USGS science supports bi-national efforts to restore riparian ecosystems in the Colorado River delta in Mexico under two 1944 Water Treaty Minutes (319 and 323)

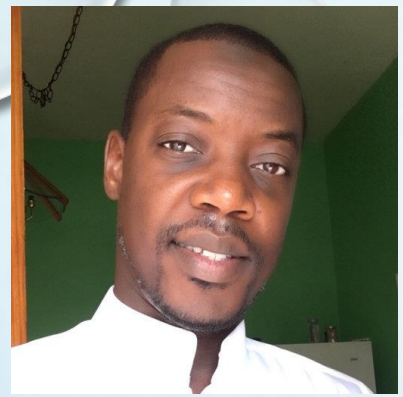
Pamela Nagler
US Geological Survey, Southwest Biological Science Center

USGS SCIENCE CENTERS & EXPERTISE

- Ecosystems Mission Area
  - Southwest Biological Science Ctr
  - Fort Collins Science Ctr
  - Pacific Is. Ecosystems Research
- Water Mission Area
  - Arizona Water Science Ctr
  - Integrated Info. Dissem. Division

riparian plant ecology, remote-sensing, avian ecology, surface and GW hydrology, database development and management, data analysis/statistics, social sciences

Professor, Biosystems Engineering
The University of Arizona



Ibrahima Sall
Research Associate
Biosystems Engineering
The University of Arizona

Government of South Australia

Martha Gomez-Sapiens
Research Associate
Geosciences, University of Arizona

Hamideh Nouri
Senior Scientist,
Environment & Water,
South Australia

THE UNIVERSITY OF ARIZONA

VIP lab.

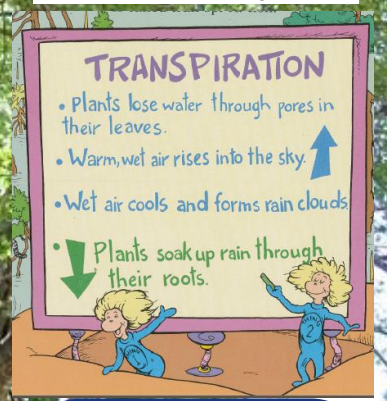
Armando Barreto-Munoz
Assistant Professor,
Biosystems Engineering
The University of Arizona

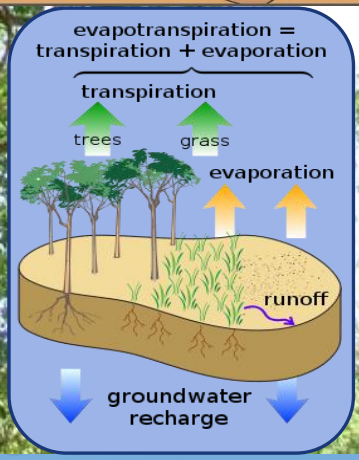
NASA

Sattar Chavoshi
Research Fellow
University of South Australia, Australia

USGS

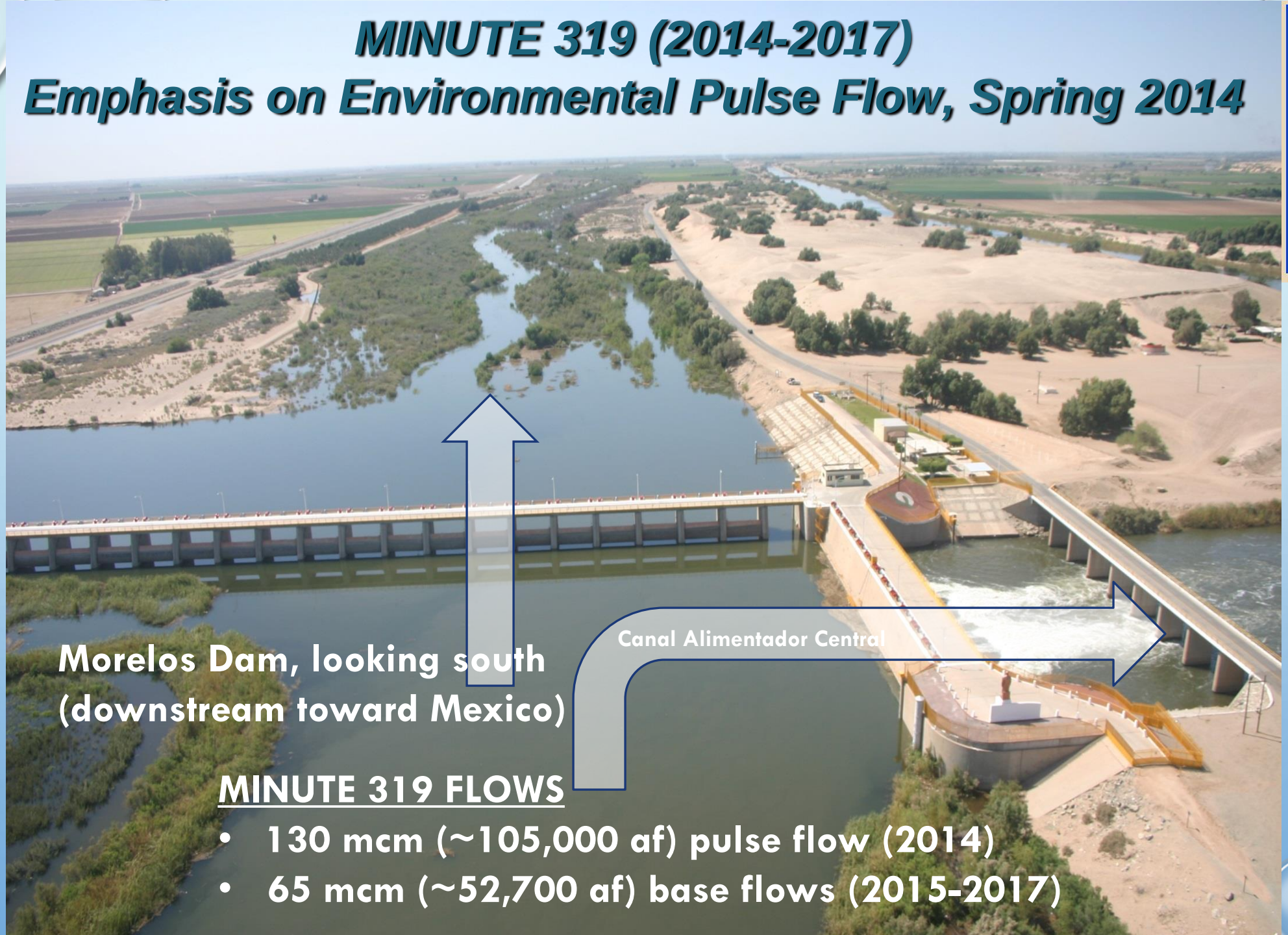
Pamela Nagler
The Nag Lab Co-Authors
USGS Southwest Biological SC





Department of Interior, U.S. Geological Survey

MINUTE 319 (2014-2017)
Emphasis on Environmental Pulse Flow, Spring 2014



Morelos Dam, looking south
(downstream toward Mexico)

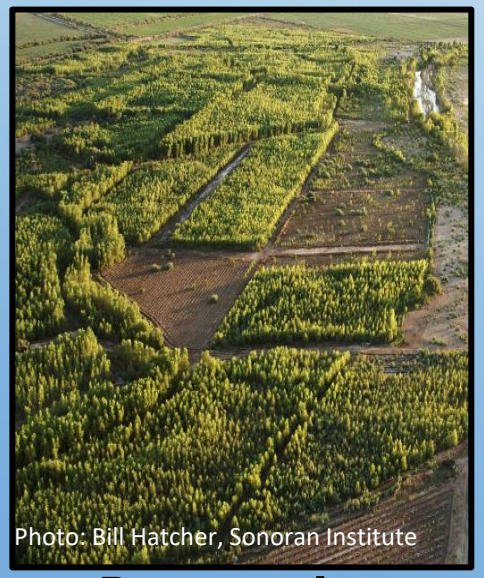
MINUTE 319 FLOWS

- 130 mcm (~105,000 af) pulse flow (2014)
- 65 mcm (~52,700 af) base flows (2015-2017)

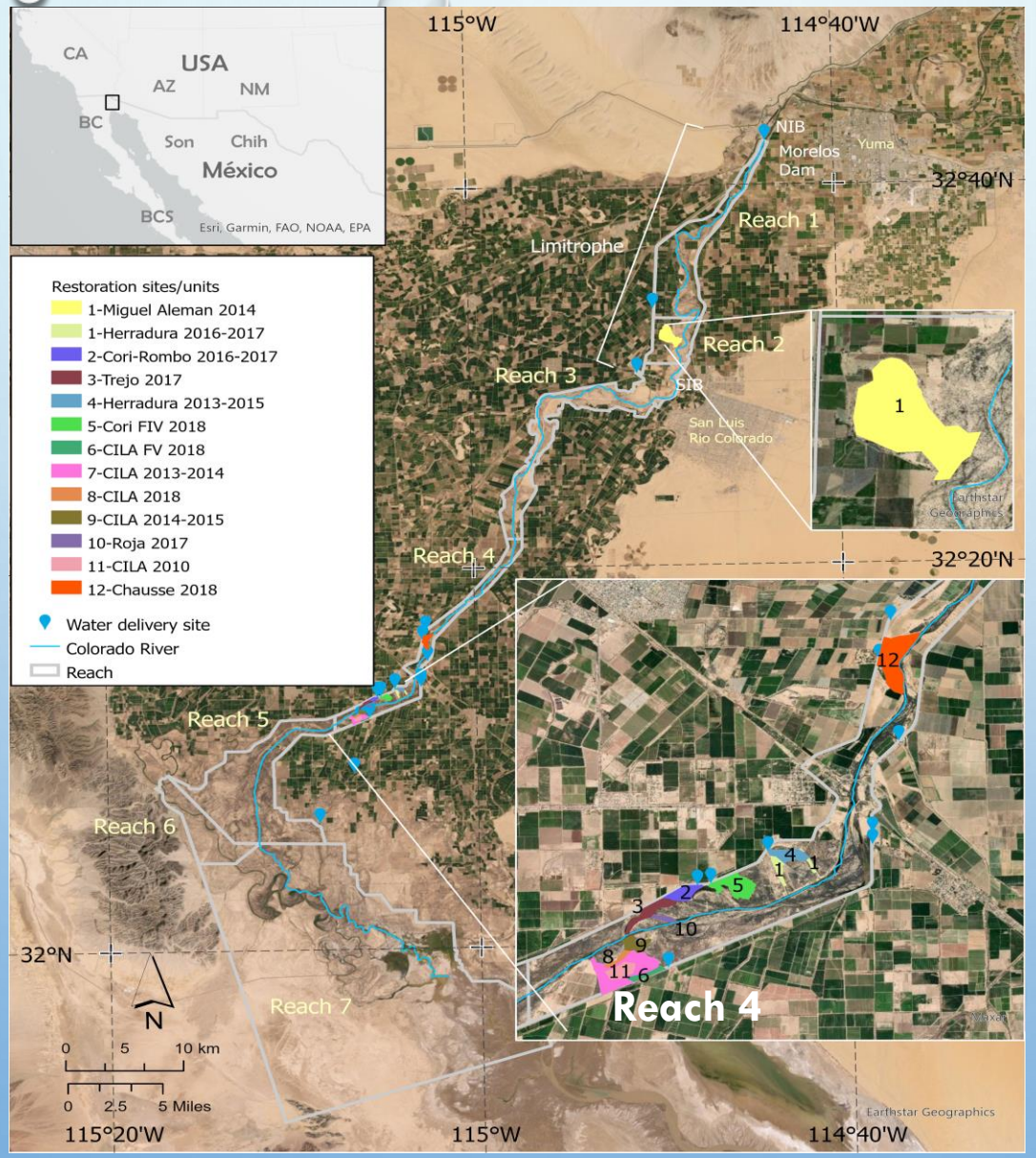
MINUTE 323 (2018-2026)
Emphasis on Active Revegetation

Native/Natural

Invaded



Restored



- Directed and excess flows were provided to over a dozen restoration sites mainly in “Reach 4.”
- These sites are planted and maintained by NGOs.
- The USGS & science team members from both sides of the border are responsible for monitoring, data delivery & producing key science findings.

USGS science for a changing world

JAWRA
JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
AMERICAN WATER RESOURCES ASSOCIATION

Research Article | Open Access

Effect of Restoration on Plant Greenness and Water Use in Relation to Drought in the Riparian Corridor of the Colorado River Delta

What we did

We assessed if restoration -- with only 7.5% of the riparian landcover -- had an impact on the unrestored reach-level corridor using two metrics, EVI2 and ET(EVI2). We compared these greenness and water use metrics in restored and unrestored areas and produced relationships between these and SPEI, a drought index.

Results

Since 2011, the unrestored reaches lost 11% EVI2 (greenness) and 28% ET(EVI2) (−0.73 mm/d), but restored sites increased 36% in EVI2 and 20% in ET(EVI2) (0.58 mm/d).

Key Finding

Unrestored riparian reaches are in decline while restored areas are increasing in greenness and water use.

This study measured remotely-sensed vegetation metrics for (1) continued post-flow (Min 319) effects in the unrestored riparian corridor & (2) directed surface water (Min 323) to restored sites (planted between 2010-2018) & the continued growth from 2018-2023.

In the Riparian Corridor

Photo: Pamela Nagler

In Restoration Sites

USGS

IMPORTANCE OF RIPARIAN VEGETATION

- Riparian vegetation is important as narrow wildlife corridors for upwards of 95% of wildlife in the dry Southwest. These zones provide critical habitat to wildlife species, are important breeding grounds and serve as avian flyways, yet they occupy less than 2% of the land area.

Photo: Pamela Nagler

The amount of vegetation largely determines about how much water is lost in evapotranspiration (ET) from the riparian ecosystem.

USGS science for a changing world

Importance of ET

- Measuring landscape ‘greenness’ is a key input for determining ET.
- Knowing how much water a riparian ecosystem uses helps managers who preserve natural areas by protecting water resources and habitat.
- The quantification of ET also helps them plan ways of retaining water in the landscape for people, plants and animals, their habitat and other ecosystem services provided by flows.
- Understanding how intact plant communities utilize water and how disturbance alters ET can help predict future ecosystem resilience.

Photo: Pamela Nagler

USGS

Importance of ET in Riparian Restoration

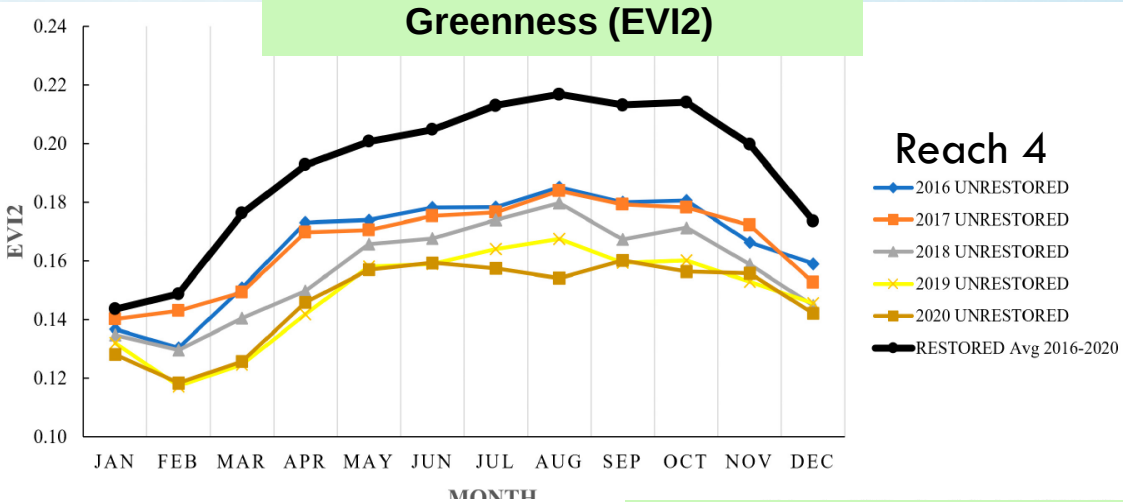
Accurate ET measurements are needed for water requirements in active restoration projects.

Tracking changes in ET over time is especially important given the pressures from changing temperatures, precipitation, fire events, invasive species (i.e., defoliating beetles), and anthropogenic factors affecting water deliveries.

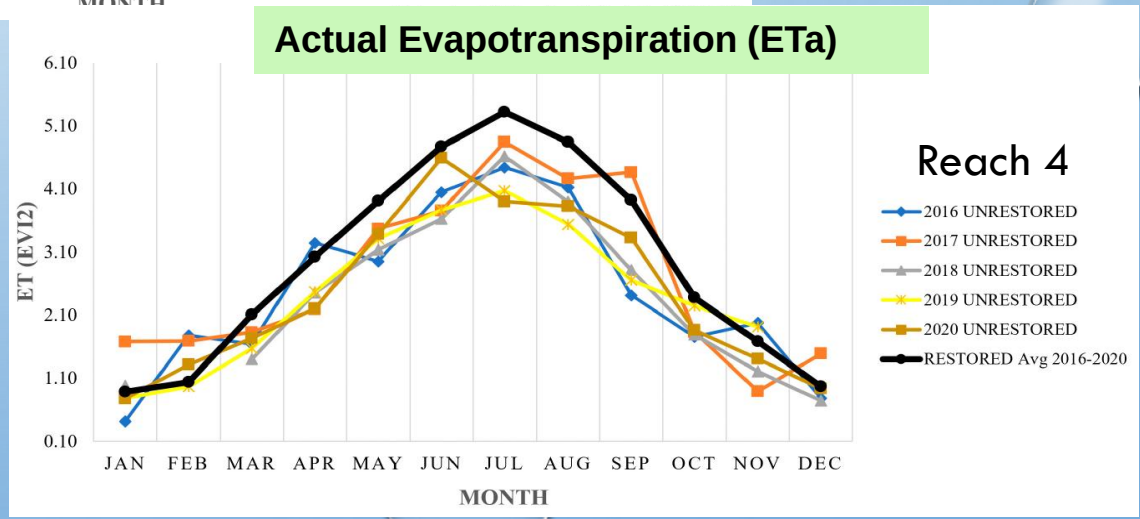
With decades of data, trends in riparian vegetation health & ET can be observed. Monitoring can highlight pre- and post-disturbances (i.e., tamarisk beetle (via defoliation), trends between unrestored & restored, and by year of plantings.

Predictive relationships were created between greenness, ET and drought indices.

Greenness (EVI2)

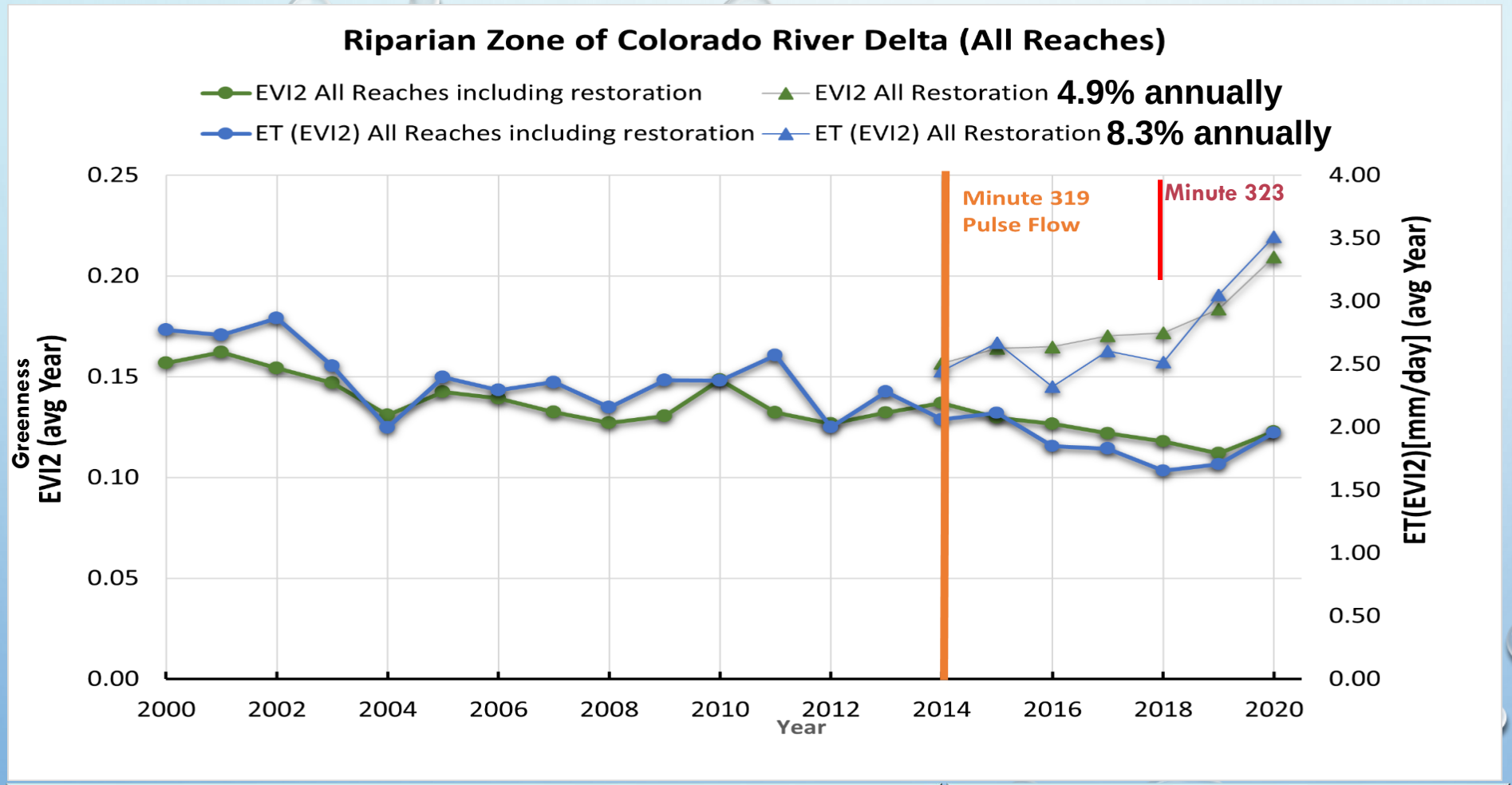


Actual Evapotranspiration (ETa)



USGS science for a changing world

Measuring Response of Added Water from Minute 323



A key finding is that over 21-years EVI2 (greenness) in the unrestored corridor decreased by 23.6% and ET(EVI2) decreased by 32% (0.87 mm/day).

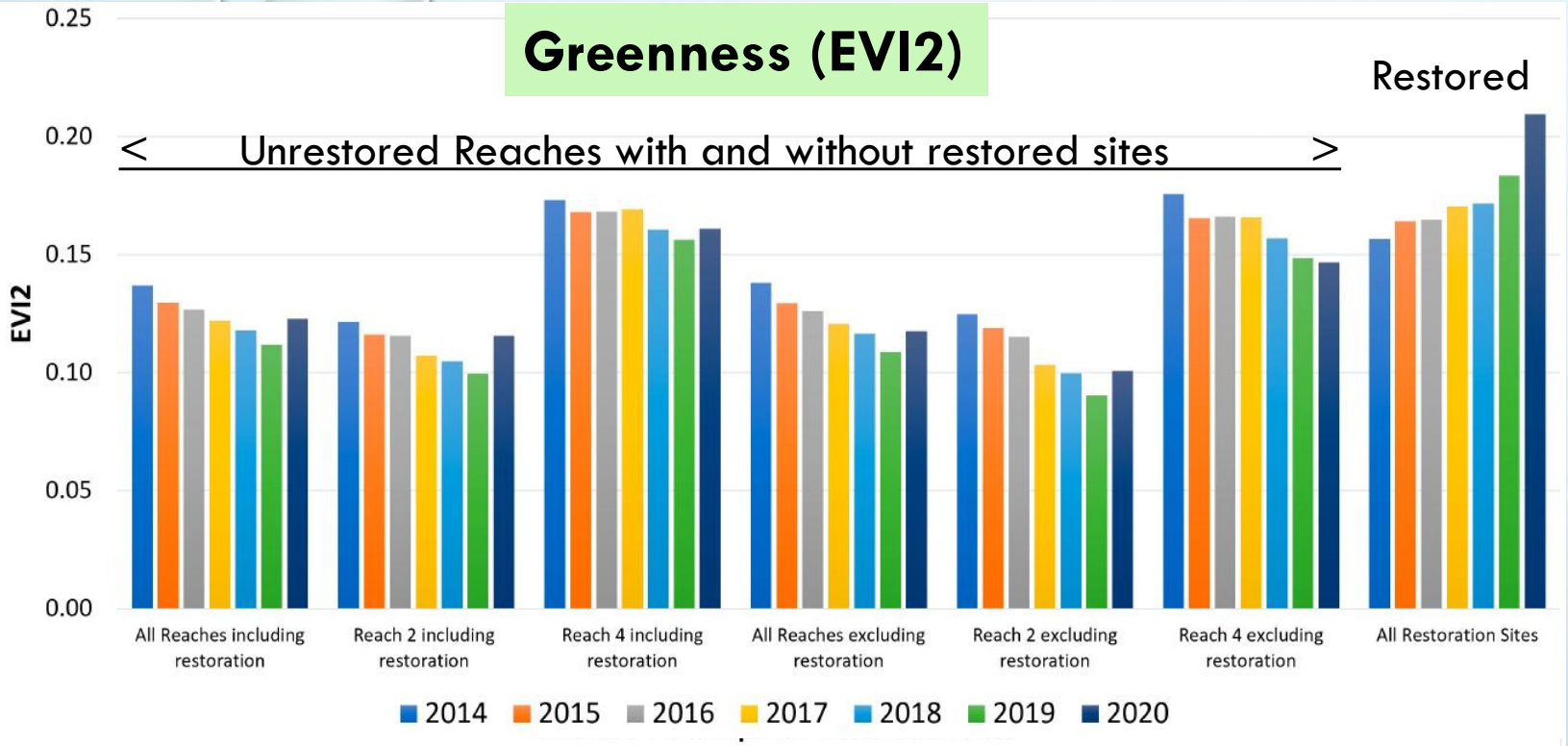
Since 2018, Minute 323 water delivered to restored sites increased EVI2 (greenness) by 33.6% and increased ET(EVI2) by 58% (1.29 mm/day).

Up until 2014, *greenness* decreased at 1.1% /year & ET decreased at 1.4% /year

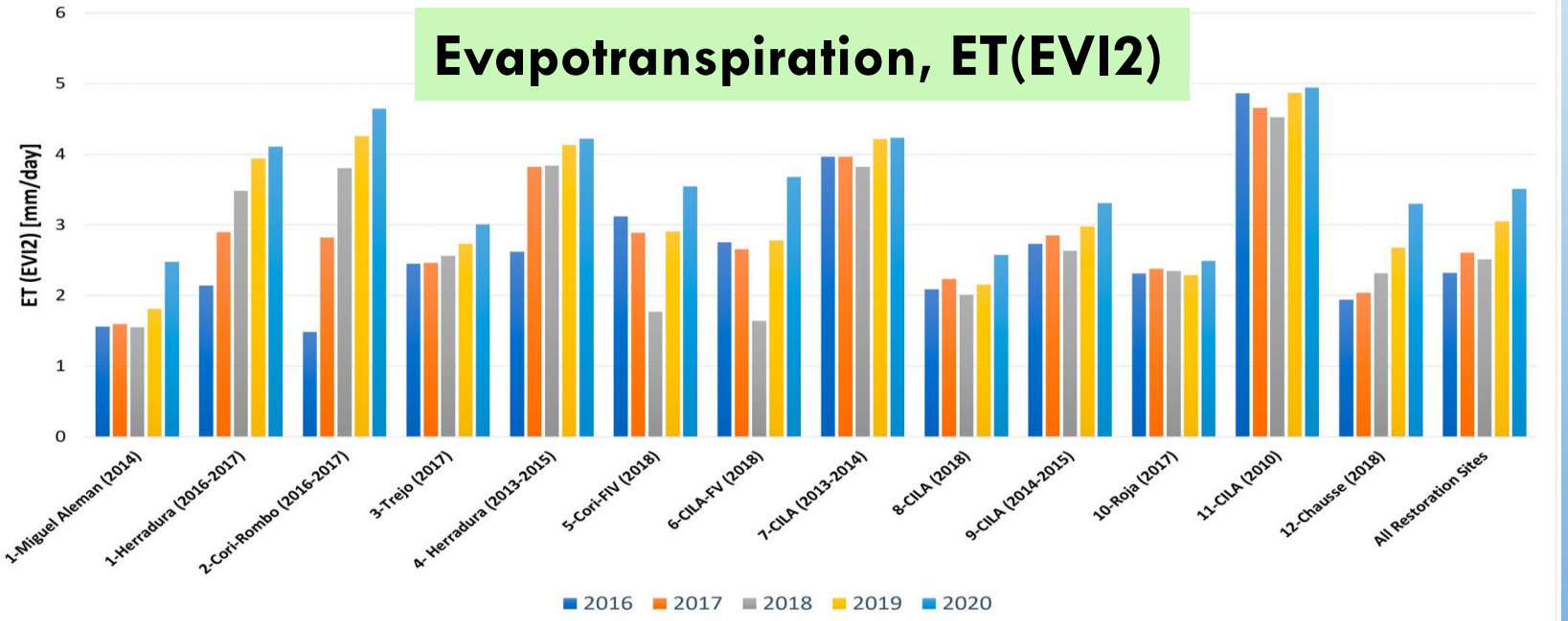
After 2014, *greenness* decreased by 1.5% /year & ET decreased at 0.9% /year

USGS science for a changing world

Greenness (EVI2)



Evapotranspiration, ET(EVI2)

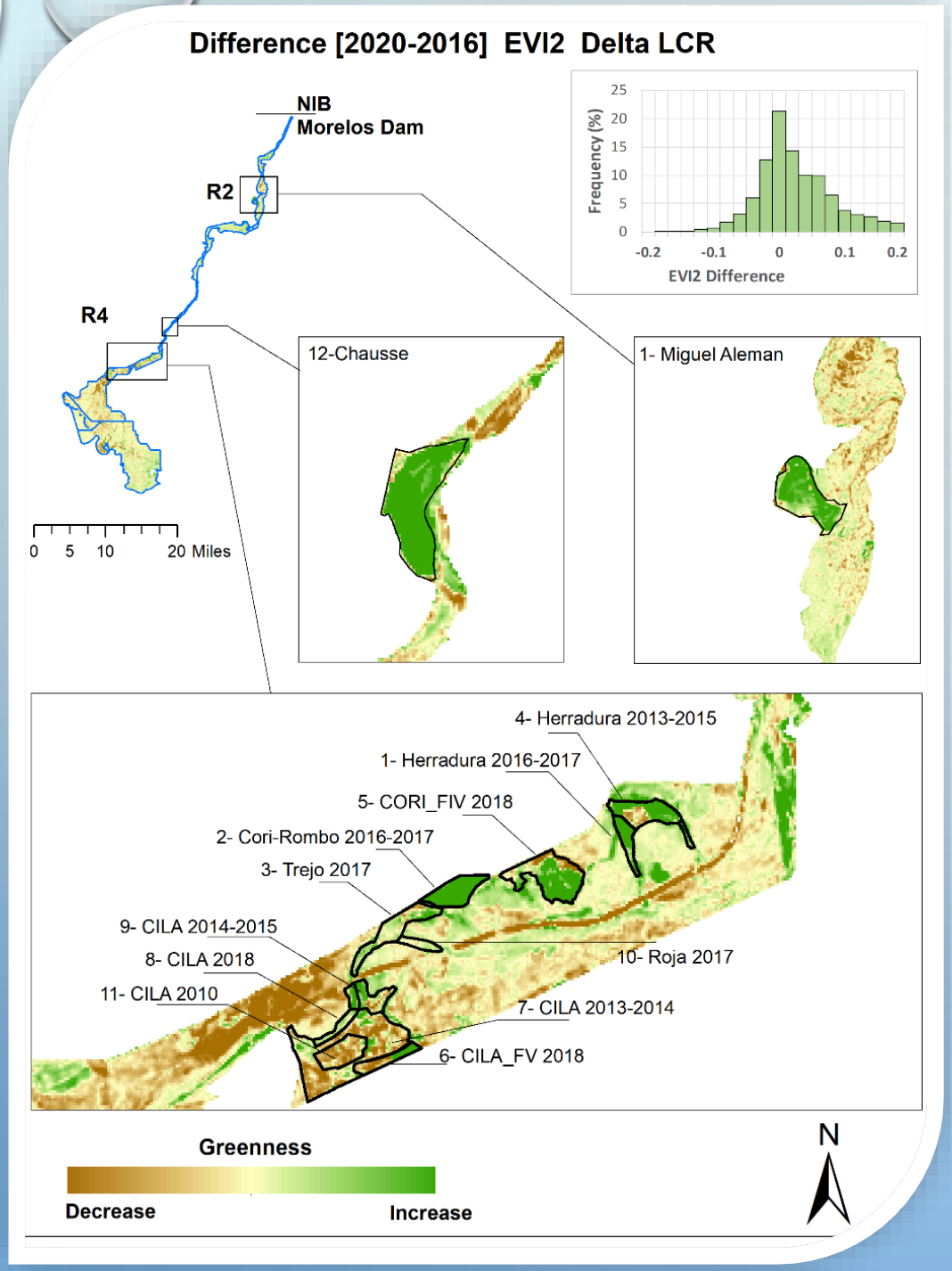


Minute 319 results led to the use of smaller surface flows to the delta and a greater reliance on directed agricultural return flows and deliveries of water to active restoration sites.

Under Minute 323, targeted water deliveries to the restoration sites have a greater influence than the pulse flow.

The restoration areas are markedly greener than the surrounding reach area's unrestored riparian landscape.

USGS

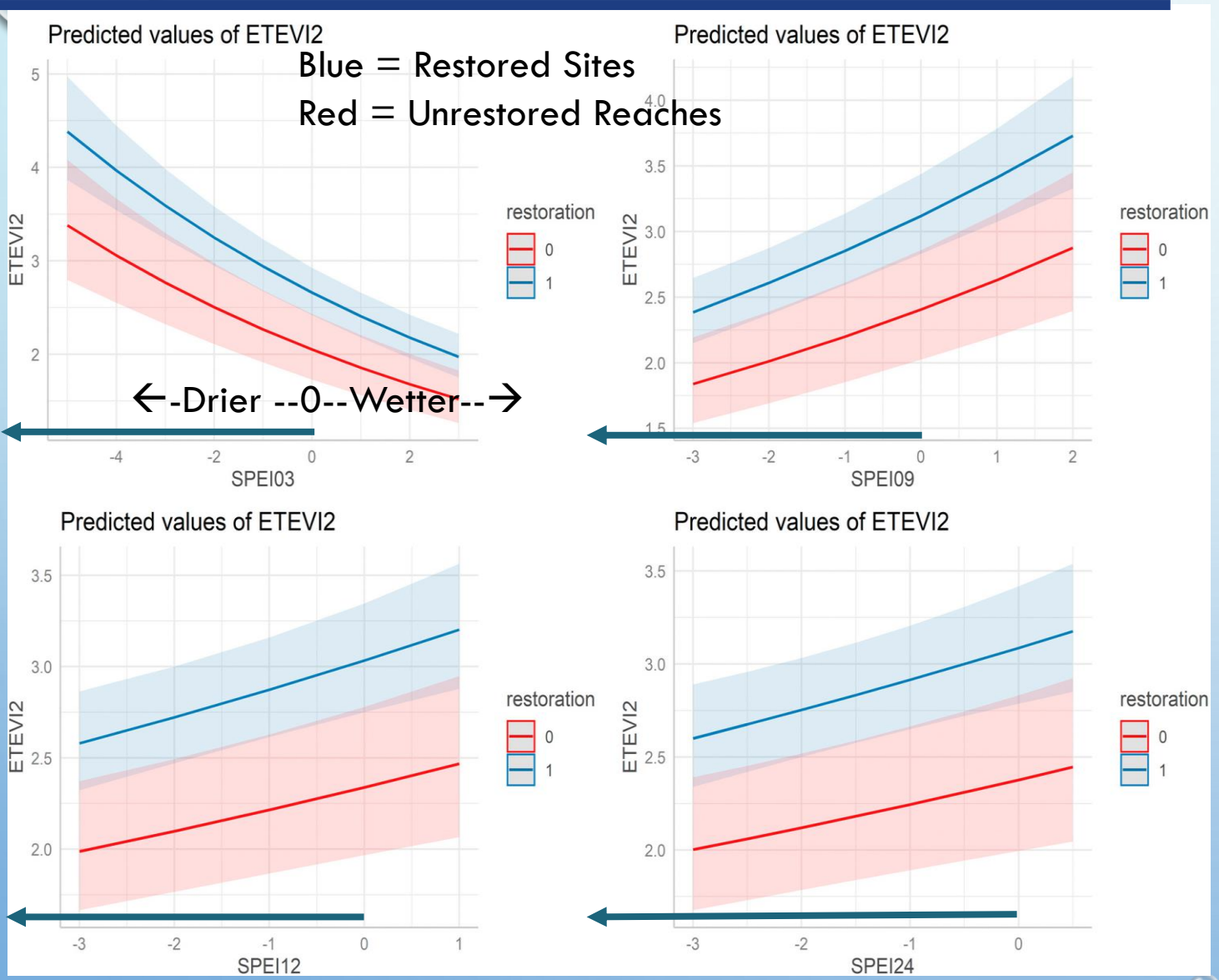


Five-year difference in EVI2 (greenness)

The restoration areas show greening and increased ET outside the restoration zones in the natural reach areas.

The change maps demonstrate the success of the restoration activities. Without additional environmental flows and more active restoration areas, long-term reduction of vegetation and increase in bare soils at the reach-level is expected to continue at a rate of 1–2% yearly decreases as measured remotely and as predicted by the drought indices demonstrate over the 21-year dataset.

Relationship between ET and SPEI



Even though drought has an impact on restored (blue shaded) and unrestored reaches (red shaded), the reduction of vegetation health and water use is more pronounced in unrestored reaches (red) with an increase in drought severity (negative, see arrows) as shown by the predictive estimates.

Our results from ET(EVI2):SPEI indicate that drought indices with a time scale of 9-, 12- and 24-months are better suited in explaining the effect of drought on riparian water use because they are positive.

Only the ET(EVI2):SPEI03 relationship showed declines.

Conclusion

Although the unrestored delta riparian corridor continues to decline in vegetation greenness and water use, restoration efforts have positively impacted the delta's habitats and native plant health.

This study contributes to decision-making to restore and maintain native vegetation through
(1) the use of smaller surface flows,
(2) a greater reliance on directed agricultural return flows, and
(3) deliveries of water to active restoration sites.

It provides information regarding how different the relationship between restored and unrestored areas is for EVI2 and ET(EVI2) as a function of drought indices over 21 years.

Impact

Our findings have continued to be used to assist managers with decision-making for ecological restoration success. These data, tools, methods, and results can be utilized by decision makers in their quest to mitigate and understand how declines of riparian ecosystems can be slowed or possibly reversed.