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International Centre for Theoretical Physics**



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*2 - 18 March 2009*

**Quantitative criteria for the assessment of ecosystem extinction risk**

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# Quantitative criteria for the assessment of ecosystem extinction risk

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Provita*

Workshop on “Theoretical Ecology and Global Change”

ICTP, Trieste, Italy

9 March 2009

# Outline

- Background: IUCN Red List categories for species.
- Quantitative criteria for assessing extinction risk of terrestrial ecosystems.
- Case studies.
- Future directions.

(Primarily Venezuelan examples)

## Red Lists and Red Data Books of Threatened Species

- International Union for Conservation of Nature (IUCN) maintains threatened species lists since 1950s.
- “Red Data Books” popularized in 1960s: birds & mammals.
- “Information explosion” in 1990s:
  - Europe: 3,562 known red lists.
  - 99 countries have produced RL for at least one taxon.

# IUCN Red List

## <http://www.iucnredlist.org/>



The IUCN Red List of Threatened Species™

2008

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Enter Red List search term(s)  [OTHER SEARCH OPTIONS](#)

**HELP  
SAVE  
SPECIES  
NOW!**

LEAST CONCERN LC

NEAR THREATENED NT

VULNERABLE VU

**<ENDANGERED> EN**

CRITICALLY ENDANGERED CR

EXTINCT IN THE WILD EW

EXTINCT EX



**Rabbits at risk in home range**  
05 March 2009 — In some parts of the world they thrive, to the extent they are regarded as pests, yet in their native range on the Iberian Peninsula rabbits are Near Threatened with extinction, according to The IUCN Red List of Threatened Species. Their decreasing numbers have also had alarming impacts on the Critically Endangered Iberian Lynx and the Spanish Imperial Eagle. [more](#)



**Quarter of antelope species in danger of extinction**  
05 March 2009 — A quarter of all antelope species are threatened with extinction, according to the IUCN Red List of Threatened Species. [more](#)



**Delete? French artist offers to work with IUCN to save species**  
02 March 2009 — French wildlife artist Thierry Bisch is developing a project with IUCN to deliver a powerful message about the need to protect threatened species. [more](#)



**Box turtles face knockout as Indonesian traders export 100 times quota**  
27 February 2009 — Unregulated trade-at 10 to 100 times legal levels-has caused Southeast Asian Box Turtles almost to vanish from parts of Indonesia, where once they were common, according to a new report by TRAFFIC, the wildlife trade monitoring network. [more](#)



**TREE HOLE CRAB**  
*Globonautes macropus*  
© Neil Cumberlidge

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© International Union for Conservation of Nature and Natural Resources.



Species Survival Commission

# IUCN Red List

<http://www.iucnredlist.org/>

| <b>Taxon</b> | <b>2008</b>   |
|--------------|---------------|
| Mammals      | 1,141         |
| Birds        | 1,222         |
| Reptiles     | 423           |
| Amphibians   | 1,905         |
| Fishes       | 1,275         |
| Insects      | 626           |
| Mollusks     | 978           |
| Plants       | 8,457         |
| ...          | ...           |
| <b>Total</b> | <b>16,928</b> |

# IUCN Red List Categories

**Extinct**

**Extinct in the wild**

**Critically endangered**

**Endangered**

**Vulnerable**

**Near threatened**

**Least concern**

**Data deficient**

**Not evaluated**

} ***Threatened***

## 1990s: major paradigm shift

- Species assigned to categories on the basis of quantitative criteria and thresholds.
- Separation of **risk assessment** (scientific exercise) from definition of **conservation priorities** (societal process).

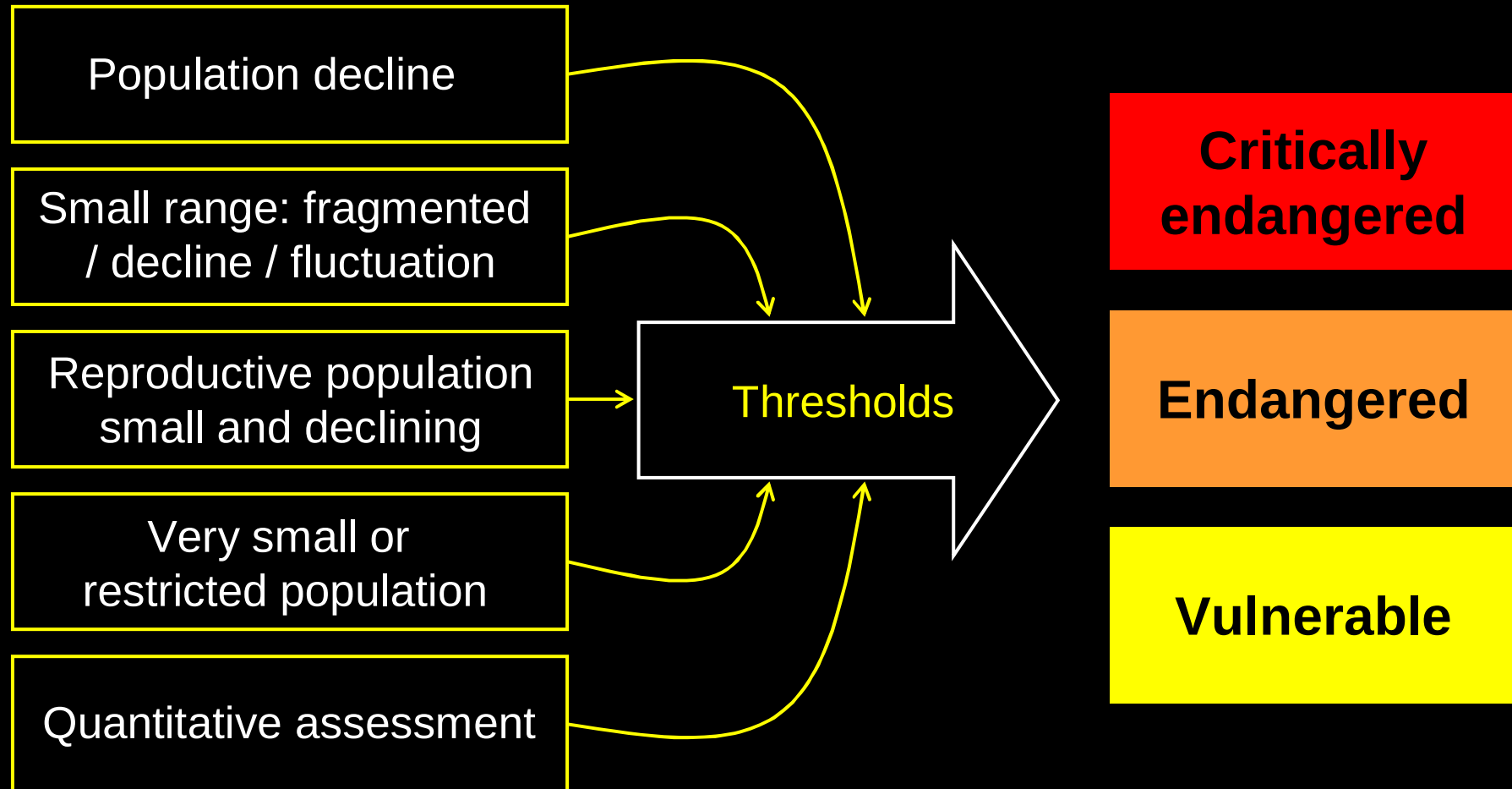


Georgina M. Mace

# Quantitative criteria: new categories for IUCN red lists



Russell S. Lande



# Conservation Priorities

**Extinction Risk**

**Distributional Factors**

**Biological Factors**

**Societal Values**

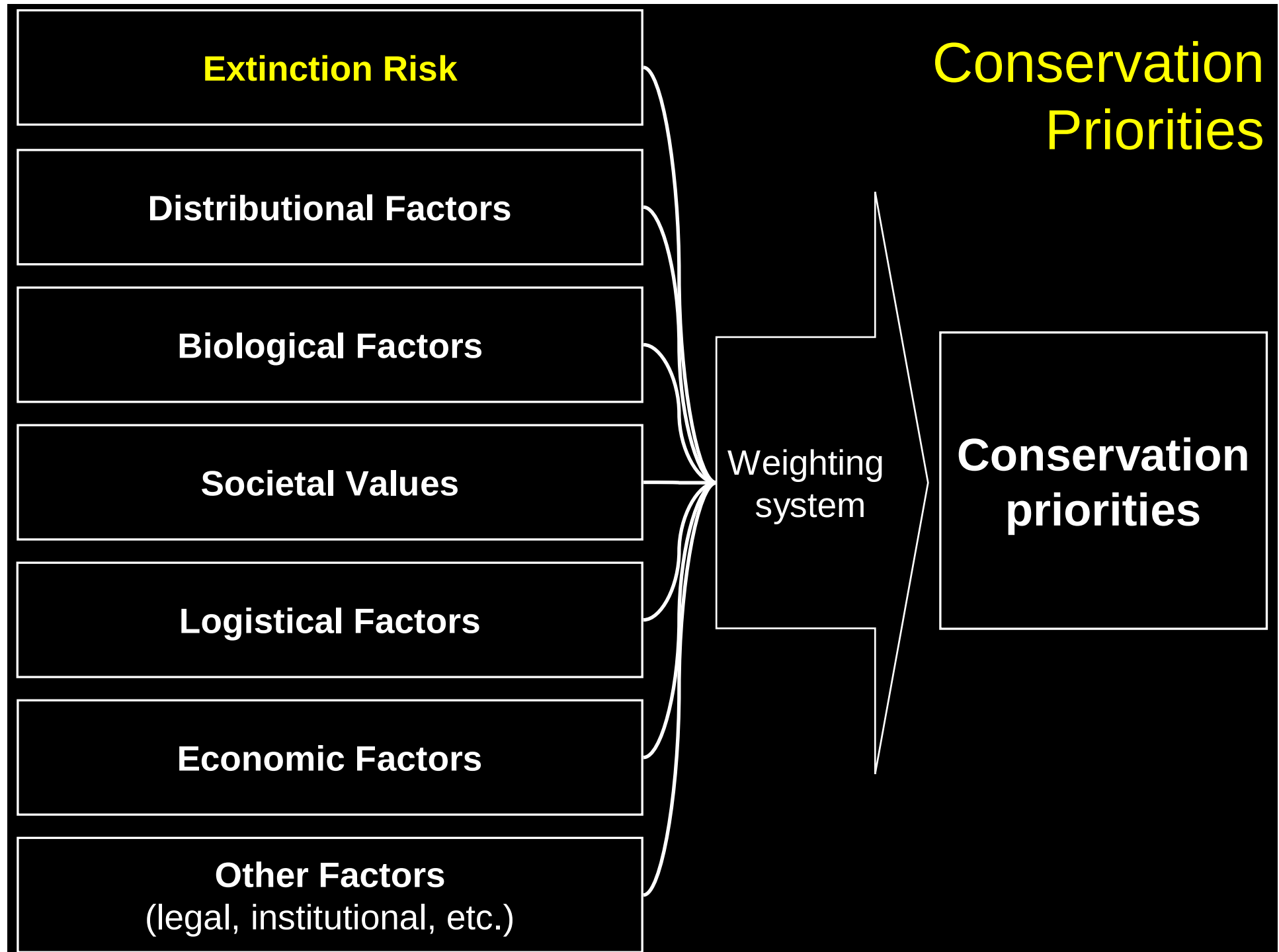
**Logistical Factors**

**Economic Factors**

**Other Factors**  
(legal, institutional, etc.)

Weighting  
system

**Conservation  
priorities**



# Extinction risk vs. conservation priorities



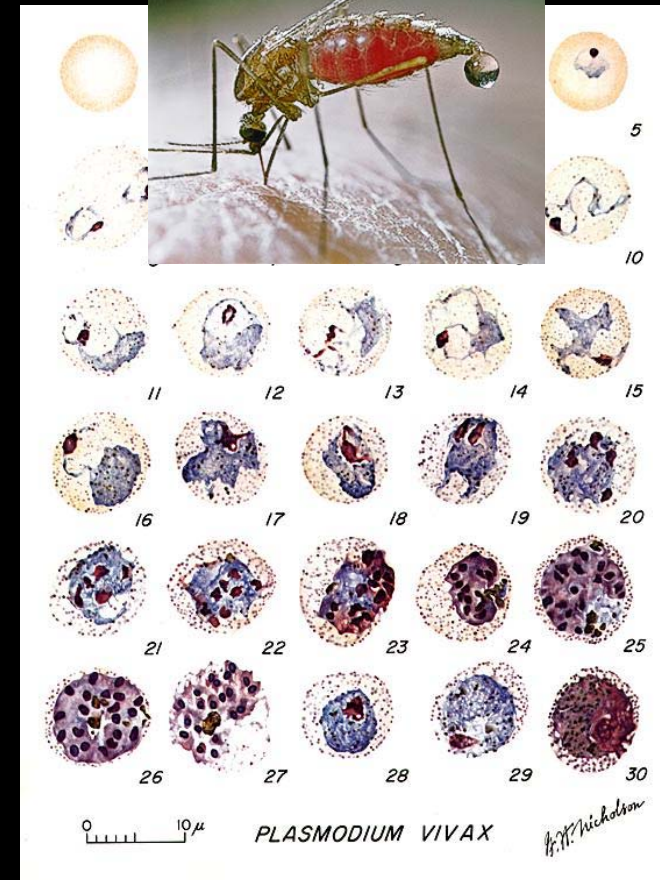
<http://www.kingsnake.com/westindian/icterus/icterusridgwayi2.JPG>

**Least Concern**

Troupial  
*Icterus icterus*



*Anopheles* sp.



<http://pathmicro.med.sc.edu/parasitology/mai8.jpg>  
<http://ucce.ucdavis.edu/files/filelibrary/5434/19394.jpg>

# Global impact of red lists

“Change in status of threatened species.”



Convention on  
Biological Diversity

Indicator for Assessing Progress towards the 2010 Biodiversity Target: “... achieve, by 2010, a significant reduction in the rate of biodiversity loss.”



UN Millennium  
Development Goals

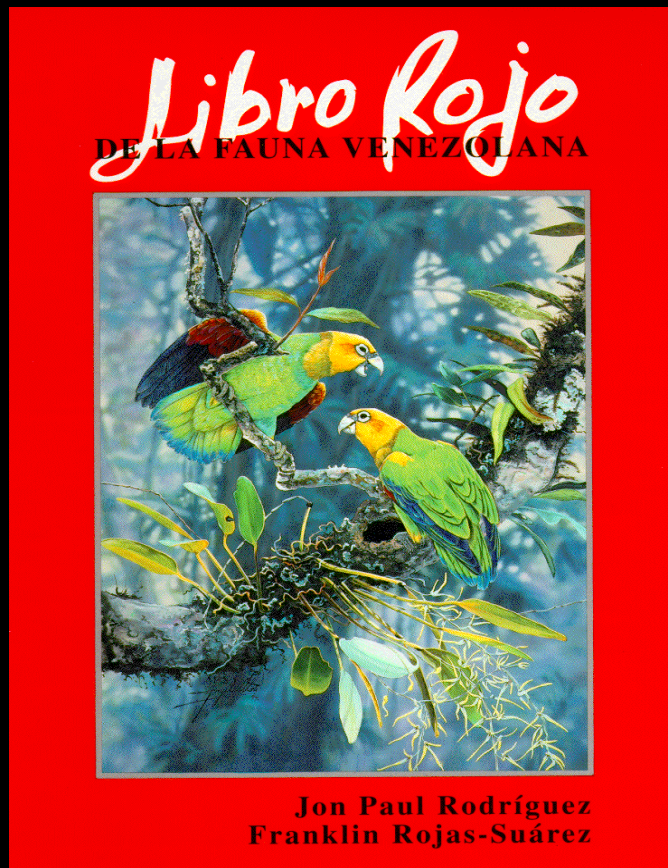
keep the promise  
Millennium Development Goals



**MDG 7:** “Ensure environmental sustainability:  
... reverse loss of environmental resources.” (by 2015)

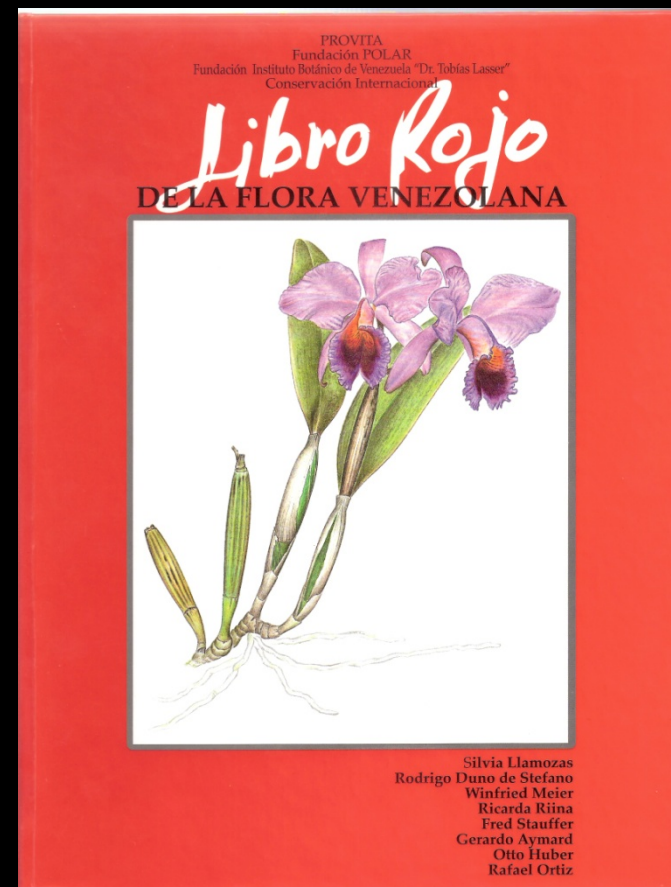
# National Impact of Red Data Books

## Fauna



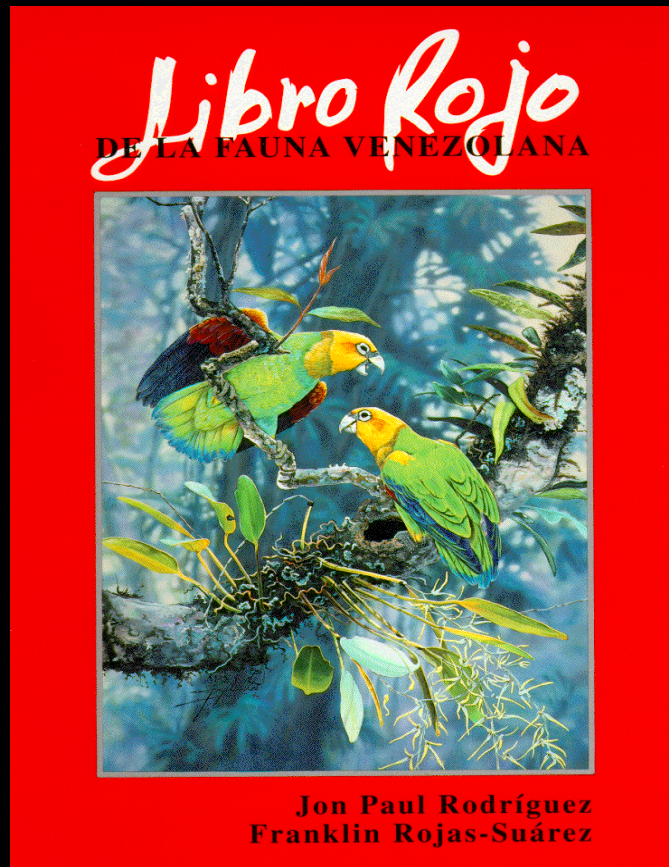
(1995, 1999, 2003)

## Flora



(2003)

# Impact of Fauna Red Book



- Threatened species decree, 1996.
- Best book for a general audience, 1996.
- One of the 63 most influential books in the last 63 years, *El Nacional*, 2006.

2008

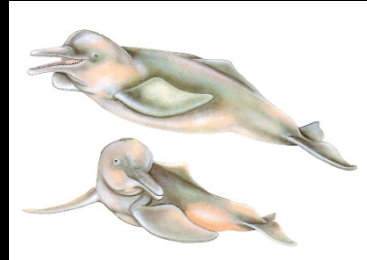


# Libro Rojo

de la fauna venezolana

Jon Paul Rodríguez  
Franklin Rojas-Suárez

# Threatened species in our hands (and pockets)



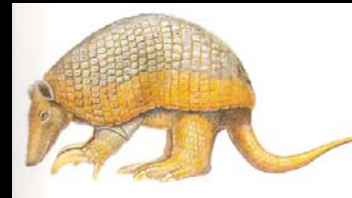
p. 43



p. 55



p.403



p. 327



p. 441



p. 51



Armando Hernández  
Fundación Polar  
(2000)

“We now have Red Data Books for  
Fauna and Flora, why don’t we do one  
for ecosystems?”

# Seven years later ...

Biodivers Conserv (2007) 16:183–209  
DOI 10.1007/s10531-006-9102-1

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ORIGINAL PAPER

## **Assessing extinction risk in the absence of species-level data: quantitative criteria for terrestrial ecosystems**

**Jon Paul Rodríguez · Jennifer K. Balch ·  
Kathryn M. Rodríguez-Clark**



Jennifer K. Balch



Kathryn M.  
Rodríguez-Clark



## Other main participants

- Irene Zager, IVIC and Provita.
- Fabián Carrasquel, Provita.
- Alix Amaya, Provita.
- Carlos Portillo, LUZ, IVIC and Provita.
- Pablo Lacabana, Provita.
- Sergio Zambrano, IVIC.
- José Rafael Ferrer-Paris, IVIC.

## Objective

Design a process for assessing **extinction risk** of ecosystems that is objective, transparent and repeatable, analogous to IUCN's Red List Categories and Criteria for species.

Separate determination of **extinction risk** from definition of **conservation priorities**.

# Motivation for a “Red List” categories system for ecosystems

- Abundant experience with Red List categories for species. Red list “explosion” world-wide (> 100 countries have applied them).
- Increased capability of geographical information systems:
  - more powerful and inexpensive computers.
  - cheaper and more user-friendly software packages.

# Motivation for a “Red List” categories system for ecosystems

- Increased availability of remotely-sensed data, covering 20-40 years.
- Existing threatened ecosystem classification systems **confound risk assessment and priority setting**.

## What measures and what does not measure extinction risk?

- **Does:** “observed, estimated, inferred or suspected” decline in distribution and/or abundance.
- **Does not:**
  - Degree of protection (national parks, reserves, etc).
  - Biological uniqueness.
  - Patterns of endemism.
  - Ecological integrity (presence of invaders, levels of pollution, lack of regeneration).

# Red List Categories for Ecosystems

(Rodríguez, Balch and Rodríguez-Clark, 2007)

- **Four quantitative criteria:**
  - Criterion A: Reduction of the land cover and continuing threat
  - Criterion B: Rapid rate of land cover change
  - Criterion C: Increased fragmentation
  - Criterion D: Very small geographical distribution
- **Eight categories:**
  - Extinct
  - Critically endangered, endangered, vulnerable (*threatened*)
  - Near threatened, data deficient, least concern, not evaluated.

# Assigning risk categories

Reduction of land cover and  
continuing threat

and / or

Rapid rate of land cover change

and / or

Increased fragmentation

and / or

Very small geographical  
distribution

**CRITERIA**

QUANTITATIVE  
THRESHOLDS

“quantitative” categories

**Critically Endangered**

**Endangered**

**Vulnerable**

“qualitative” categories

**Not evaluated**  
**Near threatened**  
**Data deficient**  
**Least concern**

# Criterion A: Reduction of the land cover and continuing threat

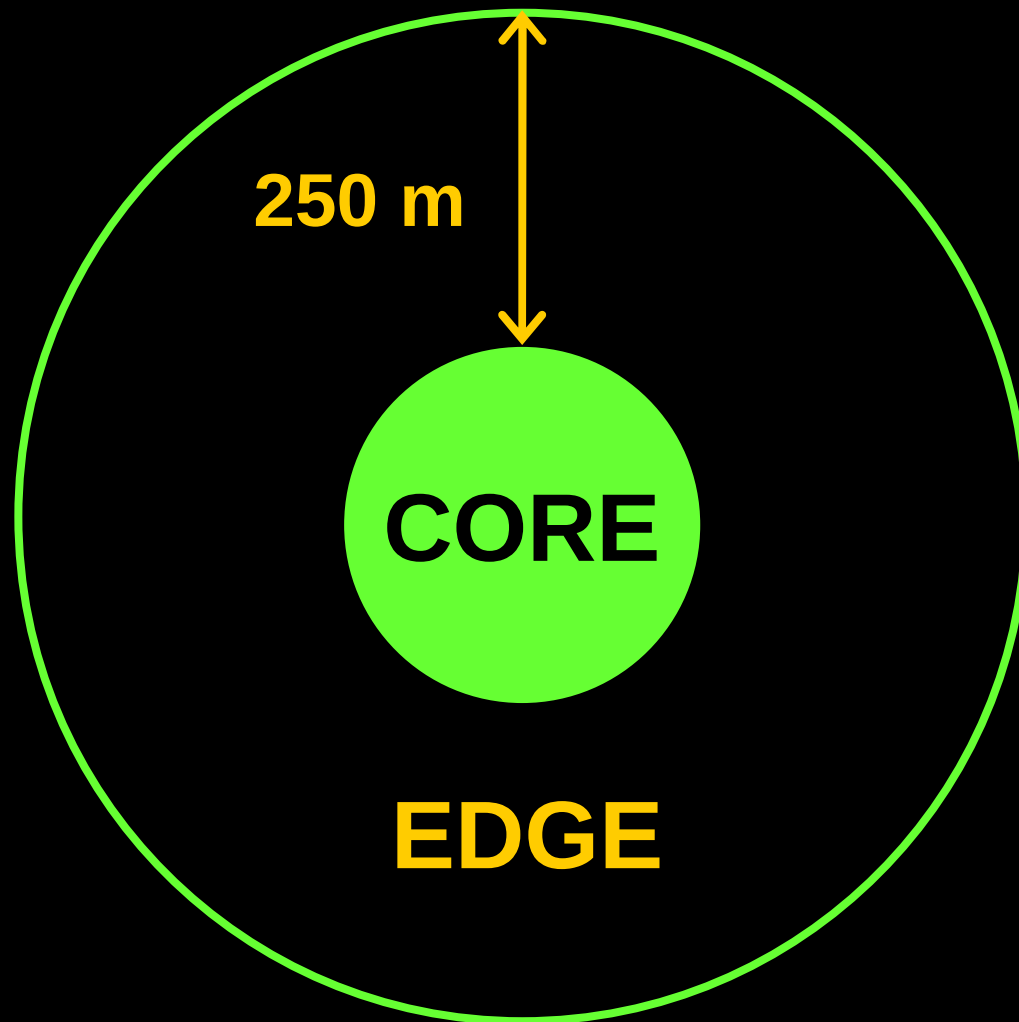
| Category              | Quantitative threshold                                                                                  |
|-----------------------|---------------------------------------------------------------------------------------------------------|
| Critically Endangered | Reduction of >90% of the original extent of the ecosystem, and evidence that the threat has not ceased. |
| Endangered            | >70%                                                                                                    |
| Vulnerable            | >30%                                                                                                    |

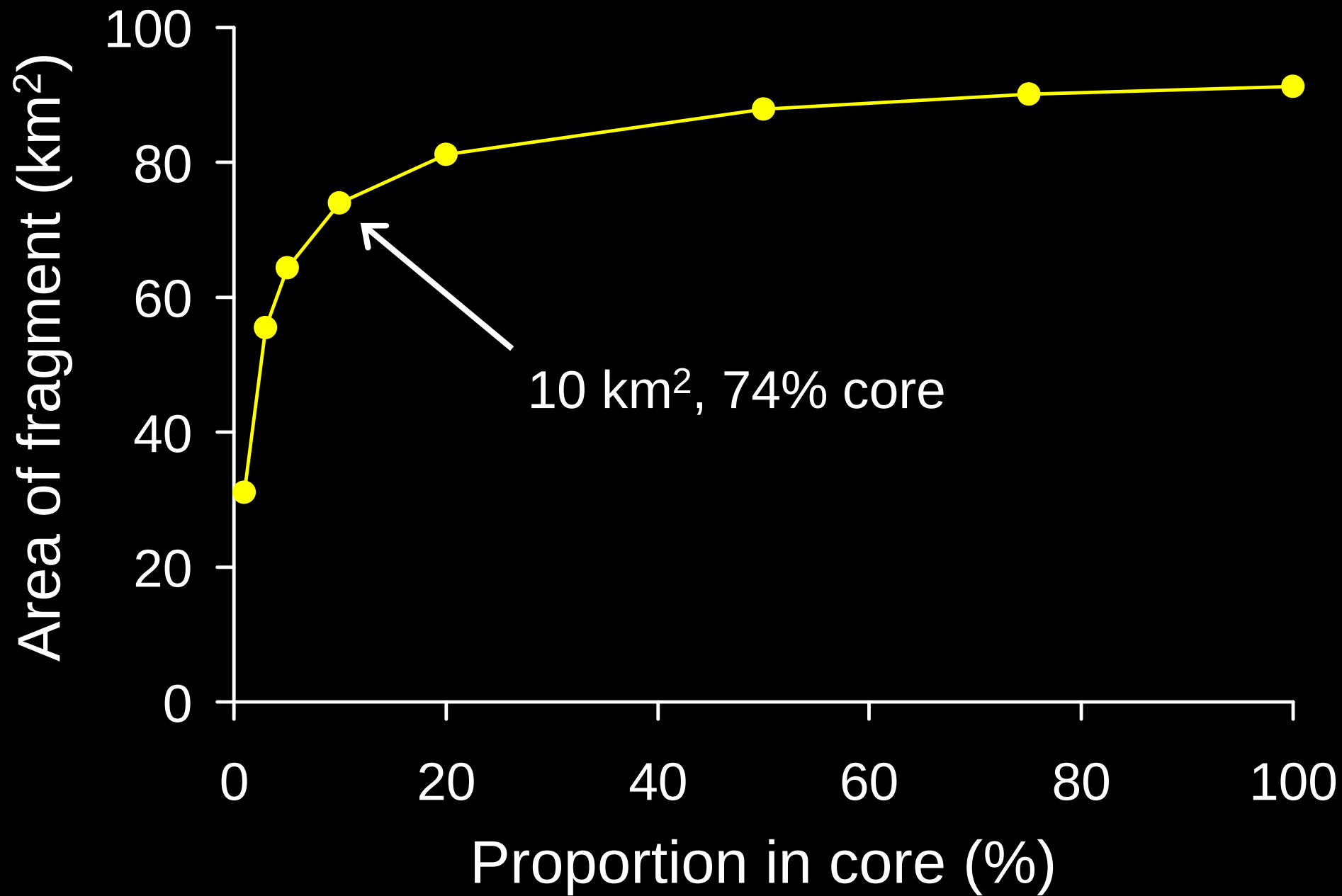
## Criterion B: Rapid rate of land cover change

| Category              | Quantitative threshold                                                                          |
|-----------------------|-------------------------------------------------------------------------------------------------|
| Critically Endangered | Reduction of >90% of the original ecosystem over the last 30 years or within the next 30 years. |
| Endangered            | >70%                                                                                            |
| Vulnerable            | >30%                                                                                            |

# Criterion C: Increased fragmentation

| Area of fragments                          | Connectivity of fragments                                                    |                                                                   |                                                                   |
|--------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|
| If > 90% in fragments < 10 km <sup>2</sup> | and > 90% of fragments > 1 km from nearest neighbor<br>Critically endangered | and > 70% of fragments > 1 km from nearest neighbor<br>Endangered | and > 30% of fragments > 1 km from nearest neighbor<br>Vulnerable |
| If > 70% in fragments < 10 km <sup>2</sup> | and > 90% of fragments > 1 km from nearest neighbor<br>Endangered            | and > 70% of fragments > 1 km from nearest neighbor<br>Vulnerable |                                                                   |
| If > 30% in fragments < 10 km <sup>2</sup> | and > 90% of fragments > 1 km from nearest neighbor<br>Vulnerable            |                                                                   |                                                                   |





## Criterion D: Very small geographical distribution

| Category              | Quantitative threshold                                                                                       |
|-----------------------|--------------------------------------------------------------------------------------------------------------|
| Critically Endangered | Entire original geographical distribution of the ecosystem is comprised of one fragment < 10 km <sup>2</sup> |
| Endangered            | three or fewer fragments < 10 km <sup>2</sup>                                                                |
| Vulnerable            | ten or fewer fragments < 10 km <sup>2</sup>                                                                  |

## Scale and the proposed system

- Since categories are assigned on the basis of extinction risk, they may be applied **at multiple spatial scales**.
- May be applied to **natural divisions** of space (ecosystem types, watersheds), **human constructs** (states, municipalities) or fully **arbitrary units** (grid cells).

## Extinction risk of selected ecosystems of the world

- Kalimantan lowland forest CR
- Brazilian Atlantic forest CR
- Dry forests Margarita Island (Ven) VU
- Dry forests Guasare watershed (Ven) CR
- Mato Grosso's tropical dry forests (Bra) VU
- South African Grasslands VU





1979

1981



1986



1996



2008



BBC Mundo.com, 3 January 2003

*2002 y sus protagonistas*

Saddam  
Hussein  
4 %

George W.  
Bush  
26 %

Hugo  
Chávez  
52 %



Ronaldo  
11 %

Lula  
7 %

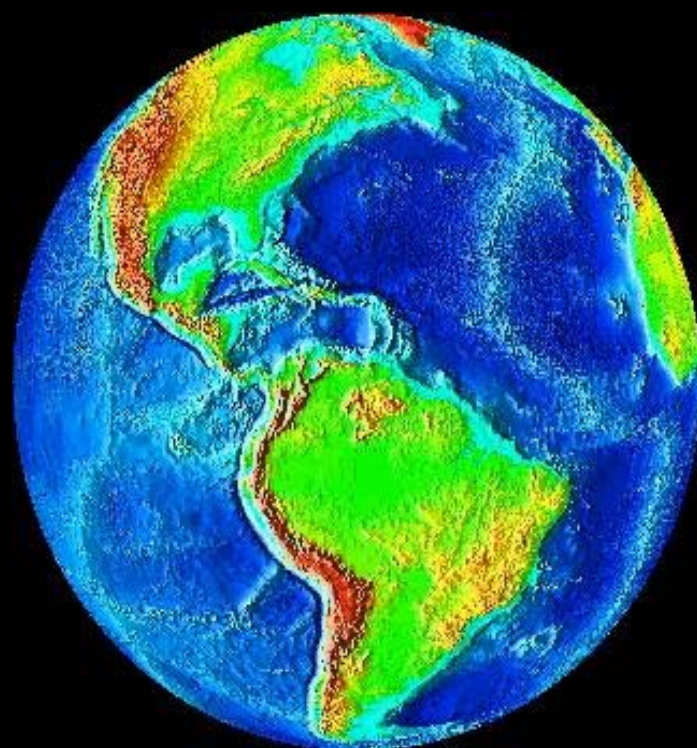
17,132 voters

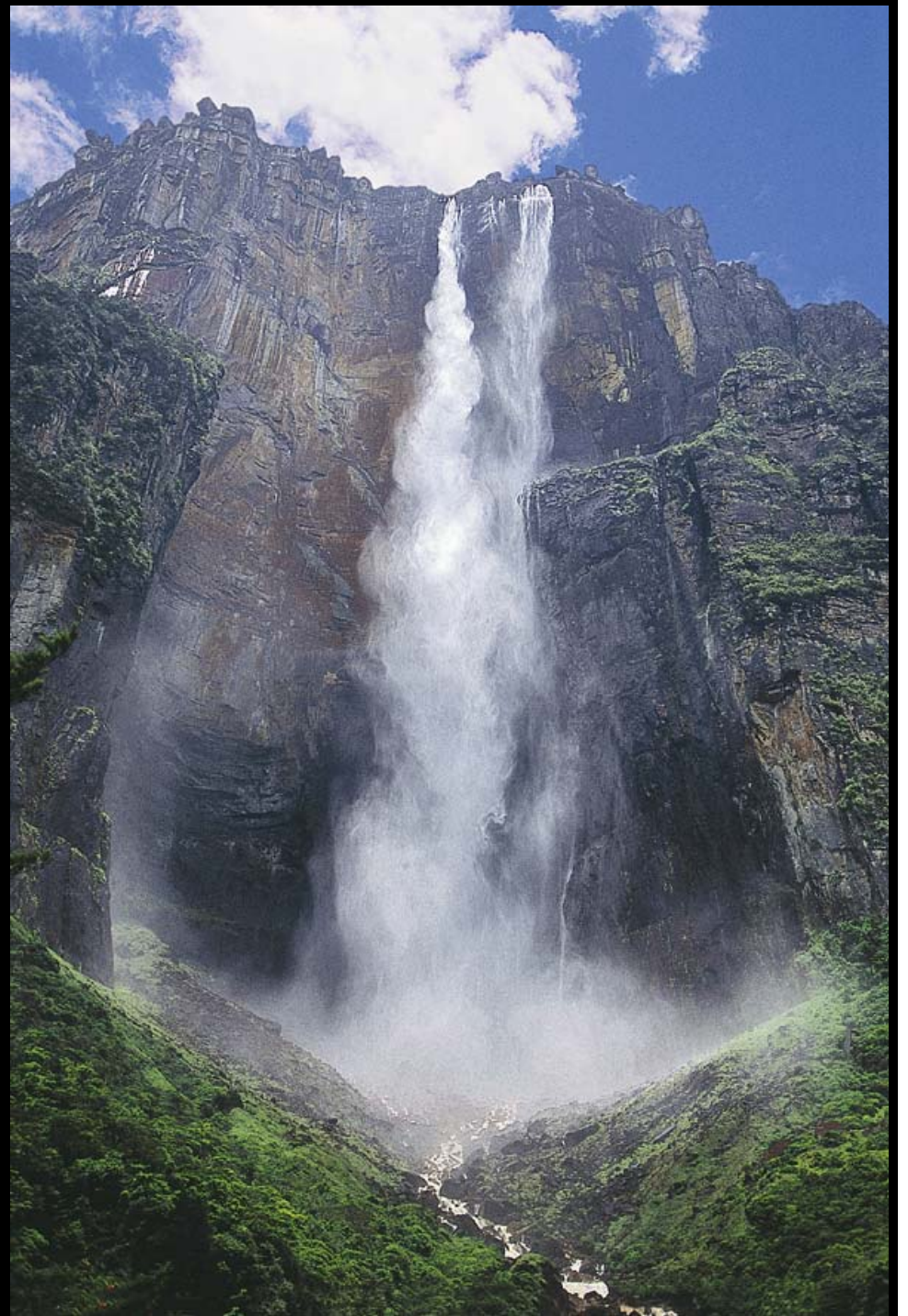
# Venezuela: megadiversity country

(in less than 1% of landmass of the world)



|               | Known species | Proportion of world |       |
|---------------|---------------|---------------------|-------|
|               | World         | Venezuela           | total |
| Higher plants | 260,000       | 25,000              | 8 %   |
| Amphibians    | 4,000         | 202                 | 5 %   |
| Reptiles      | 6,550         | 259                 | 4 %   |
| Birds         | 9,672         | 1340                | 13 %  |
| Mammals       | 4,327         | 323                 | 7 %   |











# Risk assessment for terrestrial ecosystems of northern Venezuela

- Two satellite images:  
1986 and 2001
- Landcover types:
  - evergreen forest
  - semi deciduous forest
  - deciduous forest
  - grasses / burnt / bare land
  - cultivated
  - urban
- Scales of analysis:
  - Entire region (~6.500 km<sup>2</sup>)
  - States (6)
  - Municipalities (29)
  - 10 x 10 km<sup>2</sup> grid
- Analyses:
  - % change 1986 to 2001:  
Criterion A.
  - % remaining next 30 yr:  
Criterion B.

## Mapa Político de Venezuela

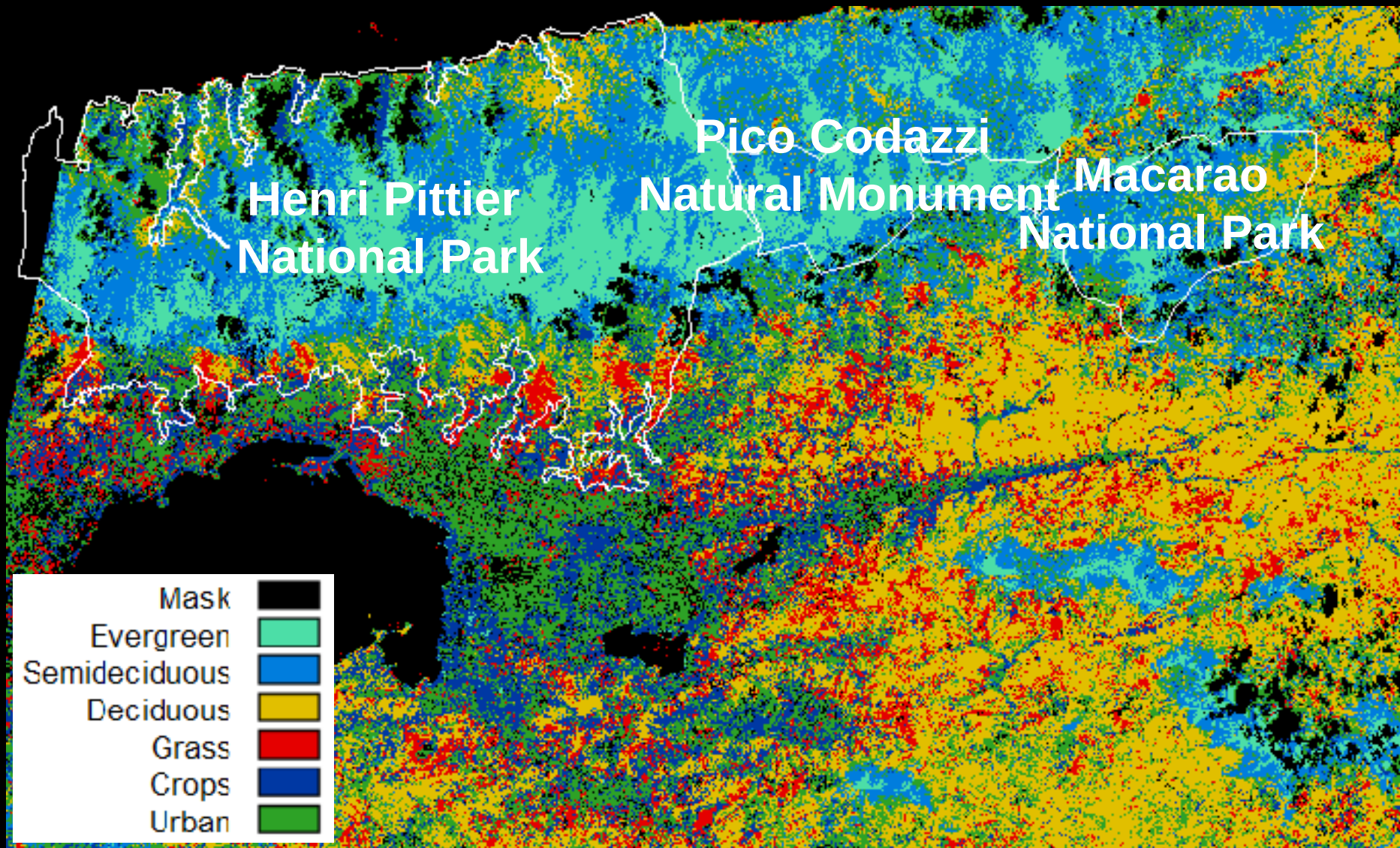


Fuente Cartográfica: Instituto Geográfico de Venezuela Simón Bolívar IGVSb, edición 3, 2001, escala 1:2.500.000.  
 Zambrano, S., E. Tapiquén, M. Armas y R. Lazo. 2004. Venezuela Digital. En: Rodríguez, J.P., R. Lazo, L.A. Solórzano y F. Rojas-Suárez (eds.). Centro Internacional de Ecología Tropical (CIET), Instituto Venezolano de Investigaciones Científicas (IVIC), UNESCO, Conservación Internacional Venezuela. Caracas, Venezuela. Disponible en Internet: <http://ecosig.ivic.ve>.

## Study region:

- Located between the cities of Maracay and Caracas.
- Part of six states.
- Encompasses two national parks and one natural monument.

# Terrestrial ecosystems of northern Venezuela (2001)



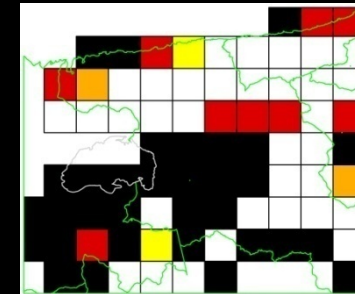
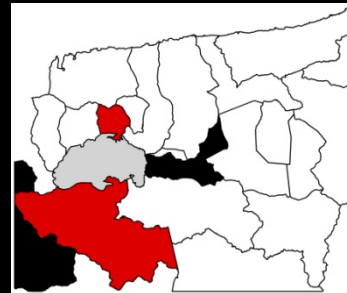
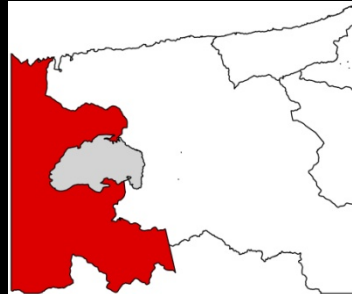
## Results: forests over the entire study area

| Forest type       | % change<br>1986 to 2001 | Category<br>(criterion A) | % remaining<br>next 30 yr | Category<br>(criterion B) |
|-------------------|--------------------------|---------------------------|---------------------------|---------------------------|
| Evergreen         | - 3                      | Least<br>concern          | 94                        | Least<br>concern          |
| Semi<br>deciduous | - 13                     | Least<br>concern          | 70                        | <b>Vulnerable</b>         |
| Deciduous         | - 30                     | <b>Vulnerable</b>         | 16                        | <b>Endangered</b>         |

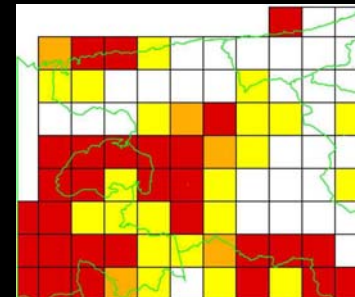
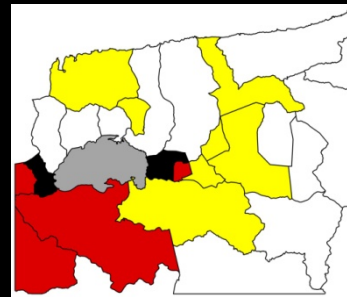
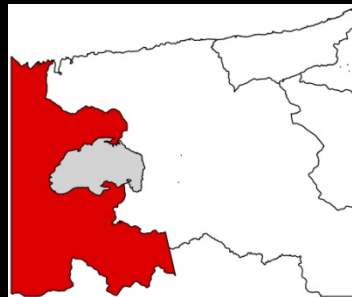
Between 1986 and 2001,  
urban + grasses / burnt / bare land **increased 69%**

# Results: forests at other spatial scales

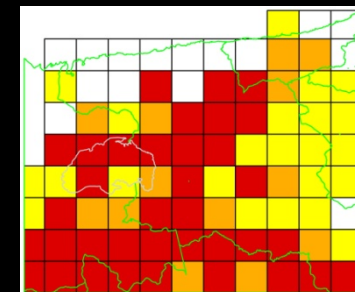
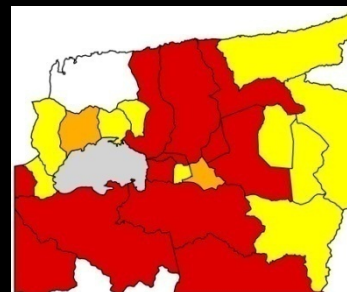
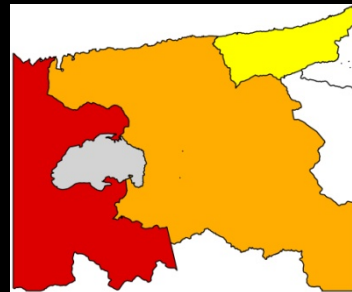
Evergreen forest



Semi deciduous forest



Deciduous forest



States

Municipalities

100 km<sup>2</sup> grid

EX

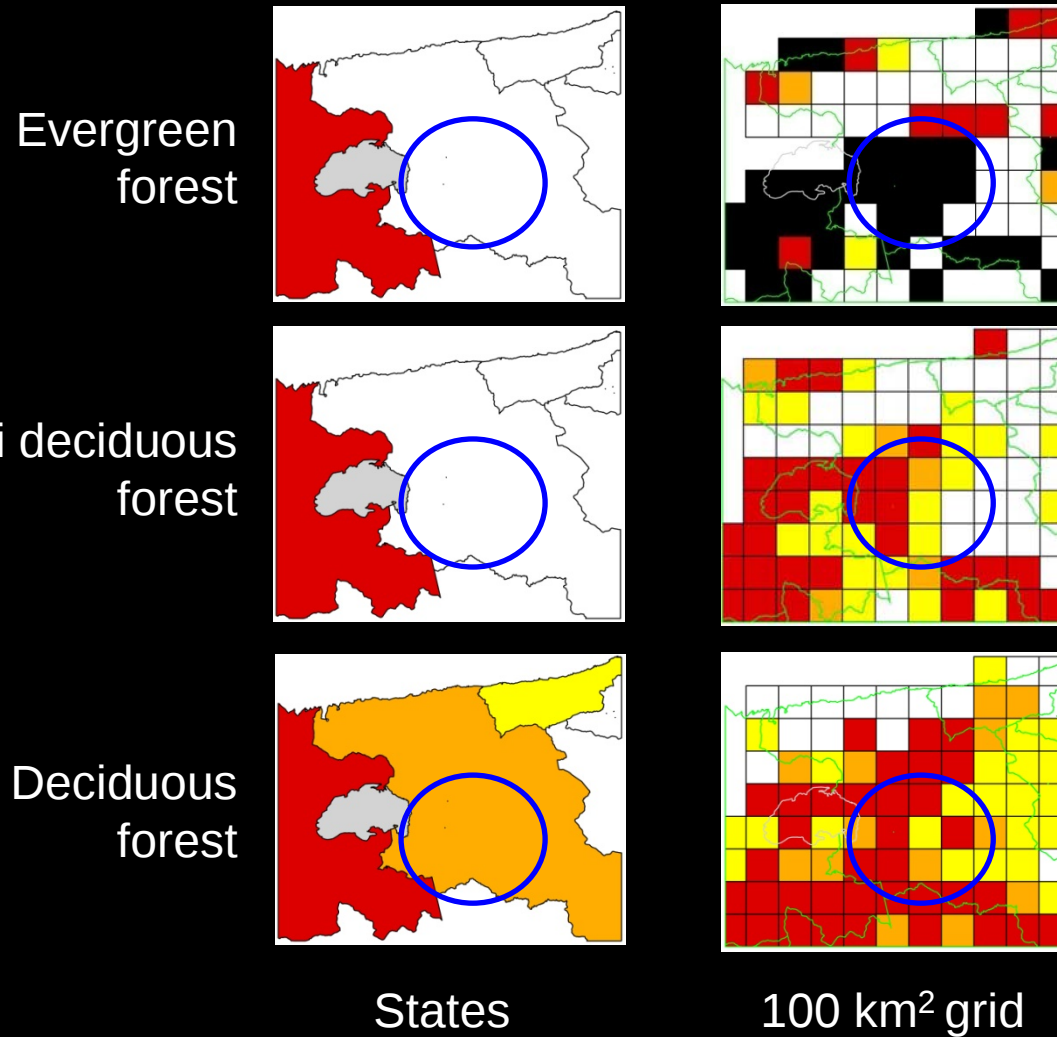
CR

EN

VU

LC

# Results: forests at other spatial scales

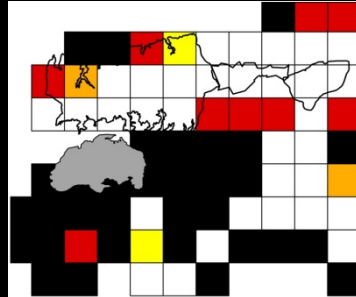


- Risk increases as area decreases, but not equally among forest types (> Evergreen and Semi deciduous)

□ EX    ■ CR    ■ EN    ■ VU    ■ LC

# Extinction risk and protected areas

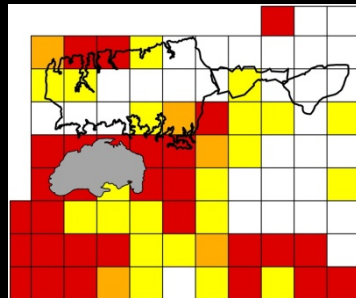
Evergreen forest



LC

- Risk levels reflect past conservation action (protected areas: Evergreen and Semi dec.).

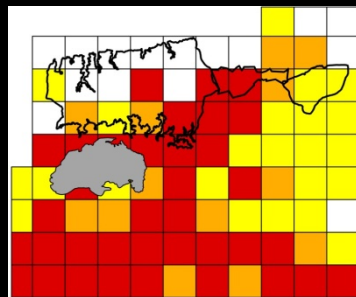
Semi deciduous forest



LC

- Lower risk for Deciduous in PA, but still threatened.

Deciduous forest



VU

EX

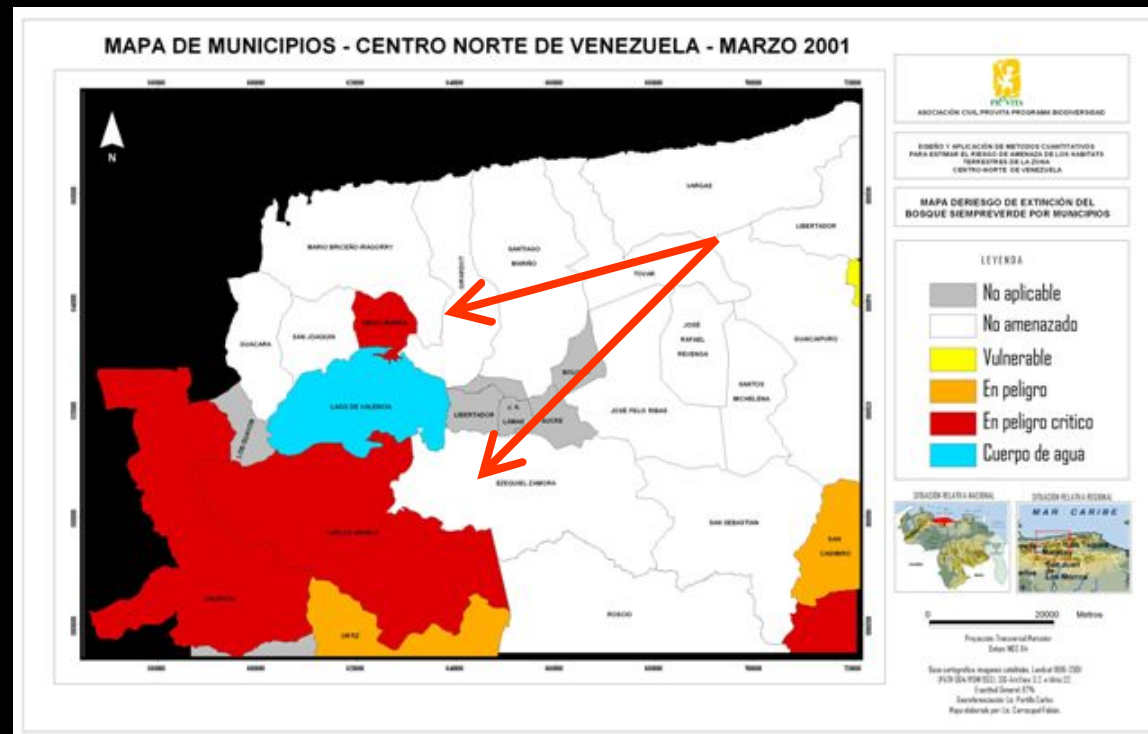
CR

EN

VU

LC

# Should the municipalities of Diego Ibarra and Carlos Arvelo invest in evergreen forest conservation?



- They started out with relatively small evergreen forests.
- Large forest tracts still remain in the region (especially in parks).

Should the municipalities of Diego Ibarra and Carlos Arvelo invest in evergreen forest conservation?

Probably not.

The evergreen forests that they have, although **critically endangered**, are **not of regional or global significance**, and **similar ecosystems are well protected** nearby. At level of the study area, they are considered **least concern**.

Should municipal and state governments of the region invest in deciduous forest conservation?

Probably yes.

## Should municipal and state governments of the region invest in deciduous forest conservation?

- Dry tropical forests are among the most threatened ecosystems in the world.
- They are **EN** at the level of the study region.
- They are **CR** in two states, **EN** in another, and **VU** in two more.
- They are *threatened* (**CR**, **EN** or **VU**) in 27 of 29 counties – 93%.
- Even within protected areas in the study region, they are *threatened* (**VU**).

Should municipal and state governments of the region invest in deciduous forest conservation?

Probably yes. But conservation efforts must be coordinated among states and municipalities, or even nationally and internationally as well.

And investment decisions should consider risk, but also take into account other factors such as biological uniqueness, global importance, legal and logistical context, and the public's preferences.

# Climate change and ecosystem movement

Temperature increase



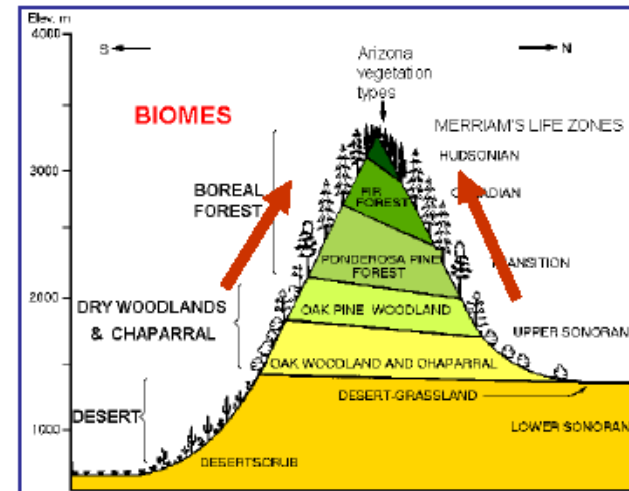
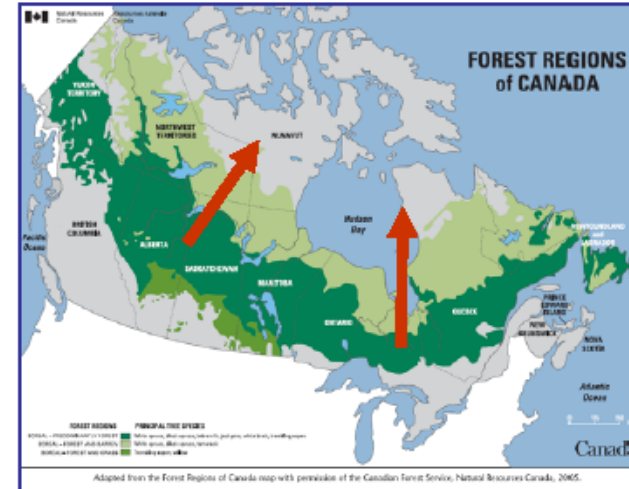
Latitudinal / altitudinal displacement



Reduction and fragmentation

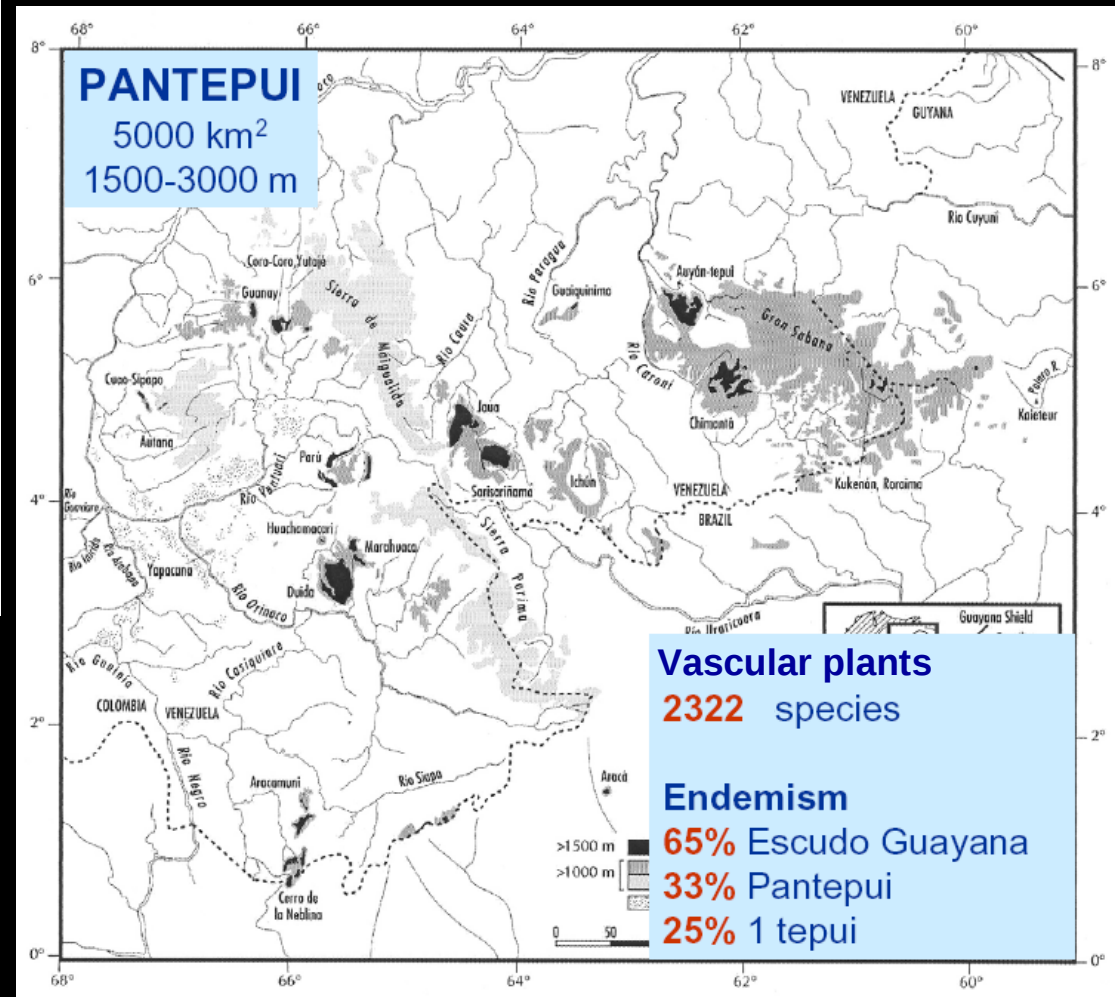
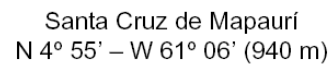


Biodiversity loss

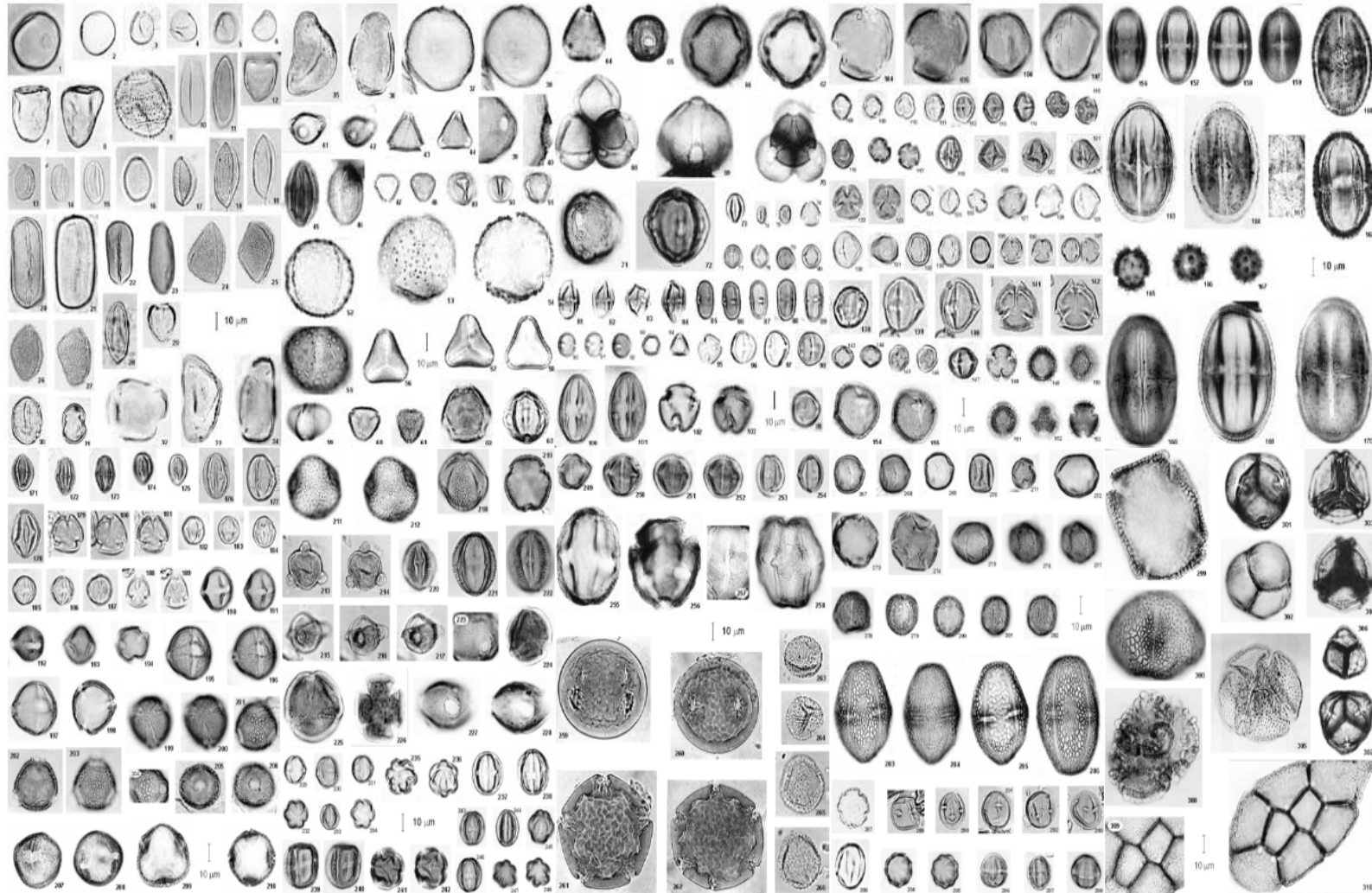




© Valentí Rull

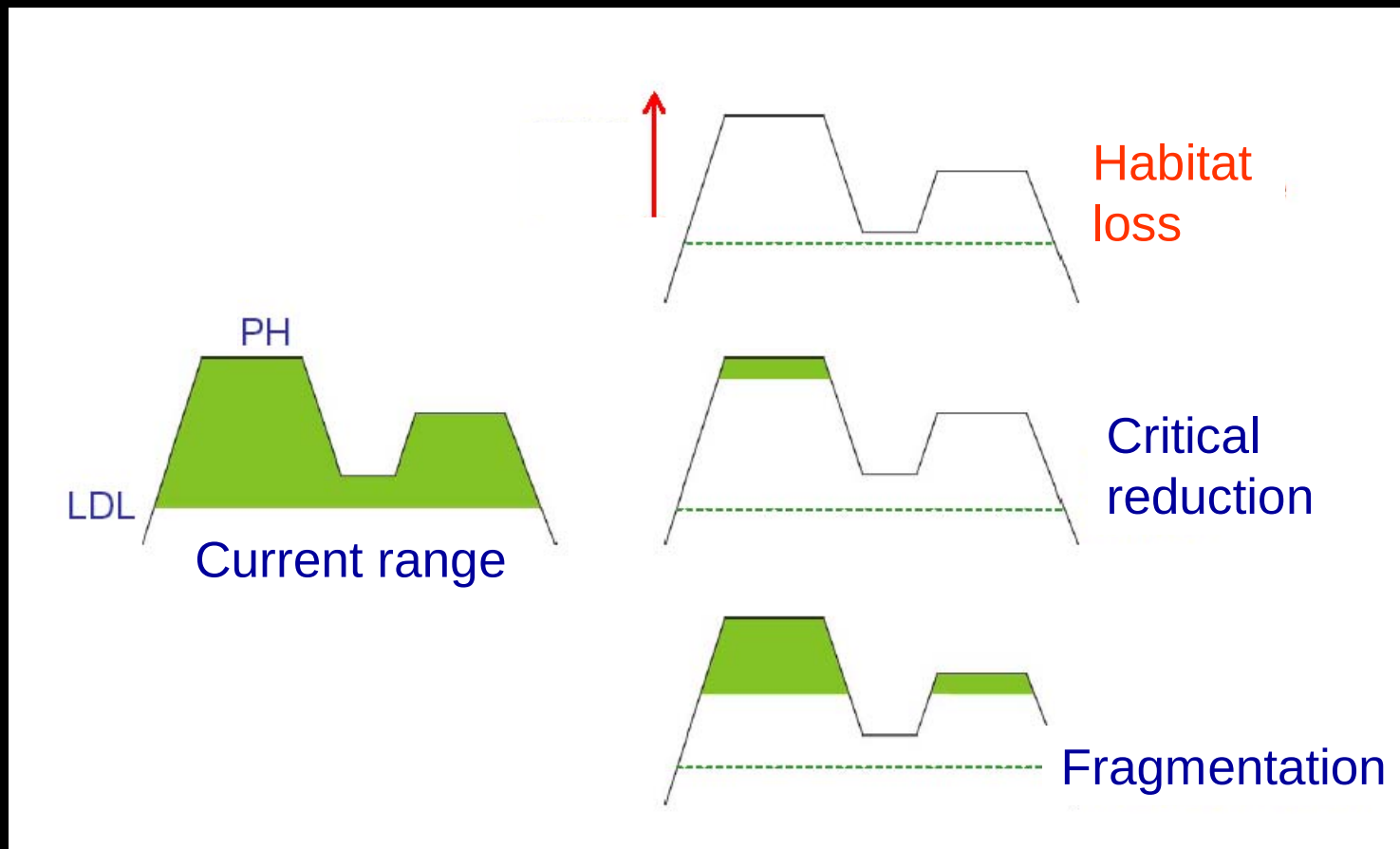


## Clave ilustrada del polen de la Gran Sabana y Pantepui

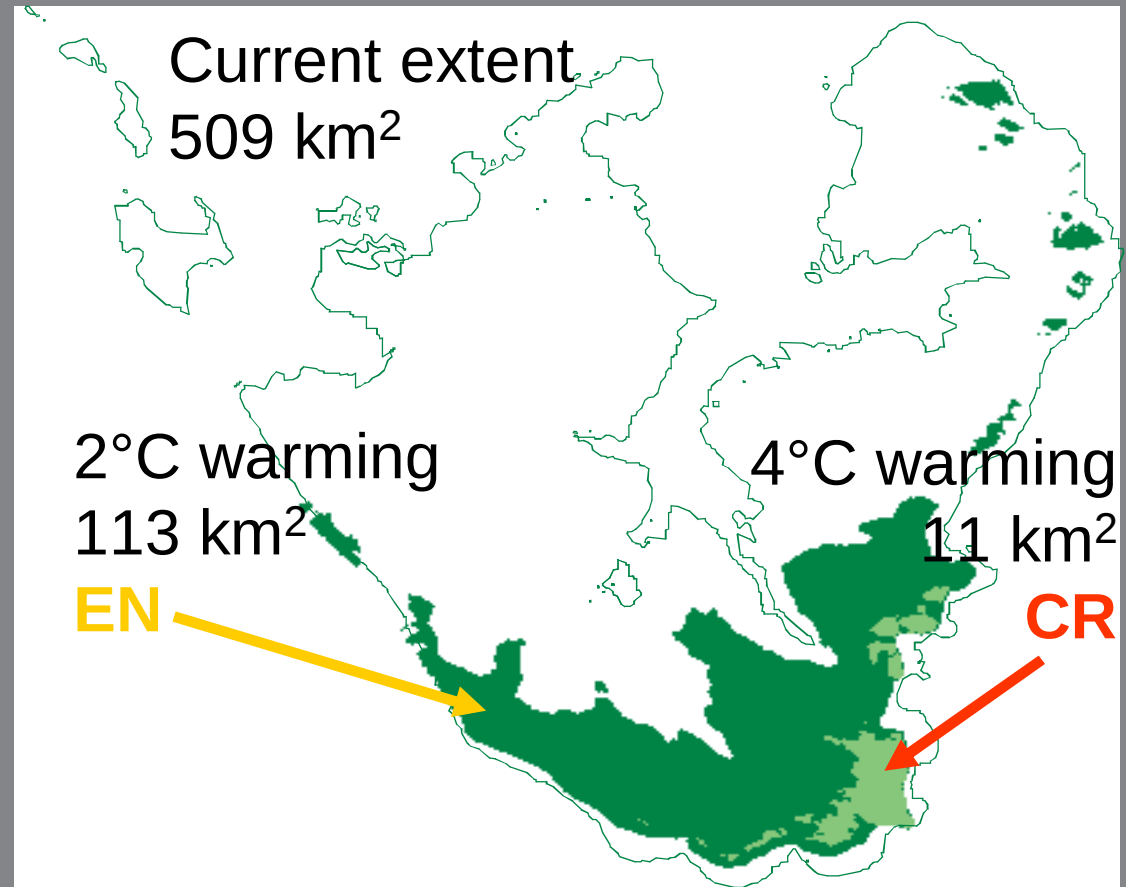


[http://einstein.uab.es/Guayana\\_key/initial.htm](http://einstein.uab.es/Guayana_key/initial.htm)

# Table mountains and climate change (Valentí Rull, Sandra Nogué, *et al.*)



# Table mountains and climate change (Valentí Rull, Sandra Nogué, *et al.*)



## Future directions

- Adoption of Resolution 4.020 at IUCN World Conservation Congress (October 2008).
- Establishment of *Ad hoc* Working Group for the Development of Red List Categories and Criteria for Ecosystems.
- 2009 onwards, design criteria for terrestrial, marine and freshwater ecosystems, and test the system at global level.
- 2012 adopt at World Conservation Congress