their future paths. Lastly, the open-endedness of the activity allows for great flexibility in the level of application of the activity. This means that students (graduate students) can take the activity to complex levels, where they analyze complementarity models to support conservation priority decision making, or else take the activity to a simpler level where they just determine the most pristine areas based on simple overlay models. The only limits are the limits of your imagination and data availability.

Acknowledgments

- Wendy P. Tori- PhD Candidate (UM-St. Louis)
- Rodrigo Rios, Andrea Loayza, Jose Fabara, Shane Siers, Corneille Ewango & Fidy Ratovoson (UM- St. Louis Graduate Students)

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- United Nations Environmental Program (UNEP). 2004. World Database on Protected Areas. URL: http://www.unep-wcmc.org/protected_areas/index.html

Appendixes

- Appendix 1.0: The handout.
- Appendix 2.0: An example, using Madagascar as a country of choice, of how a group might develop the ArcMap (or paper) document.
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APPENDIX 1

Appendix 1- **HANDOUT**

GROUP PROJECT INVESTIGATION

Introduction:

Conservation efforts are often focused on two areas: (1) '**hotspots**' – sites of unusual importance in terms of endemic species and overall richness that are in immediate threat (i.e., > 75% of habitat already altered), and (2) **large wilderness areas** (i.e., areas that have, to date, undergone little direct or indirect impact from human activities). On a global level, the location of 'hotspots' and great wilderness areas have been identified by Conservation International (CI). Yet, conservation actions often occur at national or regional levels, so identifying potential wilderness areas and measuring human impacts at these smaller geographic scales also is important for biodiversity conservation. The United Nations Environmental Program (UNEP) in collaboration with Wildlife Conservation Society (WCS) and World Wildlife Fund (WWF) has hired your team of researchers to evaluate human influence and determine the "last great wild places" in the country of **Madagascar**. The results from analyses at the national level will be used to plan conservation efforts in these countries. Moreover, your analysis will be used as a model for larger regional scale planning.

Main Tasks:

1) **Develop a conceptual model to estimate human influence** and identify "last great wild places" within Madagascar. In other words, BRAINSTORM with your team to discuss the variables needed and outline a <u>general</u> approach to the problem.
2) **Propose your model** (by the end of October 8th) to UNEP-WCS-WWF consortium represented by <Instructors Name> in order to gain access to available digital data. Using the data provided by the committee, revise your model and finalize a specific plan to accomplish the project. Your plan should indicate each step of the analysis using appropriate ArcGIS operations (this will form the basis of your Appendix for the report). We suggest that you review this final plan with the consortium representatives and *pay close attention to the spatial analysis hints (and restrictions)* at the end of this document. We strongly recommend that you complete steps 1 and 2 by 3 PM, October 8th.
3) **Conduct GIS analyses** to quantify human influence and identify wilderness areas (see comments at the end of this document).
4) **Develop a 15 minute power-point presentation** to present the conceptual model, data, GIS analyses (as appropriate), and recommendations to the consortium (during the afternoon of October 29th). Be sure to explain the **pros** and **cons** of using this approach and how this method might or might not work at larger geographic scales.
5) **Prepare a 2-4 page double spaced document** to explain and support your work. Graphs, tables, and appendices do not count in the page limit. Include an appendix that briefly outlines the GIS analysis steps.

General Products (a guideline):

1) ArcMap document (*.mxd file) (identify where this file can be found, although consortium partners will likely rely solely on your power-point presentation and document for evaluation)
   - document should contain appropriate data layers used for analysis and created during evaluations (some temporary grids can be deleted to clean up the document)
   - three data frames: (1) **raw datasets** used; (2) **human influence map**; (3) **map identifying "last great wild places"**.

- **a table** that summarizes information about the identity, size, and characteristics of the 'last wild places' your team has identified.

2) Paper Document
   - introduction where question is raised and conceptual model presented
   - methods where data variables are described and specific analytical plan explained
   - results and discussion where you (1) identify the areas with greatest human influence and highlight the 2-5 most important "wild places" (i.e., lowest human influence and greatest contiguous area, among other criteria you deem important), (2) discuss advantages/weaknesses of your model and methods, and (3) discuss prospects for applying your approach to larger regional scales.
   - appendix that briefly outlines the analysis steps; for example (1) Create buffer of ….

3) Power-point Presentation
   - objectives, approach, graphics to describe analyses briefly as appropriate, final map products that demonstrate human influence and highlight last wild places
   - discussion of pros/cons of model and later applications, concluding remarks.

All documents are due by noon on October 29th, 2004. E-mail the Power-point presentation and WORD document to <Instructor's name>. Identify in the WORD document, where we can find the grpproj.mxd file (i.e., under whose directory).

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<u>Hints and Recommendations for Analysis</u>

1) Store all ArcMap Documents and related data, Power-point presentation, and report in a directory called "groupproject" (remember NO spaces in folder names) under one of your team's j:\GIS\ directory. **Name this document "grpproj.mxd".** Make sure you set the Working Directory in Spatial Analyst Options to this directory so that all data and grids are stored here. Do NOT copy the original data folder – you should not need to do this and it will take up additional valuable space in your folder. [Hint: Do not forget to save often and make back-ups of your ArcMap document].
2) Be sure to first load the country shapefile as the first item in the ArcMap document. We will do this to be sure that the data frame layer is set to Geographic Coordinate System, WGS 1984. Many of the grids and coverages are in this coordinate system, although some are in the old Clarke 1866 datum.
3) Set the extent (to shapefile of your country) and the cell size to 0.017999 decimal degrees (or approximately 2 km).
4) Do NOT use the Buffer Wizard to create buffers. Use "Distance, Straightline" option in the Spatial Analyst menu; be sure to set a maximum distance. You can then use the reclassify option to assign the appropriate values to your newly created distance raster. [Hint: Change 'No Data' to a numeric value (e.g., 0)].

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- United Nations Environmental Program (UNEP). 2004. World Database on Protected Areas. URL: http://www.unep-wcmc.org/protected_areas/index.html

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Data and Metadata

Data Specifics and Sources

Dataset Type	Data Set Name	Year	Data Type/ Resolution	Sources	Reference
Land Transformation	Global Land Cover	2000	32.14286 arc-sec	JRC	JRC 2004
Access: Roads, Rails, Rivers, Coastlines	Digital Chart of the World	1993	1:1'000,000	ESRI	ESRI 1993
Cities, Settlements	Digital Chart of the World	1993	1:1'000,000	ESRI	ESRI 1993
Population (Count/ Density)	Gridded Population of the World	1990 1995	2.5 arc-min	CIESIN	CIESIN 2000

CIESIN- Center for International Earth Science Information Network, Columbia University; **JRC**- Joint Research Centre of the European Commission; **ESRI**- Environmental Service Research Institute.

Data Layers Description needed for this inquiry (Example Madagascar).

Layer	Description	
MADAGASCAR:	Country shape file	
MDG_PONET	An outline of Madagascar Coastline	
MDG_LULC	Land uses in Madagascar	
MDGGP95AG	Population Density in Madagascar	
MDGAREAG	Population Count in Madagascar	
MDG_RRLINE**	(LINES)	Main Railroad lines in Madagascar
MDG_DNNET**	(POLYGON)	Main Rivers that could be navigated
MDG_RDLINE**	(LINES)	Roads in Madagascar
MDG_PPPOINT**	(POINTS)	Location of Settlements (Includes cities too)
MDG_PPPOLY**	(POLYGON)	Location of Big Settlements/ Built ups (Cities)

** No detail description is needed for these layers

APPENDIX 2B: Data Layers Detailed Description.

For detail explanation of the Variables see the following website- DIGITAL CHART OF THE WORLD (DCW): http://www.maproom.psu.edu/dcw/ or, DCW Documentation in CD: **dcwdocument.pdf**

MDG_PPPOINT			
No	**Variable**	**Description**	**Units**
1	FID	Identifier	
2	SHAPE	Type of Vector data	
3	NAME	Name of City	
4	POPULATION	Count	

MDG_LULC			
No	**Variable**	**Description**	**Units**
1	ObjectID	Identifier	
2	Value	Land use type (See Below)	km^2
3	Count	Number of pixels with that value	km^2

MDGGP95AG			
No	**Variable**	**Description**	**Units**
1	ObjectID	Identifier	
2	Value	Population density value expressed as people/ square kilometer	People / km^2
3	Count	Number of pixels with that value	km^2

Land Use land Cover Classification Data Example

Type	GLC Global Class (according to LCCS terminology)
1	**Tree Cover, broadleaved, evergreen (EVERGREEN BROADLEAVED FOREST)** *LCCS >15% tree cover, tree height >3m* Examples of sub-classes at regional level *: *closed > 40% tree cove; open 15-40% tree cover*
2	**Tree Cover, broadleaved, deciduous, closed (DECIDUOUS BROADLEAVED FOREST)**
8	**Tree Cover, regularly flooded, saline water, (EVERGREEN BROADLEAVED)** **(**daily variation of water level)
9	**Mosaic: Tree cover / Other natural vegetation (SHRUBLAND)**
12	**Shrub Cover, closed-open, deciduous (SAVANNAS)** Examples of sub-classes at reg. level *: (i) sparse tree layer
13	**Herbaceous Cover, closed-open (GRASSLAND)** Examples of sub-classes at regional level *: (i) natural, (ii) pasture, (iii) sparse trees or shrubs
16	**Cultivated and managed areas (CROPLANDS)** Examples of sub-classes at reg. level *: (i) terrestrial; (ii) aquatic (=flooded during cultivation), and under terrestrial: (iii) tree crop & shrubs (perennial), (iv) herbaceous crops (annual), non-irrigated, (v) herbaceous crops (annual), irrigate
17	**Mosaic: (CROPLAND/ OTHER VEGETATION)** **Cropland / Tree Cover / Other natural vegetation, Grasses**
20	**Water Bodies** (natural & artificial)
22	**Artificial surfaces and associated areas (URBAN & BUILT-UP AREAS)**

APPENDIX 2

Appendix 2- **STUDENT EXAMPLE**

A. Conceptual Problems: What variables you might need for the analysis?
(See Fig. 1.0) For flow diagram.

I. Human Influence Variables (Data sets & Data types)
Population (GPW density 1995)

- Population density (GPW1995)

Land transformation (Land use land cover)

- Global land use: (GLC2000)
- Roads (DCW)
- Railroads (DCW)
- Settlements Villages & others (DCW)
- Settlement Built-up (DCW)

Accessibility (Roads, rivers and other access points)

- Major rivers (DCW)
- Coastline (DCW)
- *Roads (DCW)*
- *Railroads (DCW)*

Power Infrastructure

- Lights visible at night (1995)

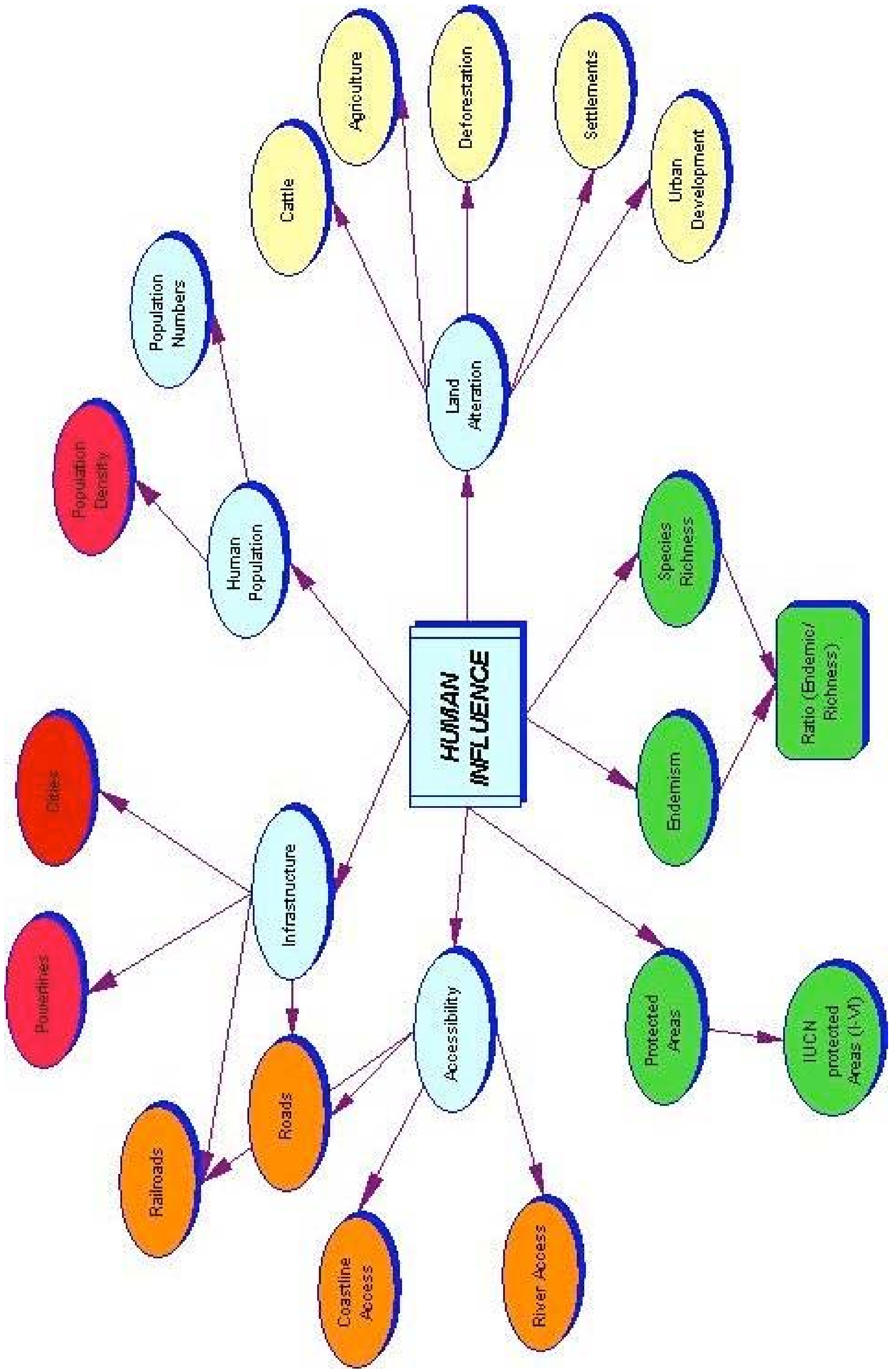


Fig 1.0: <u>Brainstorm Example from students</u>

B. Data Processing Model

I.1 Data Processing: Human Footprint
With Madagascar Layers

a. Add all the datasets to data frame: Population density, Land use, Roads, Railroads, Settlements (Built up & others), Rivers, Coastlines, Lights visible at nights
b. Set Data frame **projection** to GCS_Assumed_Geographic_1 and **display** units Km.
c. In spatial analyst set the **extent** of the data frame equal to Land Use with 2km (0.017999 dd) **cell size** (resolution). This is done because the accuracy of the data layers is good until 2km.
d. Set the working raster space to a desired directory.
e. Create Dissolved Buffers for: [1] (Fig. 2.0)
    - Roads & Railroads (Land Use)- 2km
    - Roads & Railroads (Access)- 2-15km (This is done separately since making buffers all the way to 15 rings with 2km separation was taking too long, same process is done for Rivers and Coastlines)
    - Settlements Point- villages, camps (Land Use)- 2km, 4km (Before creating this buffer students need to remove those points that correspond to the mayor built-up areas in Settlement Polygons)
        i. Select **all** points then remove from set those points that are completely contained in Settlement Polygon.
    - Settlements Poly- Built up areas, i.e. cities (Land Use)- 2km, 4km (Note: Include outside and inside + 2 rings every 2km)
    - Coastline (Access)- same as roads & rail (2-15km) (Note: since we are only working on terrestrial zones the marine part may need to be discarded later on when dealing with "Last of the Wild Activities"
    - River poly (Access)- same as roads & rail (2-15km) (Note: We don't use ALL the rivers since we are assuming that only those that could be shown as polygons are big enough to be used for access. Although it is known that this is not the case.)
f. Convert each buffer zone into a raster dataset (Grid format) (Note: Converting roads to 2km raster set may take a couple of minutes)
g. **Weigh** impact of different variables and then reclassify grid layers in the following way: (Fig. 3.0)
    - Land Use (6 categories)
        i. (Urban) Artificial Surfaces & Associated areas = 10
        ii. (Cropland) Cultivated and Managed Areas = 8
        iii. (Mosaic) Cropland, Shrub, Grassland = 7
        iv. (Mosaic) Cropland, Tree cover & other = 6
        v. (Grasslands) Herbaceous & Sparse herbaceous = 4
        vi. (Other) Tree cover, shrub, bare, water, snow, etc = 0
    - Population Density (10 categories)
        i. 1-10 h/km^2 = 1-10 score
        ii. >10 = 10]
    - Buffered Road & Rail (Note: it is important to determine zero so that when the index is calculated and the buffers are reclassified the indexing works fine. Since buffers overlap you reclassify Buff-2km to 4 & 0 and you reclassify Buff-15km to 4 & 0, when the calculations are performed those values within 2km will have a value of 8 and those between 2-15km will have a value of 4.)
        i. 2km = 8
        ii. 2-15km = 4

[1] Effect of Roads depends on factors like amount of traffic and type of road this are not considered for this analysis. The other factor to consider is the overlapping influence of multiple roads, not considered either.

iii. >15km =0

- Settlement (camps, buildings, villages, monuments) (Note: In the case of these buffers, since they come from a buffer ring the conversion to raster separates the two and when you reclassify you just reclassify both at the same time)
  - i. 2km = 8
  - ii. 4km = 4
  - iii. >4km = 0
- Settlement Poly (Built up areas)
  - i. 2km = 10
  - ii. 4 km = 6
  - iii. >4km = 0
- Coastline & River (Same as Road and Rail)
  - i. 2km = 8
  - ii. 2-15km = 4
  - iii. >15km =0
- Lights at night
  - i. >80% = 10
  - ii. 80-60% = 8
  - iii. 60-40% = 6
  - iv. 40-20% = 4
  - v. 0-20% = 2
  - vi. 0% = 0

h. Use the raster calculator to obtain a summative value of human impact or else use cell statistics
   - Build a simple arithmetic calculation to get the overall impact.
   - Values will range from 0 = No impact to 80 = largest impact.
   - In our case the larges impact was 64 and occurred in the big cities (E.g. Antananarivo)
   - Values where recalculated with raster calculator to create an index of 100%

i. Compare findings to actual human footprint by subtracting using raster calculator. (Fig. 4.0)
   - Findings were very close to human footprint but since there is a slight variation in the indexing we differ by 4 points with the actual value from Sanderson's publication in Bioscience.

j. Change raster to vector using spatial analyst and then select those areas that have only been affected 10% or less than 10%.

k. With geo-processing dissolve (merge) the layers and select those polygons with the largest areas.
   - Find the area for each polygon by re-projecting Madagascar to an appropriate projection and the calculating the area or else use script for ArcGIS to calculate polygon area adding a new column.

C. Data Layers & Their explanations

See APPENDIX 1.0

D. Results of Spatial Analysis. An example of student work.

See Fig 1-4.

Rationale for the variables used and score determination: (Most of them transferred from Sanderson, et al 2002)

The project bases itself in mapping the human footprint focusing on defining human influence through geographic proxies, such as population density, settlements, roads, other access points (rivers, railroad), and includes factors such as remoteness and size of an area.

- People in a given area, is frequently cited as primary cause of declines in species and ecosystems. A study in Ghana National Parks showed that extinction could be explained by size of park, number of people living within 50km. Higher density → higher extinction rate. More people, more resources. In terms of sustainable hunting the land's carrying capacity for people who depend exclusively on game meat will not greatly exceed 1 person/ km^2, even under the most productive circumstances.
- Land transformation has resulted in loss and fragmentation of habitats in many ecosystems and is also called the greatest single threat to biological diversity. Land is transformed by humans to grow food, settlements and other economic uses (accessibility). Presence of roads is highly correlated with presence of species for example but depends in it's use, size and degree of overlap with other access features. It has been estimated that the effect of American roads extend over a band of approximately 600m. Due to spatial accuracy 2km was used.
- Access through roads, rivers and coastlines provide opportunities for hunting and extraction of resources, pollution and waste disposal, that translates in disruption of systems as well as social and economic gain. In tropical systems access through rivers may play a more important role than access through roads. To estimate access they used how much a person could walk in one day in a difficult-to- traverse ecosystem (E.g. Tropical moist forest), as 15km. Reason for the buffer zone. Rivers considered only those wide enough like Amazon where a polygon is used instead of a line.
- Power or electrical power is a good estimate of technological development of an area. Lights at night provide a good proxy of population distribution and have been correlated with human settlements.
- At the end where human influence is the highest, ecosystems will be most modified and species will be under most pressure due to human activity.

FIGURE 2.0: Buffering Layers for Future creation of Grids and evaluation of Human influence

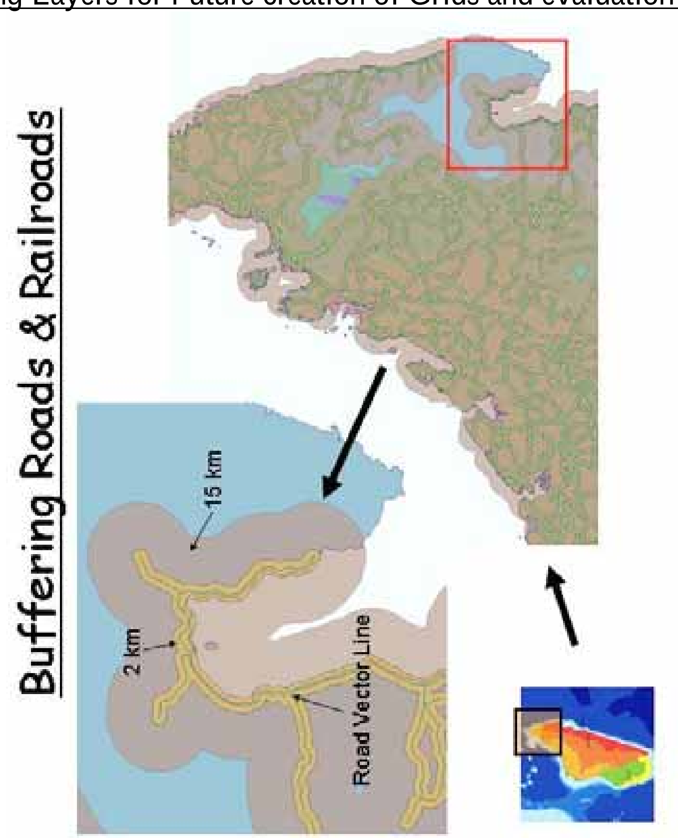


FIGURE 3.0: Indexing and Scoring Human Influence

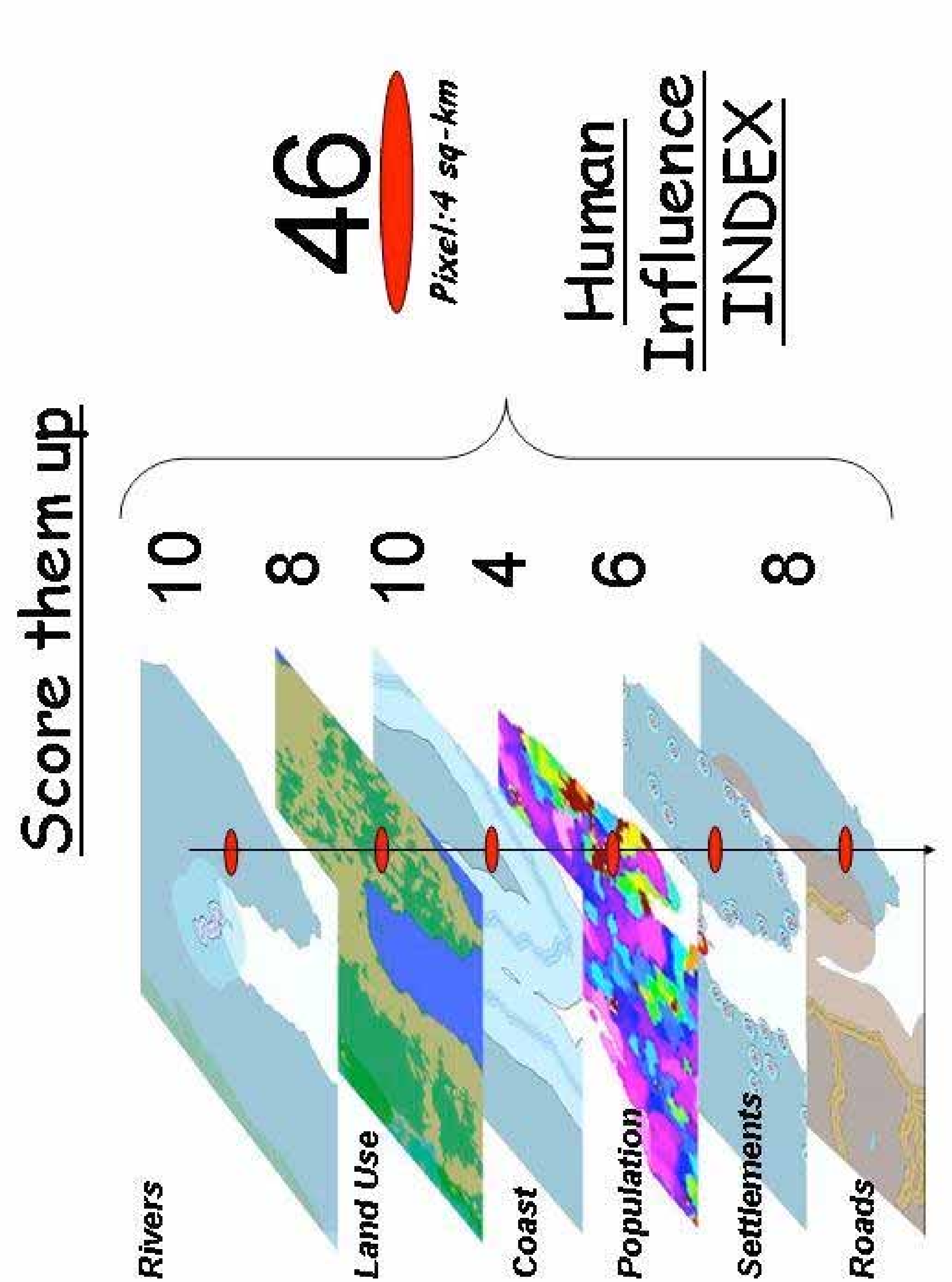
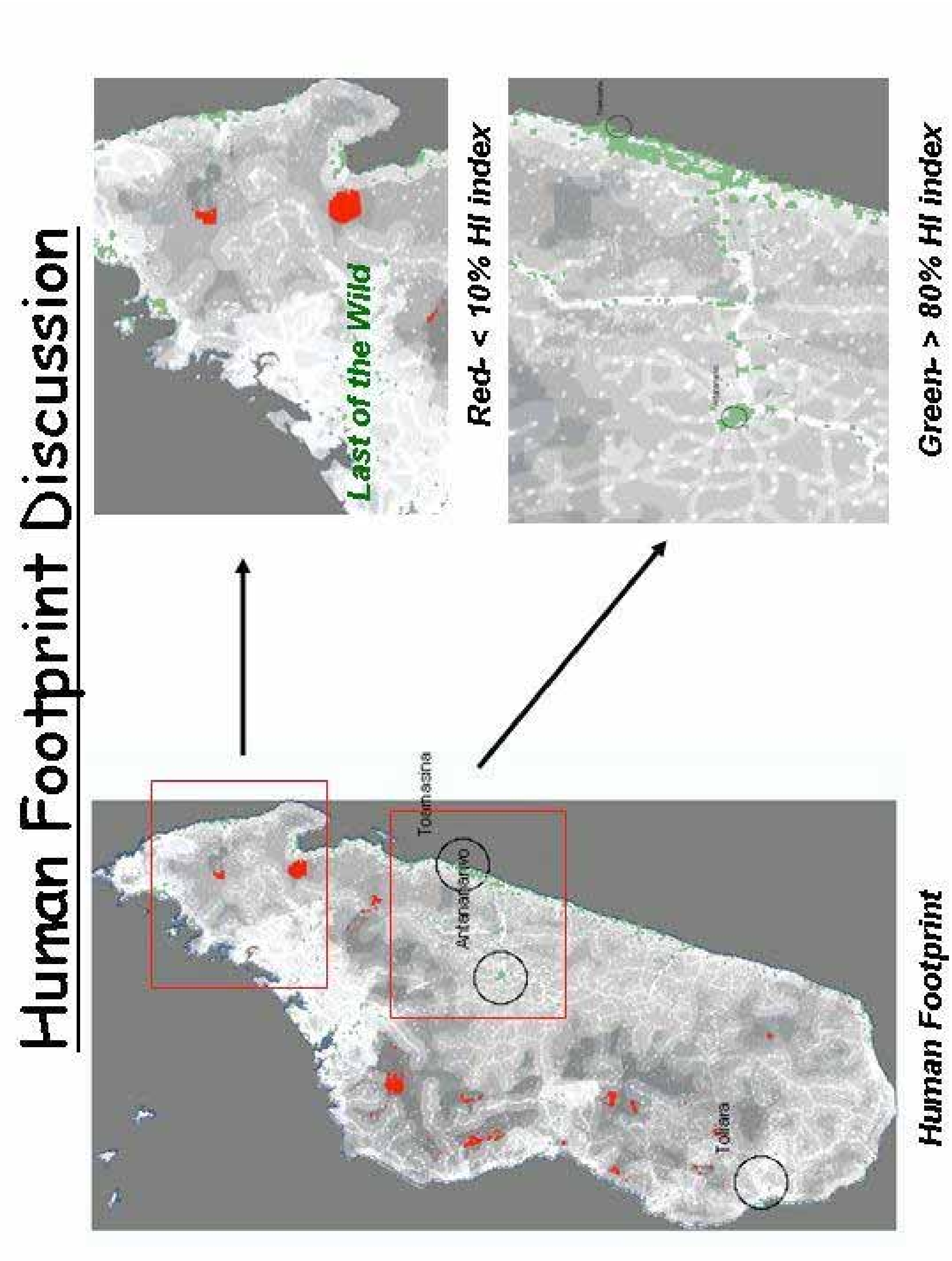
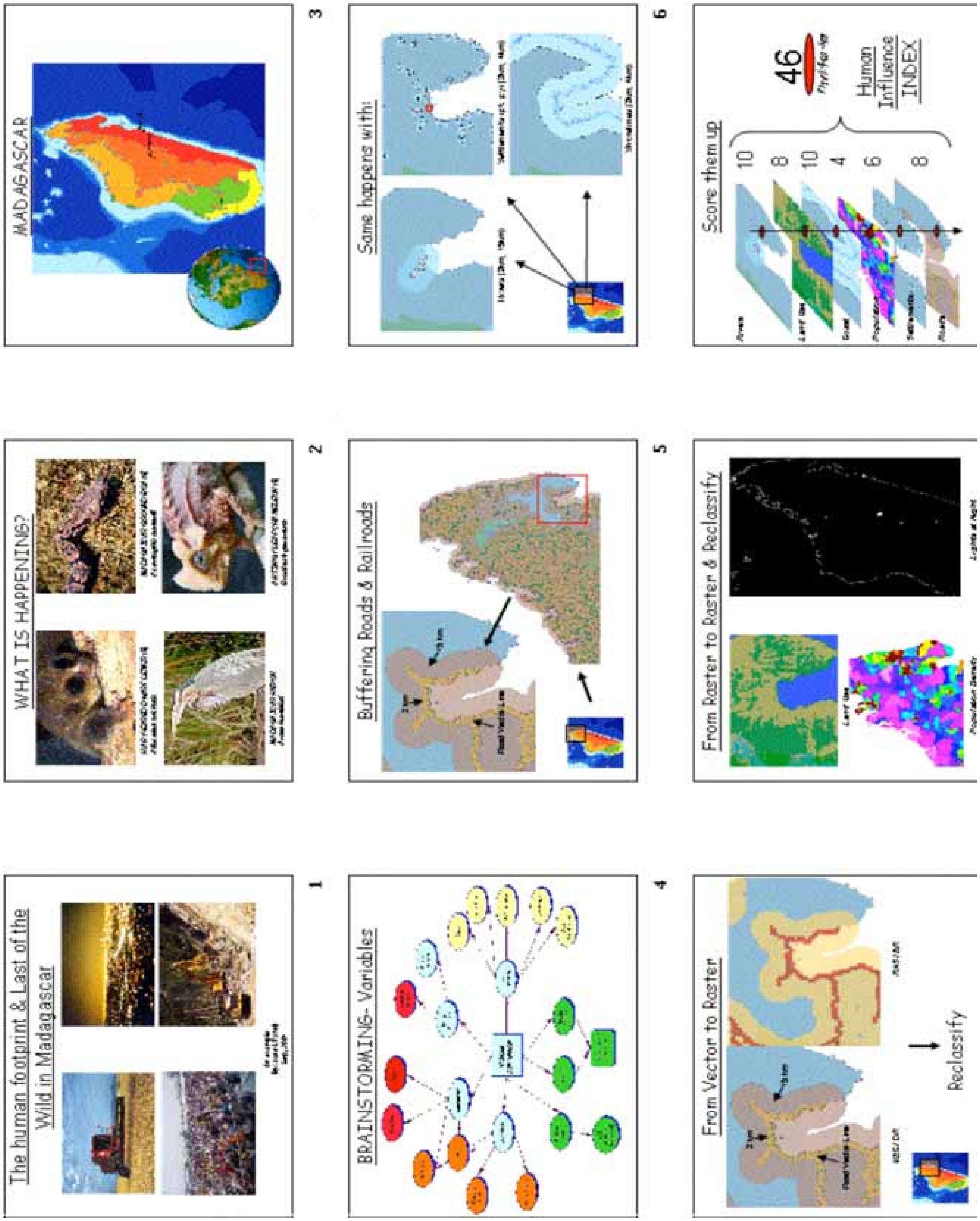


FIGURE 4.0: The Human Footprint



APPENDIX 3

Appendix 3- **PRESENTATION EXAMPLE**



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