Biodiversity Hotspot Analysis Using Diversidad Software

A Background Document In Preparation of the Laguna Merin Workshop

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By

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Diversidad Background

All else being equal, preserving a regions biodiversity (its genetic and evolutionary capital), is paramount to the sustainability of both human and wild populations. This is especially true at a time when the direct and indirect effects of humans on the biosphere is increasing at an alarming rate.

The first step in preserving biodiversity is be able to speak with authority on where the biodiversity resides in the biosphere. Like other ecological phenomena such as species and habitats, biodiversity is not distributed uniformly in either space and time. Rather, biodiversity is clumped and organized into “hotspots” and these hotspots can operate at different scales of organization from the global (such as equatorial rainforests), to the local (such as habitat edges and ecotones).

While biodiversity preservation is arguably among the most important tasks facing ecologists, a great irony is that identifying the location of biodiversity hotspots is among the most expensive, (both monetarily and intellectually), activities that ecologists can undertake. Great expense can be incurred during intensive field surveys and the taxonomic expertise required across diverse assemblages of species can be daunting. For this reason, any method that can help to identify biodiversity hotspots faster, better, cheaper, would be welcome.

Diversidad is a software tool developed for ecologists and land managers that automatically identifies candidate biodiversity hotspots by filtering digital earth images and automatically identifying those sub-regions with the greatest pixel-class richness.

How Diversidad Works

Algorithmically, Diversidad uses the same information theory models, (pioneered by information scientist Claude Shannon (Shannon and Weaver (1949), that ecologists use to measure diversity within ecological communities. In these ecological applications taxonomic surveys are conducted where two types of biological data are gathered at a site; the number of species and the number of individuals per species. Those sites with the greatest number of species ***and*** the most equitable distribution of individuals within a species; are considered to be more biodiverse and more heterogeneous than homogeneous sites with few species and where one species is numerically dominant over other species.

In Diversidad, field sites are replaced by sub-regions of a digital earth image and biological species are replaced by pixel color classes. In Diversidad, those sub-regions of the image with the greatest number of pixel color classes ***and*** the most equitable numerical distribution of pixels within a color class, are considered to be more information-rich regions.

In both applications of the model, heterogeneity is favored over homogeneity. Diversidad further hypothesizes that information rich regions of the image will prove to be field sites with high biological richness. This leap of faith is based on the underlying assumption of Diversidad that ***pixel heterogeneity is a reasonable surrogate for ecological diversity***. Field validation projects have supported this assumption (see references to Podolsky and Freilich in Appendix A).

Diversidad is a four step process as follows:

Step 1 - Diversidad computes the **diversity - H’** of a image region. To do so, users specify the size of the sampling grid for this computation. Grid size can be between 9 and 900 pixels (pixel radii of from 1-15).

Step 2 - Diversidad calculates the **theoretical maximum diversity - Hmax**. **Hmax** is just that, the richness a region of an image would have if diversity was has high as possible.

Step 3 - Diversidad computes the **percent of maximum diversity - PD** achieved for all the sampled pixels.

Step 4 - Diversidad renders a new 100-level gray scale image where black represents those pixels whose grid sample regions achieved 100 percent of maximum diversity, white represents those regions whose samples had 0 percent of maximum diversity and all 98 gray values of gray in between their corresponding percent of maximum diversity. In this way, the dark gray to black regions of the Diversidad image correspond to information hotspots and the light gray to white correspond to regions with relatively low information content.

The mathematical models that Diversidad uses are familiar to most ecologists and are derived from the work or Shannon and Weaver (1949). The three models used in Diversidad are: Diversity (H'), Maximum Diversity (Hmax) and Percent of Maximum Diversity (PD). These variable are calculated as follows:

1. <u>Diversity</u>: H' = - ∑(pi • ln pi)

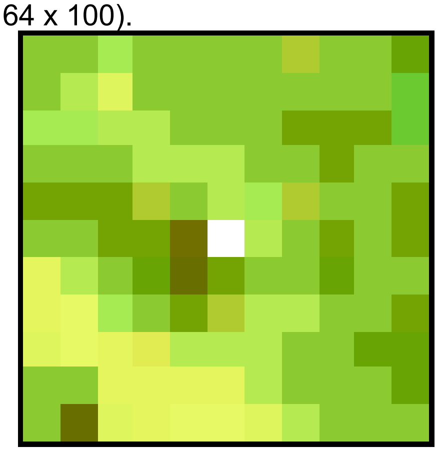
Where pi = p/s

pi = proportion of color i pf total of pixels in the sample grid
p = total number of pixels of color i
s = total number of pixels in the sample grid

2. <u>Maximum Diversity</u>: Hmax = -s(p/s • lnp/s) = -ln (1/s)

3. <u>Percent of Maximum Diversity</u>: PD = H' / Hmax • 100

The sample grid below contains a total of 121 pixels of 14 colors. As such, it achieves 73.5% of its maximum possible diversity (1.94 / 2.64 x 100).



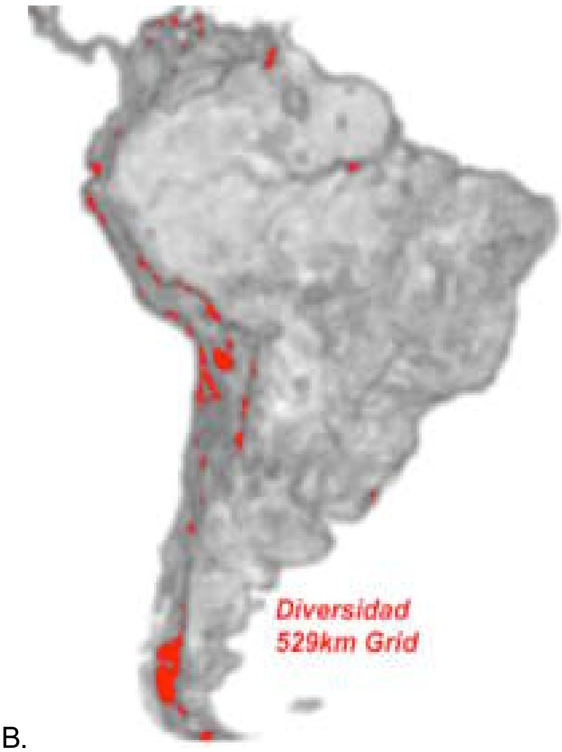
Color	pi	Pixels
0	0.43	52
1	0.41	5
2	0.33	4
3	0.50	6
4	1.30	16
5	0.33	4
6	0.17	2
7	1.20	15
8	0.08	1
9	0.08	1
10	0.66	8
11	0.17	2
12	0.33	4
13	0.08	1
	1.00	**s=121**

H' = 1.94
HMax= 2.64
PD = 73.5%

Example Analysis – Continent Scale Application

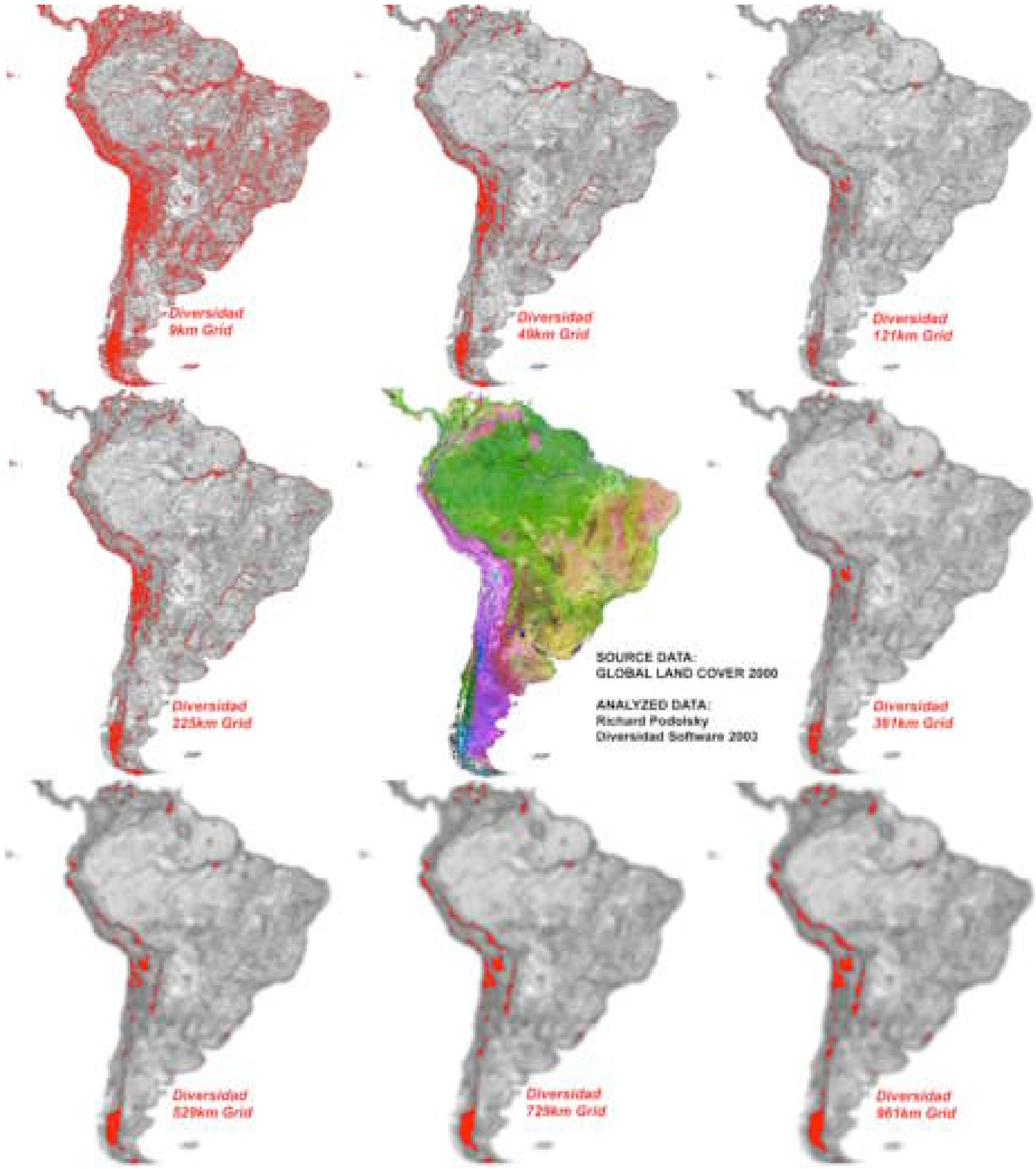
The two sample images below demonstrate the process the whereby a raw (GLC 2000) image (A.) is processed by Diversidad to produce a Diversidad image (B.). In this example, the darkest regions of the Diversidad image that represent those pixels whose grids yielded values of PD of 75% or greater have been colored red. Lake Merin is the southern and eastern most red spot.

A.



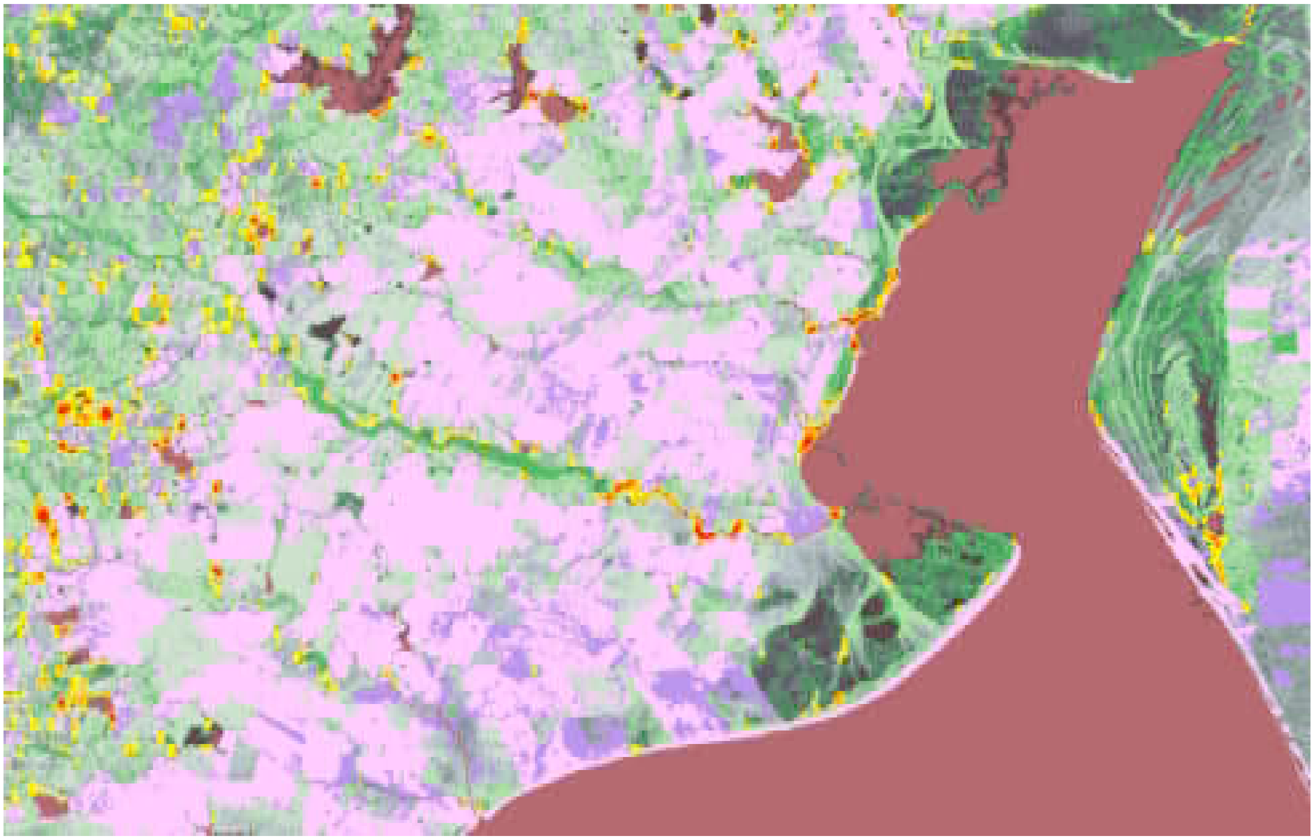
B.

The poster on the follow page is a montage showing 8 Diversidad images surrounding the raw GLC 2000 image. In clockwise progression around the central image, each Diversidad image represents a larger sampling grid size from 9km to 961km.


Diversidad
9km Grid
Diversidad
49km Grid
Diversidad
121km Grid
Diversidad
225km Grid
SOURCE DATA:
GLOBAL LAND COVER 2000
ANALYZED DATA:
Richard Podolsky
Diversidad Software 2003
Diversidad
361km Grid
Diversidad
529km Grid
Diversidad
729km Grid
Diversidad
961km Grid

Example Analysis – Regional Scale Application

In the image of the northern end of Lake Merin, Diversidad hotspots have been overlaid on to the thematic vegetation map. Yellow corresponds with regions where PD was between 75 and 79 percent, orange regions are where PD was between 80 and 84 percent, and red regions are those with PD values equal to or greater than 85 percent.



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