The Abdus Salam
International Centre for Theoretical Physics

United Nations
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2022-12

Workshop on Theoretical Ecology and Global Change

2 - 18 March 2009

The Neotropical Biodiversity Mapping Initiative (NeoMaps)

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VENEZUELA

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Workshop on “Theoretical Ecology and Global Change”

ICTP, Trieste, Italy

9 March 2009

Co-investigators

Christopher J. Sharpe

José Rafael Ferrer-Paris

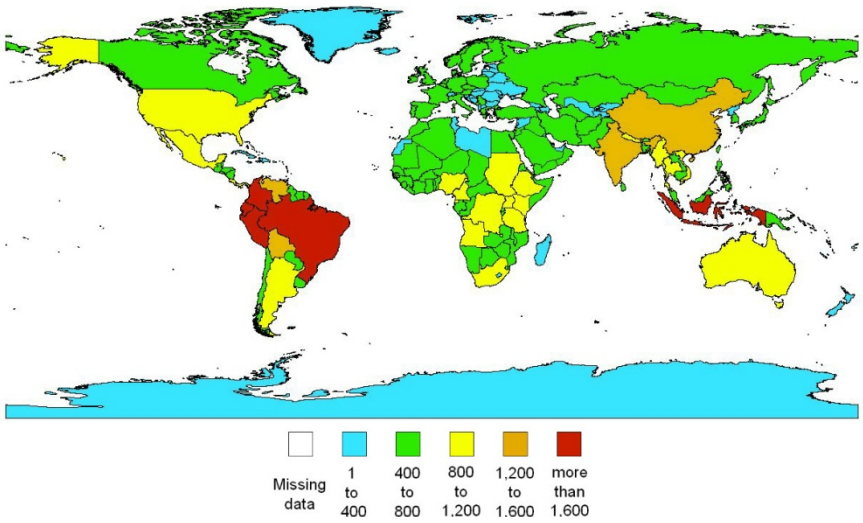
Tatjana Good

Paradox of biodiversity:

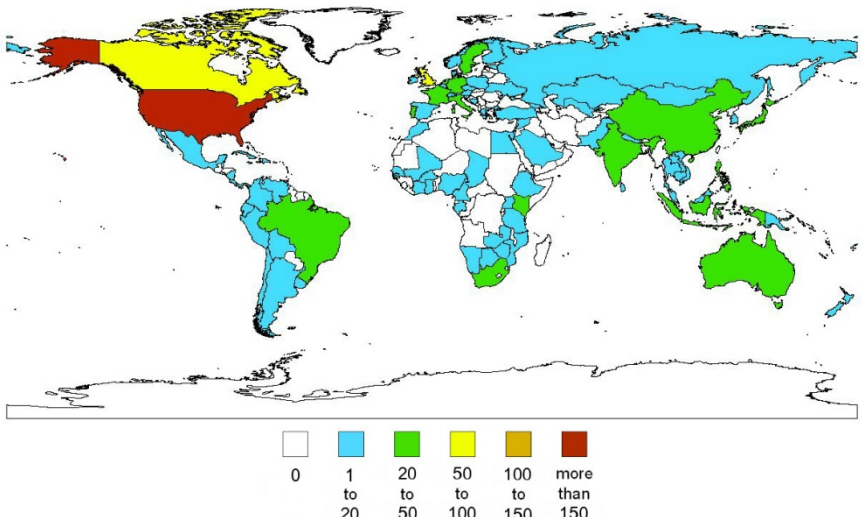
species richness ≠ resource richness

species richness ≠ resource richness

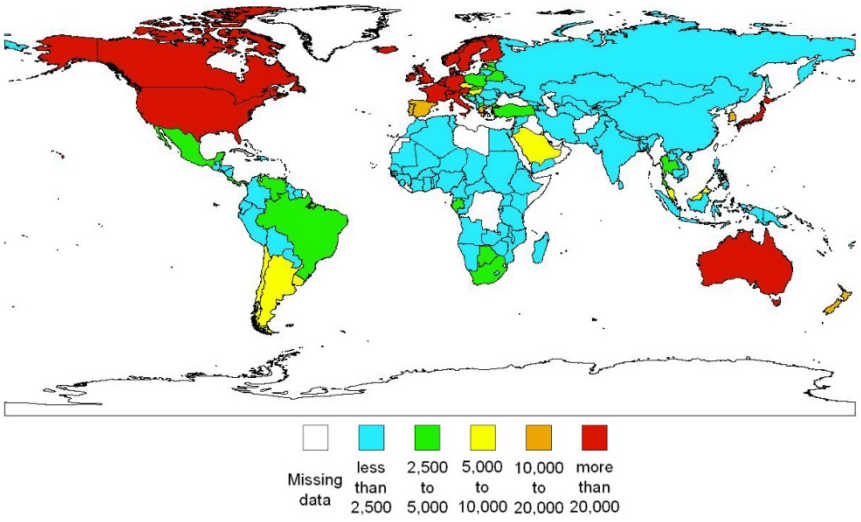
Bird Species richness (Avibase, 2005)



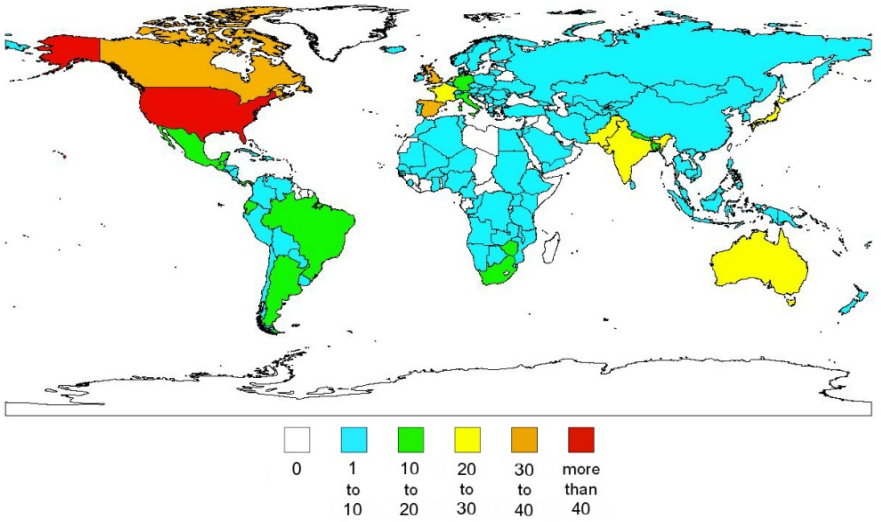
Number of authors (MEA directory, 2005)



Per capita GDP (World Resources Institute, 2000)



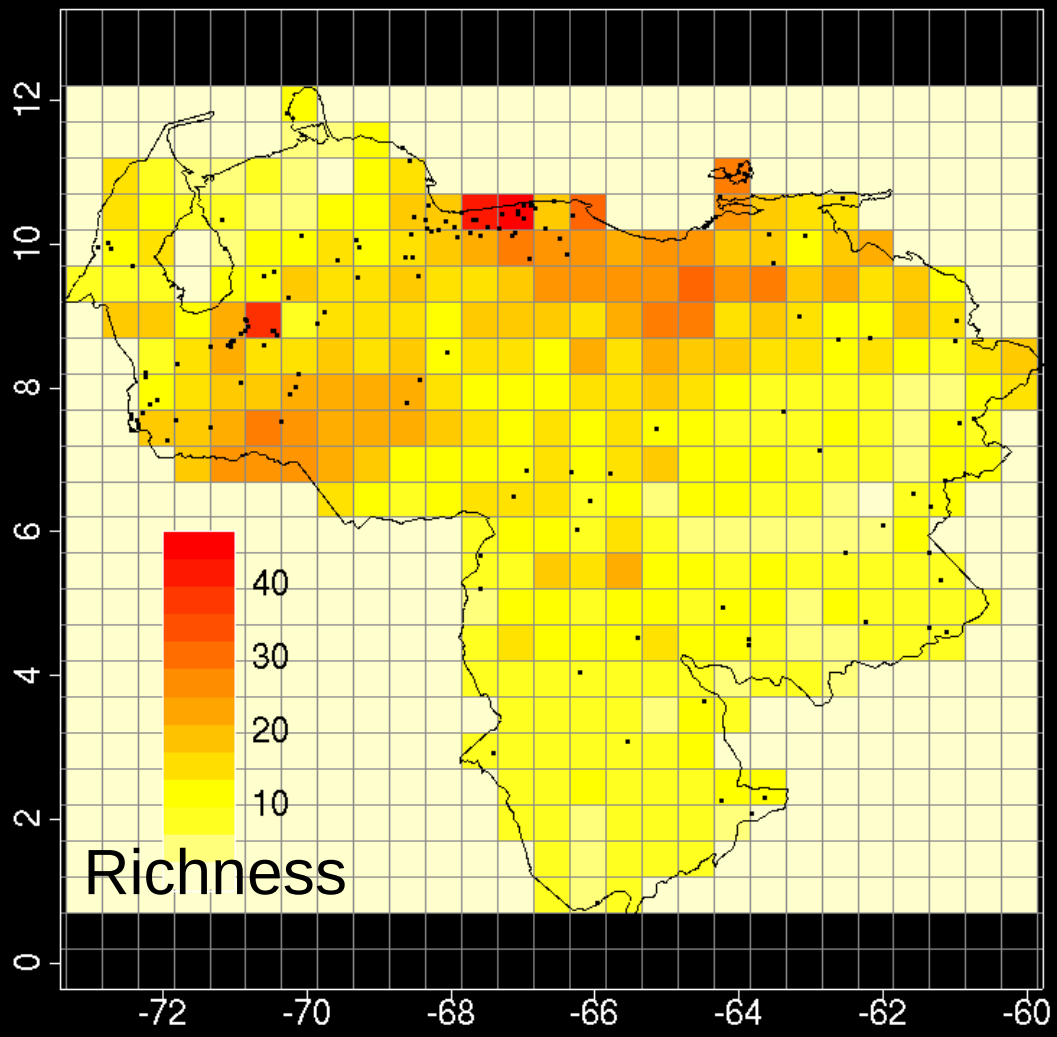
Conservation NGOs and Governmental agencies (IUCN directory, 2004)



Problems

- Lack of knowledge about patterns in the distribution and abundance of tropical biodiversity.
- Available information limited to intensive studies in at few locations, or extensive, non-systematic (opportunistic) studies that do not control for sampling effort or location.
- Insufficient time, money or personnel for implementing surveys.
- Without data, it is not possible to systematically plan or monitor biodiversity conservation, and global change.

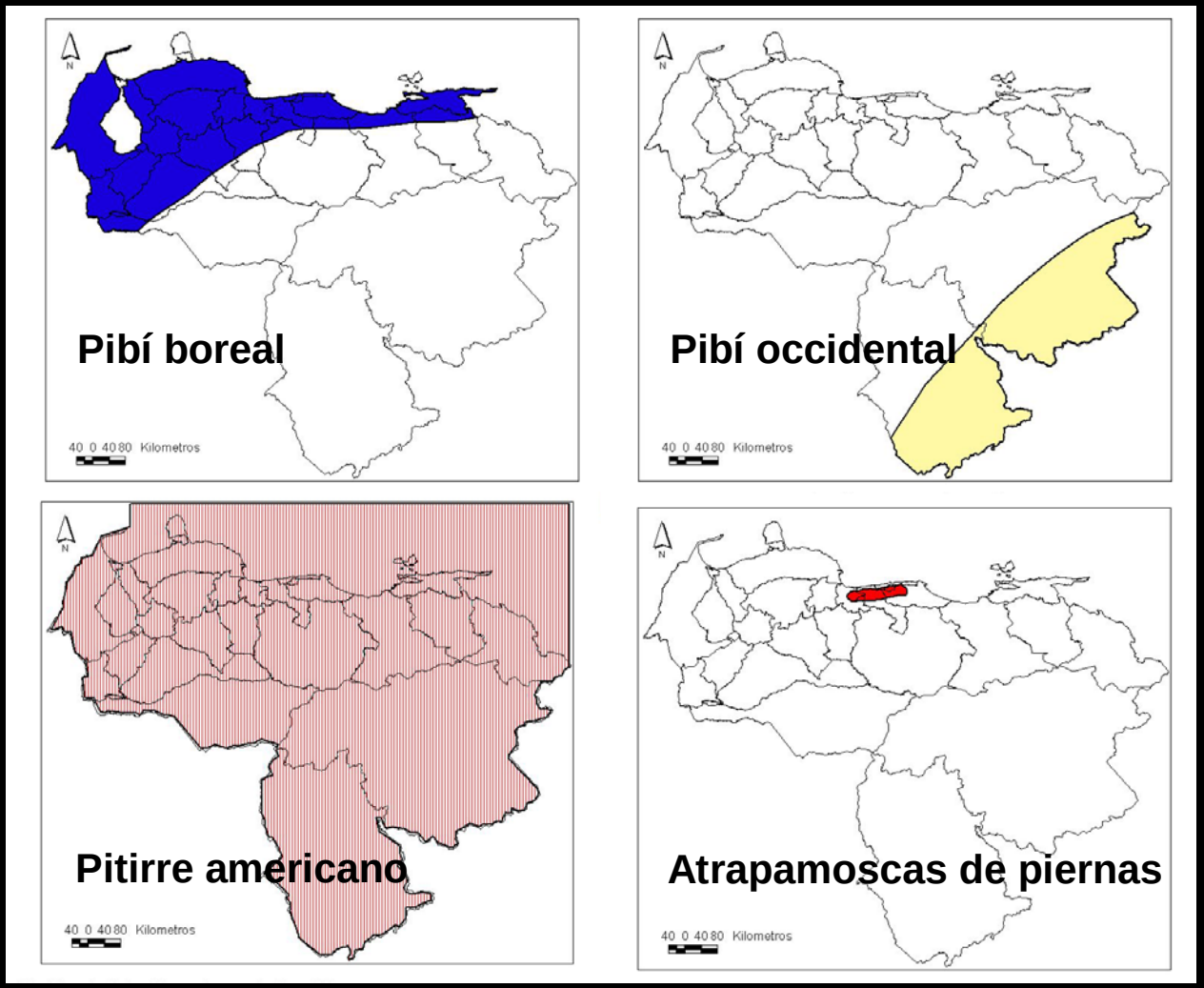
Pieridae (Lepidoptera) richness



- Museum collections (black dots).
- Are all dots equivalent? Sampling techniques?
- Absences or concentration of dots:
  - Biological pattern?
  - Sampling effort?
- Relative abundances?

Ranges of Venezuelan birds

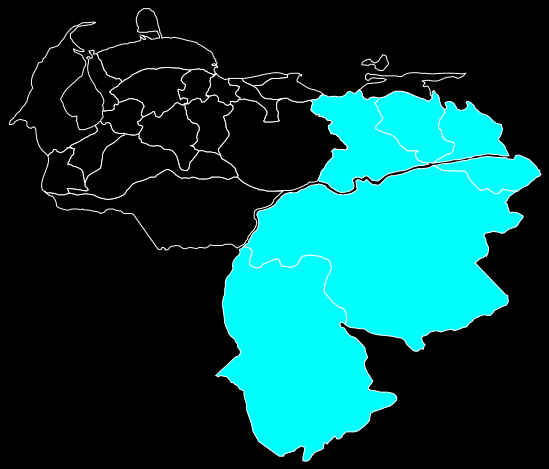
From *Birds of Venezuela*, second edition (Hilty 2003)



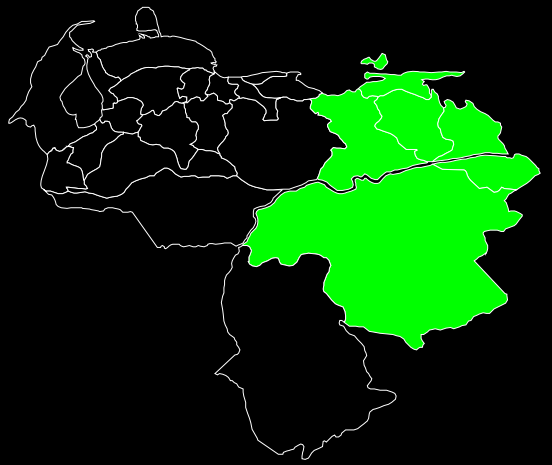
- Methods?
- Sampling effort?
- Present throughout the area?
- Relative abundance?

Priority: number of species

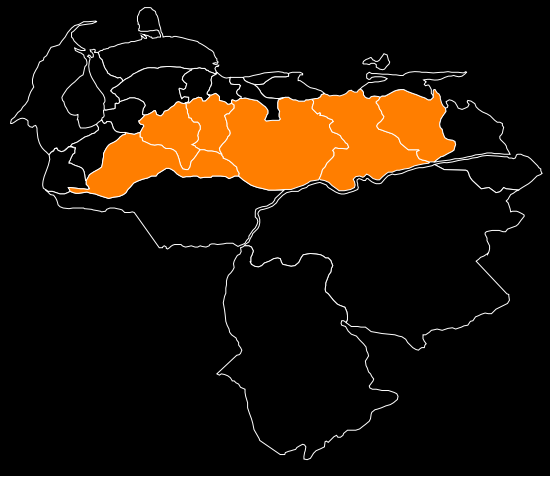
Species A



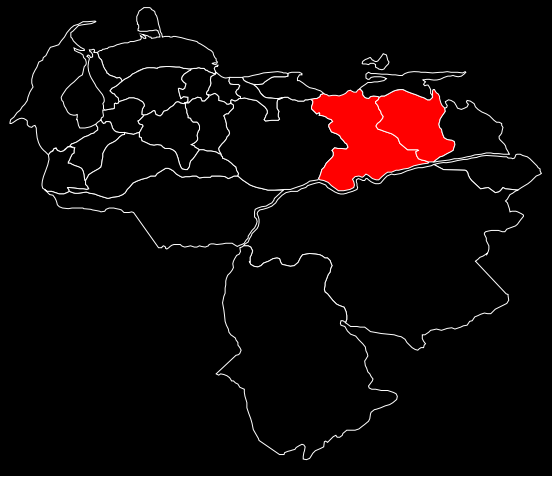
Species B



Species C

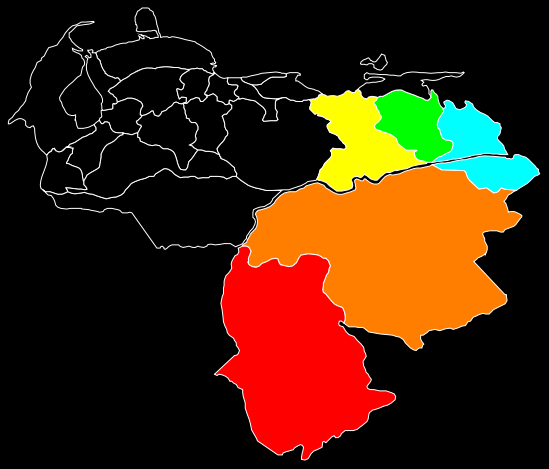


Priority areas

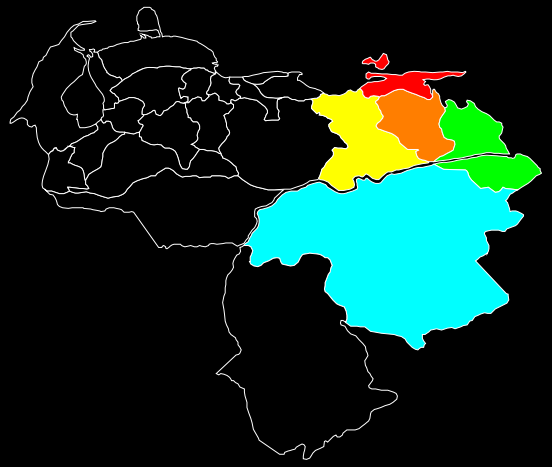


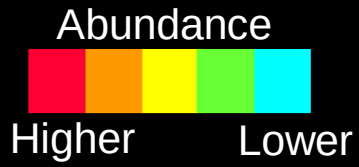
Priority: high-abundance areas

Species A

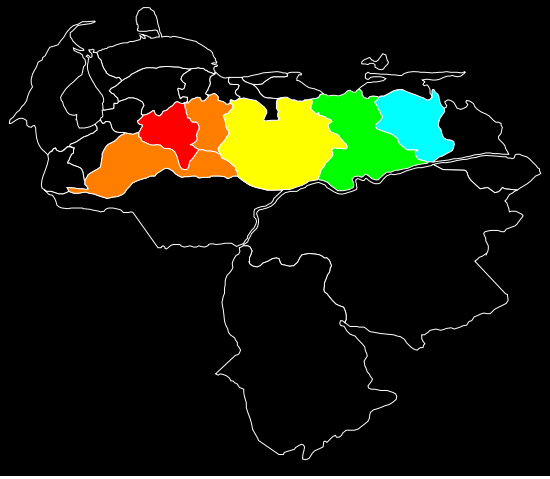


Species B

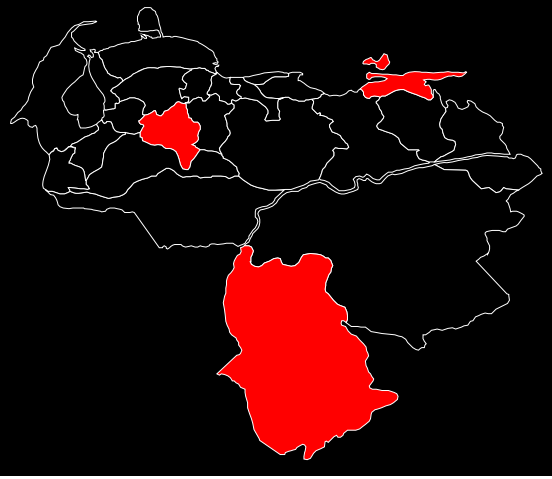




Species C



Priority areas



NeoMaps

the Neotropical Biodiversity Mapping Initiative

- ✓ Minimizes sampling effort by employing an environmentally stratified sampling design and applying spatial interpolation methods.
- ✓ Generates data that can be contrasted to data collected in other regions (constant sampling effort).
- ✓ Develops and strengthens local capacity.
- ✓ Methods are simple, but scientifically rigorous.
- ✓ Fast, allowing to sample an area of the size of Venezuela in six months.
- ✓ All data collected in public domain.

Outline

- Sources of inspiration:
  - British National Grid (BNG)
  - North American Breeding Bird Survey (BBS)
  - BioRap (Australia)

- Neotropical Biodiversity Mapping Initiative
  - Venezuelan Biodiversity Grid (inspired by BNG)
  - Sampling effort (inspired by BBS)
  - Spatial sampling (inspired by BioRap)
  - Next steps

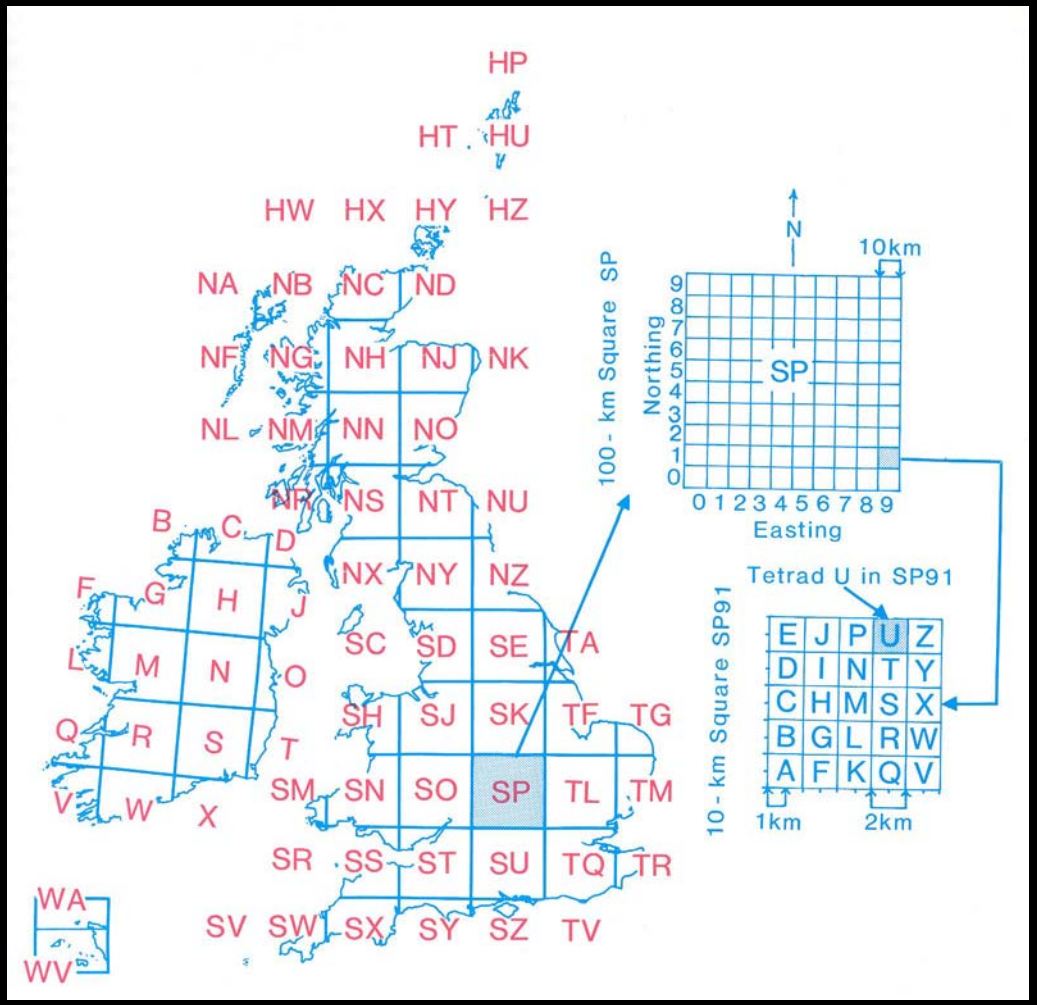
British National Grid

Complete spatial coverage

- Exhaustive sample of British biodiversity (cells 1 km^2 = 100 ha).
- Very detailed information on distribution and abundance.
- Very detailed spatial coverage, temporal coverage limited.
- Very high cost (though volunteers' time is "free").
- Standardized grid for many taxonomic groups (e.g. birds, butterflies, plants).

British National Grid

Complete spatial coverage



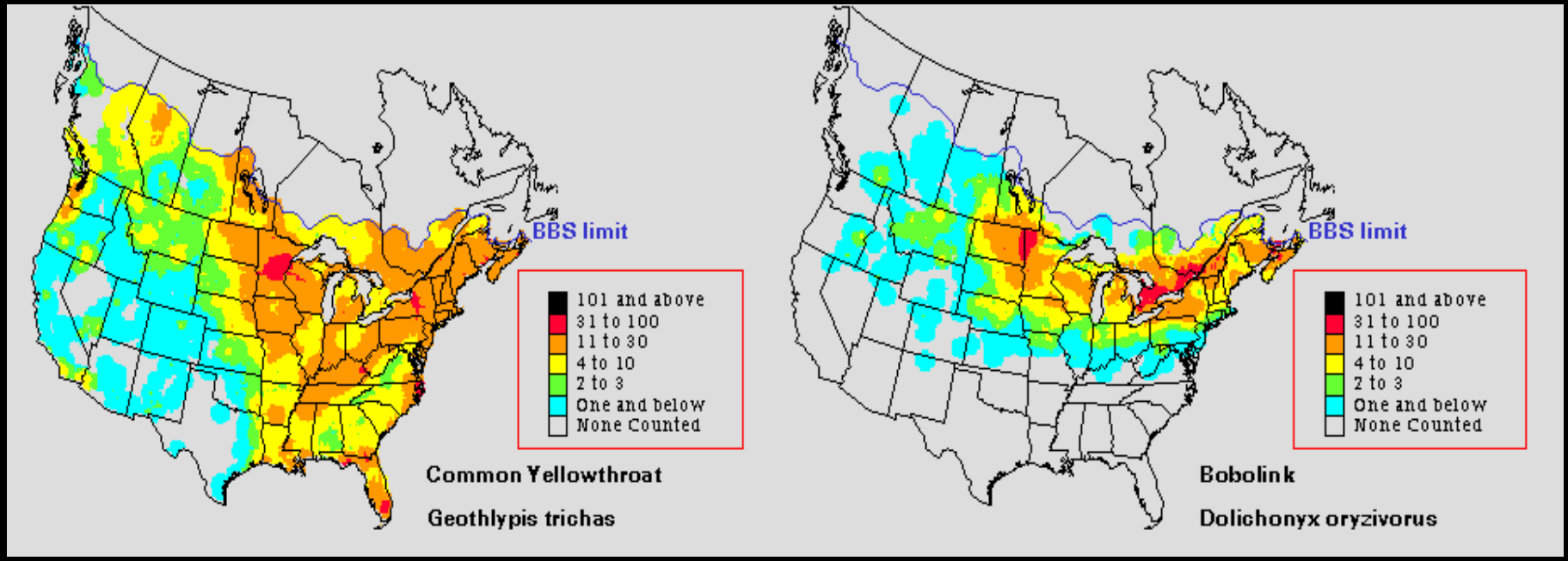
North American Breeding Bird Survey (BBS)

Distribution and abundance of North American birds

- Once a year, volunteers sample ~3,000 roadside routes in United States and Canada.
- 40 km transects, 50 3-min consecutive counts, 800 m from each other.
- Abundance of 600+ species estimated annually.
- Data available since 1966. Continental coverage from 1968 onwards.

North American Breeding Bird Survey (BBS)

Distribution and abundance of North American birds

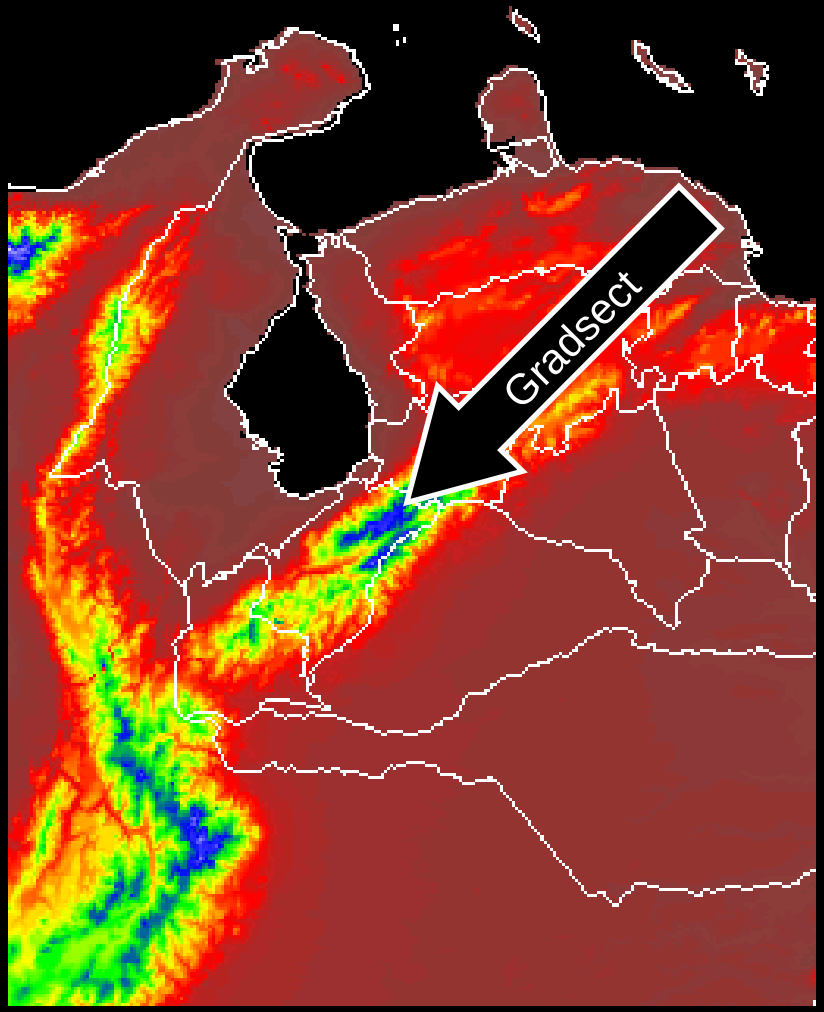


BioRap (Australia)

- Objective: create a spatial sample that minimizes the resources required for generating data on the distribution and abundance of one or more measure of biodiversity.

- Steps:
  - Define the sampling unit.
  - Quantify the distribution of causal variables.
  - Identify “gradsects.”
  - Plan sample along gradsects, which allows:
  - Extrapolation using generalized linear models.

BioRap (Australia)



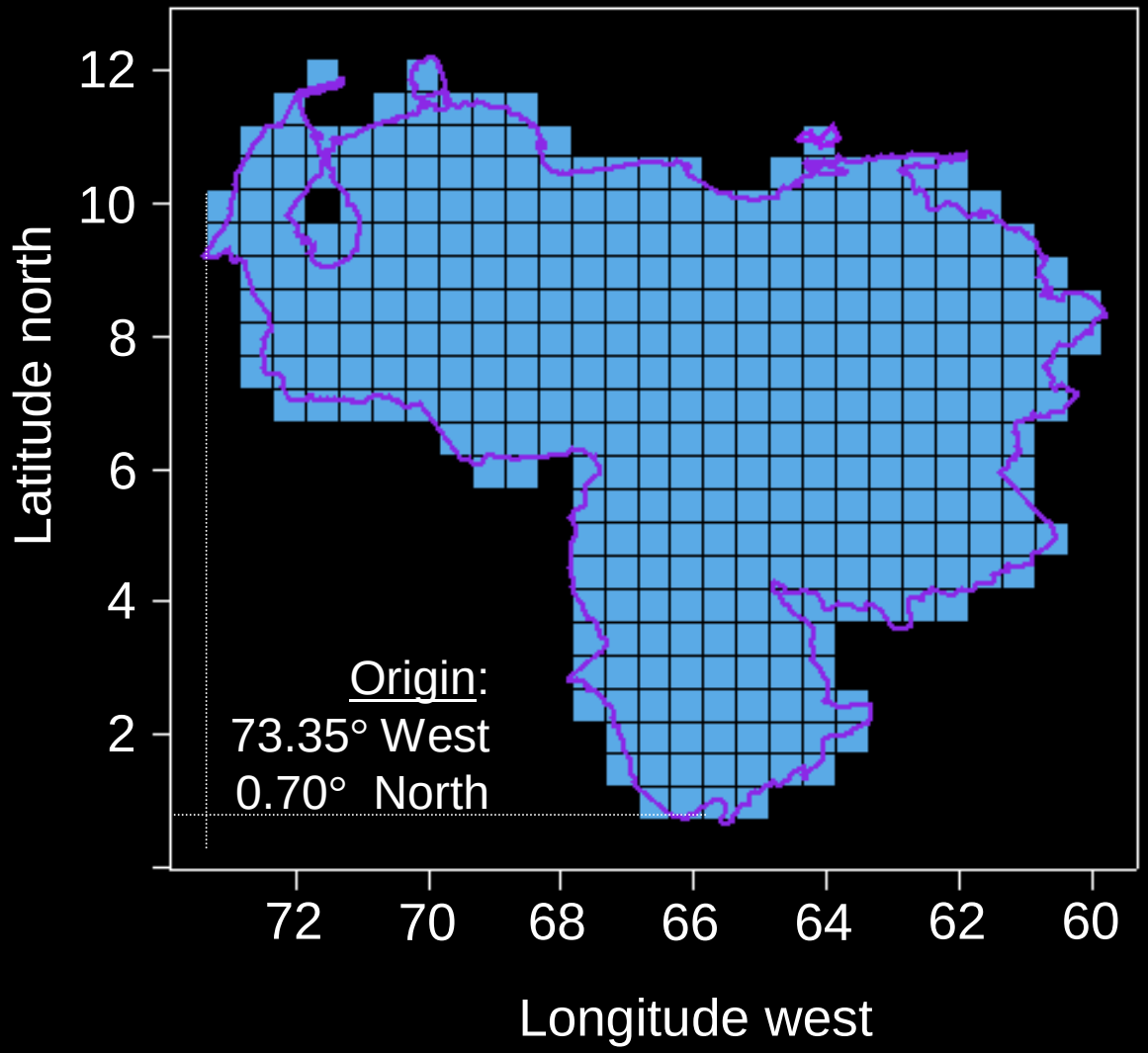
Gradsect: transect along an environmental gradient

Outline

- Sources of inspiration:
  - British National Grid (BNG)
  - North American Breeding Bird Survey (BBS)
  - BioRap (Australia)

- Neotropical Biodiversity Mapping Initiative
  - Venezuelan Biodiversity Grid (inspired by BNG)
  - Sampling effort (inspired by BBS)
  - Spatial sampling (inspired by BioRap)
  - Next steps

Venezuela Biodiversity Grid



- Cells 0.5 x 0.5 º
  ~ 50 x 50 km
  ~ 250.000 ha
  (scale of BBS routes)
- Shifted origin
- 377 cells

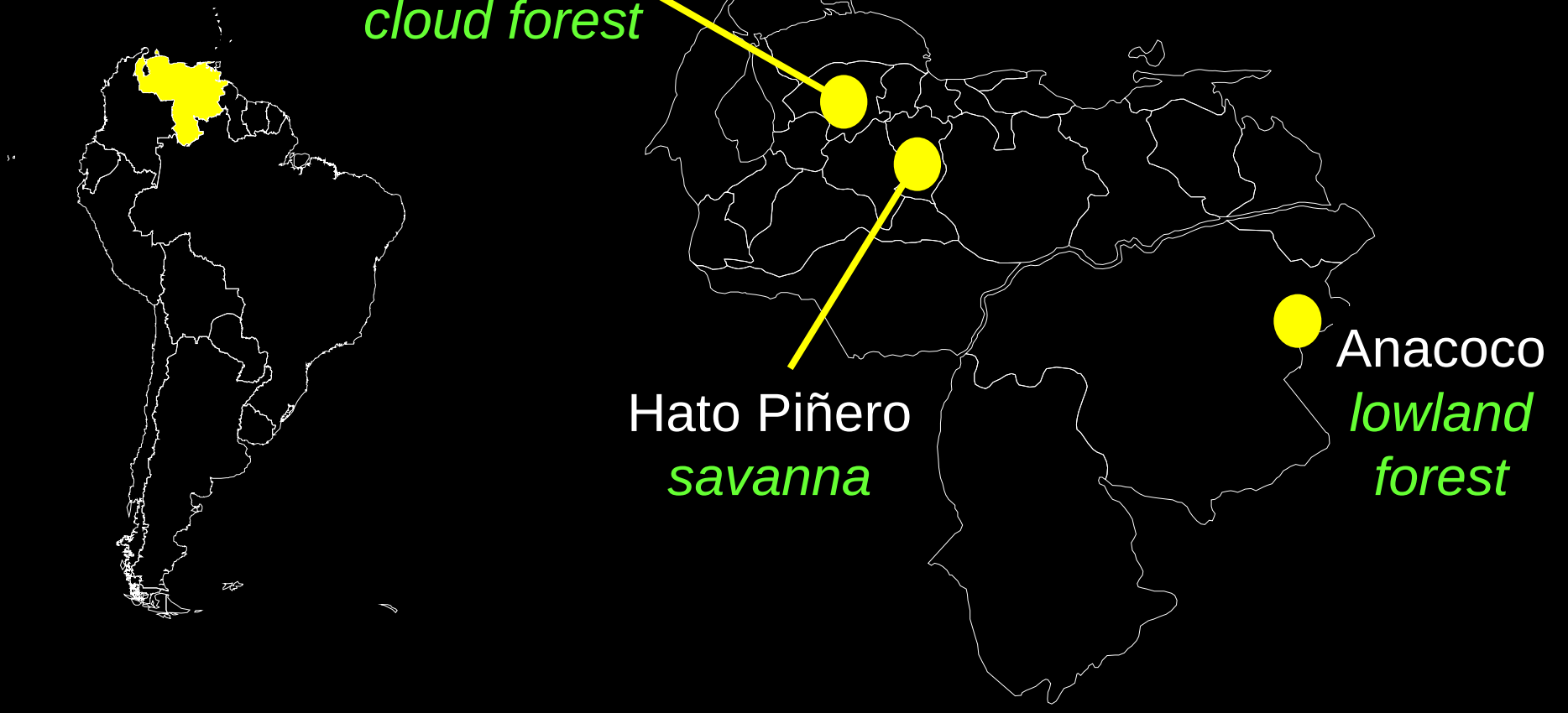
NeoMaps' ornithological sampling effort

- Methods based on BBS protocol (50 counts, 3 min ea, 40 km transect, 800 m between counts).
- Principal constraint: birds' limited activity interval.
- Tropical constraints:
  - Reproduction not synchronized (nor territorial calls).
  - More species than in North America.
  - Habitats more complex than in North America.
- How to "tropicalize" the protocol?
  More time needed at fewer count sites?

NeoMaps' ornithological sampling effort

- Variations on the BBS:
  - 50 counts, 3 min, 800 m between counts.
  - 25 counts, 6 min, 1600 m between counts.
  - 15 counts, 10 min, mainly 3200 m between counts.
- Criteria for selection of best method:
  - Highest richness estimate, lowest variance.
- Record calls with omnidirectional microphone.
  - Verification of field identifications.
  - Can they be used alone?
- Test methods in three contrasting ecosystems.

Field sites


Yacambú
cloud forest
Hato Piñero
savanna
Anacoco
lowland forest

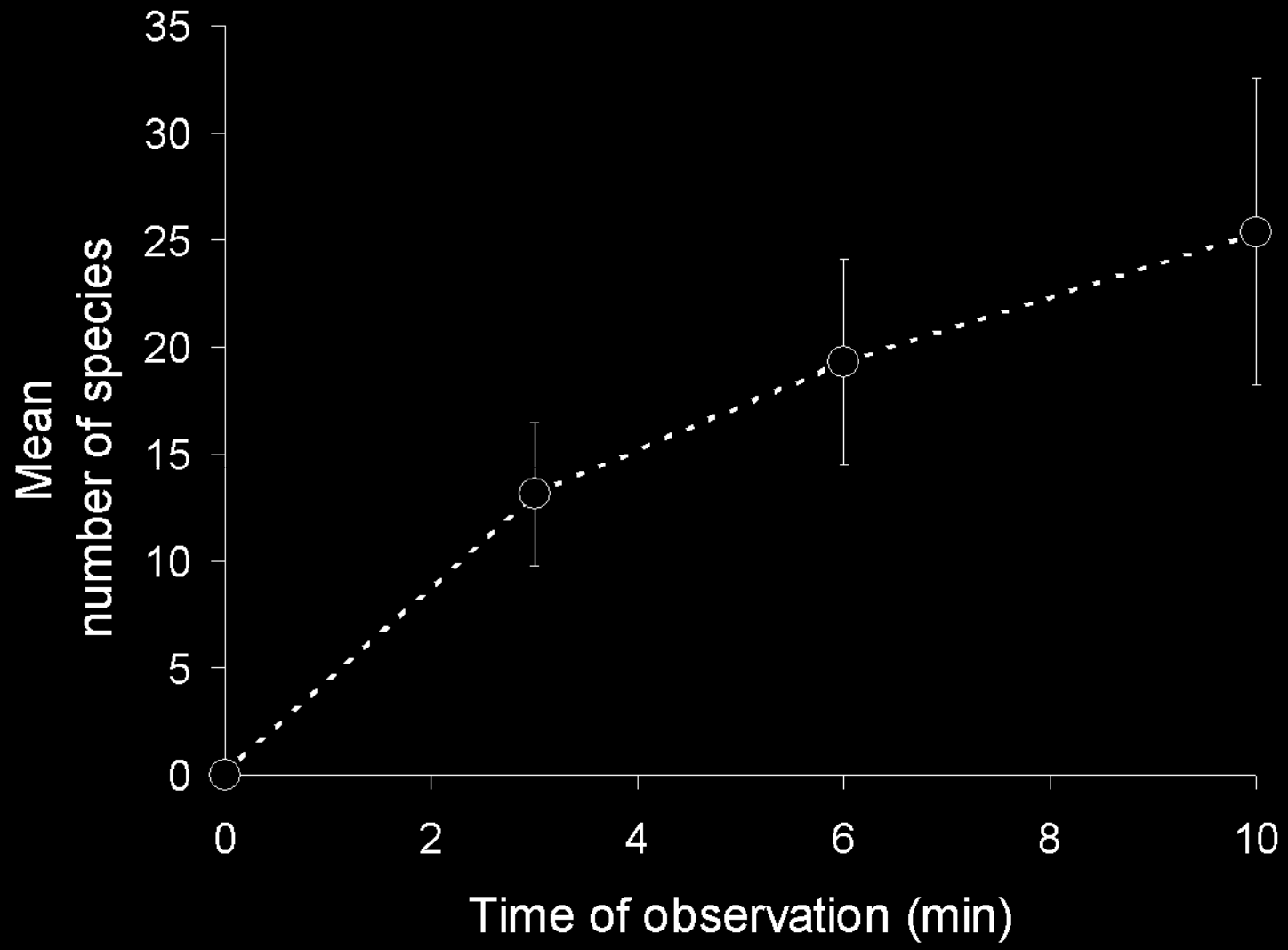
Number of species detected

A priori “complexity” gradient

	Piñero		Anacoco		Yacambú	
Sampling protocol	Obs	Rec	Obs	Rec	Obs	Rec
50 stops, 3 min ea.	119	81	99	83	127	n/a
25 stops, 6 min ea.	114	79	86	89	97	n/a
10 stops, 10 min ea.	123	84	81	72	103	n/a
Species richness	290		200-400		285	
Proportion “captured”	> 1/3		~ 25-50%		> 1/3	

Obs: direct observation Rec: Recordings

Comparison of 3, 6 and 10-min counts at 15 stops



Summary of main findings: recordings

- Omnidirectional recordings tend to "detect" fewer species than direct observation (which includes visual and aural identifications).
- No major differences between 3, 6 and 10-min counts.
- Recordings do not allow for estimation of abundance, only presence/absence.
- Recordings require long processing times, on the order of ten days per route.
- Only a handful of species were detected from recordings only.

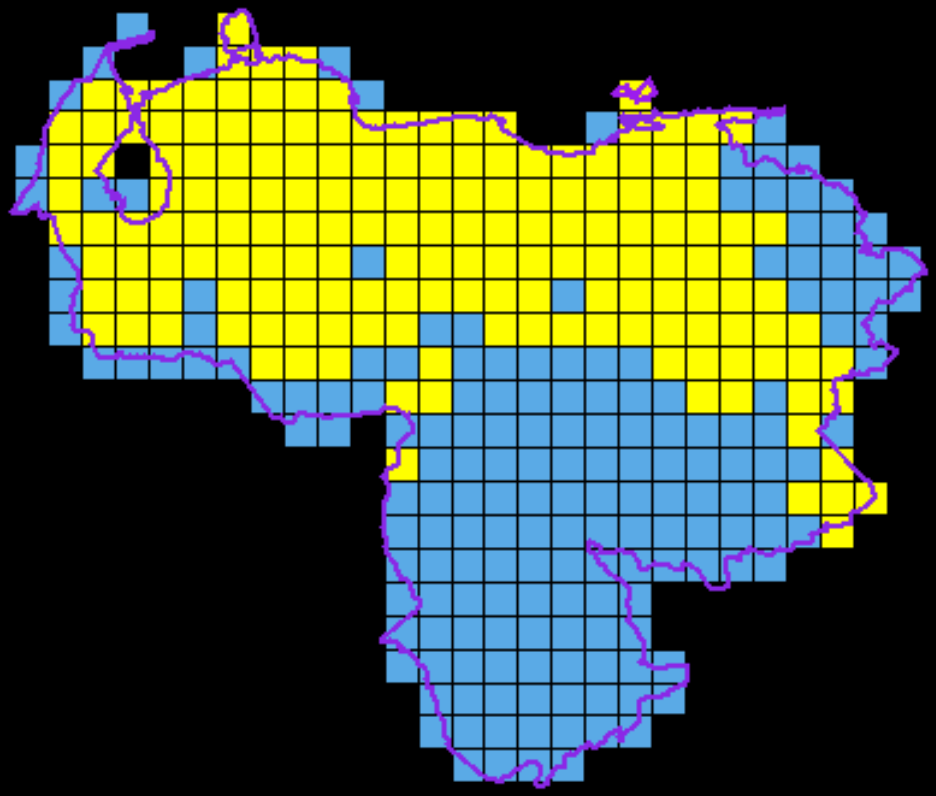
➢ In short: we do not recommend recordings for surveys.

Summary of main findings: direct observations

- A relative large proportion of the bird community sampled by surveys.
- Some species better “captured” than others: noisy, active birds better than quiet, secretive birds.
- More, shorter counts (50 3-min stops), tend to detect more species at the route level.
- Though fewer species are detected at individual, shorter counts (e.g. 3 vs. 10 min), the variance is smaller.

➢ Recommendation: apply BBS protocol, but focus long-term monitoring efforts on better sampled species.

NeoMaps' sampling universe: 170 cells



- Yellow cells have roads.
- How many cells are needed to "capture" environmental and regional variability?

➢ Stratify sample by bioregions and environmental variables.

Environmental variables considered

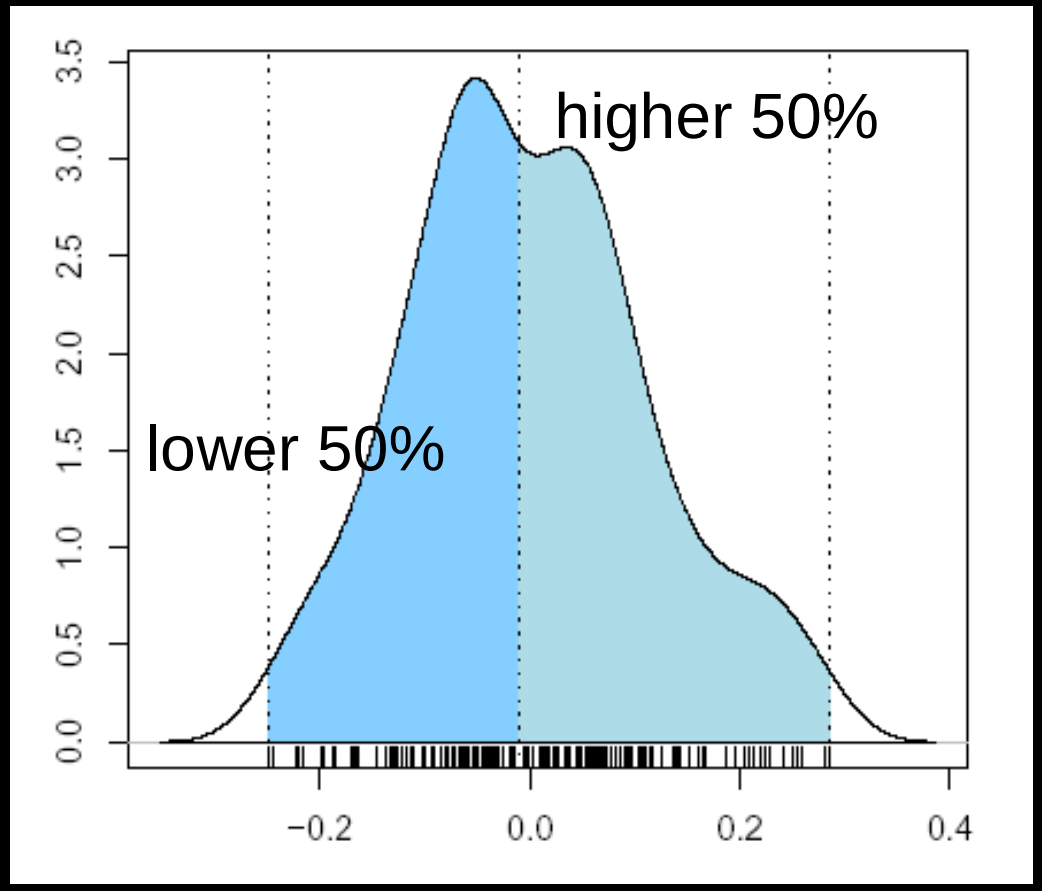
- 14 biological, physical, and climatic variables were quantified for each cell:
  - Longitude
  - Latitude
  - Elevation (mean and range)
  - Total annual precipitation (mean and range)
  - Mean annual temperature (mean and range)
  - Number of dry months (mean and range)
  - Total forest cover (mean and range)
  - Deciduous forest cover (mean and range)

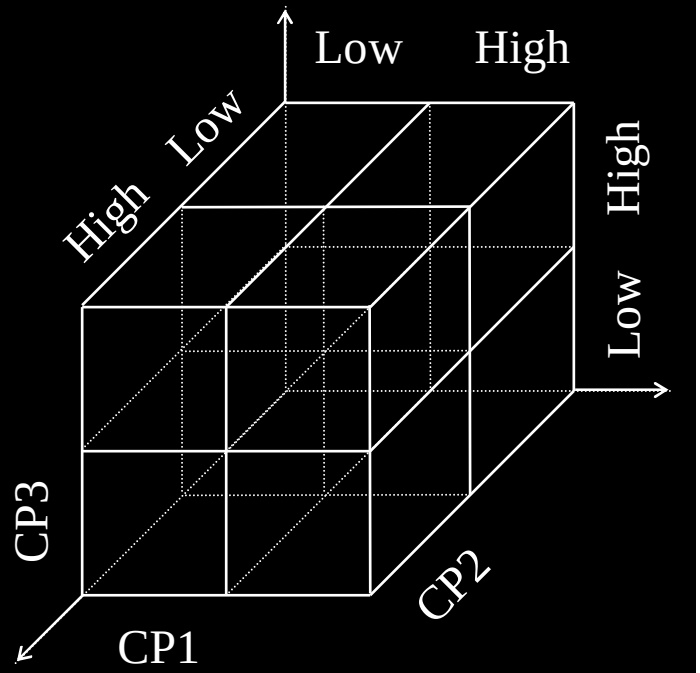
- Environmental variation space reduced with principal components analysis.

Principal components analysis

- Principal components 1+2+3 = ~ 70% variance
- CP1 (physical-climatic): mean elevation, mean and range of precipitation, range of temperature, and the mean number of dry months.
- CP2 (vegetation): mean and range of the total and deciduous vegetation cover.
- CP3 (drought intensity): mean precipitation, the range of the number of dry months, and the range of the deciduous forest cover.

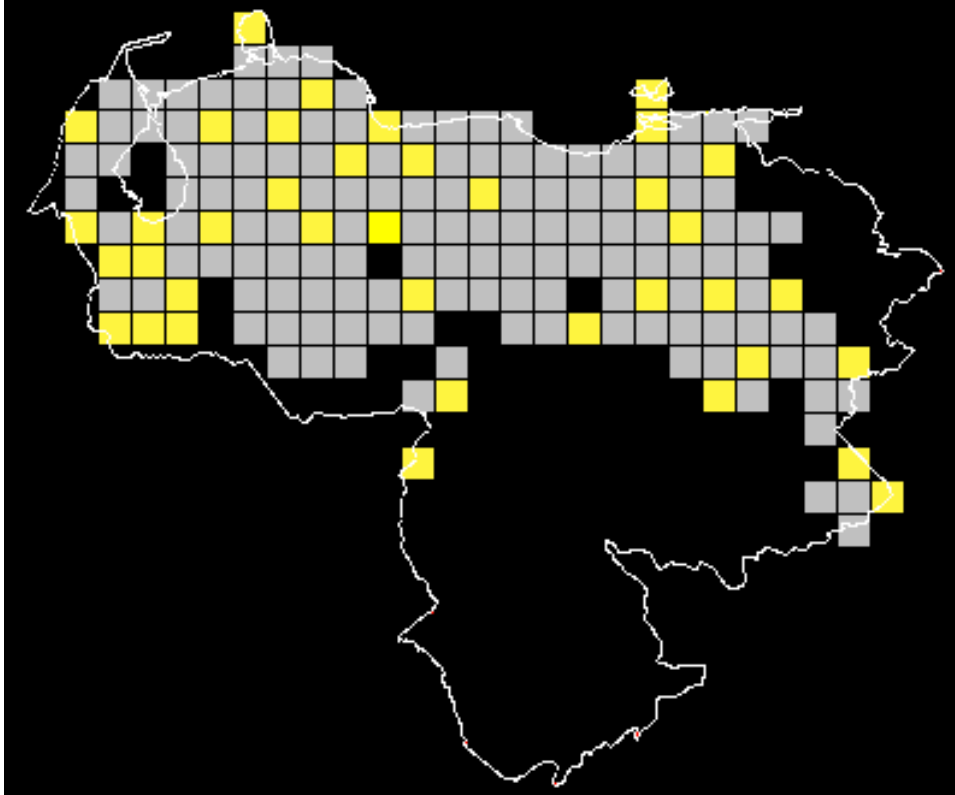
Eight bio-physical-climatic strata





Five bioregions

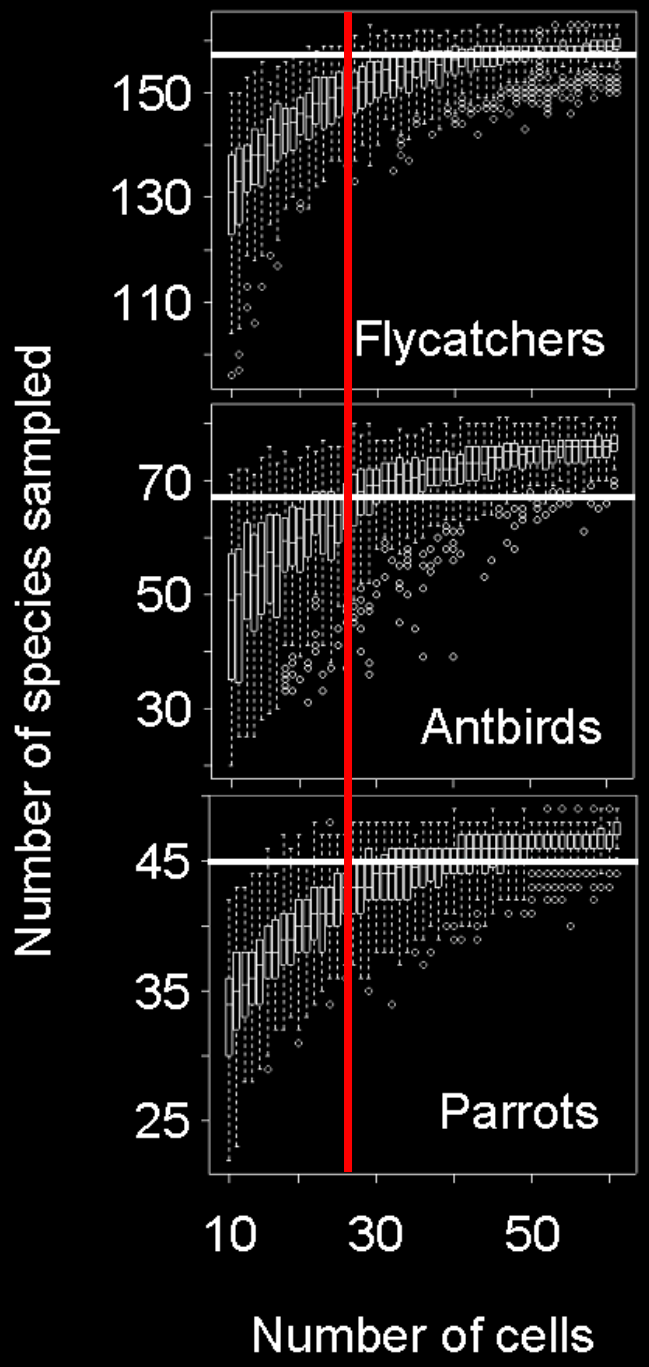
NeoMaps' spatial sample: 27 cells



- 40 possible combinations
  (5 geographic x 8 bio-physical-climatic strata).
- 26 combinations present.
- Unique combinations selected.
- One of each remaining combinations chosen.
- One additional cell added to include páramo (high alpine meadow) vegetation

Test of NeoMaps' spatial sample on birds

- Geographical distributions tested:
  - Psittacidae: parrots, parakeets and macaws, 49 spp. (Desenne & Strahl 1994)
    - Well detected by field surveys
    - Susceptible to direct human impact (poaching)
  - Formicariidae and Thamnophilidae: antbirds, 81 spp. (Giner 2001)
    - Associated to forests
    - Susceptible to indirect human impact (deforestation)
  - Tyrannidae: flycatchers, 163 spp. (Hilty 2003)
    - Generalists



NeoMaps sample captures:

- 97% flycatchers
  79% antbirds
  92% parrots

- Random sets of 27 cells outperformed our sample (1,000 iterations):
  - 6% of the time for flycatchers
  - 54% of the time for antbirds
  - 20% of the time for parrots

- Likelihood of randomly sampling entire range of environmental variation is very low ($p = 8.96 * 10^{-6}$).

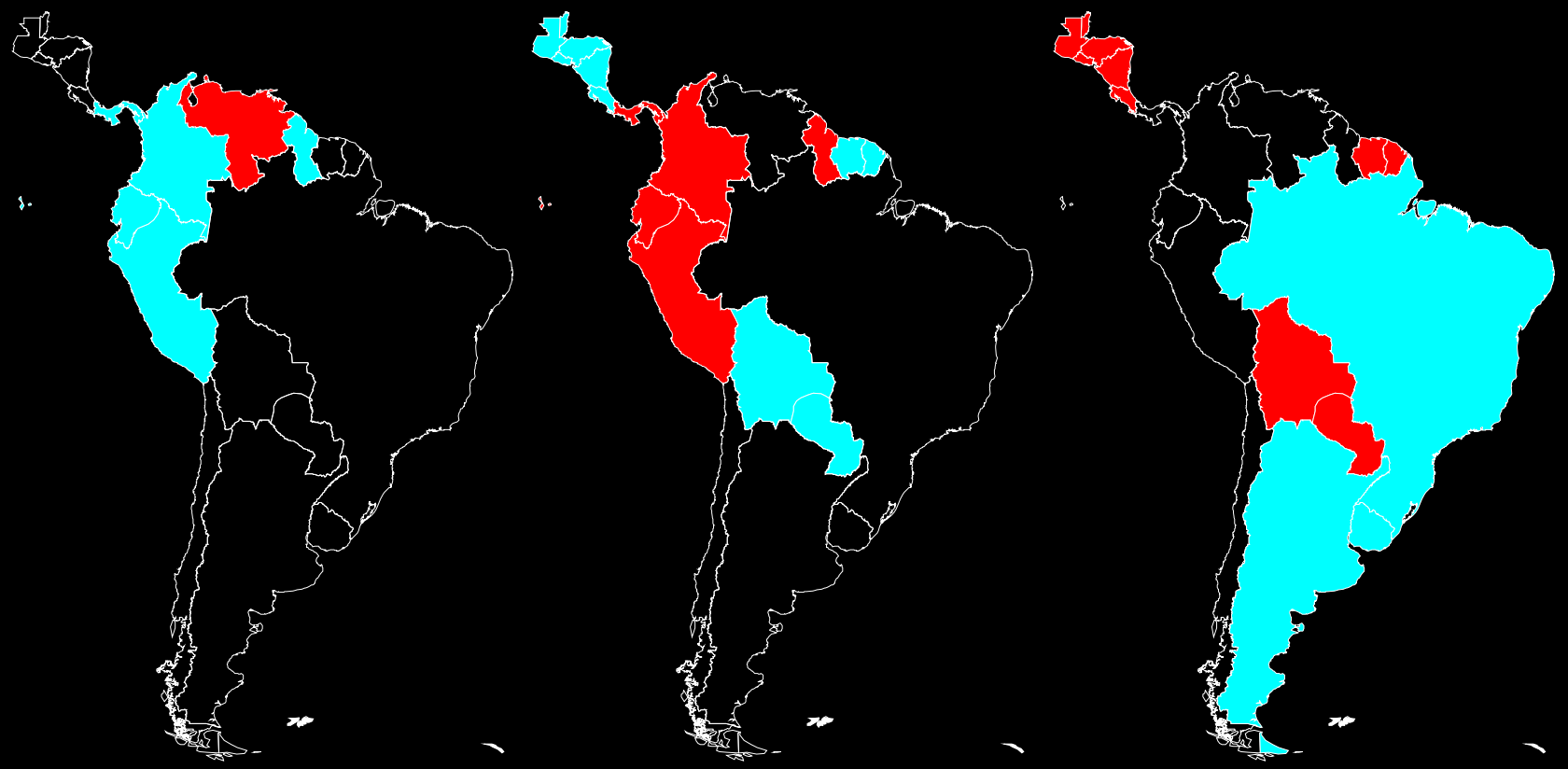
Next steps…

- First set of preliminary field surveys in Venezuela in 2006: butterflies and dung-beetles.
- Venezuelan butterfly and dung-beetle survey: 2009
- Venezuelan bird survey: 2010
- Spatial sampling design for other countries being considered.

Ideal model for Venezuela bird surveys

- Seven or eight field groups:
  - In each group, one experienced observer and 1-3 beginners.
  - Three experienced observers from Venezuela, the rest from neighboring countries, beginners mostly Venezuelan.
- Meet for a week prior to performing surveys, to become acquainted with field methods.
- Each group, supplied with a vehicle, visits 3-4 cells (20-40 field days per group).

Expansion to other countries in the region



2009 2010-2011 2012-2013

Critiques

- Trade-off between geographical coverage and level of detail of surveys.

- Data biased due to:
  - species detectability differences
  - roadside habitat bias
  - rare / very abundant species not well quantified
  - observer differences

But...

… never before, in any tropical region in the world, has a comparable database been developed.

International course on biodiversity inventory and monitoring

Intensive course for postgraduate or advanced undergraduate students in ecology and related disciplines.

This course is integrated with the Neotropical Biodiversity Mapping Initiative (NeoMaps), and will adress the question of how to implement a large scale biodiversity inventory and monitoring program for indicator taxa.

Students will be trained in specific field techniques for sampling two indicator taxa: dung beetles and butterflies. However, the basic concepts and theoretical questions regarding design, planning and large scale implementation are valid for other taxa as well.

- The course will be offered by the Instituto Venezolano de Investigaciones Científicas (IVIC), and is eligible for academic credit.
- The course is intensive and will be held from **3 August to 5 September 2009**.
- Duration: 34 days – 5 days of lectures and practical training at IVIC, in Caracas; 23 days of field work in various locations throughout Venezuela; 6 days processing samples and data analysis at IVIC.
- The course is designed for up to 25 students. We aim to have equal participation of Venezuelan and foreign students. All academic activities will be carried out in Spanish.
- Please contact Ada Y. Sánchez Mercado (**asanchez@ivic.ve**) or J. R. Ferrer Paris (**jferrer@ivic.ve**) for more information on how to participate.
- Applications accepted until **13 March 2009.**

Building conservation capacity for conservation science worldwide

What can’t you do with US$ 20 million?

B-2 stealth bomber

US$ 2.200.000.000 ≈ 100 * US$ 20 million

2004 operating/functional expenditures for major big international NGOs

The Nature Conservancy, US$ 407 million

US$ 20 million = 0.6 months

Wildlife Conservation Society, US$ 144 million

US$ 20 million = 1.7 months

World Wildlife Fund, US$ 126 million

US$ 20 million = 1.9 months

Conservation International, US$ 92 million

US$ 20 million = 2.6 months

International Fund for Animal Welfare, US$ 70 million

US$ 20 million = 3.4 months

World Conservation Union (IUCN), US$ 44 million

US$ 20 million = 5.4 months

Real Madrid 2005

David Beckham, 30 million US$

Ronaldo, 23 million US$

Zinedine Zidane, 15 million US$

What can you do with US$ 20 million?

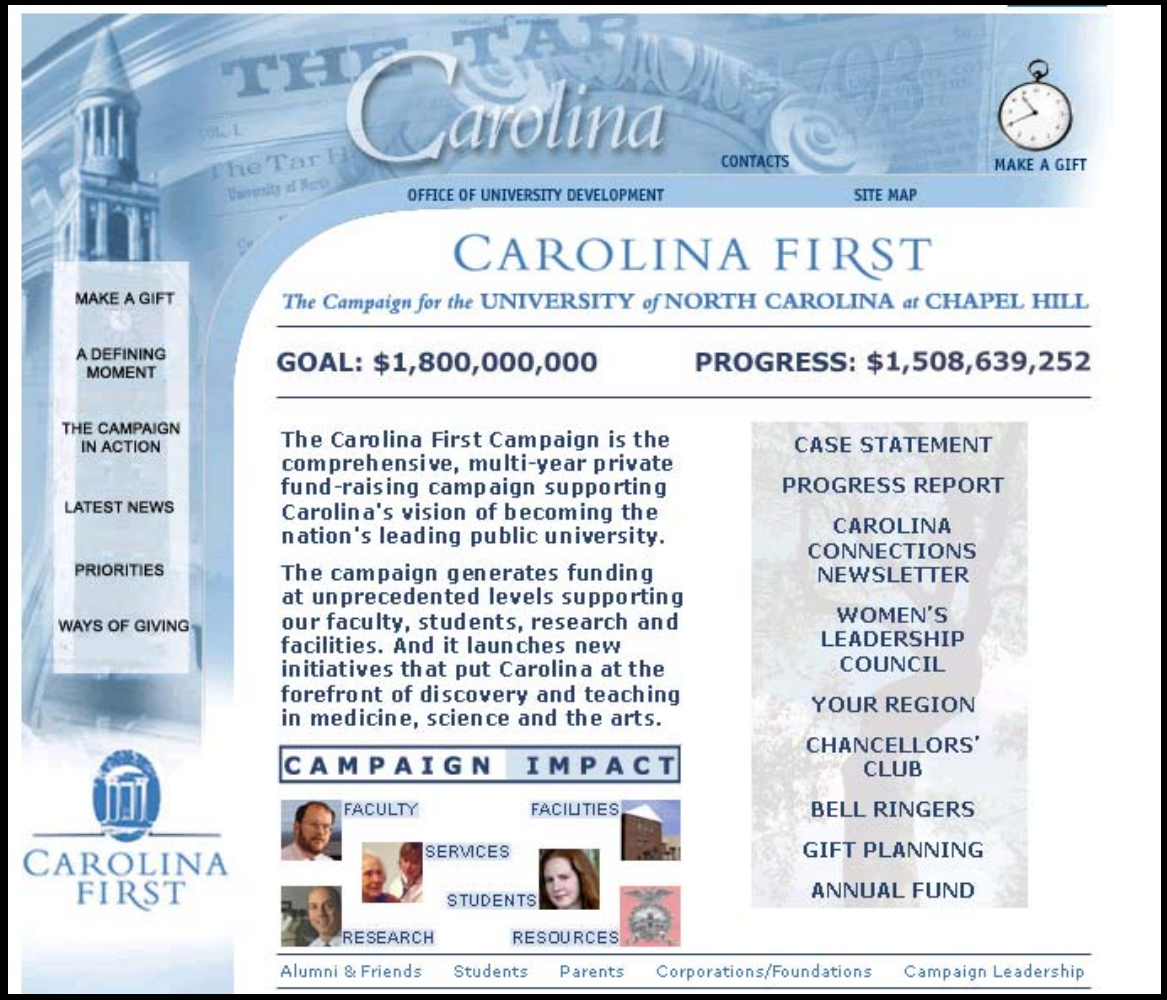
Legacy corporate jet by Embraer

~ US$ 20 million

Millennium Ecosystem Assessment

- > 1,300 authors
- 95 countries
- 14 major global-level reports
- Four-year budget: US$ 17 million + ~ US$ 7 million in in-kind contributions

Endow 20 professorships at US universities



"Endow a Distinguished Professorship … $1 million"

What else can you do with US$ 20 million?

- Provide incentives for the creation of 300 new academic positions in conservation science.
- Organize six short courses per year.
- Fund students' and young professionals' independent research initiatives.

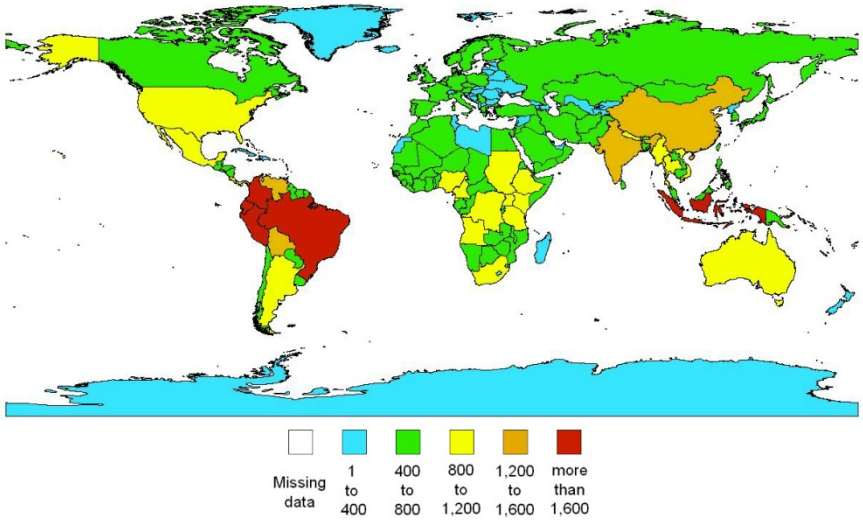
And in 3-5 years change the landscape of conservation science in Austral and Neotropical America (ANA) forever.

Paradox of biodiversity:

species richness ≠ resource richness

species richness ≠ resource richness

Bird Species richness (Avibase, 2005)



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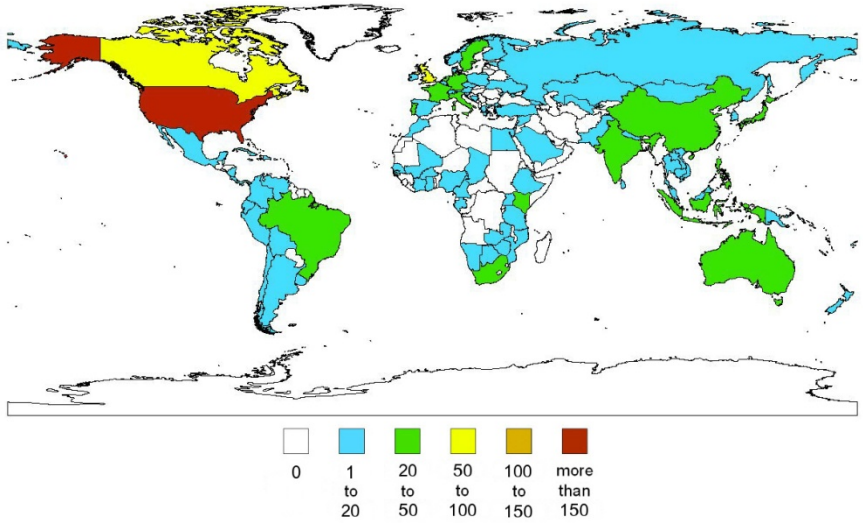
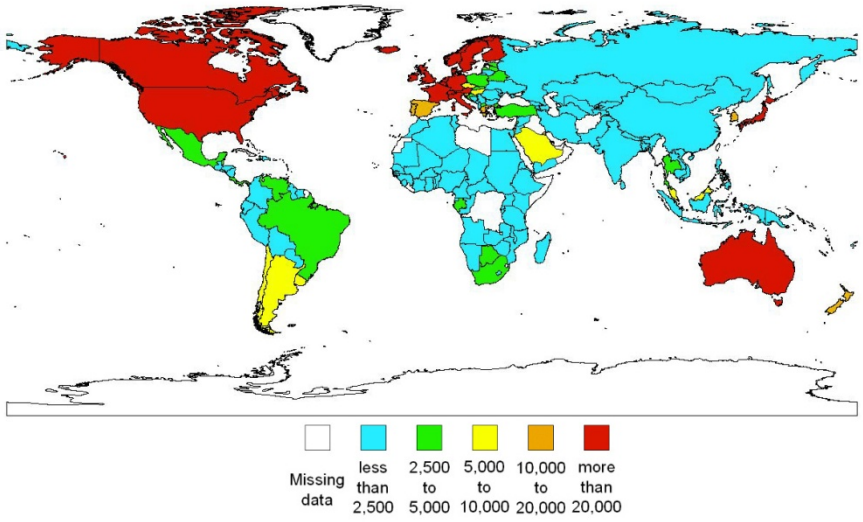


Per capita GDP (World Resources Institute, 2000)



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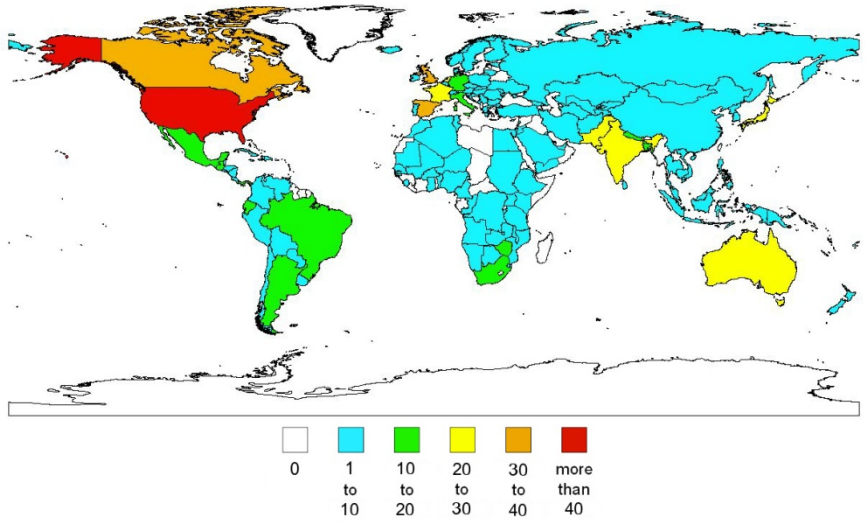

Example: Capacity building in Austral and Neotropical America (ANA)

- How large is the demand for conservation capacity building in ANA?
- How many people are available for the job?
- How much is there to conserve?

The Demand

- Latin American Botanical Network: international conservation biology course (1993-2003).
  - 751 students from 23 countries applied, 5 courses in total.
  - 13% admitted, 19 students in each course.
- Conservation genetics course held in 2004.
  - 107 students from 14 countries.
  - 19% admitted, 20 students.

The Task Force

- Out of 26 countries analyzed, 12 have conservation biology (or related disciplines) academic programs.
- A total of 42 academic programs available in Austral and Neotropical America.

The Road Ahead

- How big should the task force be?
- United States as a reference:
  - 95 academic programs (A)
  - 288 million people (0.329 A/10^6 people)
  - 1,082 species of birds (8.8 A/10^2 bird species)

Scaling by human population and number of species

	Academic programs (A)	People (10^6)	A/10^6 people	Bird species	A/10^2 bird species
United States	95	288	0.329	1,082	8.8
ANA	42	530	0.064	4,000	0.1

For the number of academic programs in ANA to be equivalent to the figure for the United States, there should be:

Per capita: 530*10^6 people * 0.329 A/10^6 people = **174 A**
Per species: 4,000 sp. * 8.8 A/10^2 sp. = **351 A**

Capacity building model

- Offer regular short courses throughout the region (predictable availability is key to career planning).
- Fund projects by students and young professionals (jump-start careers of early conservation biologists).

Short term

- Strengthen academia by facilitating the creation of new positions (multiplying effect).

Long term

Cost of capacity building model

- Short courses
  - Five or six per year, distributed throughout the region, with their locations rotated every year.
  - Competitive admission, participants fully funded.
  - Textbooks written and classes taught in local languages.
  - US$ 35,000/course * 6 courses/year = US$ 210,000/year
- Funds for projects
  - US$ 100,000/year for projects by course participants

Cost of capacity building model

- Expanding the academic network in ANA
  - In 1990s in the US, Pew Charitable Trusts program for development of conservation biology programs
  - 36 universities, US$ 2.3 million (mean = US$ 64,000 each)
- To achieve per capita target: 174-42 = 132 new programs
  - 132 * 64,000 = US$ 8,448,000
- To achieve per species target: 351-42 = 309 new programs
  - 309 * 64,000 = US$ 19,776,000

Cost of capacity building model

- Short courses
  - US$ 210,000/year
- Funds for projects
  - US$ 100,000/year

Three years
~ US$ 1,000,000

- Expanding the academic network
  - US$ 8.5-20 million

Expansion to the rest of the world

- Austral and Neotropical America:
  ~530 million inhabitants.

- To implement capacity building model to the rest of the world it would require ~10 times the funds, or
  ~US$ 200 million.

Is the model financially viable?

- Global Environmental Facility
  - 2002-2004
  - Brazil, Costa Rica, Ecuador, Mexico
  - US$ 140 million for biodiversity related projects
- Global Amphibian Conservation Strategy esimated to require ~US$ 500 million.

There is no alternative.