

# Gypsum ecosystems as biodiversity hotspots

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# CONTENT



Biodiversity hotspots

Plant diversity in Mexico

Overview of the gypsum ecosystems in the Chihuahuan Desert (CD)

Areas of endemism for the Mexican lineages of Angiosperms

Centers of endemism in Mexico

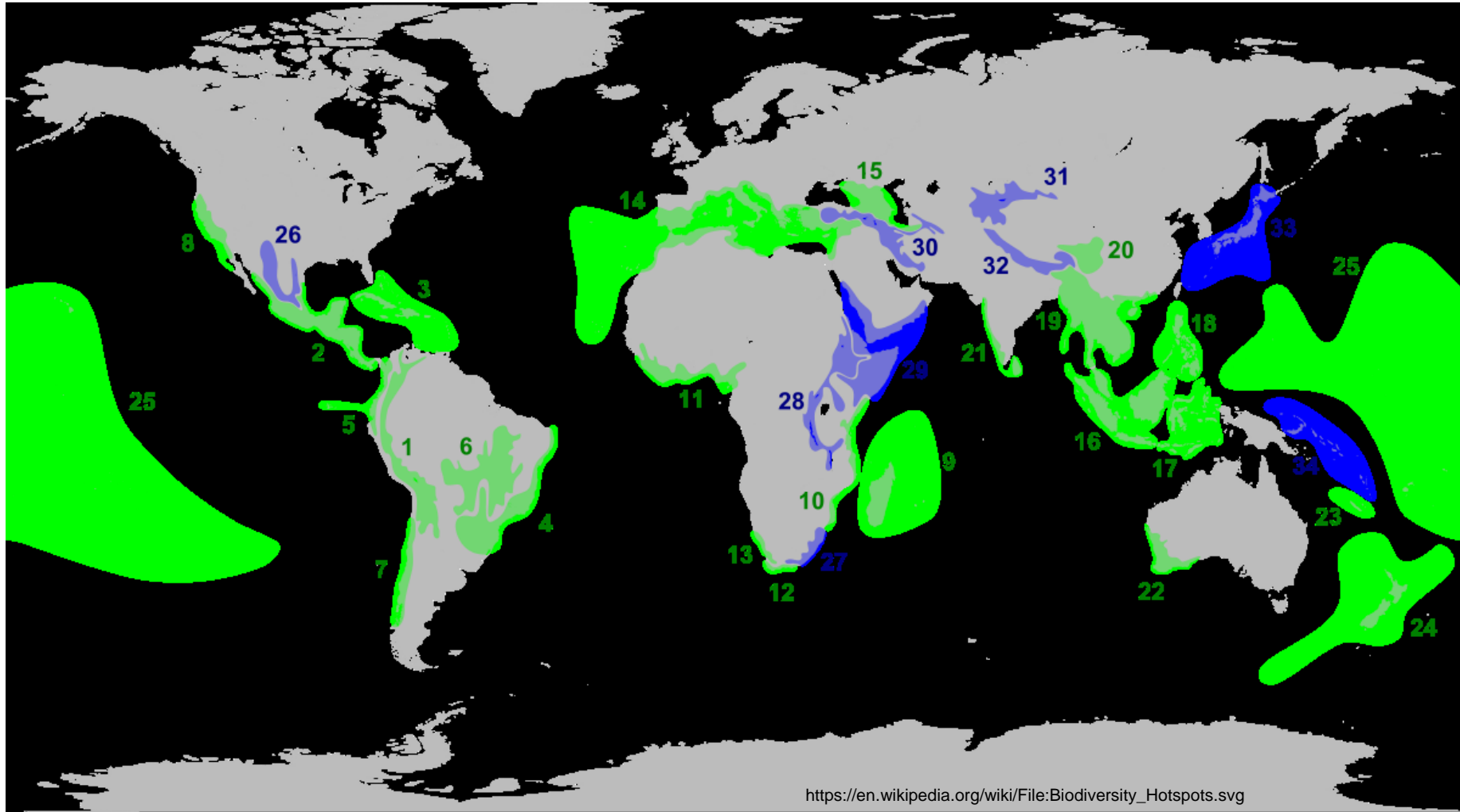
Natural protected areas in the CD

Summary

Conclusions

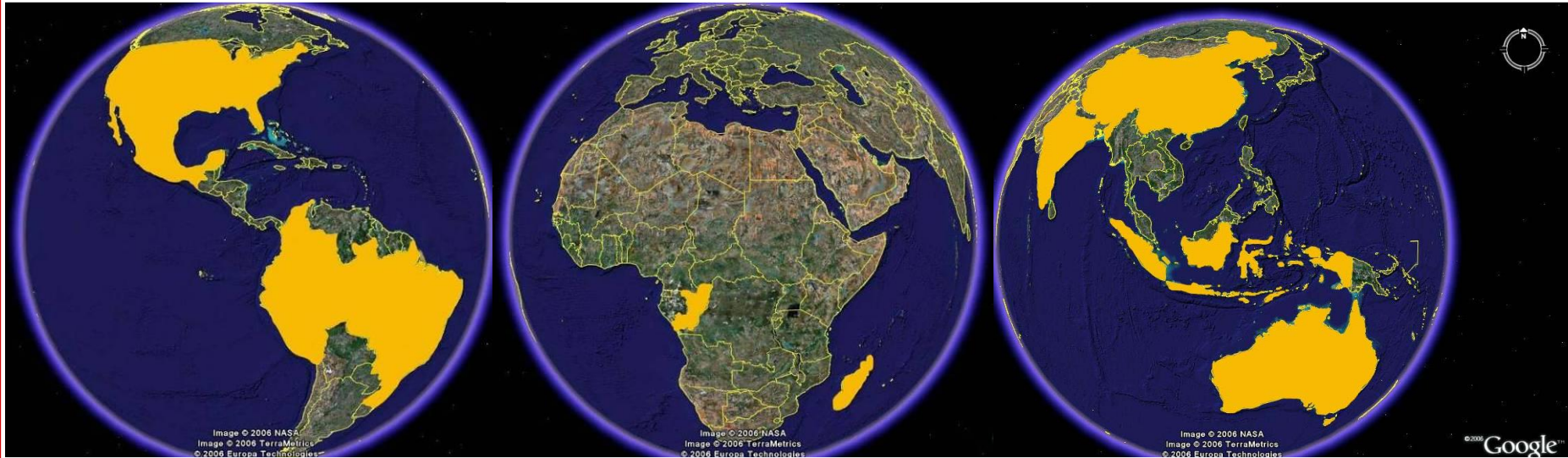


# BIODIVERSITY HOTSPOTS



25 (green) as indicated in **Myers *et al.* (2000)**,  
9 (blue) added by **Lamoreux *et al.*, 2006 & Pimm *et al.*, 2014**

# BIOLOGICAL DIVERSITY OF MEXICO



<http://www.elbalero.gob.mx/bio/html/peculiar/megadi.html>

±170 countries around the world

12 have 70% of the biodiversity

Megadiverse: Australia, Brasil, China, Colombia, Ecuador, India, Indonesia, Madagascar, **Mexico**, Perú, República Democrática del Congo, United States.

17 megadiversity countries mostly in tropics and subtropics.

Developing countries economically poor and biodiversity rich.

# PLANT DIVERSITY OF MEXICO

24,000 - 30,000 vascular plants  
42-52% endemic

Approximately 1 of 10 species of the world distribute in Mexico  
(Espejo *et al.*, 2004: 11%, Rzedowski, 1991: 9.6%).



# PLANT DIVERSITY OF MEXICO

Levels of organization:

- Biomes
- Ecosystems
- Types of vegetation
- Life forms
- Species
- Phylogenetic
- Genetics



# GYPSUM SOILS OF THE CHIHUAHUAN DESERT

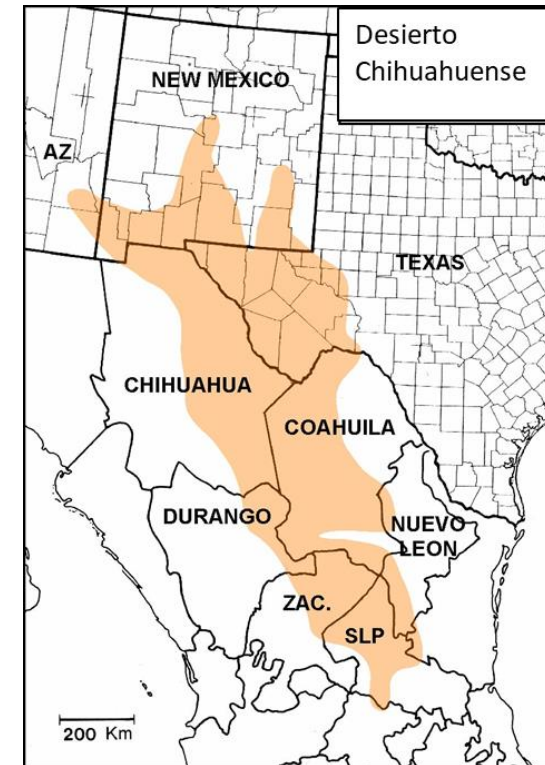


## Chihuahuan Desert

The largest in America

A limestone ocean with numerous gypsum “islands”

Out of the Mesoamerica and Madrean Pine-Oak woodlands biodiversity hotspots



# GYPSUM IN THE CHIHUAHUAN DESERT

## Underground



[http://es.wikipedia.org/wiki/Mina\\_de\\_Naica](http://es.wikipedia.org/wiki/Mina_de_Naica)

© Copyright 2008, Proyecto Naica

## Exposed



Norman Douglas, 2013



Norman Douglas, 2013



dust





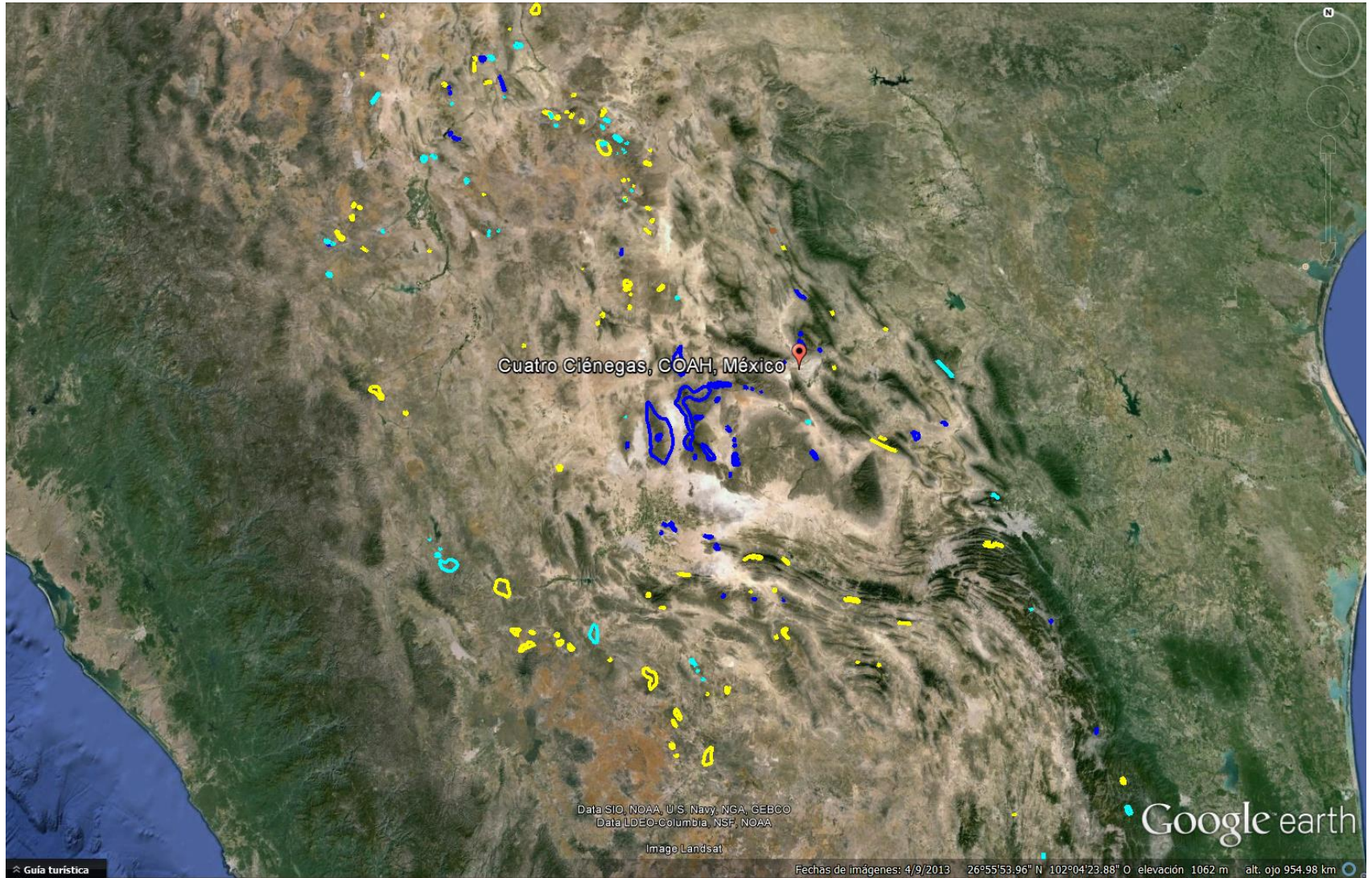
# SOILS OF MEXICO

Flores Olvera *et al.*: Gypsum ecosystems as biodiversity hotspots.



# GYPSUM "ISLANDS" IN THE CHIHUAHUAN DESERT

Flores Olvera *et al.*: Gypsum ecosystems as biodiversity hotspots.



- Sure**
- Highly probable**
- Possible**

According to Moore *et al.*, in prep.

# GYPSUM "ISLANDS" IN THE CHIHUAHUAN DESERT



WHITE SANDS NATIONAL MONUMENT, NEW MEXICO, USA



RILEY, NEW MEXICO, USA



YESO HILLS, NEW MEXICO, USA

# GYPSUM "ISLANDS" IN THE MEXICAN PART OF THE CHIHUAHUAN DESERT (MCD)



CUATRO CIÉNEGAS, COAHUILA, MEXICO



SAN JOSE DEL SITIO, NUEVO LEON, MEXICO



TLAHUALILO, DURANGO, MEXICO

# LIFE FORMS OF GYPSUM PLANTS

Flores Olvera *et al.*: Gypsum ecosystems as biodiversity hotspots.



# LIFE FORMS OF GYPSUM PLANTS

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# GYPSUM VEGETATION IN THE CHIHUAHUAN DESERT

Flores Olvera *et al.*: Gypsum ecosystems as biodiversity hotspots.





# GYPSUM VEGETATION IN THE CHIHUAHUAN DESERT

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# GYPSUM VEGETATION IN THE CHIHUAHUAN DESERT ENDORHEIC BASINS



# GYPSUM VEGETATION IN THE CHIHUAHUAN DESERT MOUNTAINS



# GYPSOVAGS



*Dahlea filiciformis*



*Eustoma barkleyi*



*Hedyotis acerosa*



*Tidestromia lanuginosa*



*Hedyotis acerosa*



*Haploësthes greggii* var. *texana*

# GYPSOPHILES



*Bouteloua chasei*



*Antiphytum hintoniorum*



*Gaillardia gypsophila*



*Sporobolus nealleyi*



*Geniostemon gypsophillum*



*Nerisyrenia hypercorax*



*Dicranocarpus parviflorus*



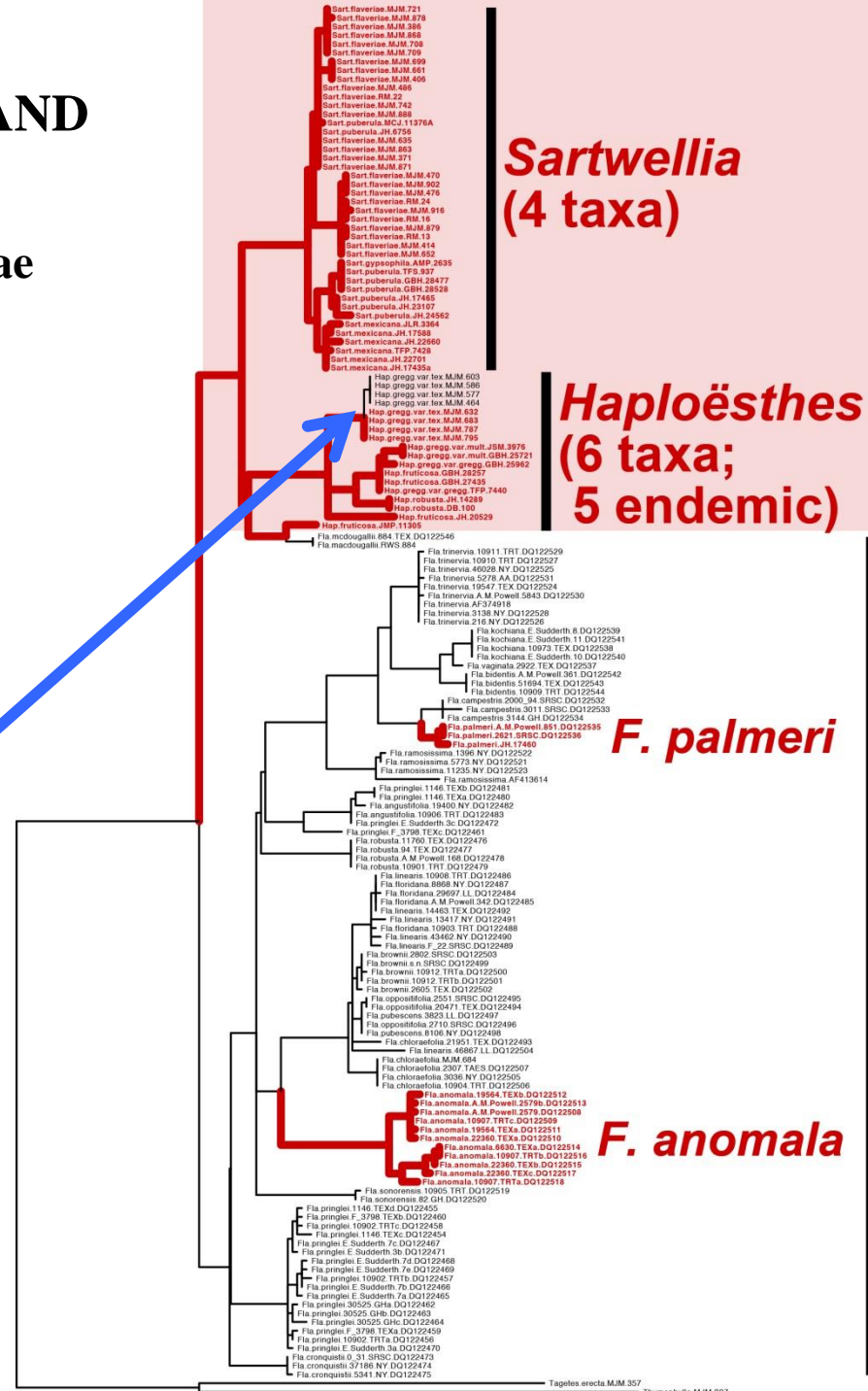
*Sartwellia flaveriae*

# MULTIPLE ORIGINS OF GYPSOPHYLE AT HIGHER AND LOWER SCALES

e.g., Asteraceae Subtribe Flaveriinae



Moore et al. unpublished



ITS



*Flaveria*



Flores Olvera et al.: Gypsum ecosystems as biodiversity hotspots.

Gypsovag

# PLANT DIVERSITY IN GYPSUM SOILS OF MEX.

## PTERIDOPHYTES

Families 2

Genera 5

Species 11

*Adiantum capillus-neneris*

*Gaga hintoniourum*

*Selaginella gypsophylla*

*S. lepidophylla*

*Notholaena sinuata*

*N. aschenborniana*

*N. bryopoda*

*N. neglecta*

*N. greggii*

*N. limitanea*

*Pellaea ribae*



# PLANT DIVERSITY IN GYPSUM SOILS OF MEX.

## GIMNOSPERMS

Families

Genera 3

Species 13

*Ephedra antisiphilitica*

*E. aspera*

*E. compacta*

*E. pedunculata*

*E. torreyana*

*E. trifurca*

*Juniperus erythocarpa*

*J. monosperma*

*J. pinchotii*

*J. saltillensis*

*Pinus arizonica*

*P. greggii*

*P. nelsonii* Tmps Bustamante





# PLANT DIVERSITY IN GYPSUM SOILS OF CD

## ANGIOSPERMS

Families 61

Genera 241

Species 630

Gypsovags 402

Gypsophyles 243

Gypso-Halophyles 41

- Atriplex* (Chenopodiaceae)
- Chamaesyce* (Euphorbiaceae)
- Cressa* (Convolvulaceae)
- Frankenia* (Frankeniaceae)
- Haploësthes* (Asteraceae)
- Heliotropium* (Boraginaceae)
- Isocoma* (Asteraceae)
- Monolepis* (Chenopodiaceae)
- Nama* (Hydrophyllaceae)
- Pseudoclappia* (Asteraceae)
- Sporobolus* (Poaceae)
- Strotheria* (Asteraceae)
- Suaeda* (Chenopodiaceae)
- Tidestromia* (Amaranthaceae)
- Varilla* (Asteraceae)



Gypso-Halophiles

# DIVERSE FAMILIES IN GYPSUM SOILS OF CD

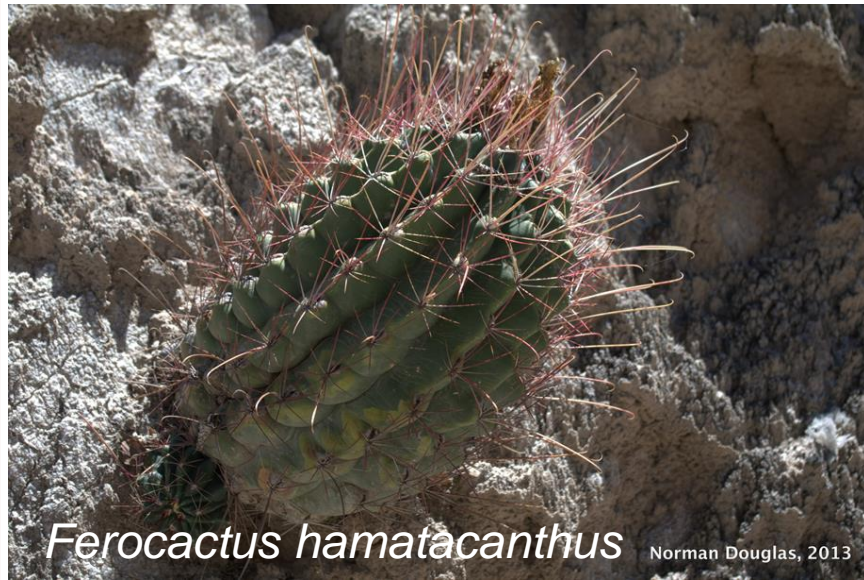
## GYPSOVAGS

Family	# Genera	# Sp
Asteraceae	75	162
Boraginaceae	4	20
Brassicaceae	7	20
Cactaceae	13	33
Caryophyllaceae	3	15
Chenopodiaceae	6	19
Euphorbiaceae	6	19
Fabaceae	7	21
Gentianaceae	4	12
Hydrophyllaceae	1	15
Lamiaceae	4	12
Loasaceae	4	21
Namaceae	1	13
Nyctaginaceae	7	32
Poaceae	21	53
Scrophulariaceae	1	11

## GYPSOPHILES

Family	# Genera	# Sp
Asteraceae	31	68
Brassicaceae	3	15
Cactaceae	4	9
Caryophyllaceae	2	10
Namaceae	1	13
Nyctaginaceae	4	15
Poaceae	3	8

# PLANT DIVERSITY IN GYPSUM SOILS OF MEXICO



# ENDEMISM IN GYPSUM SOILS OF MEXICO



J.M. Solichon

*Geohintonia mexicana*



J.M. Solichon

*Aztekium hintonii*



*Turbinicarpus zaragozae*<sup>Z8</sup>

# CONSPICUOS GYPSUM ENDEMIC OF THE CHIHUAHUAN DESERT

Asteraceae	<i>Dicranocarpus</i>	<i>parviflorus</i>	1/1
	<i>Haploësthes</i>	spp	5/6
	<i>Sartwellia</i>	spp	4/4
	<i>Gallardia</i>	spp	7/25
	<i>Xanthisma</i>	spp	7/15
	<i>Verbesina</i>	spp	3/100
	<i>Marshalljohnstonia</i>	<i>gypsophylla</i>	1/1
	<i>Strotheria</i>	<i>gypsophylla</i>	1/1
Boraginaceae	<i>Antiphytum</i>	<i>hintoniorum</i>	1/8
	<i>Tiquilia</i>	spp	3/30
Cactaceae	<i>Aztekium</i>	spp	2/2
	<i>Geohintonia</i>	<i>mexicana</i>	1/1
Caryophyllaceae	<i>Drymaria</i>	spp	6/60
Brassicaceae	<i>Nerisyrenia</i>	spp	10/11
Fouquieriaceae	<i>Fouquieria</i>	<i>shrevei</i>	1/11
Hydrophyllaceae	<i>Phaselia</i>	spp	4/100
Lamiaceae	<i>Scutellaria</i>		1/+100
Leguminosae	<i>Dalea</i>		1/+100
	<i>Dermatophyllum</i>	spp	2/7
Lentibulariaceae	<i>Pingüicola</i>	spp	3/?
Loasaceae	<i>Mentzellia</i>	spp	3/60
	<i>Petalonyx</i>		1/5
Lobeliaceae	<i>Lobelia</i>	spp	2/?
Namaceae	<i>Nama</i>	spp	9/55
Nyctaginaceae	<i>Acleisanthes</i>	spp	5/17
	<i>Anulocaulis</i>	spp	2/5
Onagraceae	<i>Oenothera</i> sect. <i>Calylophus</i>		?/6
Papaveraceae	<i>Argemone</i>	spp	2/?
Poaceae	<i>Sporobolus</i>	<i>nealleyi</i>	1/?
	<i>Bouteloa</i>	spp	3/?
Rubiaceae	<i>Hedyotis</i>	<i>teretifolia</i>	1/?
Scrophullariaceae	<i>Leucophyllum</i>	spp	3/?
Sellaginellaceae	<i>Selaginella</i>	<i>gypsophylla</i>	1/?

# spp gypsum/total



# GENERA WITH ENDEMIC SPECIES IN GYPSUM SOILS OF THE CHIHUAHUAN DESERT

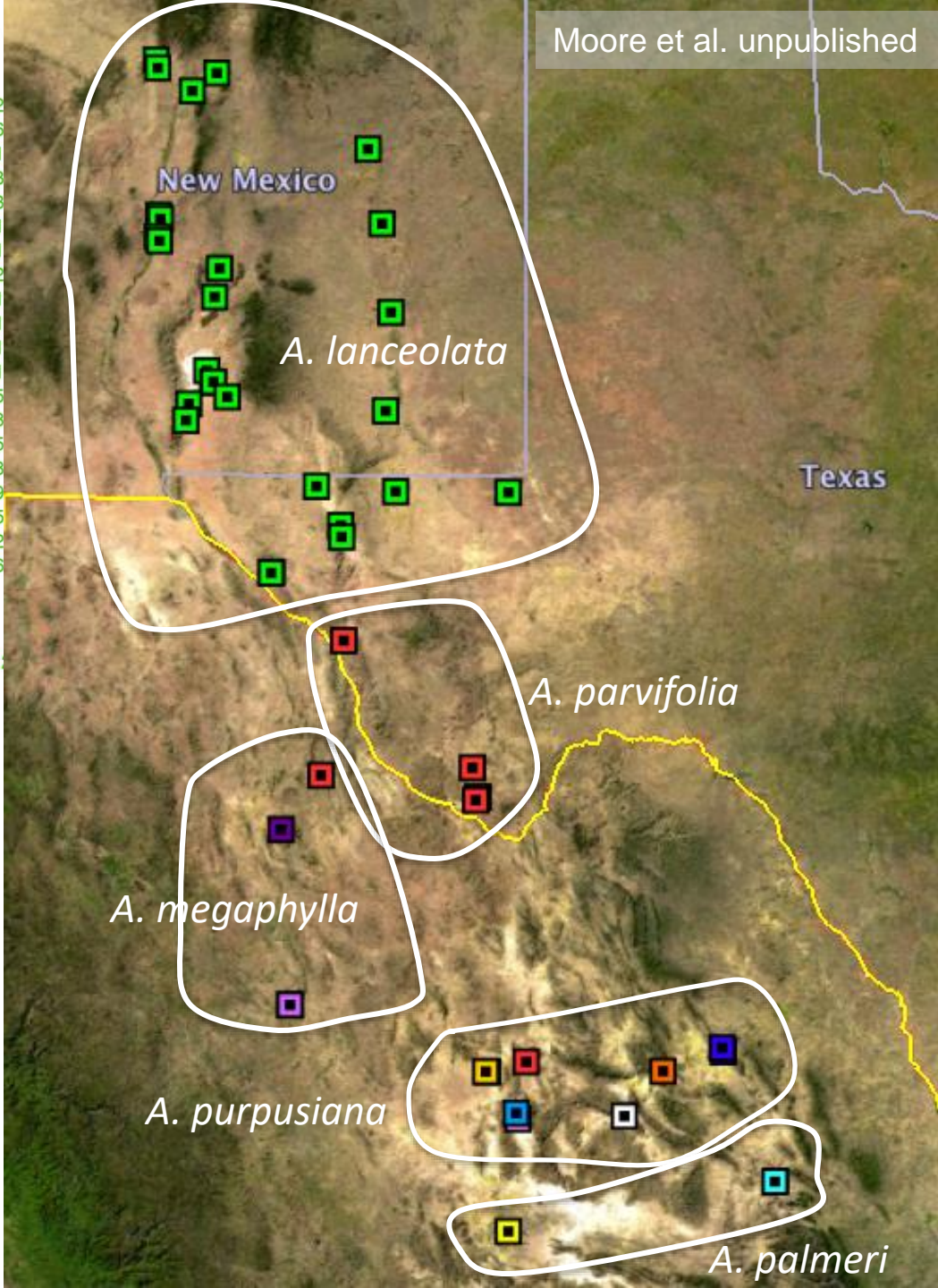
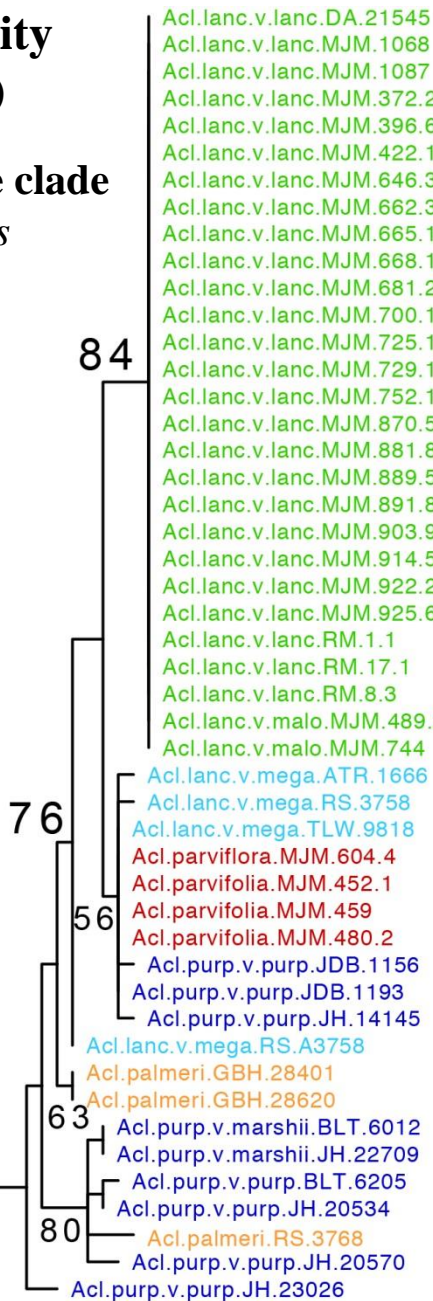
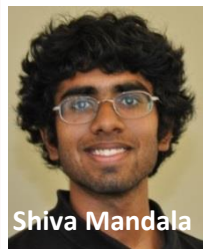
46 genera with 2 gypsum endemic species to the DC

25 genera with 3-5 endemic species to the CD



# Genetic diversity (haplotypes)

E.g., the gypsophile clade of *Acleisanthes*



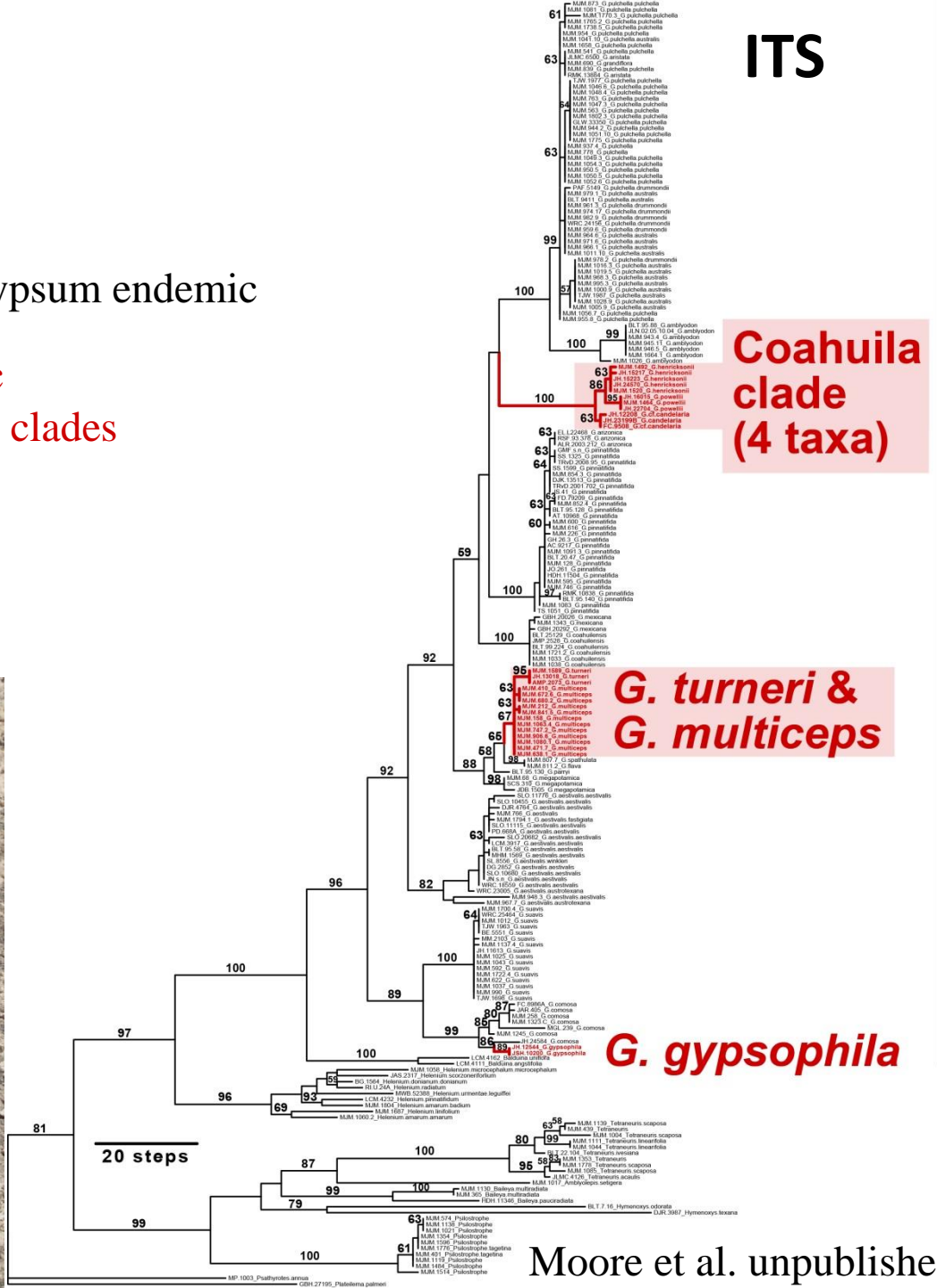
Gaillardia 25 spp; 7 gypsum endemic

Red Taxa = endemic

Red shadow = endemic clades



Gaillardia multiceps



ITS

Coahuila clade (4 taxa)

G. turneri & G. multiceps

G. gypsophila



Carolyn Stange

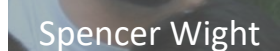
Gaillardia



Flora Samis



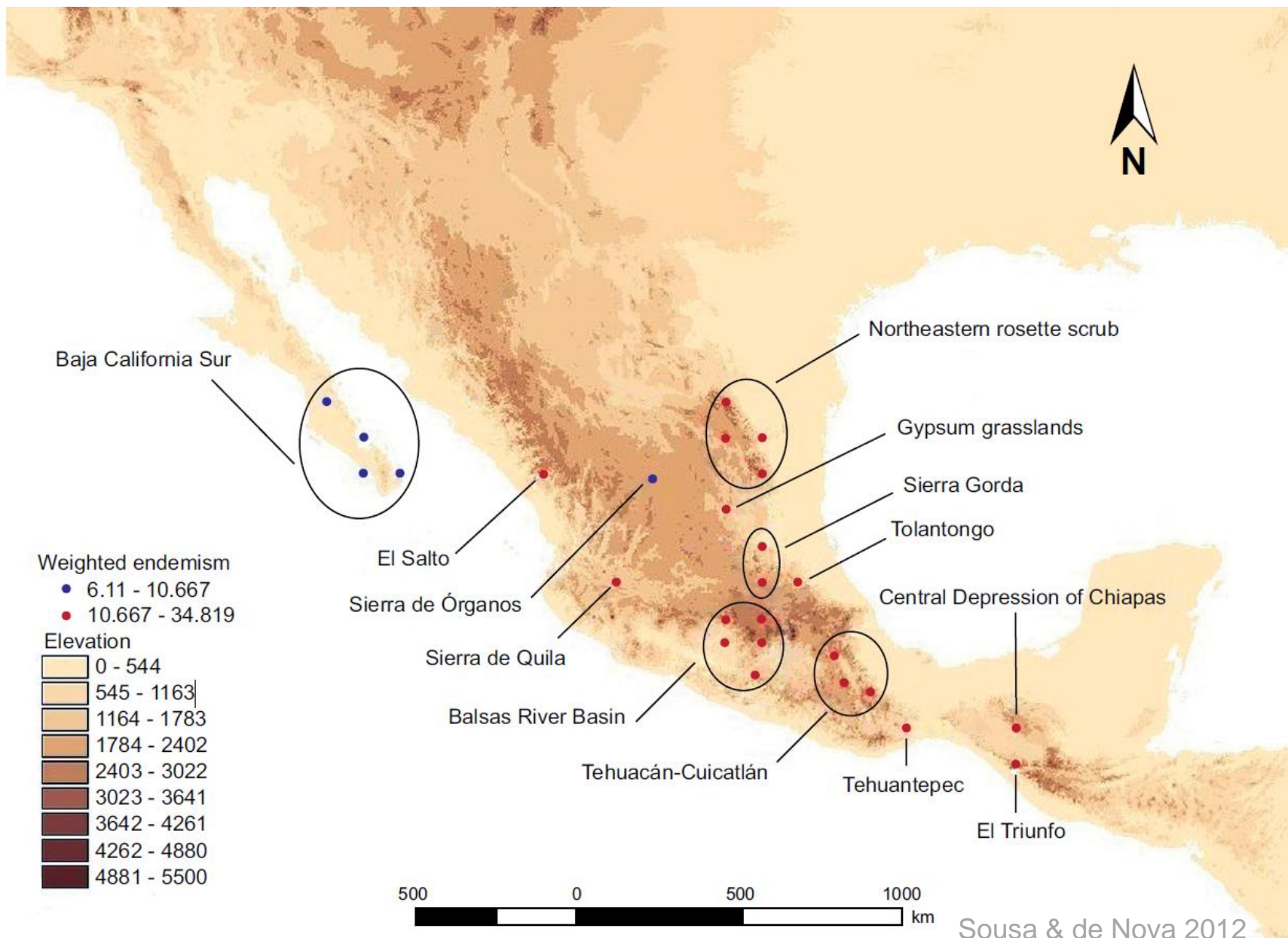
Moore et al. unpublished



Spencer Wight

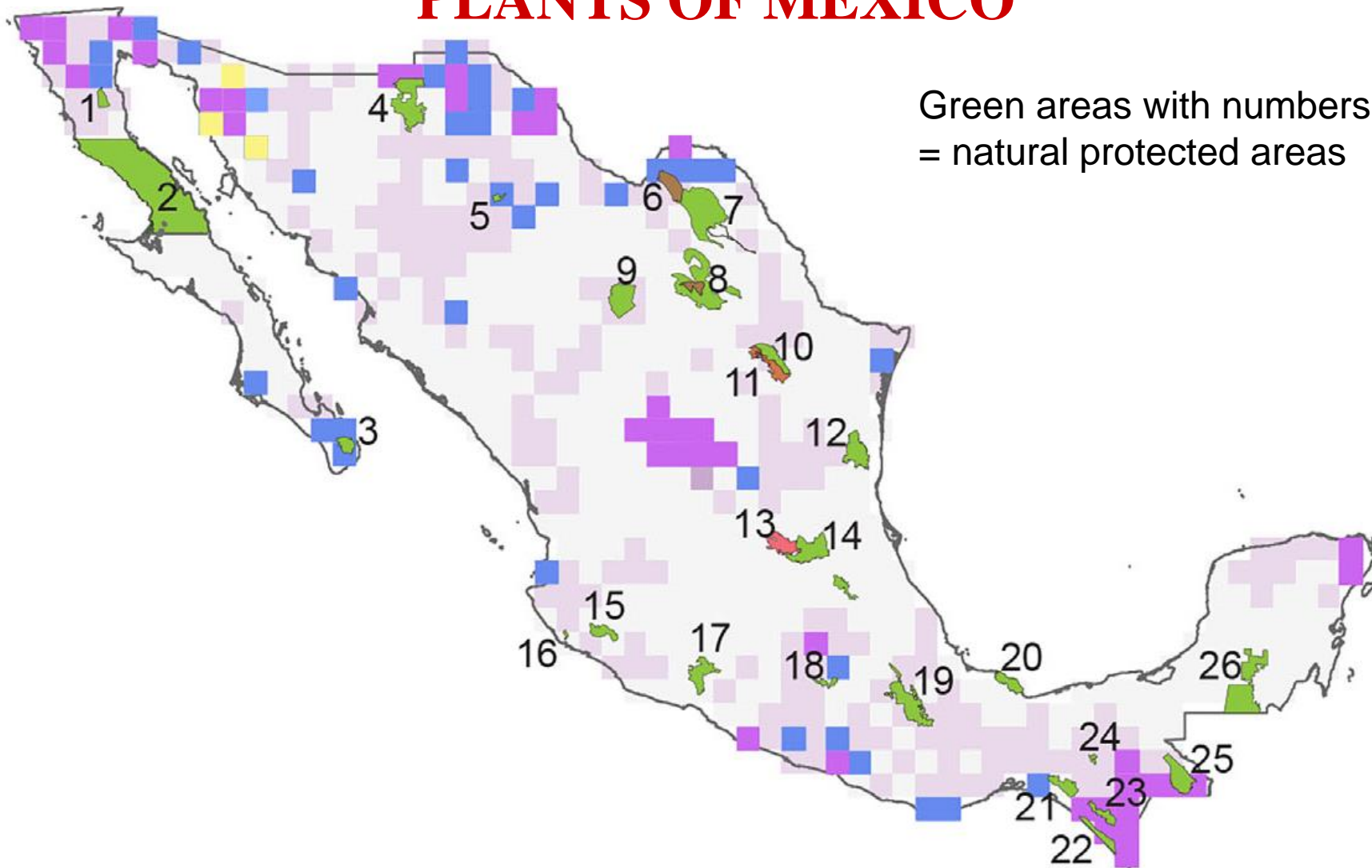


# AREAS OF ENDEMISM FOR THE MEXICAN LINEAGES OF ANGIOSPERMS



Sousa & de Nova 2012

# CENTERS OF ENDEMISM IN THE VASCULAR PLANTS OF MEXICO

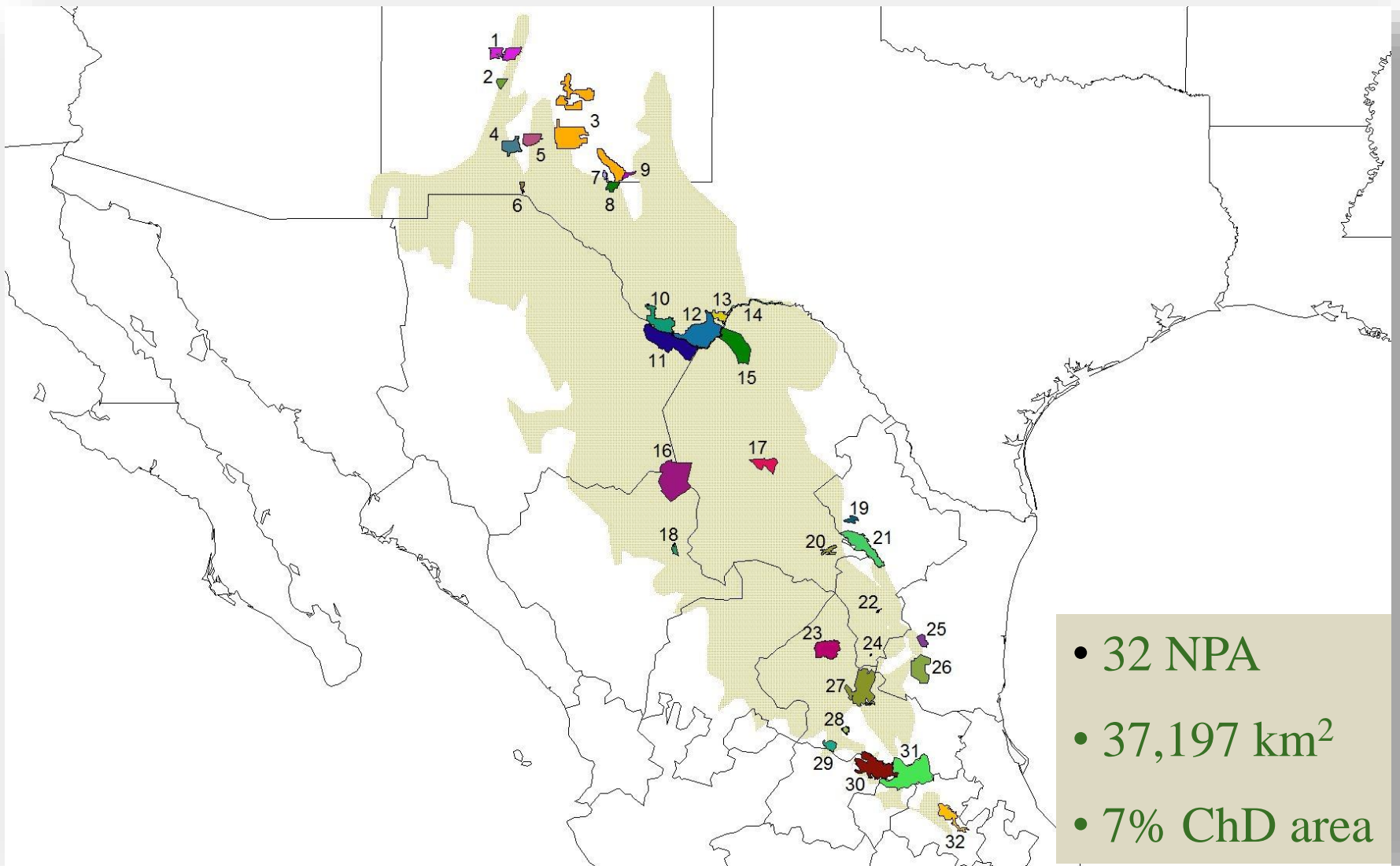


Green areas with numbers  
= natural protected areas



# NATURAL PROTECTED AREAS OF THE CD

Flores Olvera *et al.*: Gypsum ecosystems as biodiversity hotspots.



(Hernández et al., 2011)

## In summary

- According to our estimations, the extension of gypsum “islands” in the MCD has been underestimated; several of these areas are under or even unexplored.
- There are complex affinities of the vascular plants to gypsum in Mexico, from edaphic endemics to gypsovagues, gipsoclines, and gypso-halophytes.
- The gypsum vegetation and flora of MCD is very diverse, including life forms, population genetics, species, and phylogenetic diversity.
- The MCD contains a high diversity of gypsum plants species ( $\pm 630$ )
- 200-350 species in 36 families are endemic to the gypsum soils of MCD (~50%)
- Most genera have few species (3-5) restricted to gypsum in the MCD
- The gypsum flora of Mexico is of broad interest to evolutionary and conservation biologist.

# Conclusions

- More exploration is urgently needed in this type of soils
- Gypsum soils favoured endemism in the Chihuahuan Desert
- As a method to identify those regions of the world where attention is needed to address biodiversity loss and to guide investments in conservation, the Mexican gypsum ecosystems should be considered a hotspot of biodiversity.

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HORIZON 2020



Norman Douglas, 2013