Bioinformatics:
Inputs for sustainable management of natural capital

José Sarukhán

CONABIO, The Mexican National Commission for the Knowledge and Use of Biodiversity

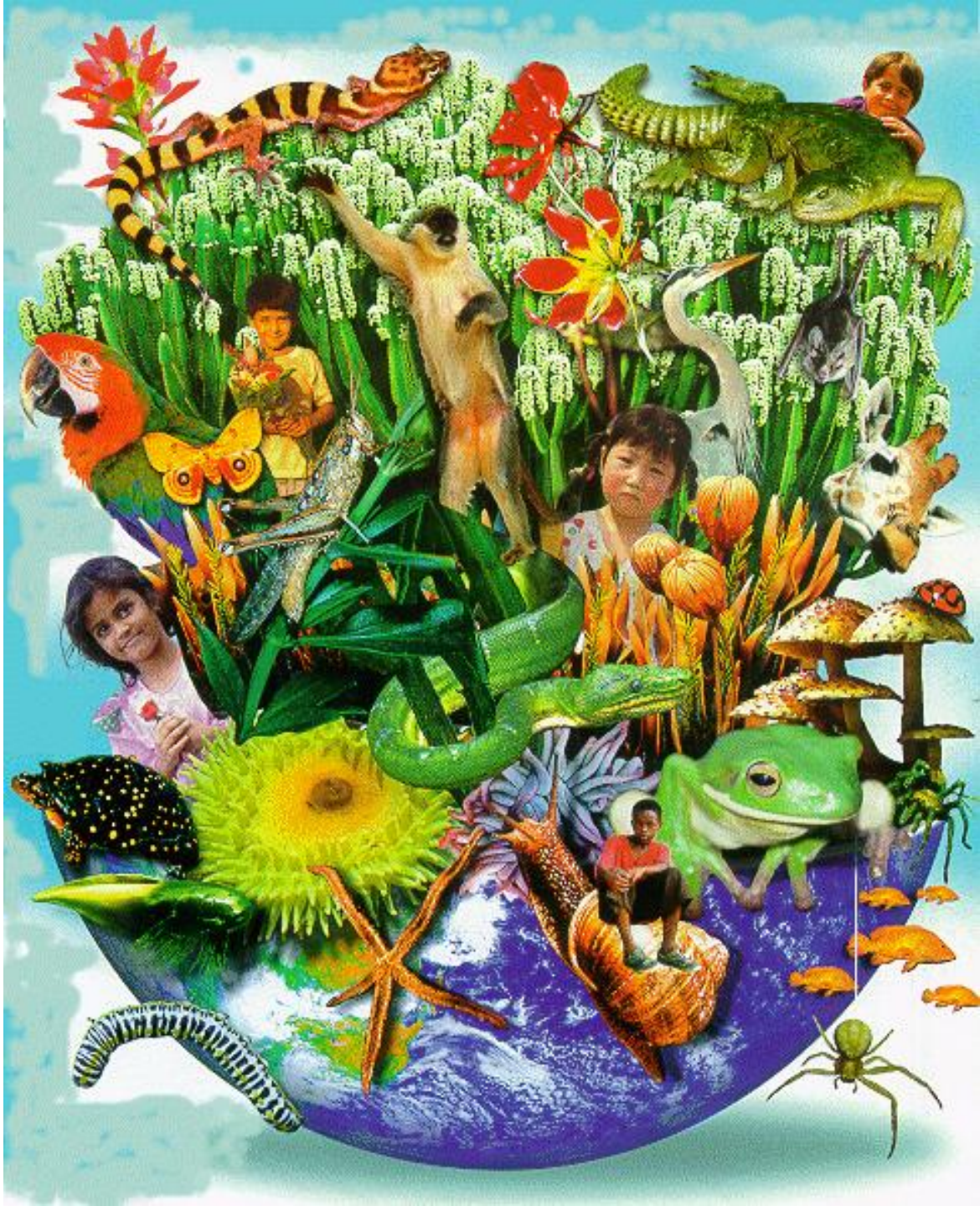
Twenty first century ecosystems: Systemic risk and the public good

U.S. National Academy of Sciences

DIVERSITAS

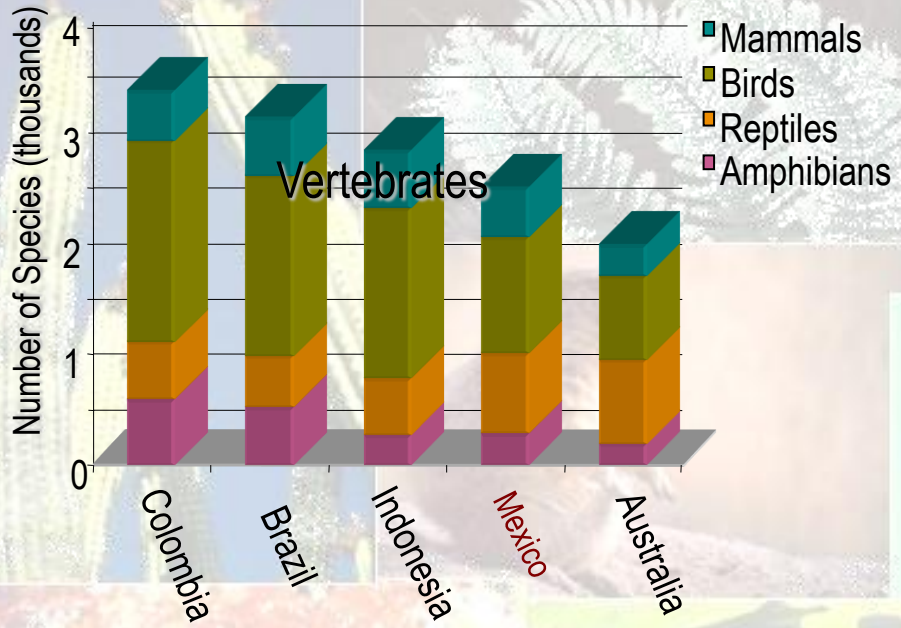
Washington, D.C.

11-13 February, 2009



Biological Richness of Mexico

- **Mexico is the fourth country in the world in overall species richness.**
- **It has a high ecological and cultural diversity**
- **CONABIO has information of some 80,000 Mexican plant and animal species.**



A megadiverse country like Mexico, needed an institution able to coordinate and support the many biodiversity-related efforts in the country.

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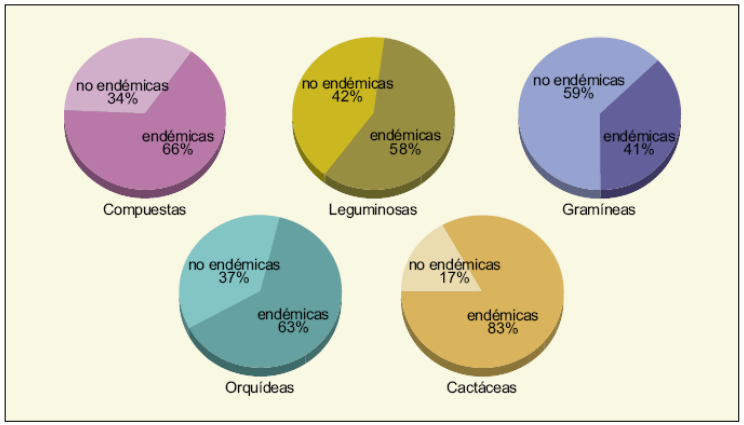

Figura 6a. Las cinco familias de plantas con mayor número de especies nativas de la flora de México y sus porcentajes de endemismo. Las leguminosas

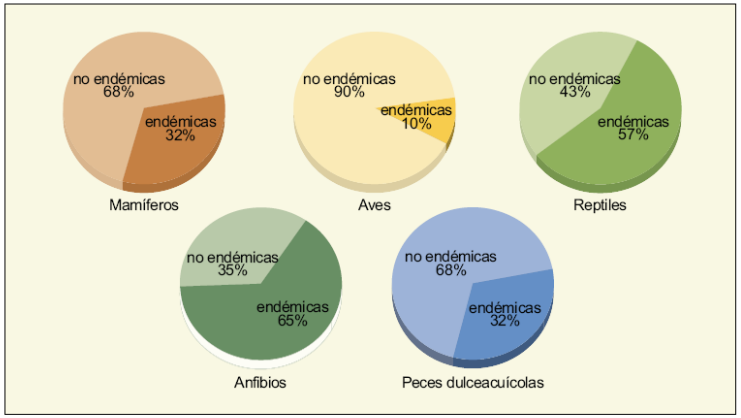

Figura 6b. Proporción de especies endémicas y no endémicas de vertebrados en México.[3-7, 12]

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*Comisión Nacional para el conocimiento y **uso** de la biodiversidad (National Commission for the knowledge and **use** of biodiversity)*

Conceived as a:

- demand-driven research organization
- promoter of basic (systematic, ecological, socio-economic) research
- compiler of existing national and international biodiversity information on Mexico
- generator of human capacity in the area of informatics for biodiversity
- an open resource of information to all society

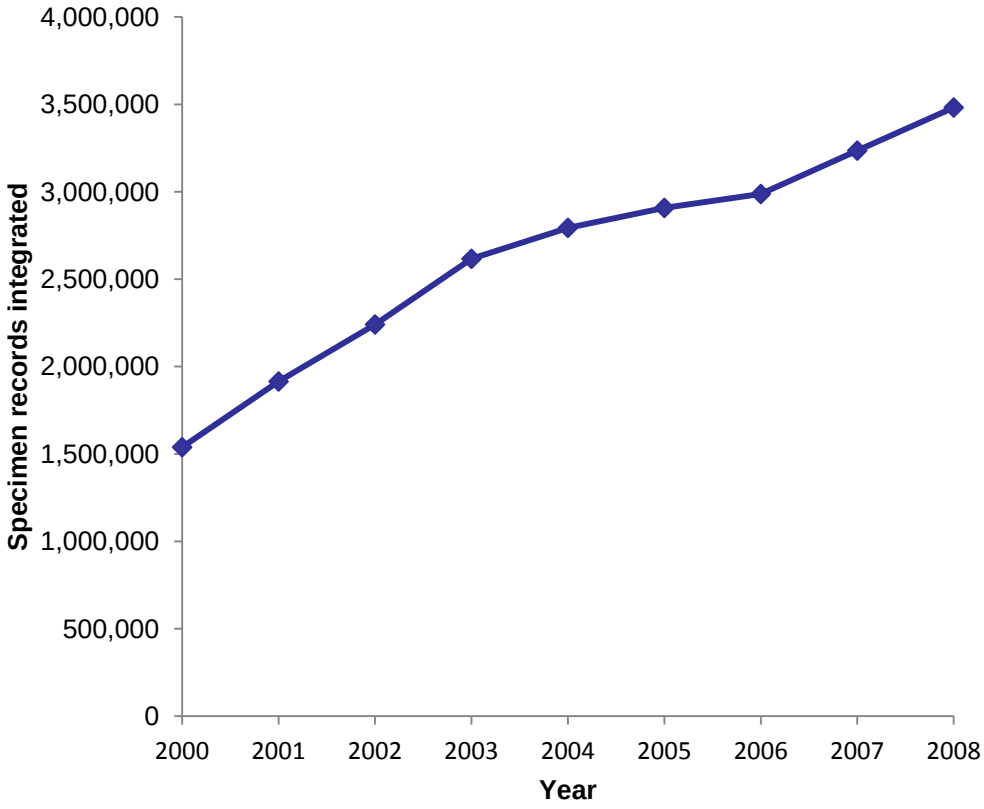
CONABIO's "philosophical" bases

- Serve as a bridging institution
- Biodiversity conservation and management based mostly on local actions by local people
- Generate intelligence of natural capital at the national level to be applied at the local level
- Most of what needs to be conserved and/or managed is outside Natural Protected Areas, and mostly owned by indigenous/rural people
- Therefore people must be a central actor of the process of conservation and management

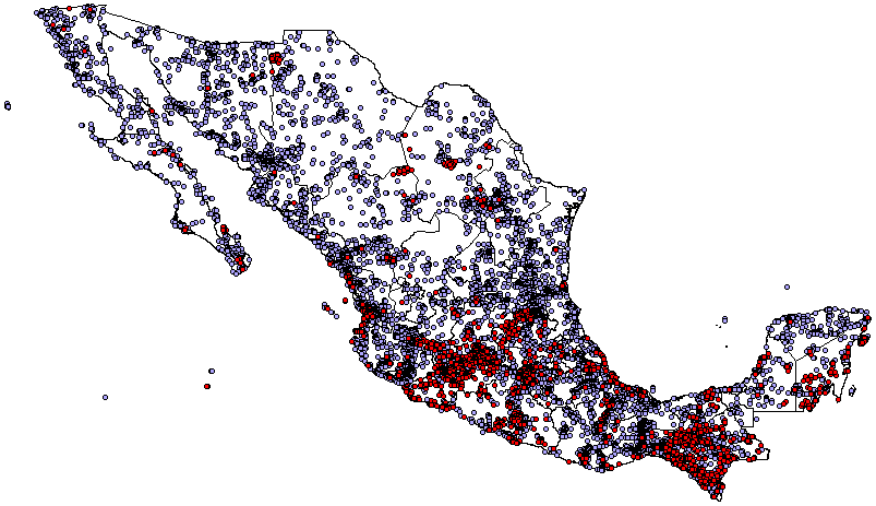
The metaphor

Becoming well informed, effective GARDENERS of the land outside Protected Areas will be the only way to achieve conservation and sustainable use of Biodiversity (ecosystems, their basic functions and their services)

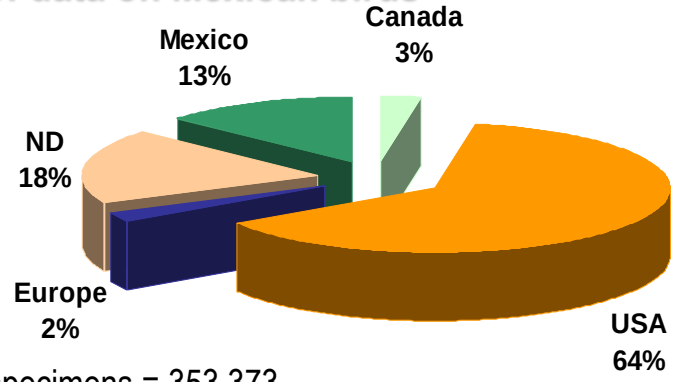
Growth of the database



Pooling data together



Repatriation of data on Mexican birds



Total of specimens = 353,373

- National museums (14)
- Foreign museums (40)

The Virtual Herbarium of Mexico

1,547,835 registers from >80 herbaria, mainly in Mexico and the U. S., plus other 25 countries.

But this represents a sampling intensity of only ~ 0.7 plant specimens/km^2

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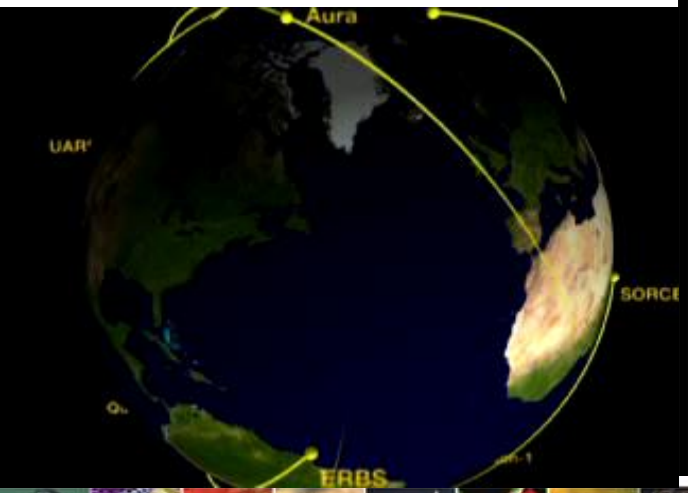
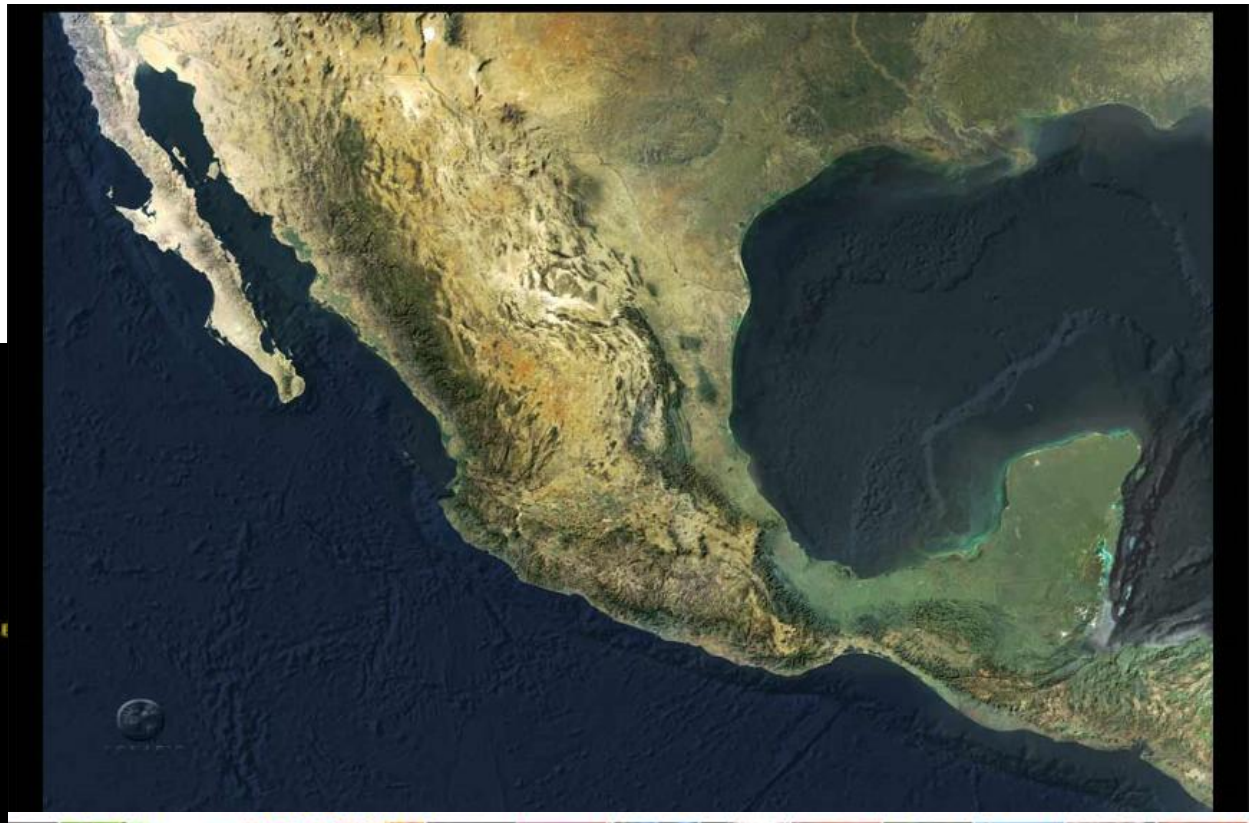
Remote sensing capabilities and electronic cartography

- National cartography at scales of 1:4,000,000, 1:1,000,000 y 1:250,000; Local a 1:50,000. Layers on extreme and average temperatures, rainfall, radiation, soil, vegetation types, biogeography and elevation.

- CONABIO receives up to 10 full images of the country daily: Landsat MSS, TM y ETM for 1973, 1993 and 2000. AVHRR and MODIS daily.





Some examples of application of bioinformatics to decision making

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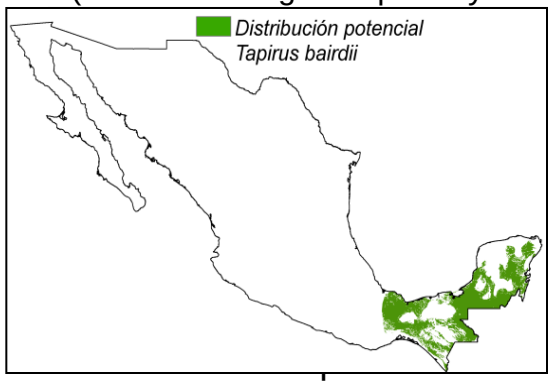
GAP Analysis – Conservation priorities

This information is an important tool for environmental decision making towards management, protection and conservation of biodiversity.

GAP Analysis – Conservation priorities for marine systems

GAP Analysis for Terrestrial environments

Fine filters
Potential distribution of species
(niche modeling from primary data)



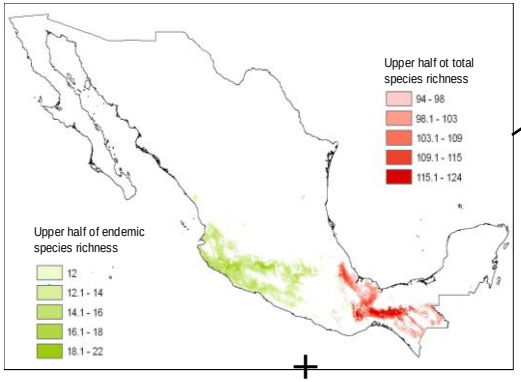
Conservation goals

Participative process (215 experts)
Five workshops to define: Scale, criteria to establish conservation targets and and threats.

1,450 layers

256 km² – 100 km²

Coarse filters
(vegetation types, species richness maps)

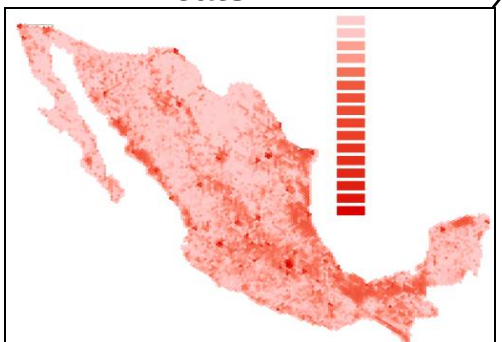


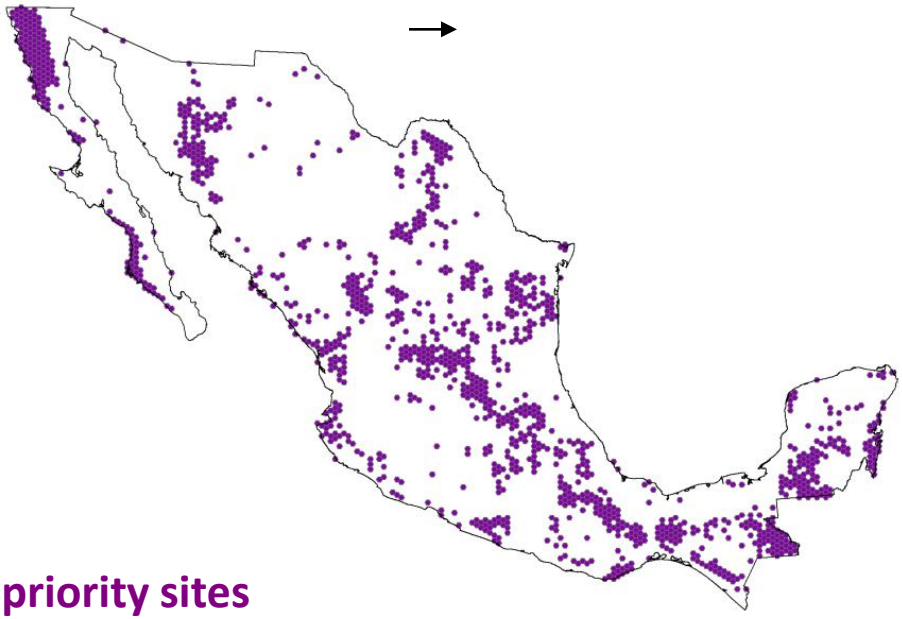
Conservation goals

Costs

19 layers

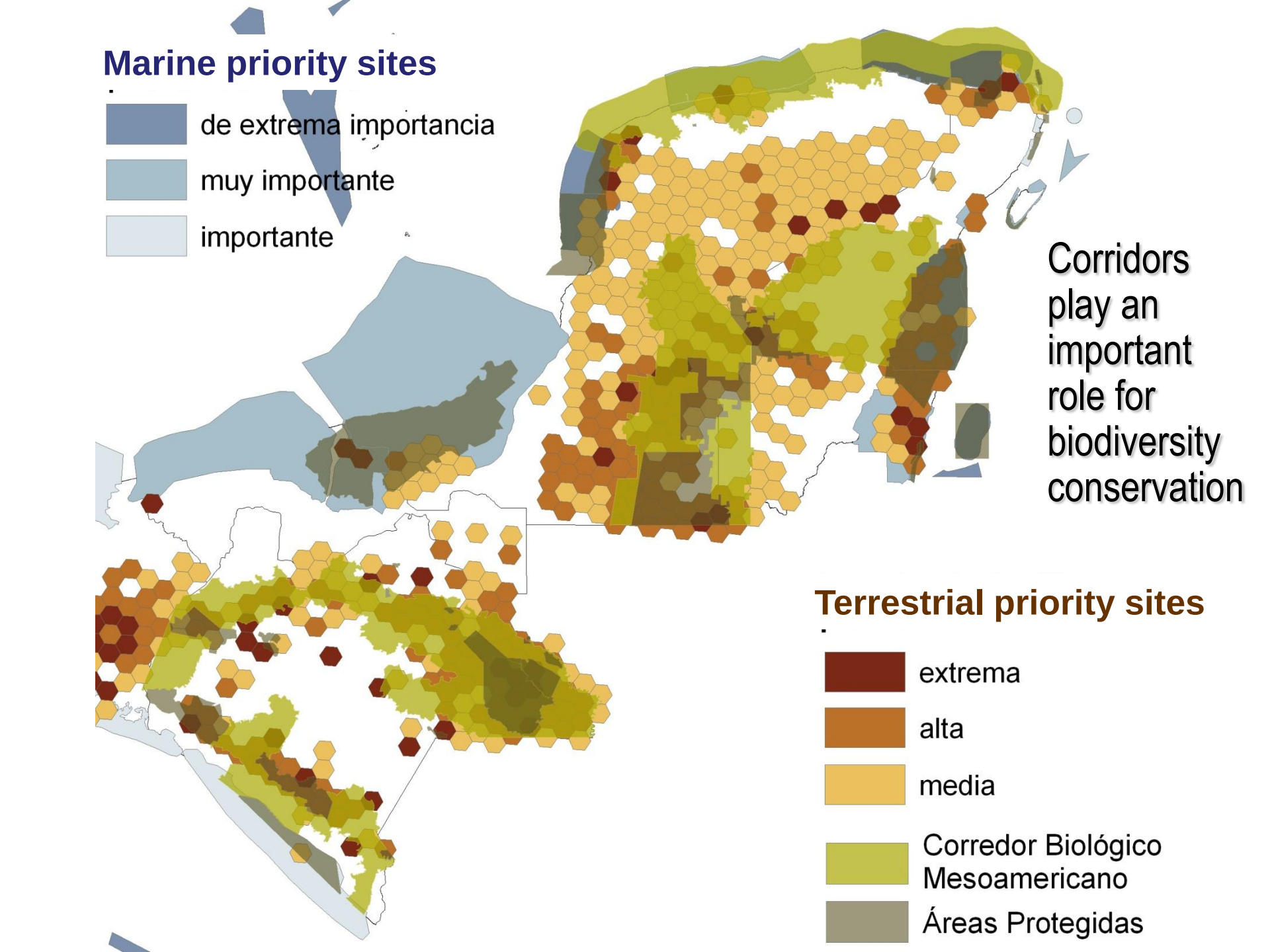
Threats



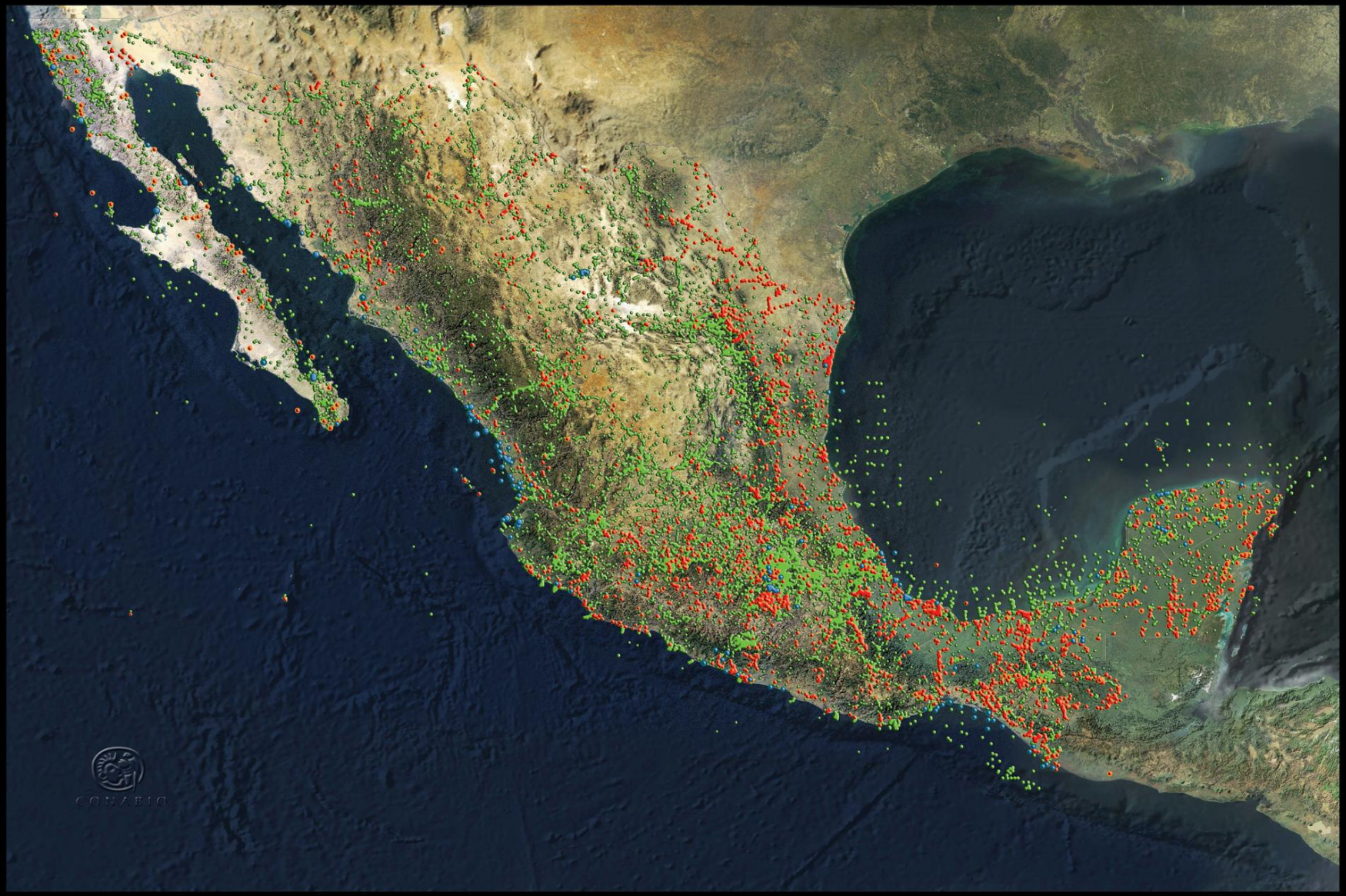


Terrestrial priority sites

Cover 594 894 km² (30.36% of the territory), but only 12.9% of this area is under the protection of federal, state and municipal PA . The extreme priority sites cover 16.6% of the continental area.


Marine priority sites
de extrema importancia
muy importante
importante
Corridors play an important role for biodiversity conservation
Terrestrial priority sites
extrema
alta
media
Corredor Biológico Mesoamericano
Áreas Protegidas

INVASIVE SPECIES RECORDS
1970-2004

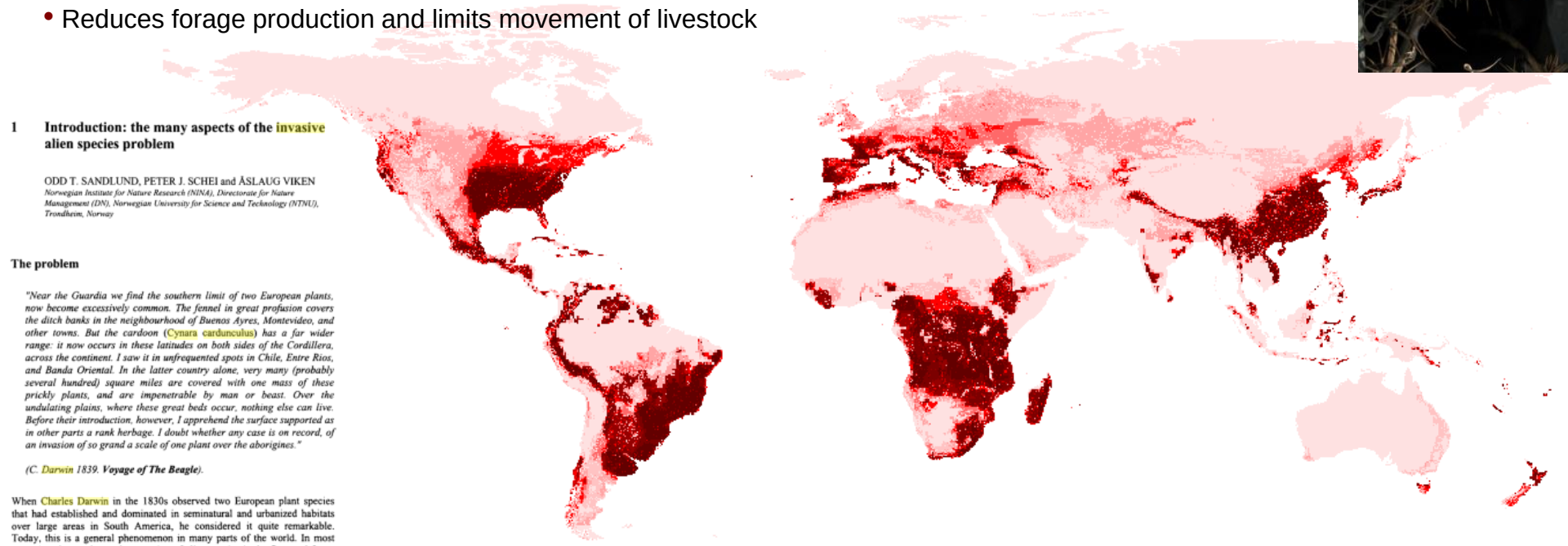


Cynara cardunculus L. (Asteraceae)

artichoke thistle, cardoon, desert artichoke, wild artichoke

Invasive plant sharing many vegetative and reproductive characteristics with the world's worst weeds

- Native to the Mediterranean
- The stout, upright yet spreading nature of the plant, its formidable spines, and high densities make wildlife movement through it difficult. The arching leaves shade a considerable area. Combined with its aggressive root system, artichoke thistle outcompetes native vegetation for light, water, and nutrients. At high densities it becomes a mono-species stand excluding shrubs, herbaceous plants, and even annual grasses.
- Reduces forage production and limits movement of livestock



Predicted niche model using GBIF data

1 **Introduction: the many aspects of the invasive alien species problem**

ODD T. SANDLUND, PETER J. SCHEI and ÅSLAUG VIKEN
Norwegian Institute for Nature Research (NINA), Directorate for Nature Management (DN), Norwegian University for Science and Technology (NTNU), Trondheim, Norway

The problem

"Near the Guardia we find the southern limit of two European plants, now become excessively common. The fennel in great profusion covers the ditch banks in the neighbourhood of Buenos Ayres, Montevideo, and other towns. But the cardoon (Cynara cardunculus) has a far wider range: it now occurs in these latitudes on both sides of the Cordillera, across the continent. I saw it in unfrequented spots in Chile, Entre Rios, and Banda Oriental. In the latter country alone, very many (probably several hundred) square miles are covered with one mass of these prickly plants, and are impenetrable by man or beast. Over the undulating plains, where these great beds occur, nothing else can live. Before their introduction, however, I apprehend the surface supported as in other parts a rank herbage. I doubt whether any case is on record, of an invasion of so grand a scale of one plant over the aborigines."

*(C. Darwin 1839. **Voyage of The Beagle**).*

When Charles Darwin in the 1830s observed two European plant species that had established and dominated in seminatural and urbanized habitats over large areas in South America, he considered it quite remarkable. Today, this is a general phenomenon in many parts of the world. In most countries, the number and proportion of alien species in the flora and fauna are frightfully high, so that seminatural ecosystems may be dominated by non-native species. This has devastating effects on native biodiversity, and introductions of alien invasive species is one of the four members of Jared Diamond's (1985) "evil quartet" of major threats to native biodiversity. Moreover, with the present development in international trade and travel, the transport of species, and thereby the risk of introduction into new areas is bound to increase (Jenkins, Ch. 15). Thus, we are in an urgent need for

1
O. T. Sandlund et al. (eds.), Invasive Species and Biodiversity Management, 1–7.

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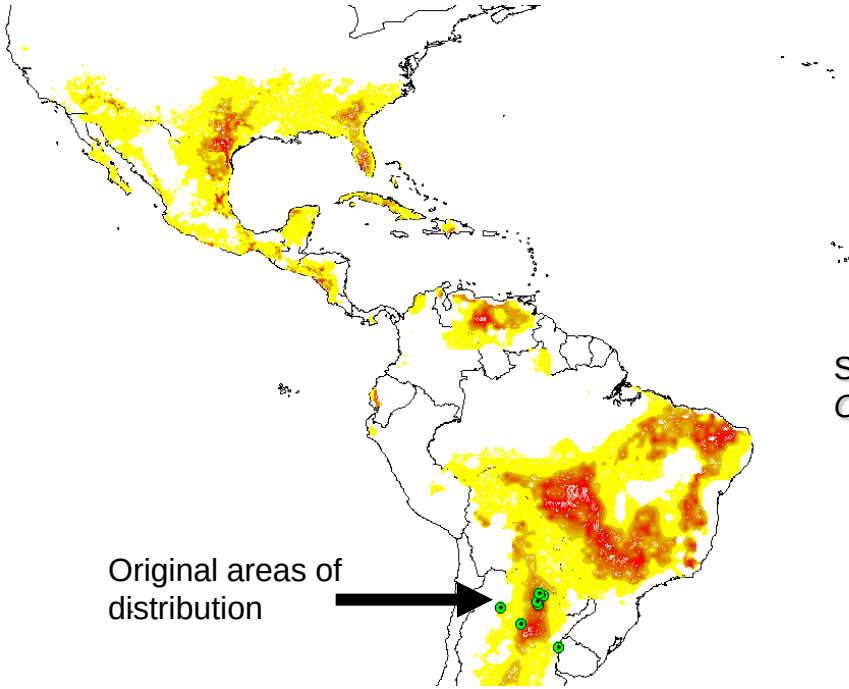
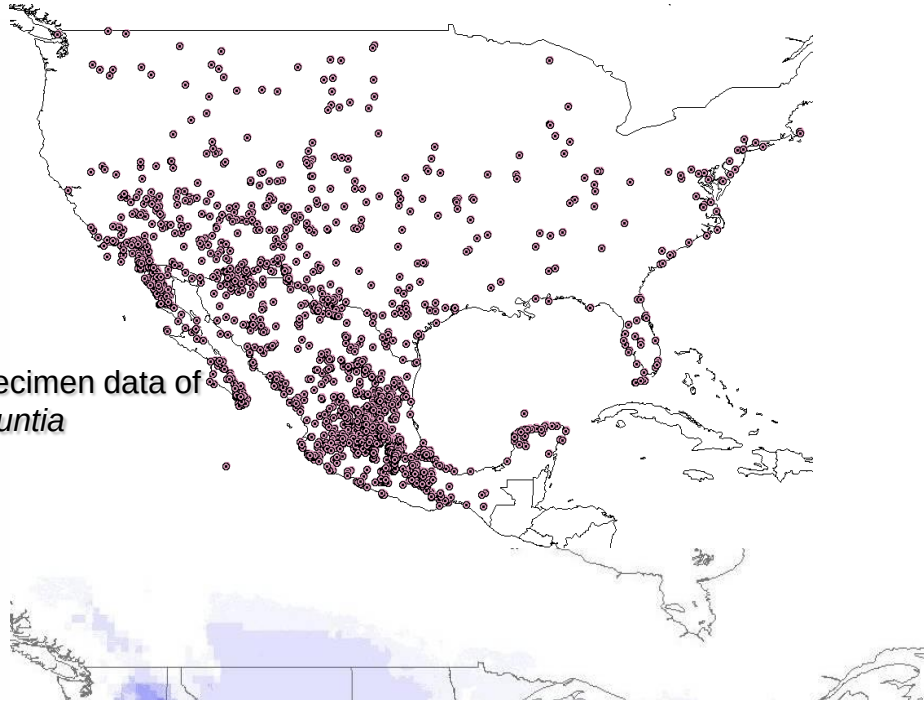
Invasive species



Original areas of distribution



Specimen data of *Opuntia*

Martes 20 de mayo de 2003 DIARIO OFICIAL

SECRETARIA DE AGRICULTURA, GANADERIA, DESARROLLO RURAL, PESCA Y ALIMENTACION

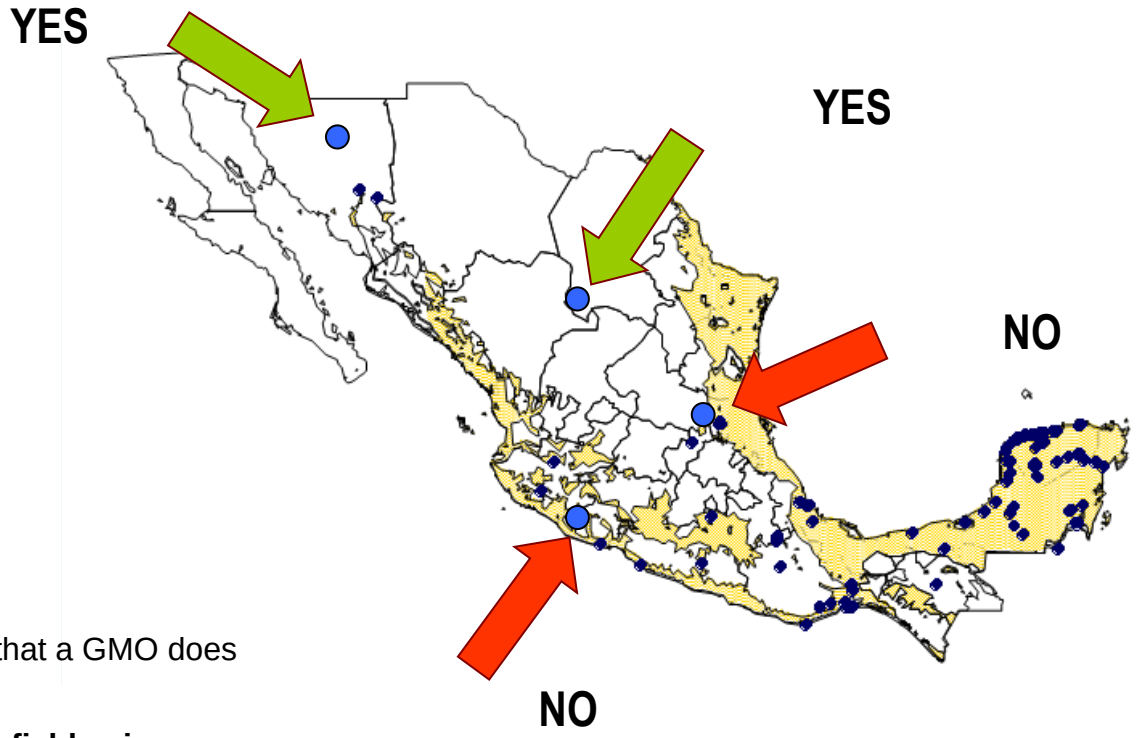
NORMA Oficial Mexicana de Emergencia NOM-EM-040-FITO-2003, Por la que se implementa el sistema para prevenir la introducción, diseminación y establecimiento de la Palomilla del Nopal (*Cactoblastis cactorum* Berg) en el territorio nacional.

Al margen un sello con el Escudo Nacional, que dice: Estados Unidos Mexicanos.- Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación.

Risk assessment of GMO's

Cotton risk assessment

Gossypium barbadense



Objectives:

Confirm, through the existing bibliography, that a GMO does not by itself represent a problem.

Detect the possibility of gene flow in the field using bibliographic and geographic (GIS) tools.

Start applying co-existence principles in the Mexican fields.

•1245 case by case recommendations on GMO crops have been issued so far.

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Prediction of climate change effects of Chagas' disease vectors *Triatoma spp*.

Specimens for prediction = 5 399
Total sites: 104

- Sites of observation
- Low probability
- Medium probability
- High probability

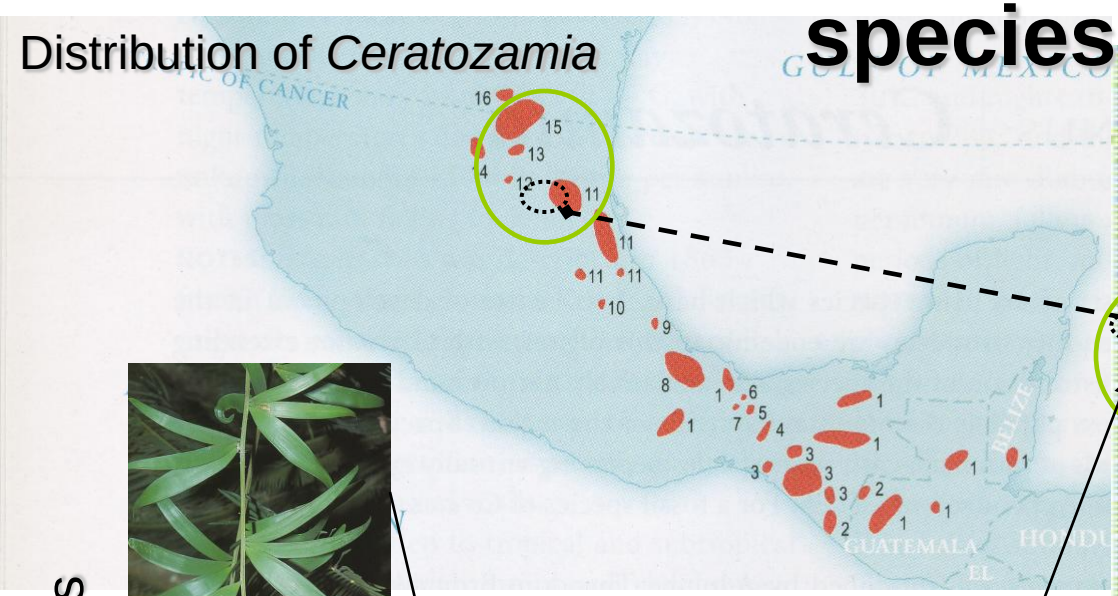
Rapid Response through forest fire detection

CONABIO detects daily, through remote sensing technology, hot spots in the country where a very high probability of forest fires exists.

This information is available daily to the public through CONABIO's web page, and is sent electronically to authorities in charge of combating forest fires in every State.

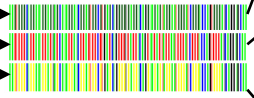
Barcoding helps conservation of endangered species

Distribution of *Ceratozamia*



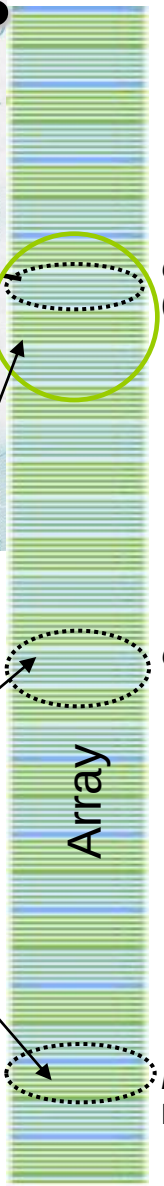
Samples

Barcode Analyzer



Barcode Sequences

Global Standard for Identifying Biological Specimens



***Ceratozamia hildae* Landry & M. Wilson 1979**
(Polulation from Xitilla, S.LP.)

Cycas chamberlanii

***Dioon edule* J. Lindley,**
Population from central Veracruz

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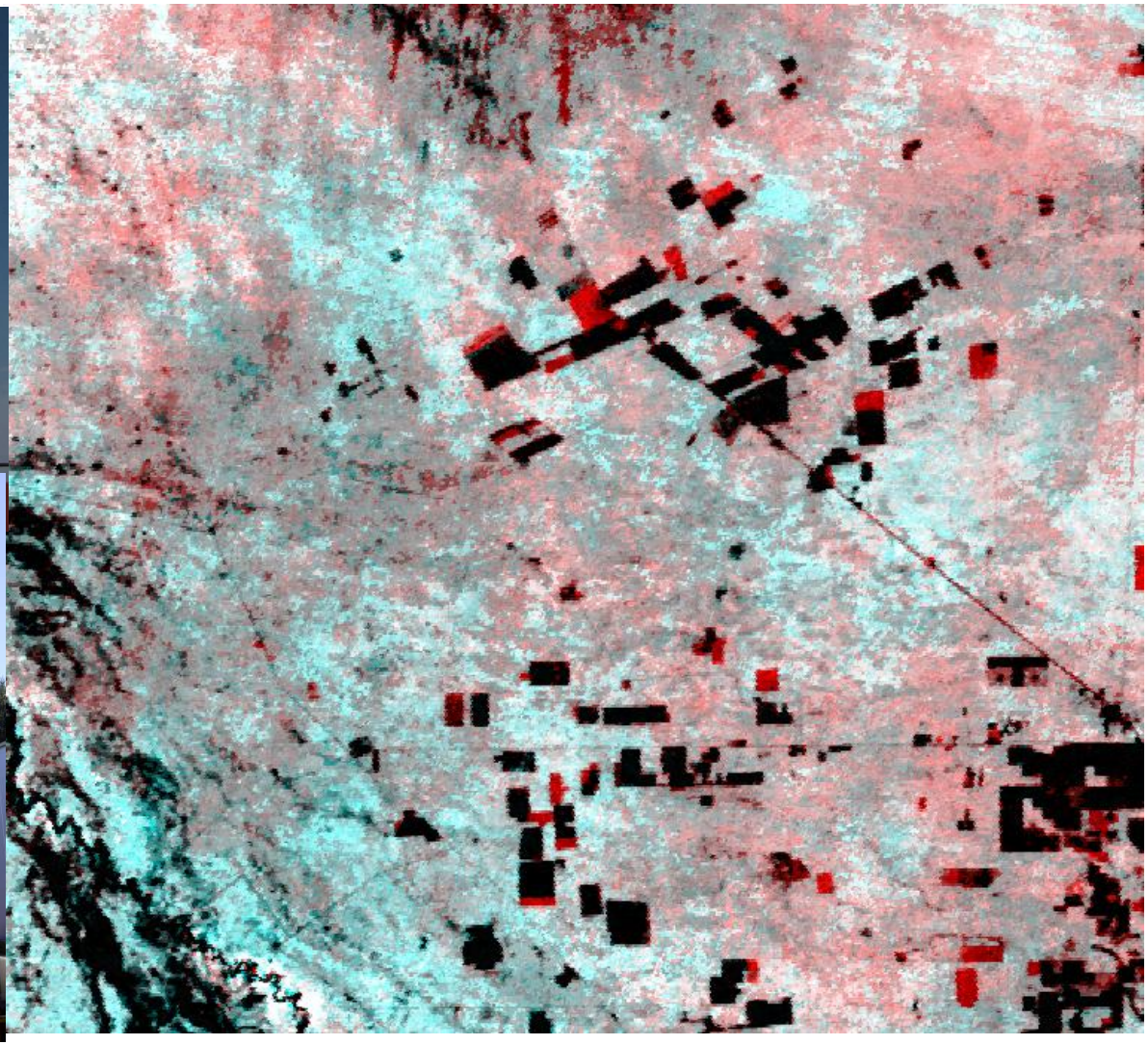
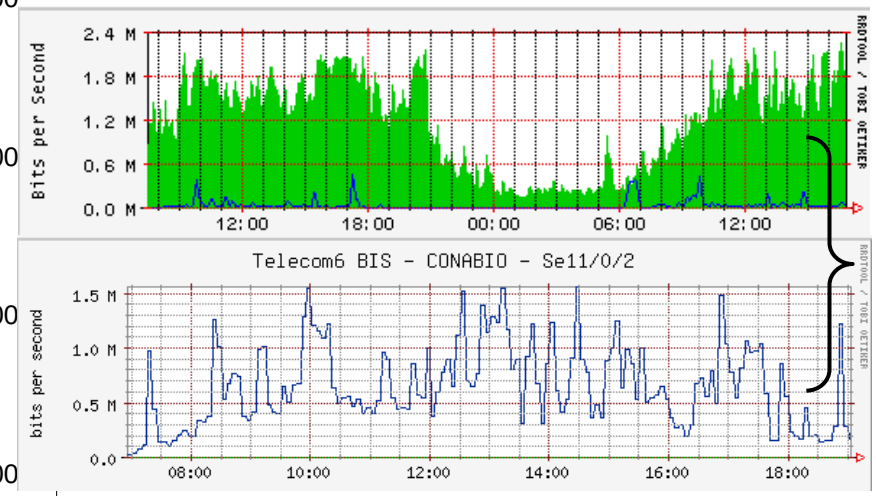
Forest cover Changes in real time



MODIS images of tree cover change 2000-2004

Matthew C. Hansen
SDSU

User intensity of CONABIO's web site



HITS →

Internet 2

Broad-band use

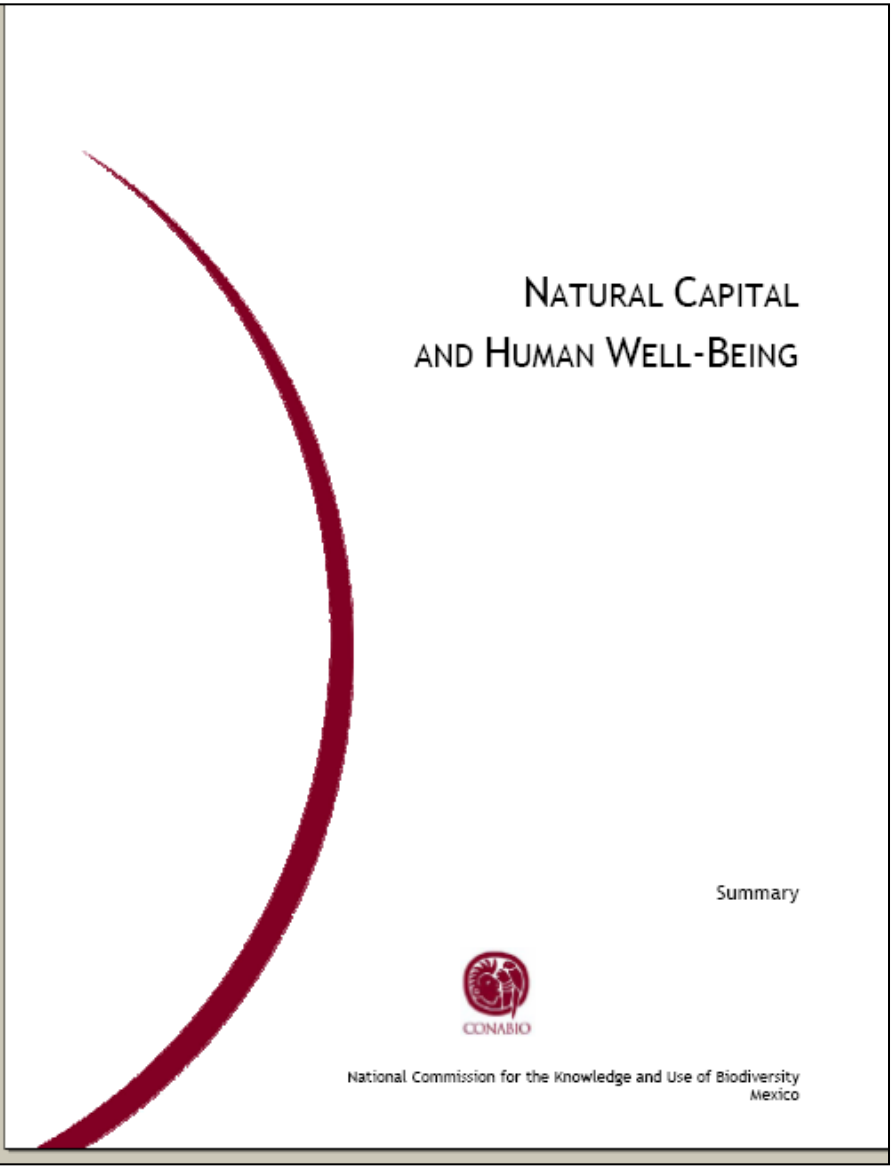
Internet

www.conabio.gob.mx

- **CONABIO's web site received in 2006 an average of 55,000 hits per day, last month 86,600 daily**
- **Information stored on line = around 2.5 TB**
- **Average broadband usage is 2 Mb per second**

→ **New Portal Design**

Ecosystem assessment of Mexico



It will comprise > 60 chapters in 5 volumes:

1. State of knowledge of biodiversity and of the ecosystems
2. Driving factors of change of ecosystems and their services
3. Policy, regulatory and economic responses to move towards sustainable use of ecosystems
4. Human, Institutional and economic capabilities for conservation
5. Future scenarios

More than 640 Mexican experts author 62 chapters, 96 reviewers
Volume I is out, and volume II y III will be ready in the next weeks. IV and V by the autumn of 2009
www.conabio.gob.mx/2EP

CAPITAL NATURAL DE MÉXICO

VOLUMEN I

CONOCIMIENTO ACTUAL DE LA BIODIVERSIDAD

COMISIÓN NACIONAL PARA EL CONOCIMIENTO Y USO DE LA BIODIVERSIDAD

Acknowledgements

To the work of Dr. Jorge Soberón and dozens of young CONABIO academic staff who have worked for over 15 years in developing what I just presented to you