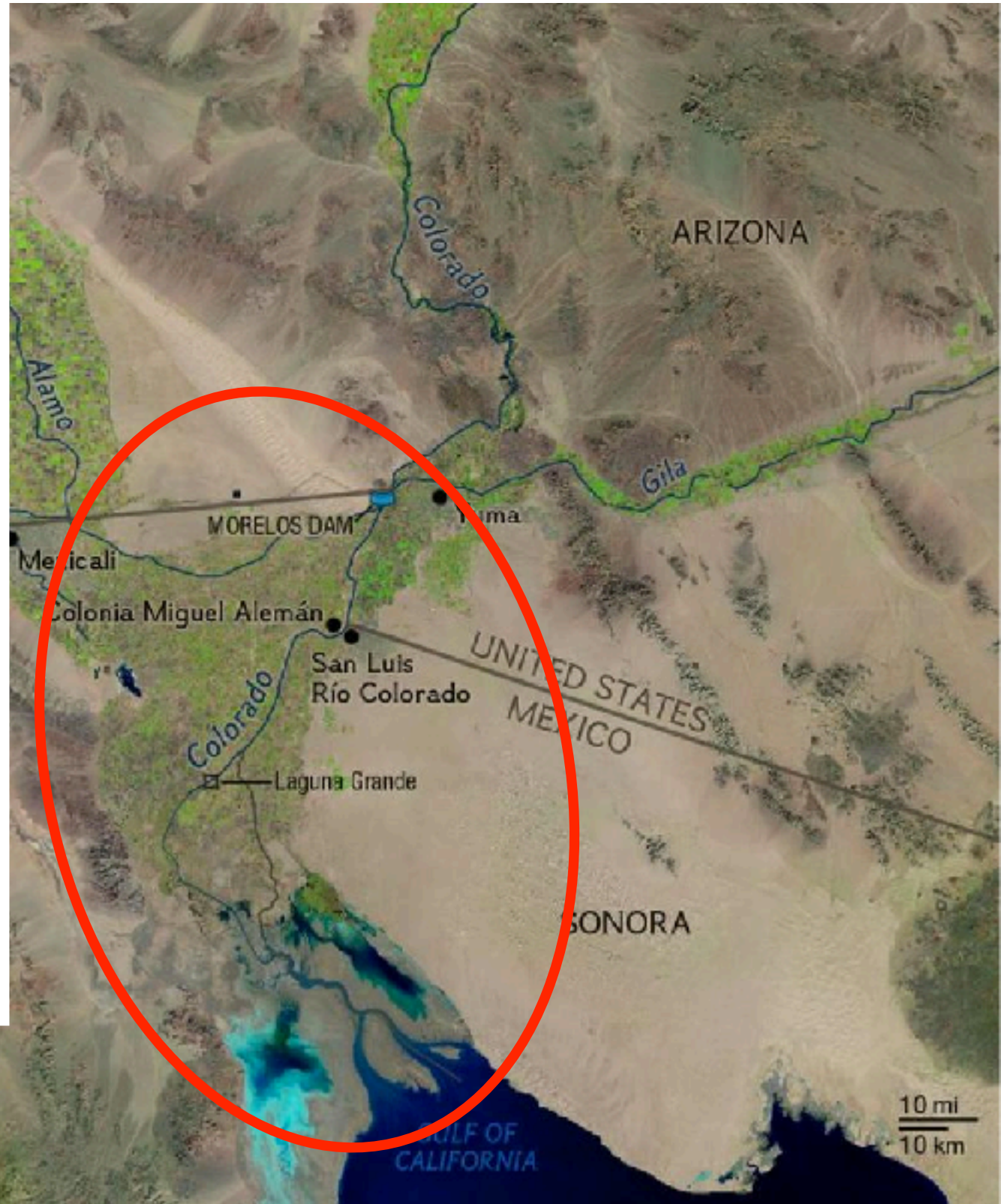


Restoration of the Colorado River Delta: Impacts of the 2014 environmental pulse flow and future directions

Micah Freedman
February 28, 2018
ECL 290 - Ecogeomorphology



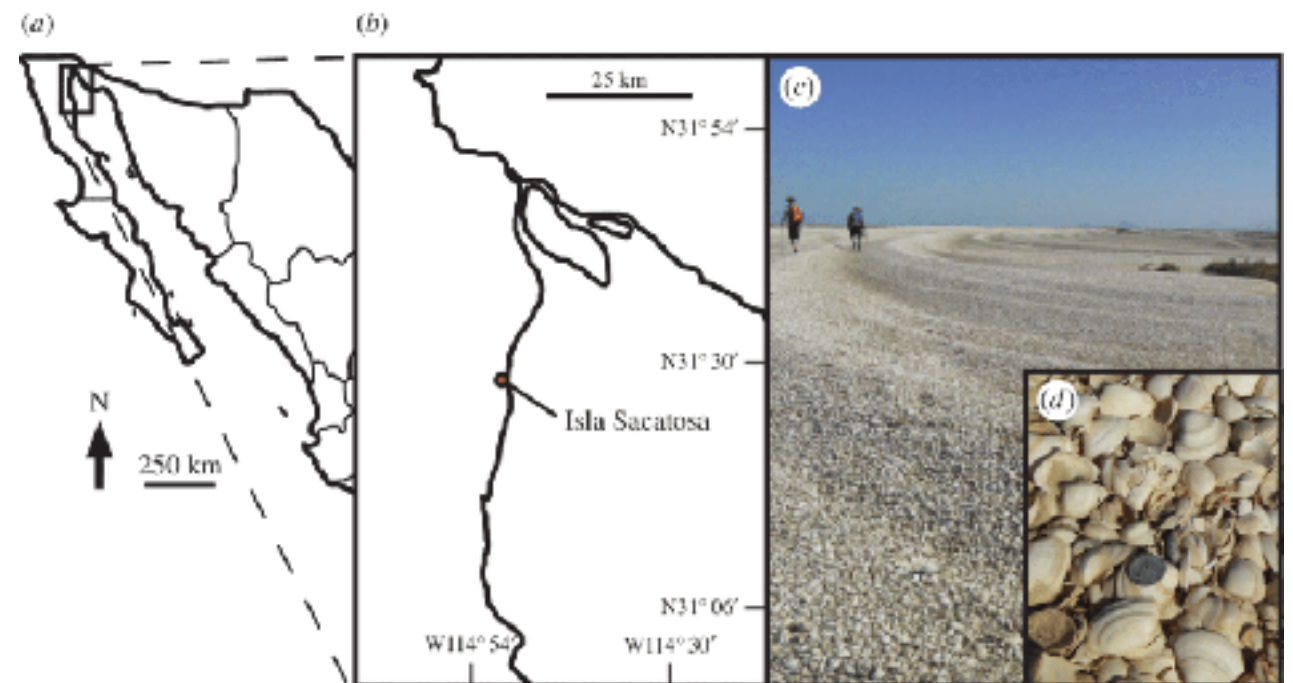


Restoration of the Colorado River Delta

- **What was there before?**
- **What is there now?**
- **Why is it important?**
- **Minute 319 and the 2014 pulse flow**
- **Effects of the pulse flow: Did it work?**

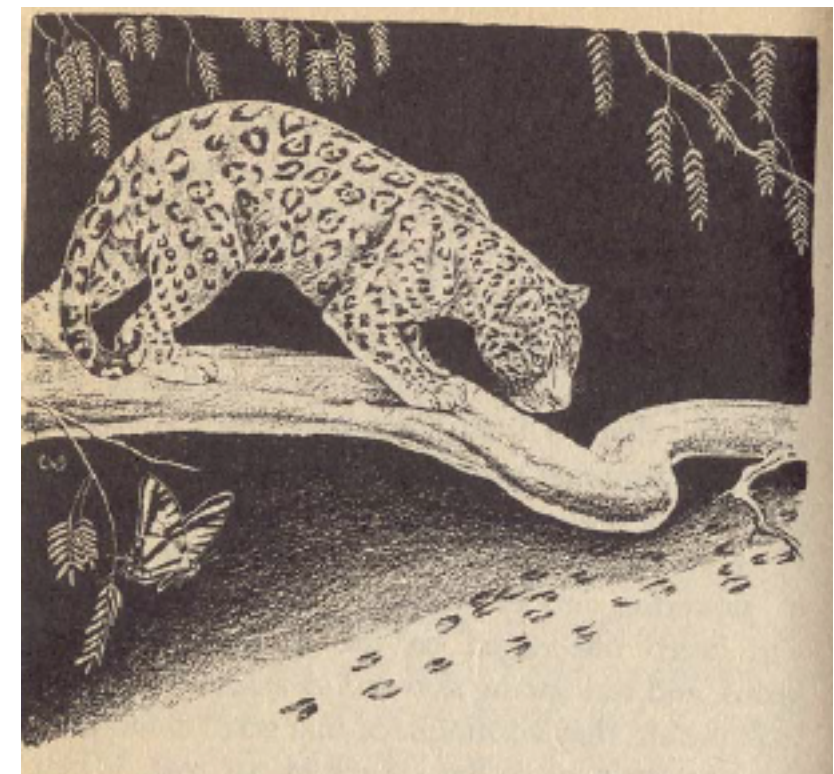
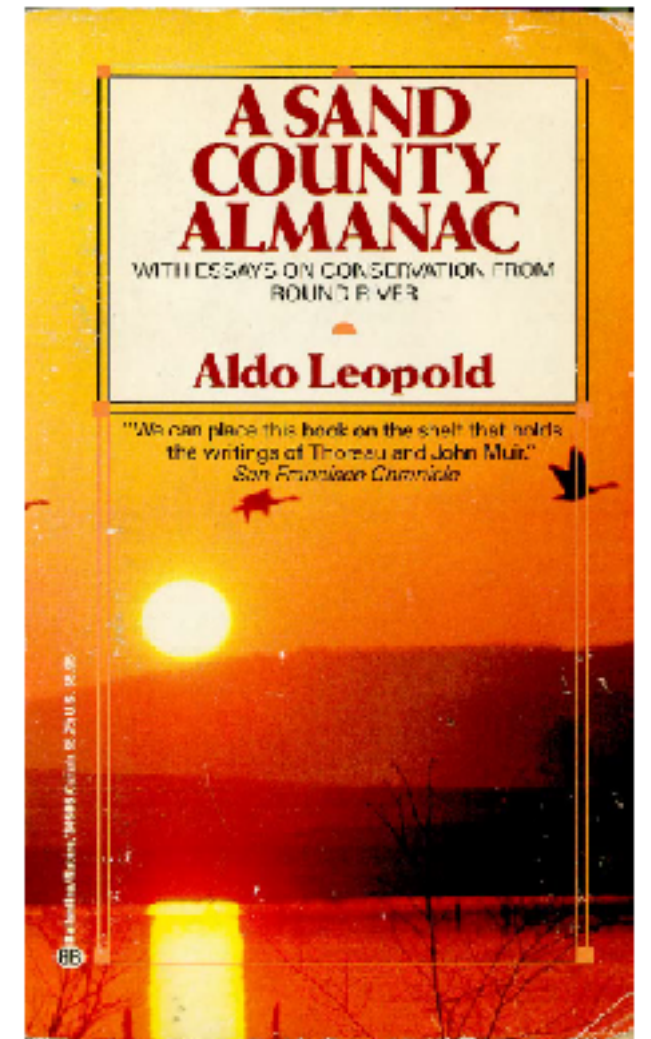
What was there before?

- Peak flows of 3,000 m³/s regularly reached the Delta
- Highly productive system covering nearly 8,000 km²:
 - Gallery forest of mesquite, cottonwood, willow
 - Backwater marshes
 - Tidal mudflats
 - Nursery for abundant Gulf of California fisheries
- Cocopá native peoples



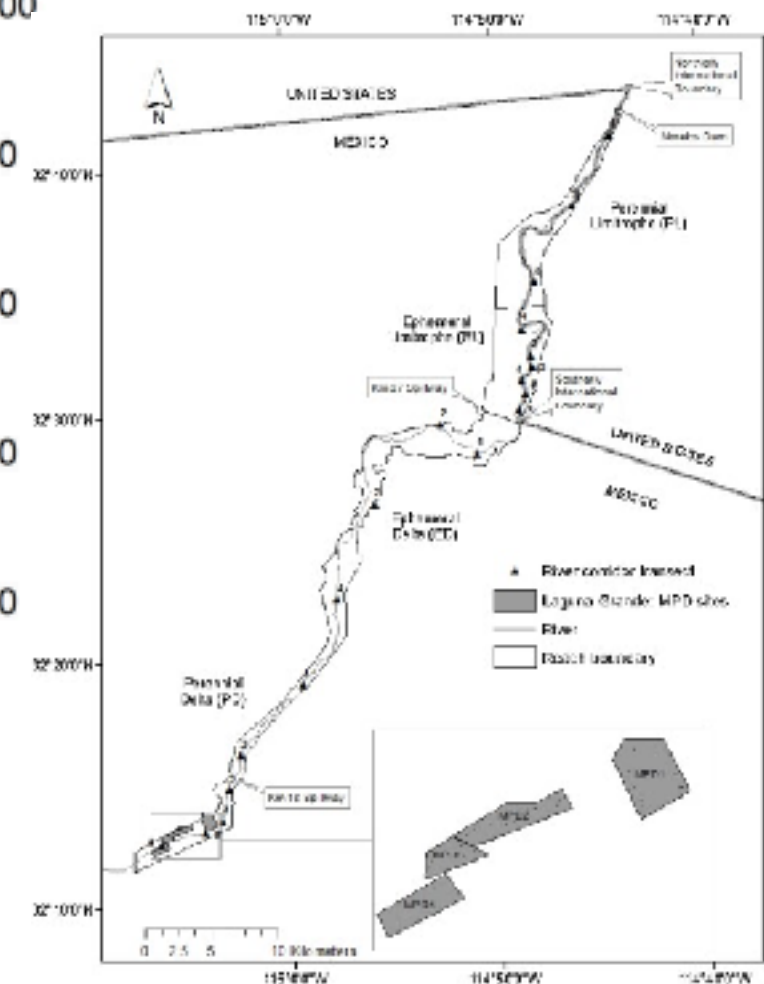
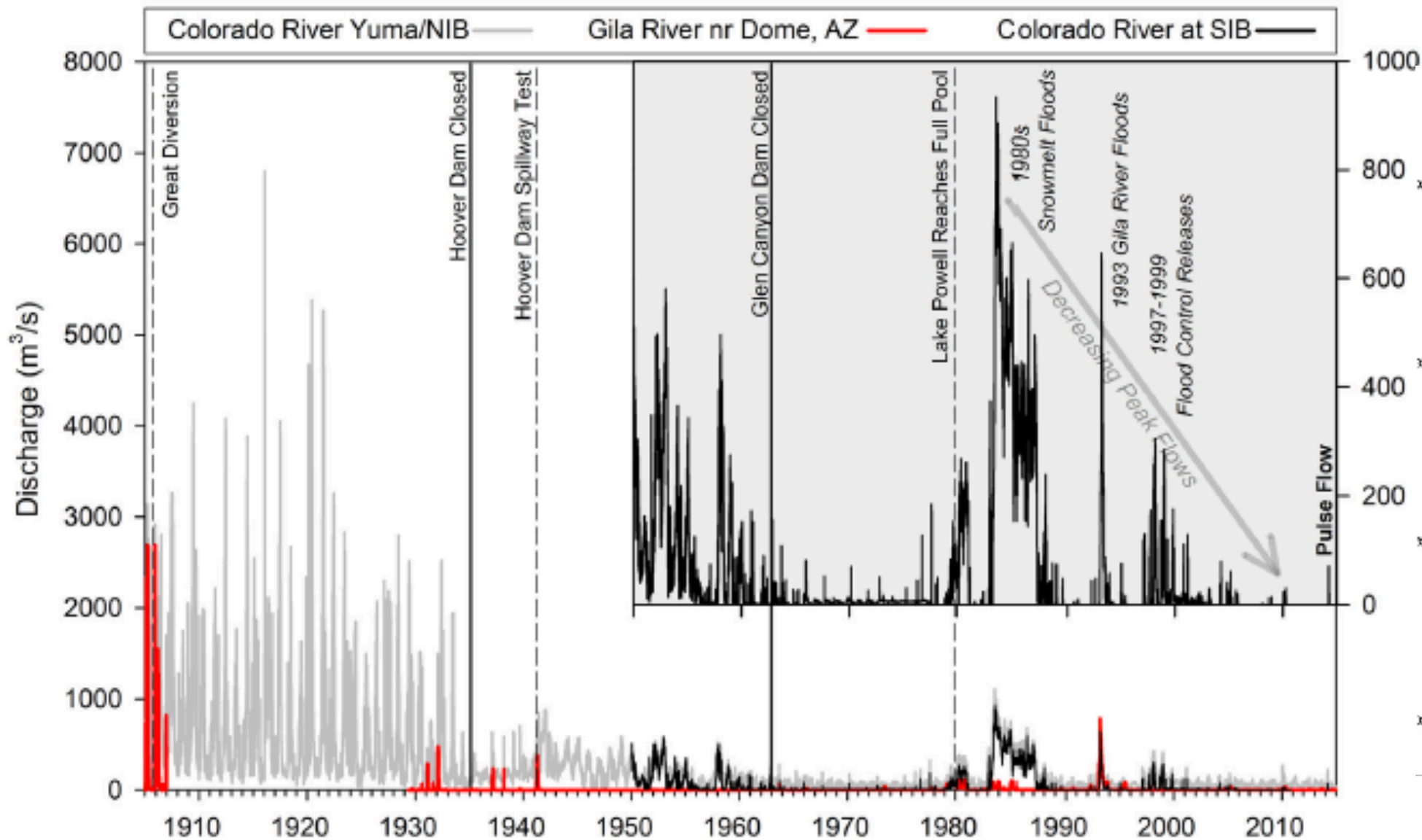
On the map the delta was bisected by the river, but in fact the river was nowhere and everywhere, for he could not decide which of a hundred green lagoons offered the most pleasant and least speedy path to the gulf. So he traveled them all, and so did we. He divided and rejoined, he twisted and turned, he meandered in awesome jungles, he all but ran in circles, he dallied with lovely groves, he got lost and was glad of it, and so were we. For the last word in procrastination, go travel with a river reluctant to lose his freedom in the sea.

— Aldo Leopold, *A Sand County Almanac*



What's there now?

- In most years, no fresh water reaches the Colorado River Delta
- Current area is ~5% of original extent



Mueller *et al.* (2017)



Photo credit: NASA



Photo credit: Armando Campbell



Photo credit: Armando Campbell

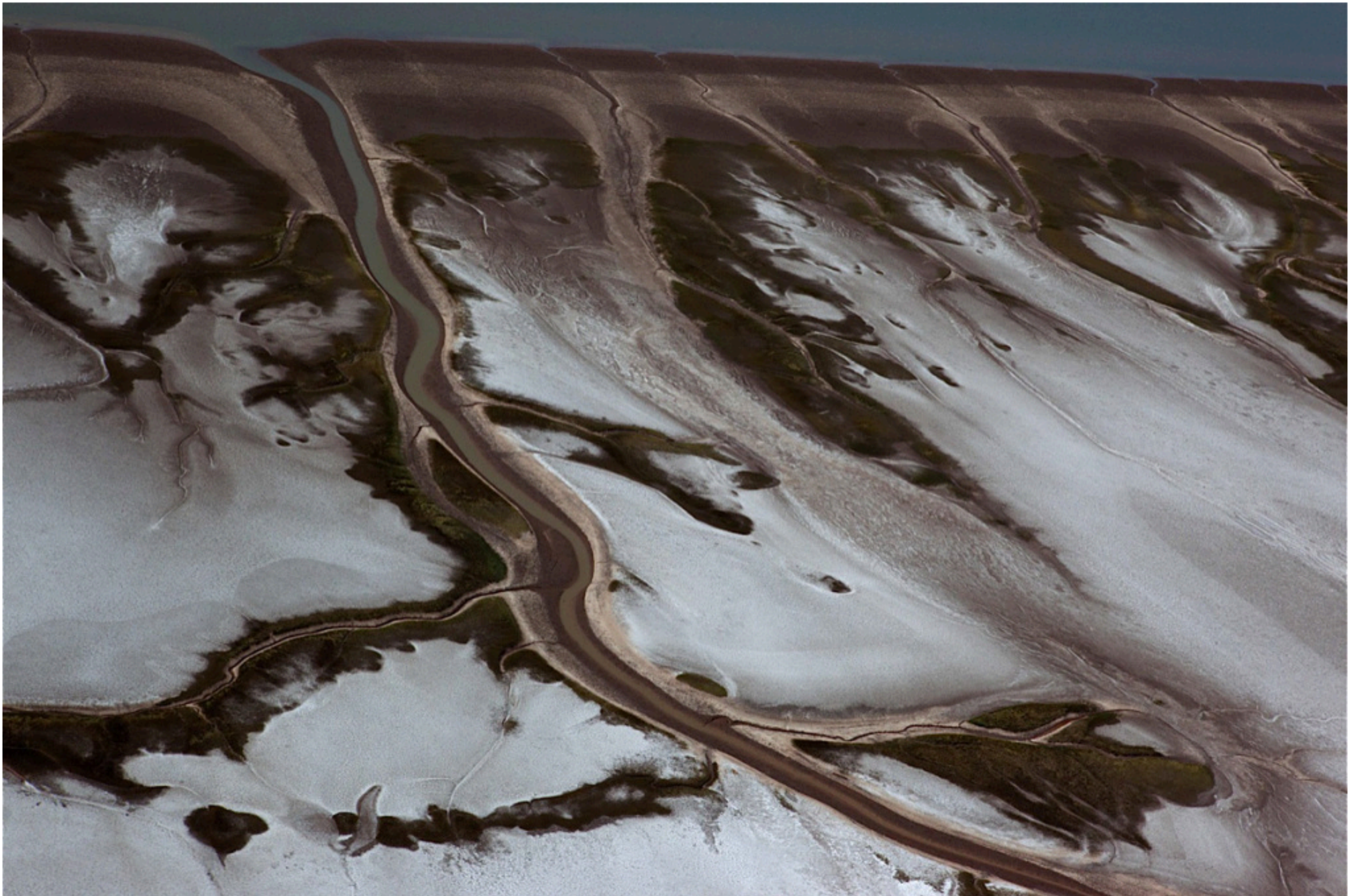


Photo credit: Armando Campbell

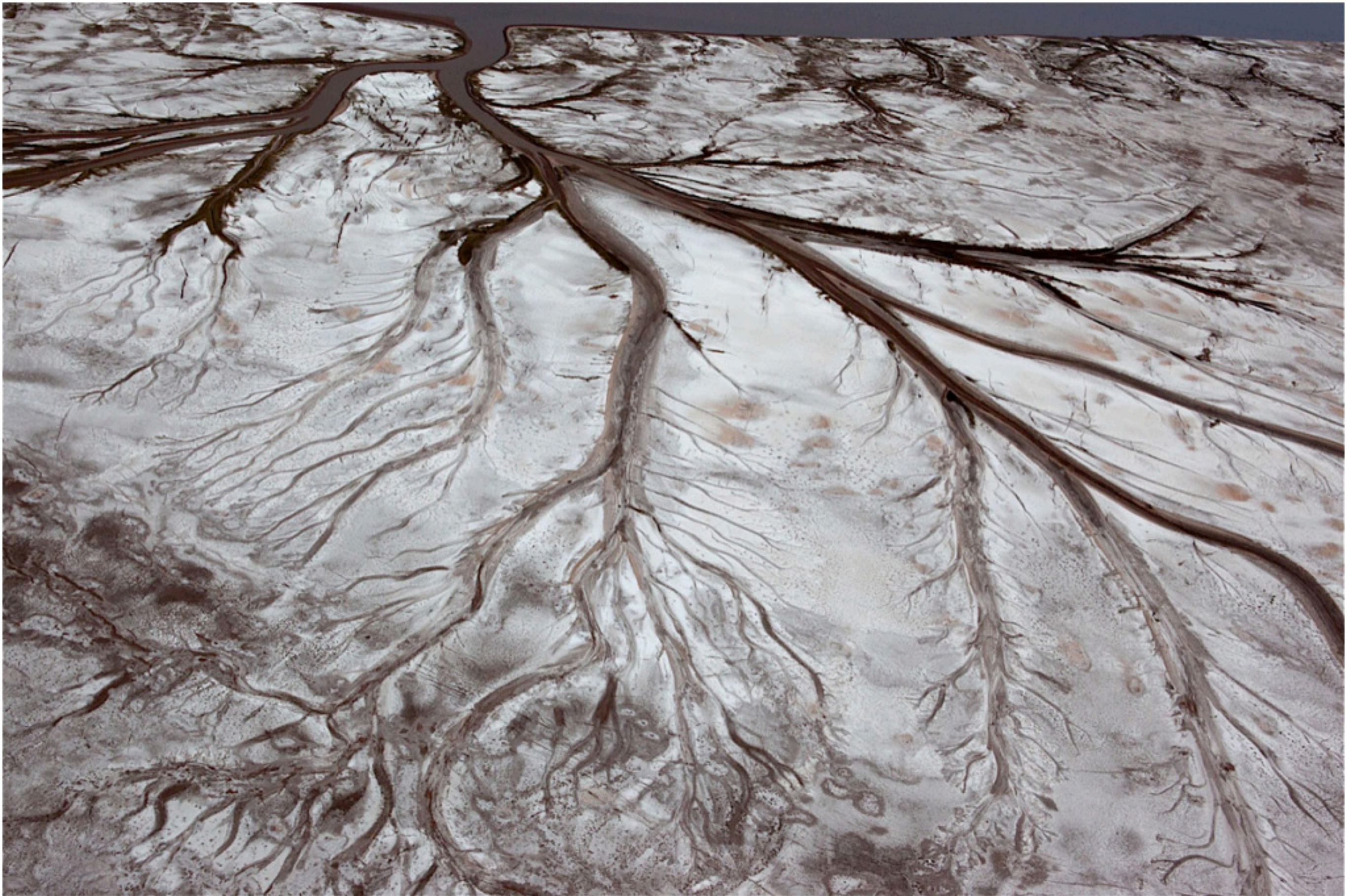


Photo credit: Armando Campbell



Photo credit: Armando Campbell



Photo credit: Peter McBride



Photo credit: Eric Rochner, National Geographic

Why is the Colorado River Delta important?

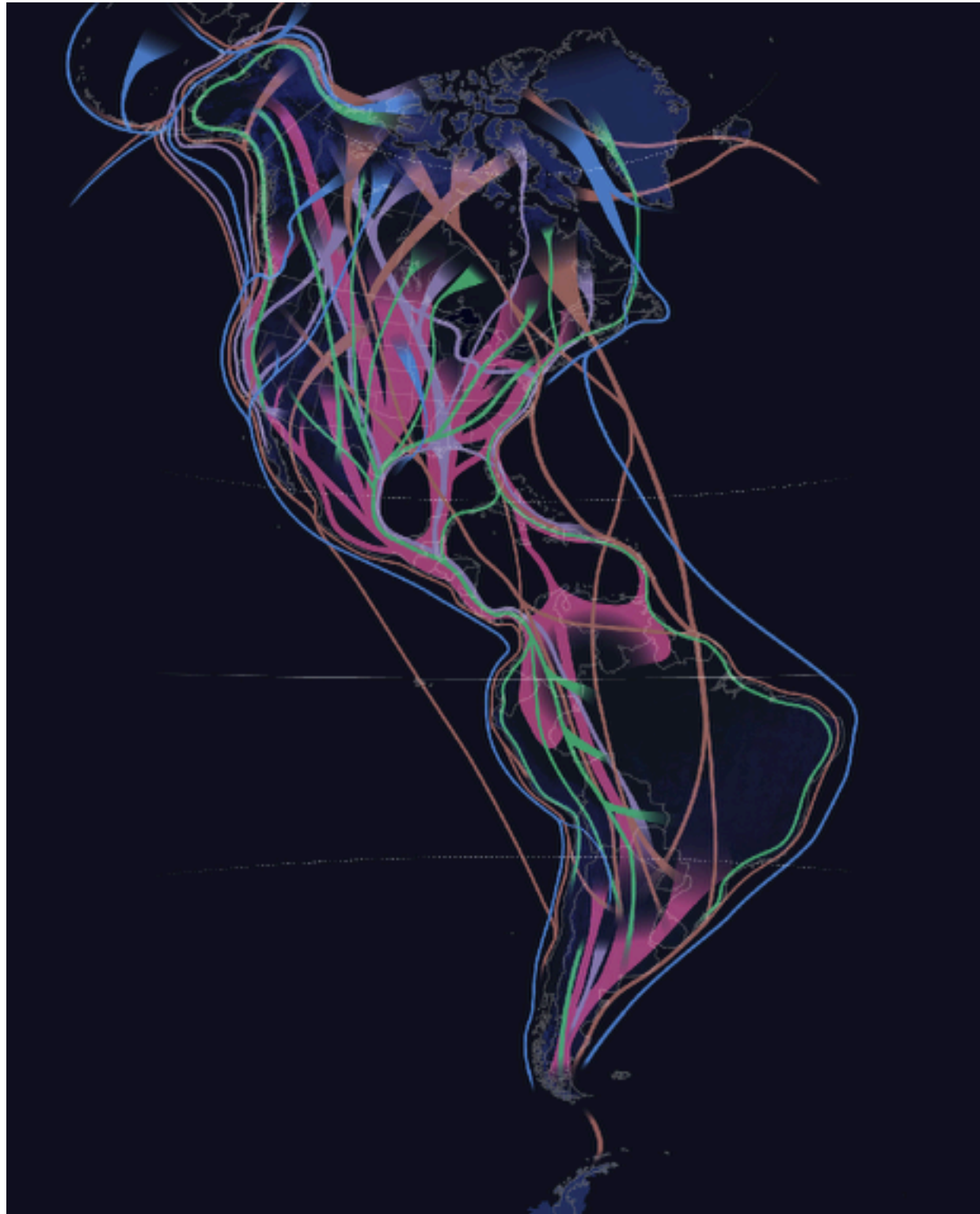


Image credit: National Geographic

**1. Crucial stopover along
the Pacific flyway**

358 documented bird species



Photo credit: Bill Hatcher



Southwestern willow flycatcher
(*Empidonax traillii extimus*)

Photo credit: NPS



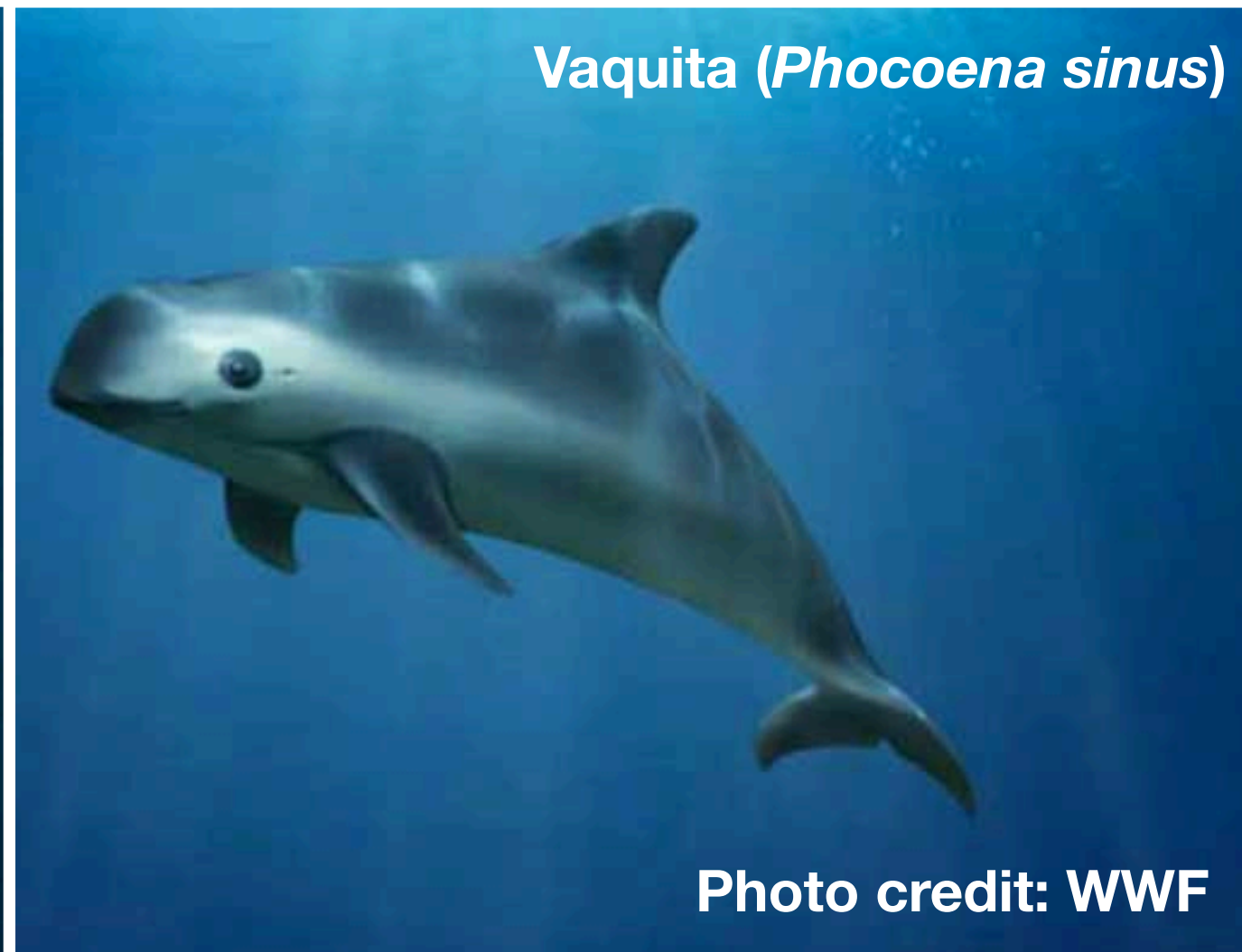
Yuma clapper rail
(*Rallus longirostris yumanensis*)

© JENNY E. ROSS

Two federally endangered birds

Why is the Colorado River Delta important?

1. Crucial stop along the Pacific flyway
2. Important estuarine habitat



Why is the Colorado River Delta important?

1. Crucial stop along the Pacific flyway
2. Important estuarine habitat
3. Commercial fisheries



Images: UC San Diego

Minute 319

- **2012 IBWC agreement between United States and Mexico**
- **Primary purpose: negotiating water rights allocations to Mexico based on Lake Mead levels**
- **Secondary purpose: environmental flows**
- **Succeeded by Minute 323***



Stated goals of Minute 319 environmental flow

1. Inundate floodplain and stimulate recruitment of cottonwood and willow
2. Fortify existing native vegetation
3. Increase riparian bird diversity and abundance

March 23 - April 14, 2014: 105,000 AF released from Morelos Dam (average $\sim 70 \text{ m}^3/\text{s}$)

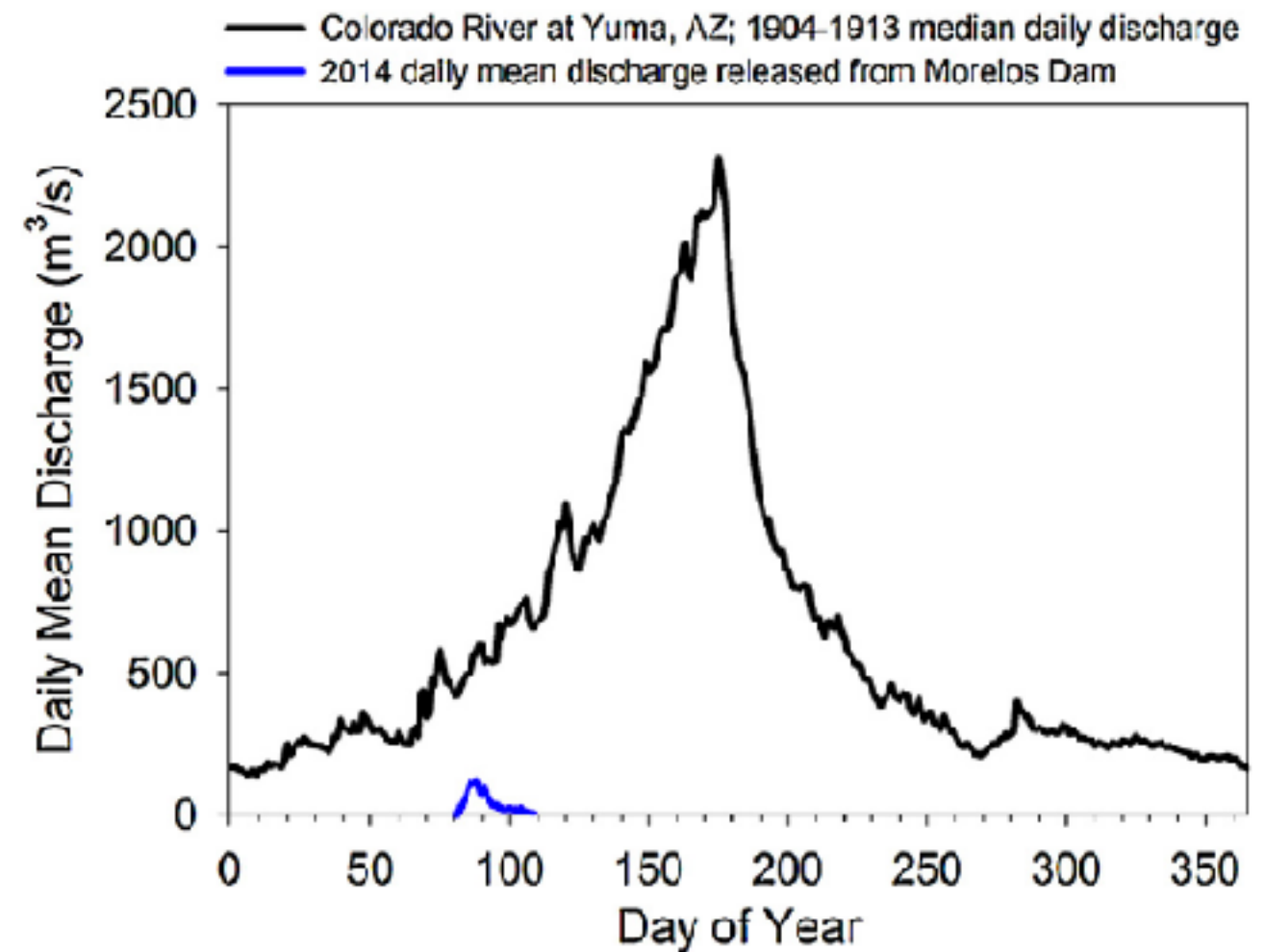
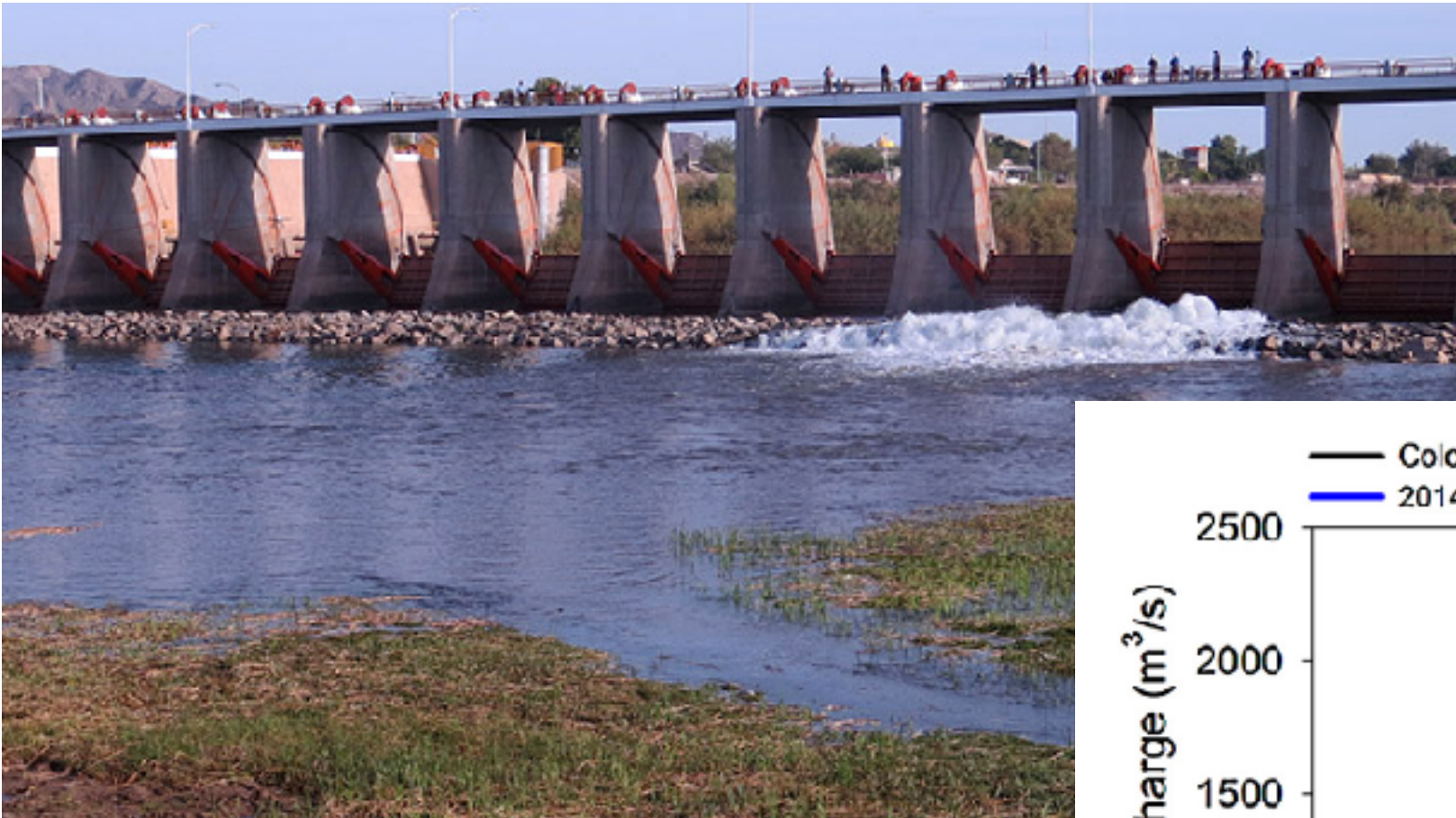


Photo credit: Nature Conservancy



Photo credit: Peter Warren

March 24: Water reaches San Luis Río Colorado



Photo credit: National Geographic

Colorado River @ San Luis Rio Colorado, MX - April 13, 2013



Image credit: NASA

Colorado River @ San Luis Rio Colorado, MX - April 23, 2014

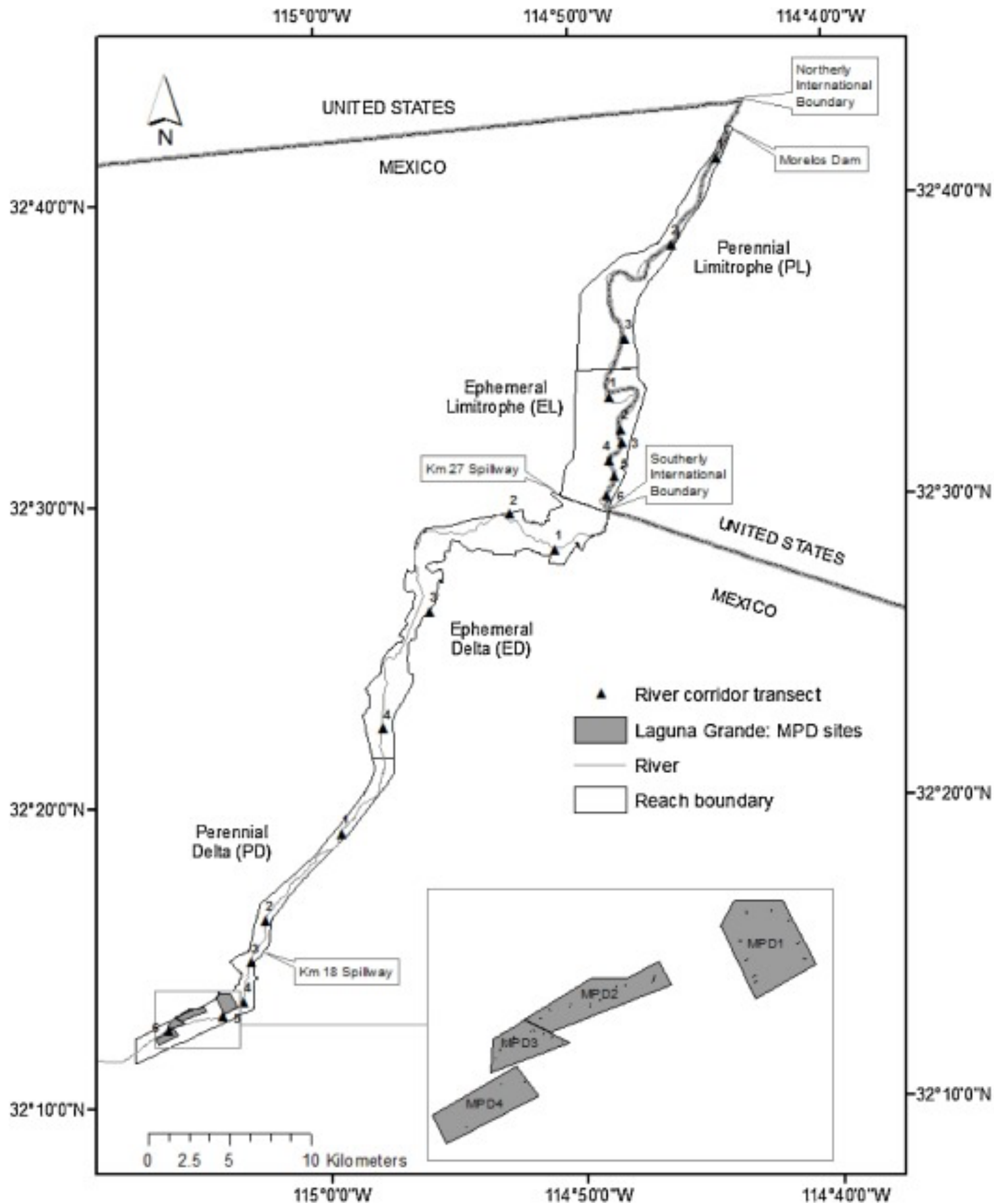


Image credit: NASA

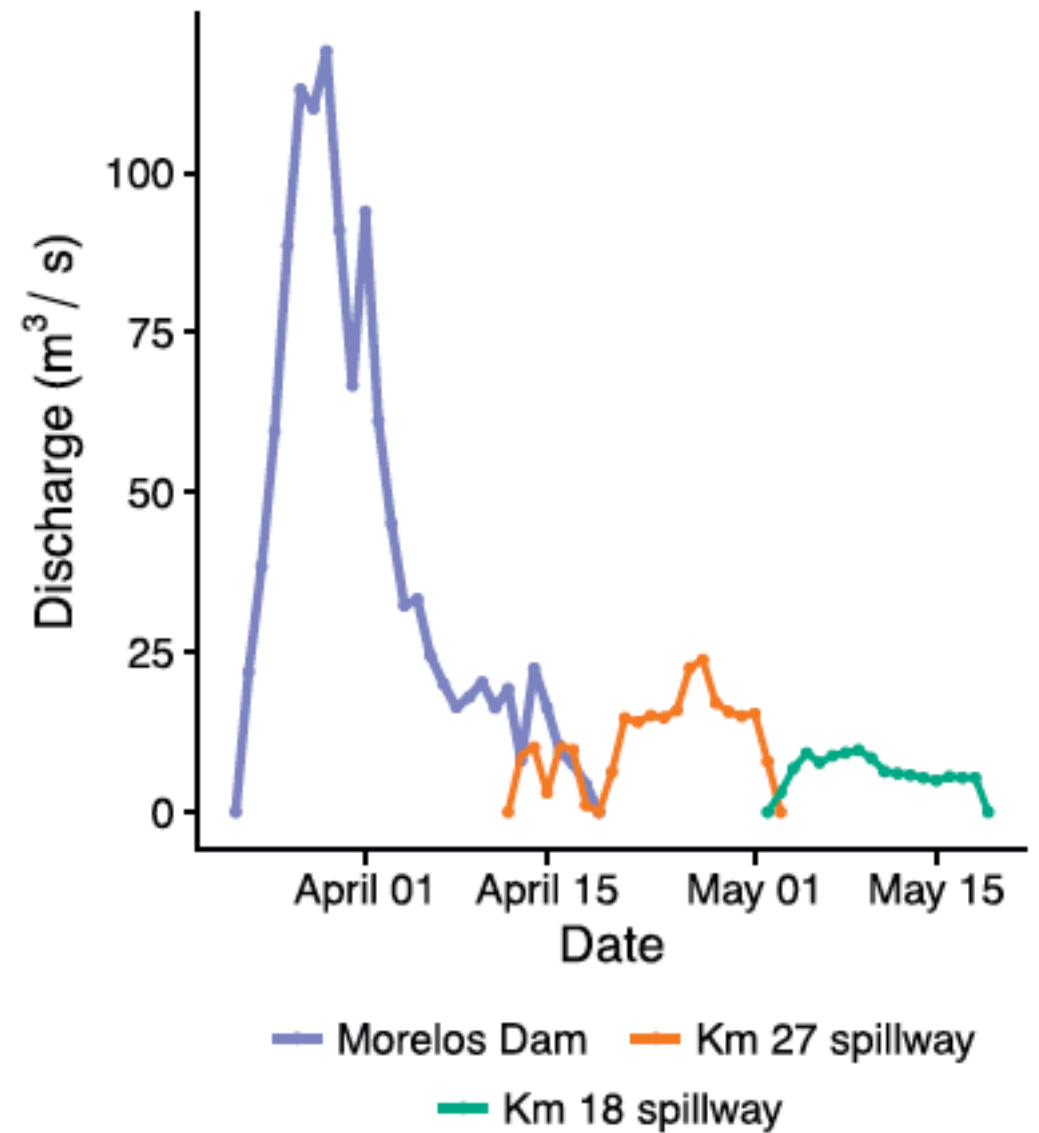
May 15th: Main channel of the Colorado River reaches the Delta for the first time since 1997



Photo credit: Francisco Zamora



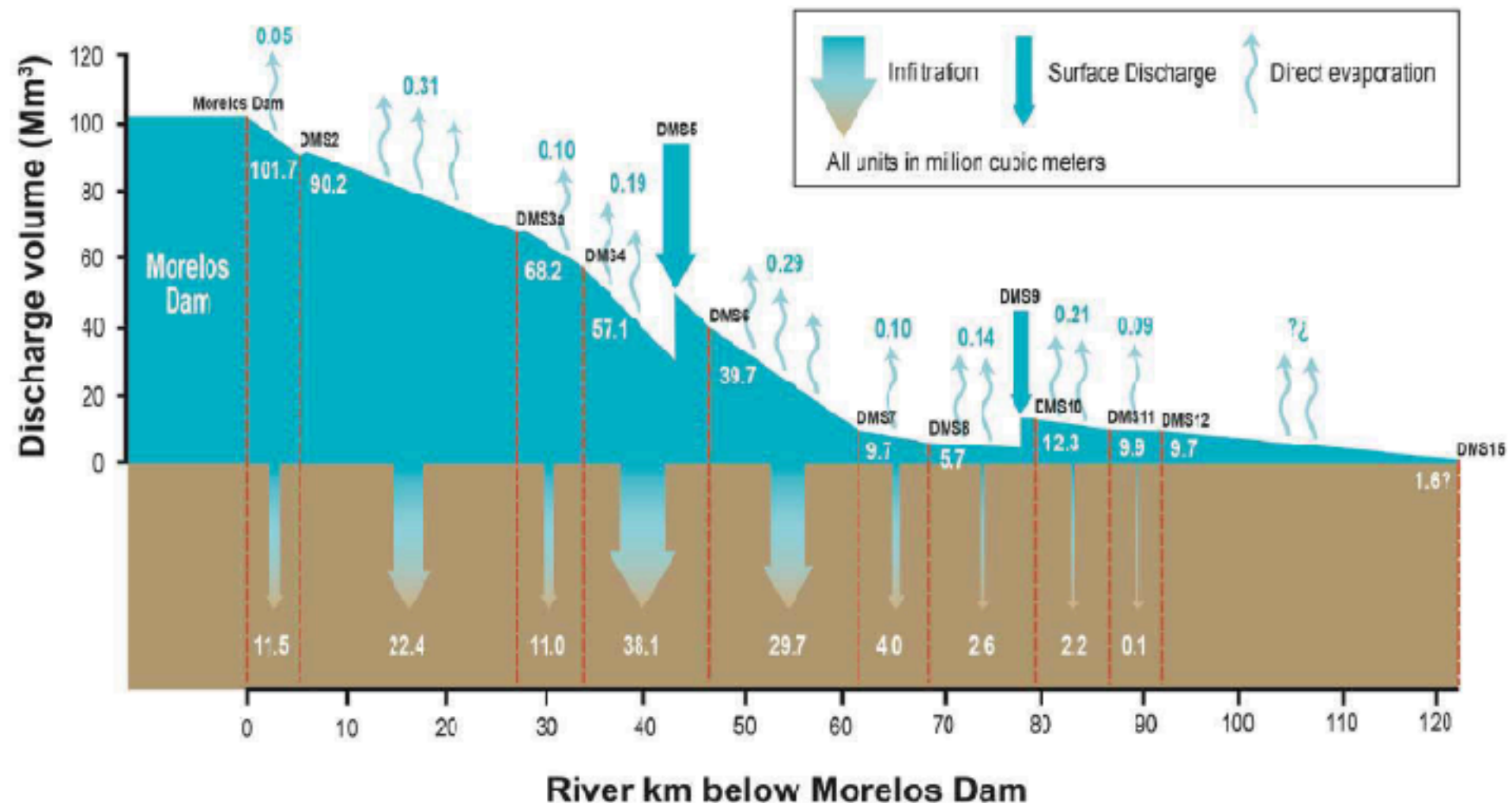
Overall average: ~17 m³/s



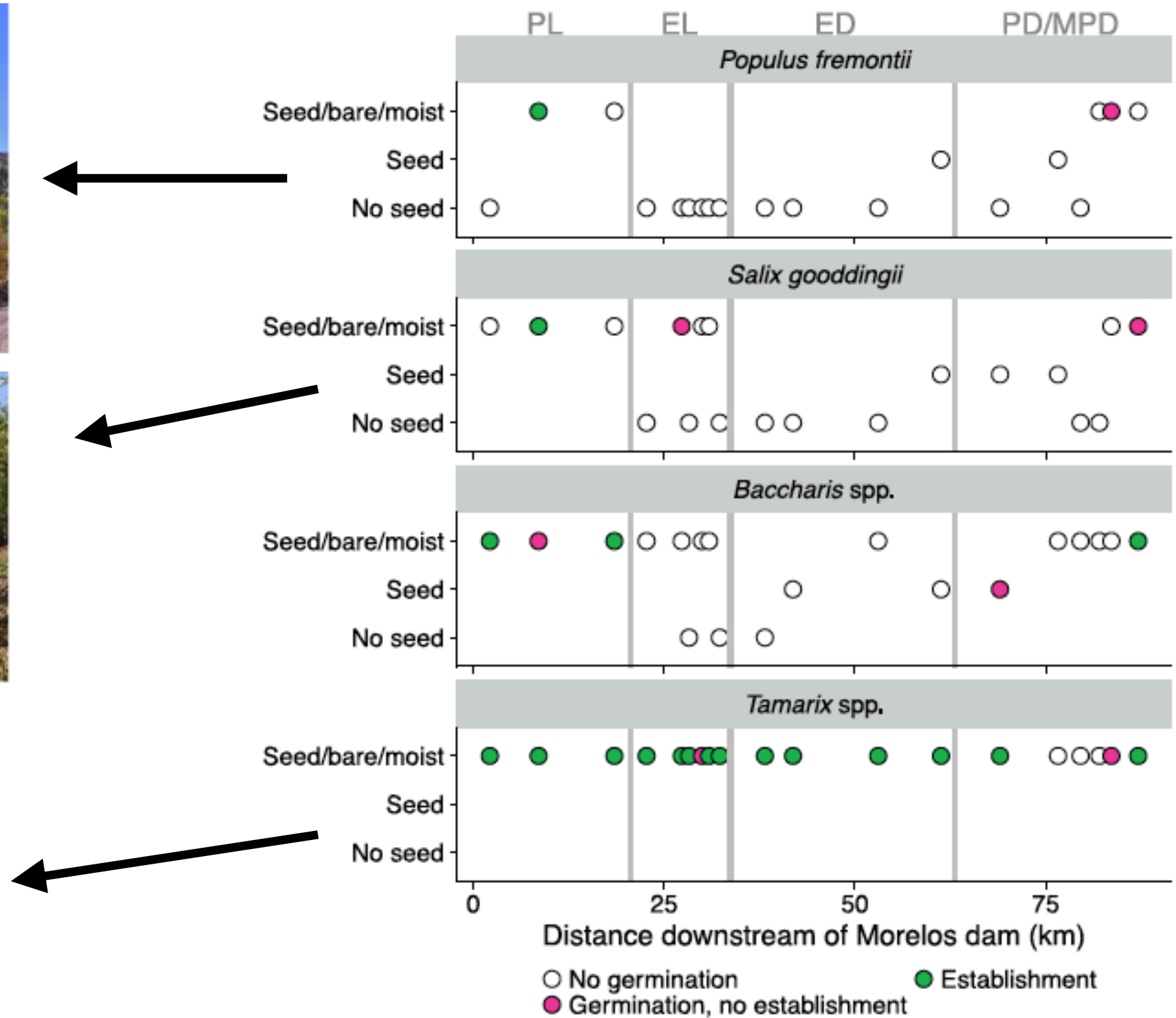
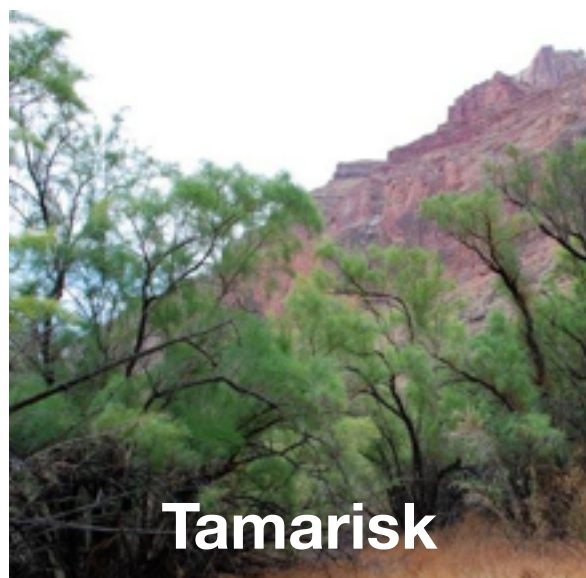
Objective 1: Inundate floodplain and stimulate recruitment of cottonwood and willow

Water did reach the Delta, but 91% of pulse flow volume infiltrated dry riverbed

Minimal / no scouring of riverbank observed



Objective 1: Inundate floodplain and stimulate recruitment of cottonwood and willow



Objective 1: Inundate floodplain and stimulate recruitment of cottonwood and willow

Low to no seed availability in many locations

Insufficient soil moisture throughout the growing season

Competition with established plants (esp. *Arundo donax* and *Phragmites australis*)



Table 1
Qualitative estimates based on comparisons to values in the literature of how well requirements for recruitment of *Populus* and *Salix* were met by the experimental flows in each reach and with the combination of flow and management actions in the MPD.

Component	Reach PL	Reach EL	Reach ED	Reach PD	Reach MPD
Seed availability	Good	Fair	Poor	Good	Good
Bare substrate	Fair	Good	Good	Poor	Excellent
Continued moisture (recession rate)	Good	Poor	Poor	Good	Good
Continued moisture (max depth to groundwater)	Good	Poor	Poor	Good	Good
Low competition	Fair	Good	Good	Poor	Good
Low soil salinity	Good	Good	N/A	Fair	Fair-poor
Lack of herbivory/grazing	Good	Good	Good	Good	Good

N/A indicates insufficient data to assess. PL – Perennial Limitrophe; EL – Ephemeral Limitrophe; ED – Ephemeral Delta; PD – Perennial Delta; MPD – Managed Perennial Delta.

Objective 1: Inundate floodplain and stimulate recruitment of cottonwood and willow

Restoration efforts most successful in areas with mechanical tamarisk removal and manual seeding / planting of cottonwood and willow

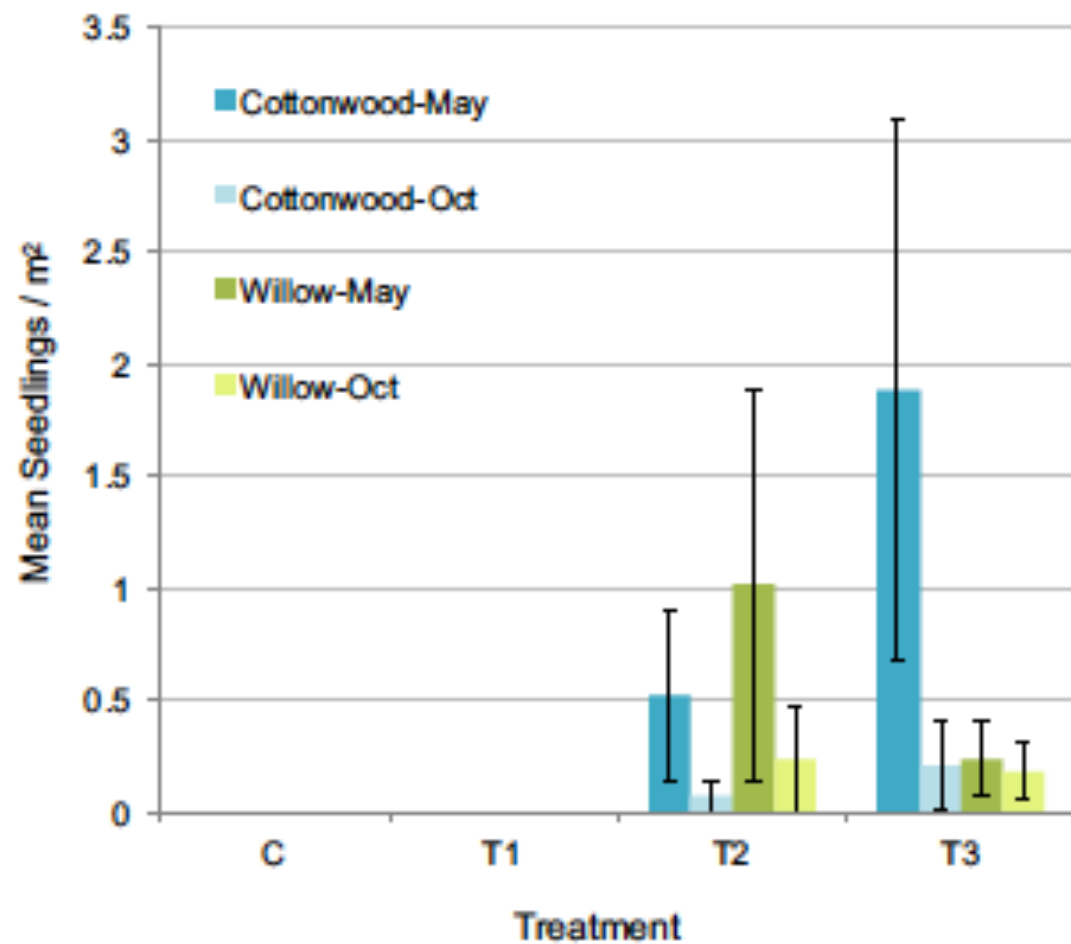


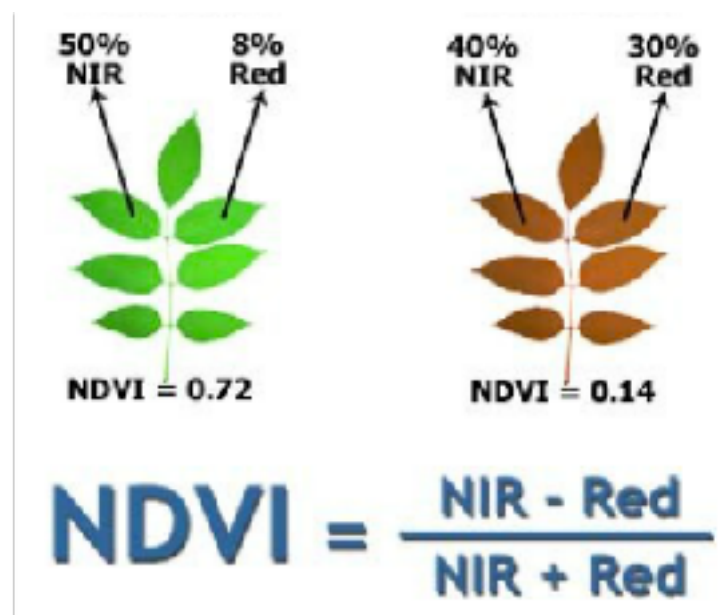
Fig. 4. May and October cottonwood and willow mean density per m² per treatment. Error bars are standard error of the mean. C= control; T1 = inundated; T2= inundated and cleared; T3 = inundated, cleared, seeded.



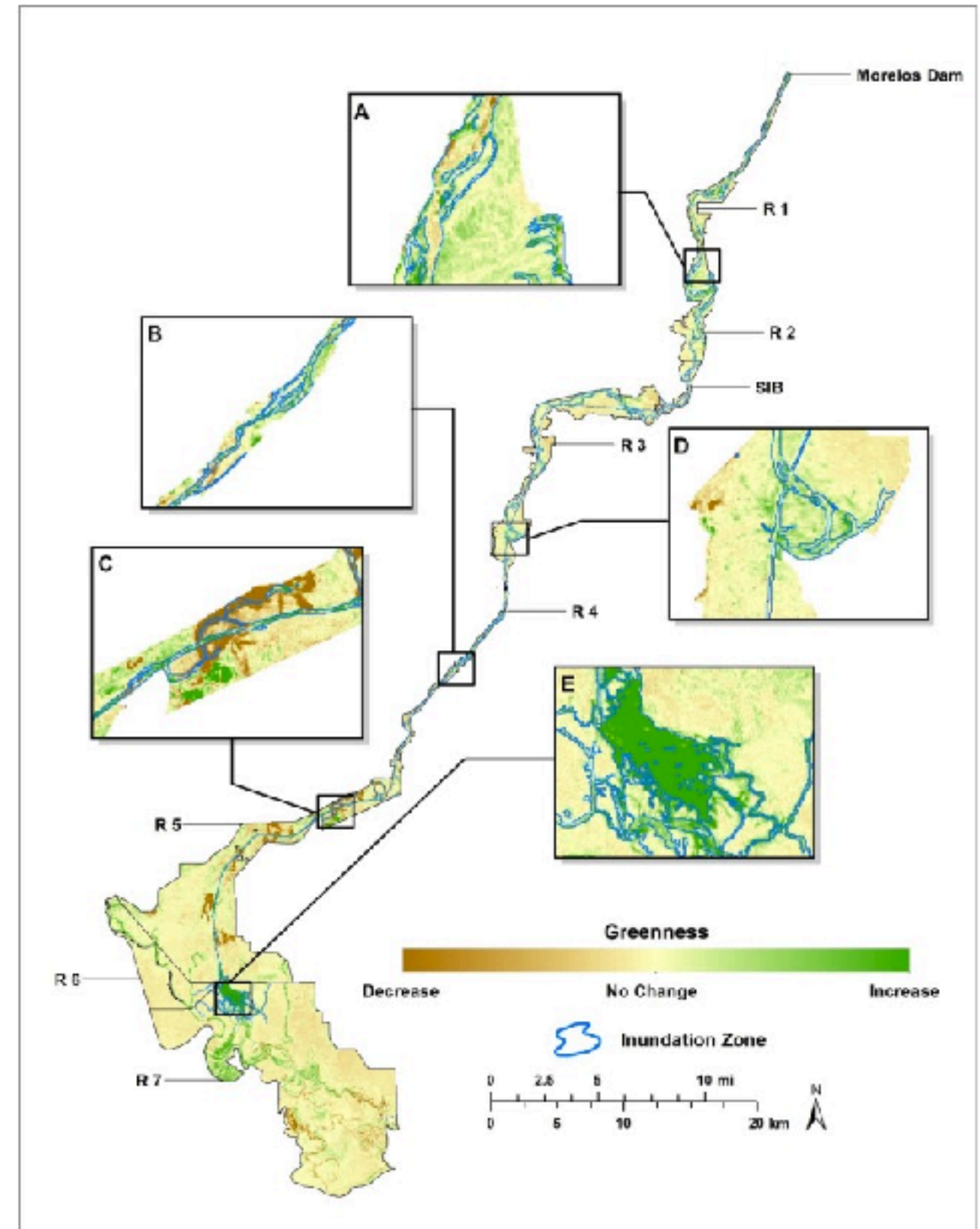
Objective 2: Fortify existing native vegetation

NDVI* did show marked increases along most river reaches, even in 2015; overall 15% increase in greenness

However, much of this was attributed to non-native vegetation



*Normalized difference vegetation index



Jarchow *et al.* (2017)

Objective 3: Increase riparian bird diversity and abundance

**19 species of conservation concern:
abundance up 49% between 2013 and
2015**

**Best results were in actively managed
restoration sites**



Data: Minute 319 Interim Report

All photos: Audobon Society

Was the environmental pulse flow effective?

1. Inundate floodplain and stimulate recruitment of cottonwood and willow



Was the environmental pulse flow effective?

1. Inundate floodplain and stimulate recruitment of cottonwood and willow
2. Fortify existing native vegetation

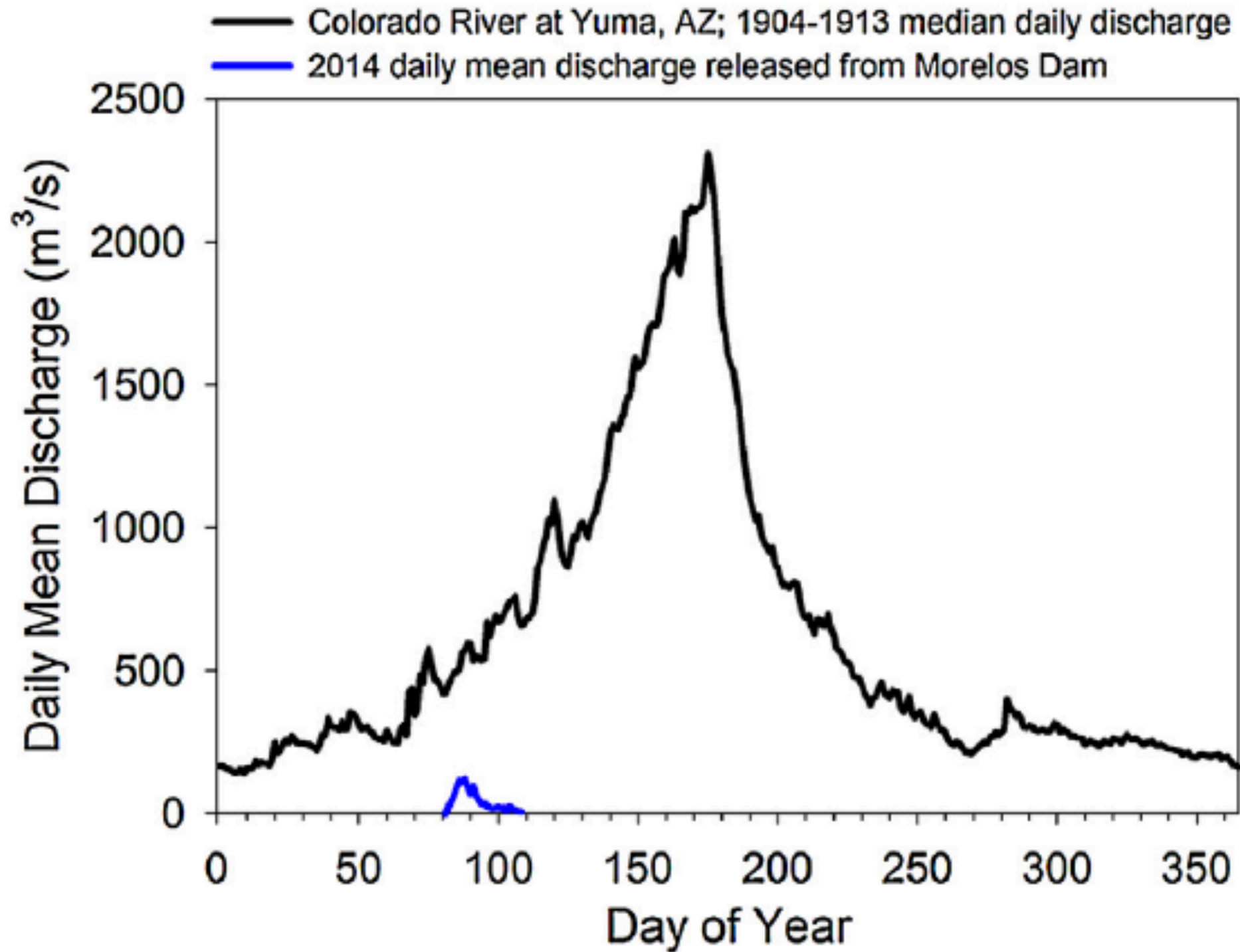


Was the environmental pulse flow effective?

1. Inundate floodplain and stimulate recruitment of cottonwood and willow
2. Fortify existing native vegetation
3. Increase riparian bird diversity and abundance

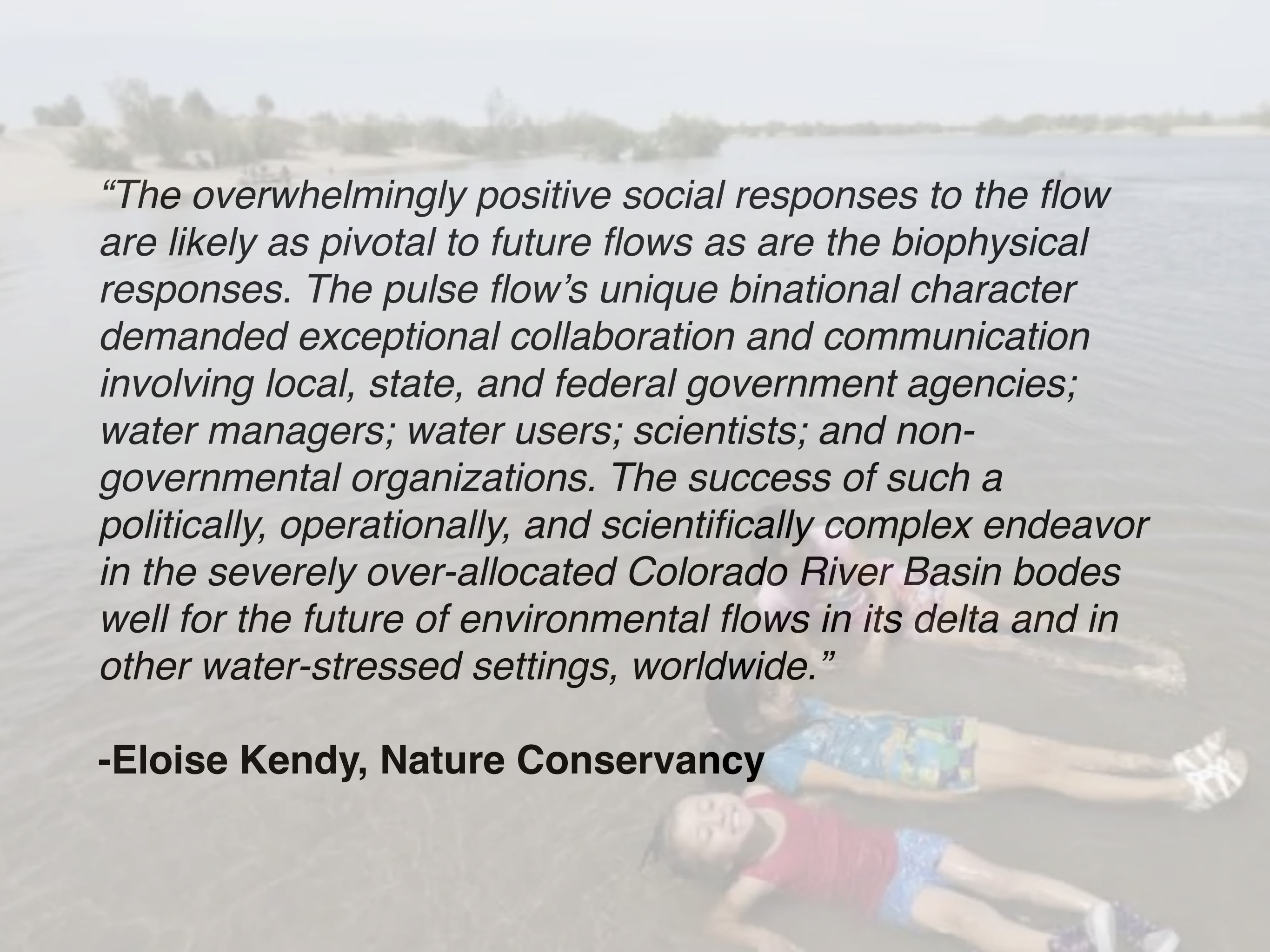


Was the environmental pulse flow effective?



Recommendations for future environmental flows

- **Actively remove non-native vegetation to promote establishment of native species**
- **Avoid releasing water into high infiltration areas**
- **Be more explicit about goals**



“The overwhelmingly positive social responses to the flow are likely as pivotal to future flows as are the biophysical responses. The pulse flow’s unique binational character demanded exceptional collaboration and communication involving local, state, and federal government agencies; water managers; water users; scientists; and non-governmental organizations. The success of such a politically, operationally, and scientifically complex endeavor in the severely over-allocated Colorado River Basin bodes well for the future of environmental flows in its delta and in other water-stressed settings, worldwide.”

-Eloise Kendy, Nature Conservancy

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An aerial photograph of a river delta system, showing a network of channels and distributaries. The water is a deep blue, contrasting with the light brown and tan sediment. In the foreground, a large, gnarled tree with a thick trunk and sparse, dark foliage stands prominently. The overall scene is a complex, organic pattern of water and land.

Questions?