

Small streams and riparian zones in California's Sacramento Valley

Ecological function and management opportunities

Alex J. Webster, Joanna P. Solins, Mary L. Cadenasso

Graduate Group in Ecology and Dept. of Plant Sciences

Univ. of California, Davis



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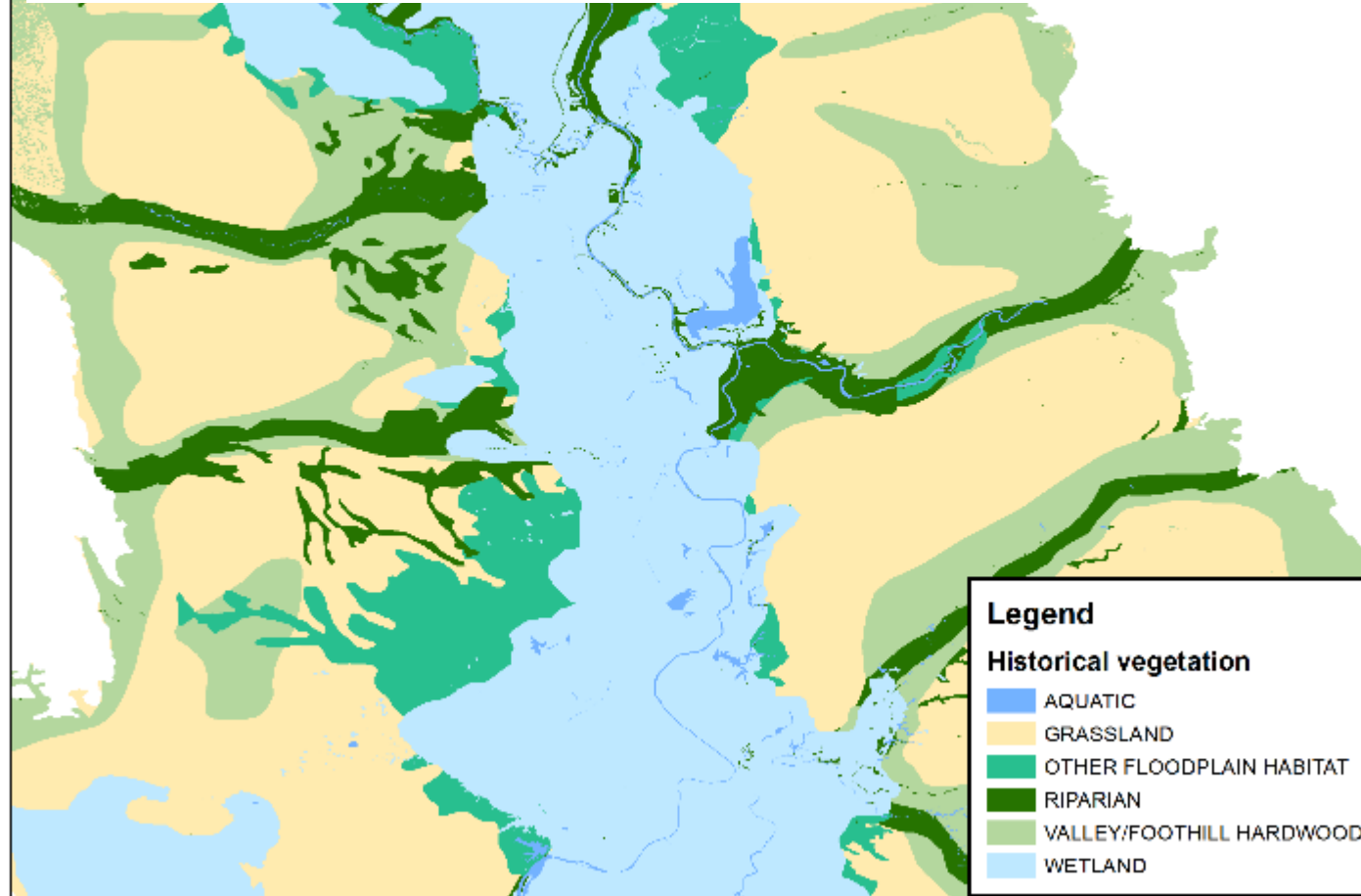
Sacramento



Sacramento

20 km

Study region: historical vegetation

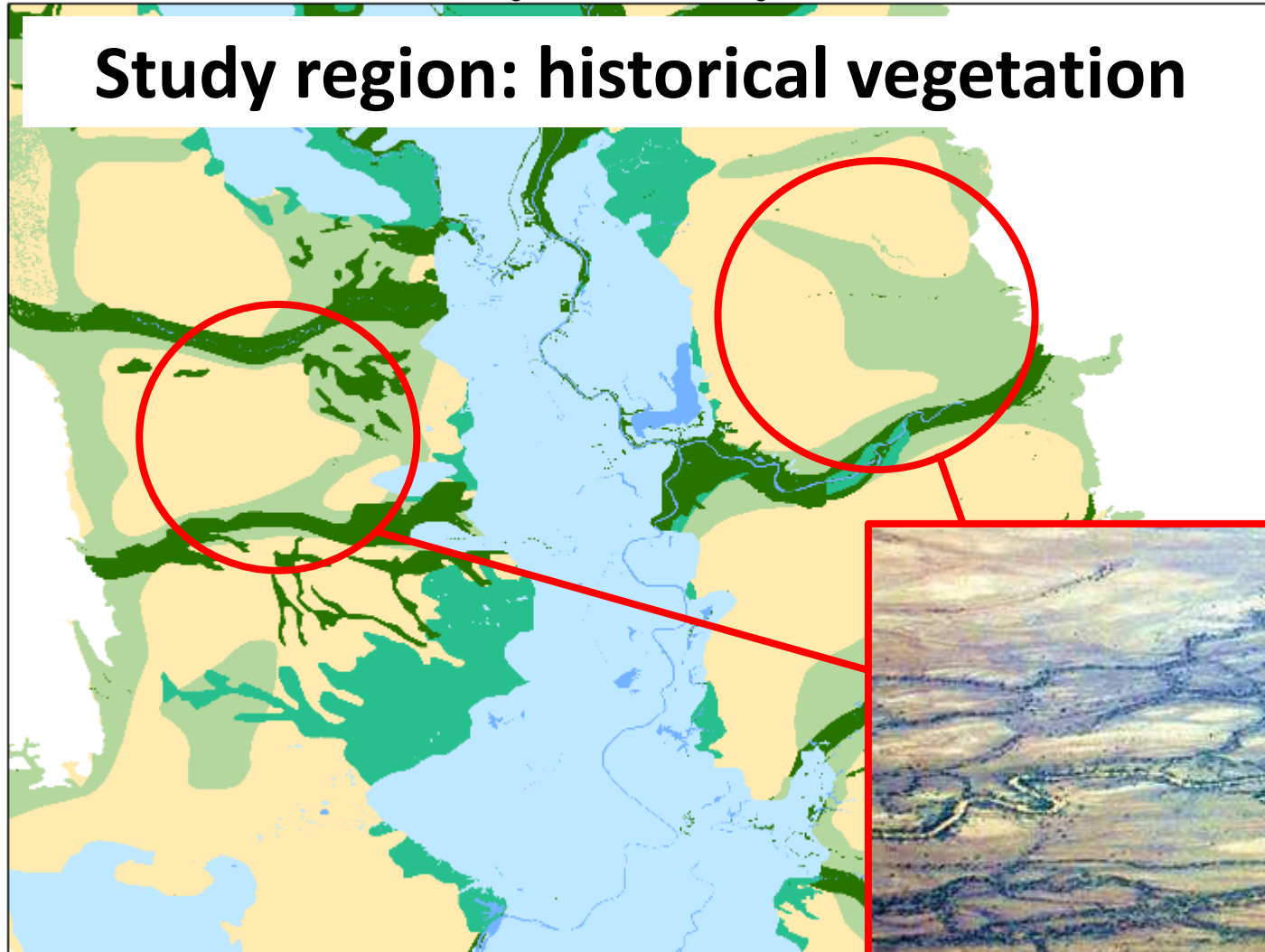


CSU Chico. 2003



20 km

Study region: historical vegetation

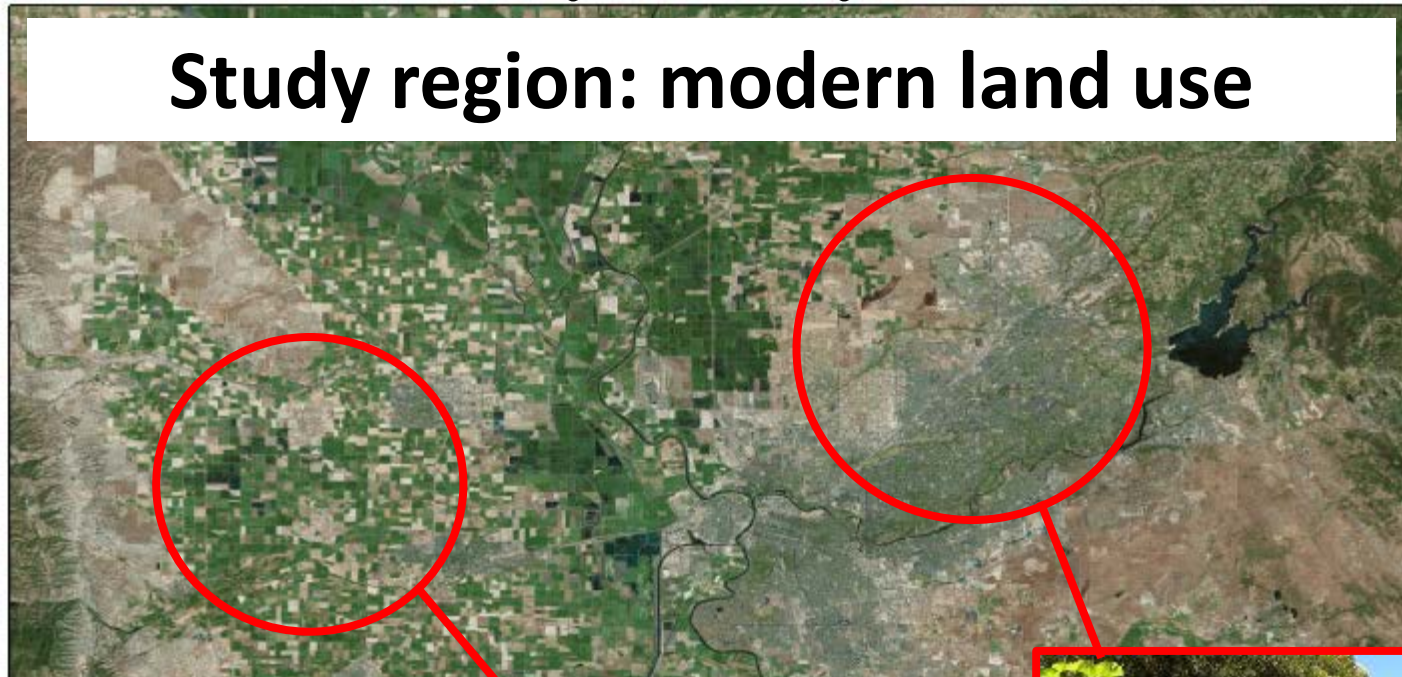


CSU Chico. 2003



20 km

Study region: modern land use



agriculture

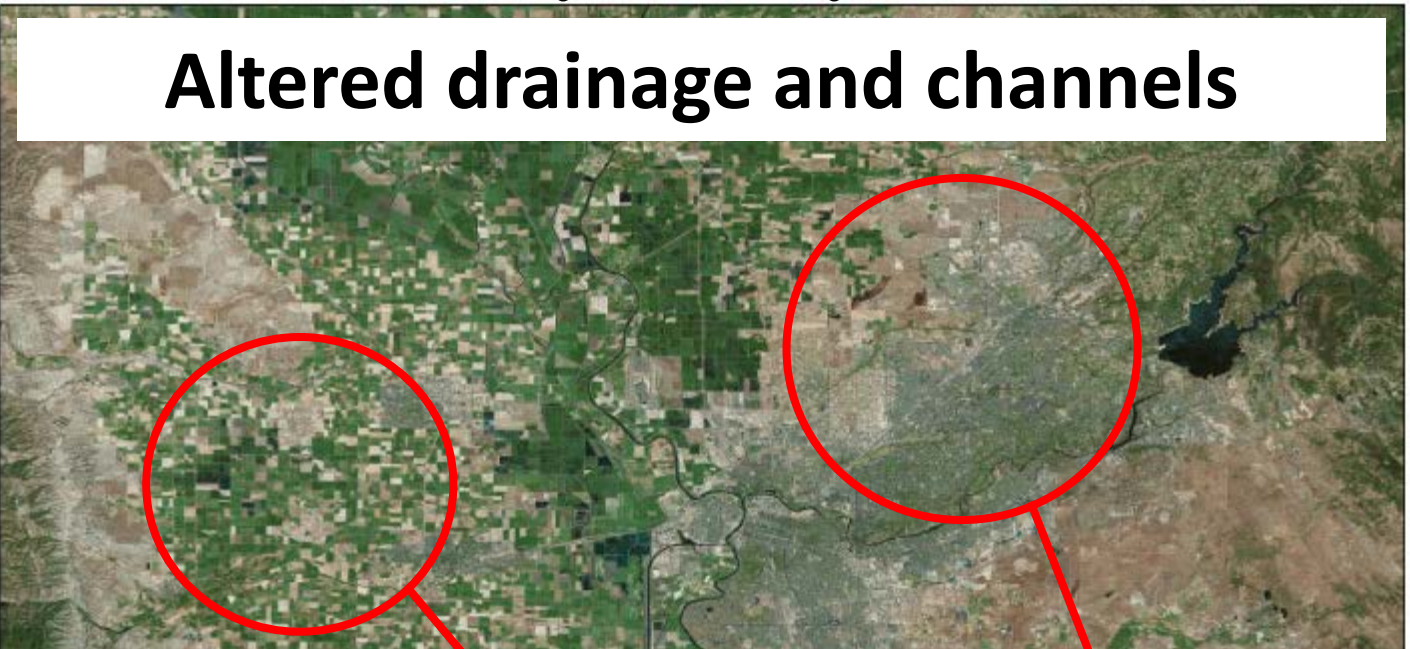


urban

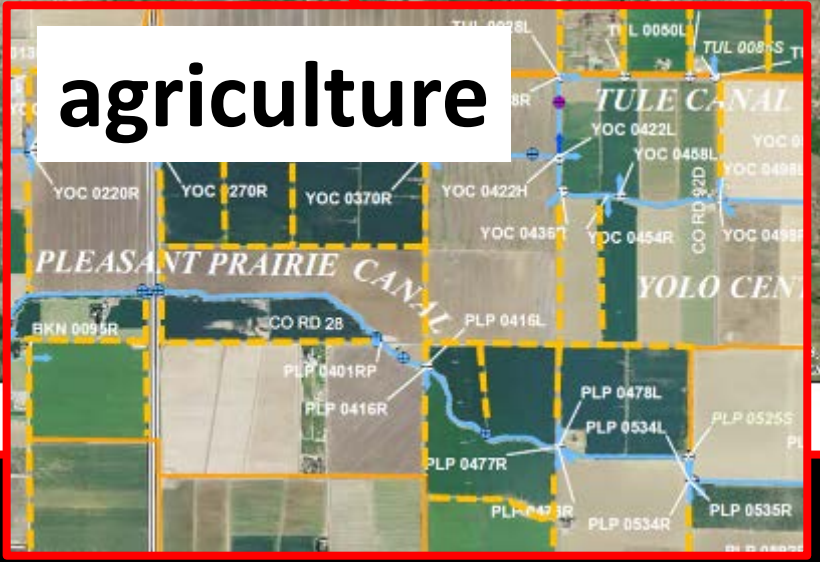


20 km

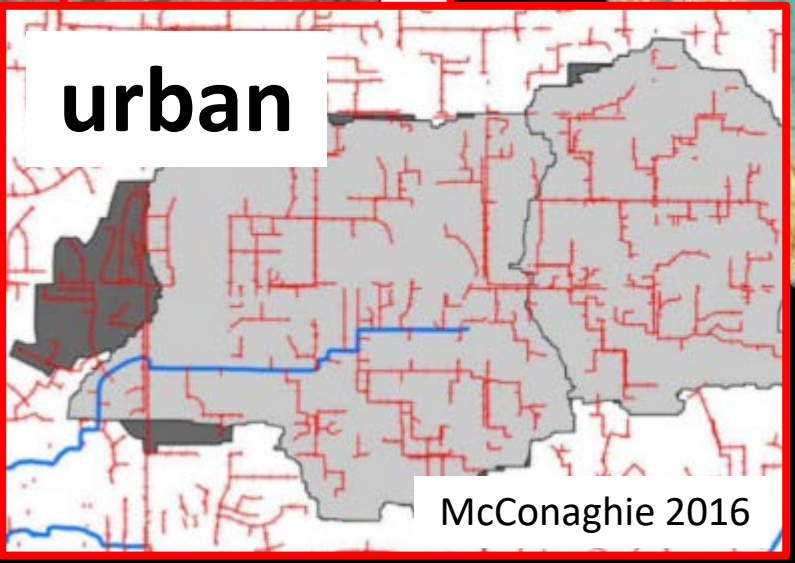
Altered drainage and channels



agriculture



urban



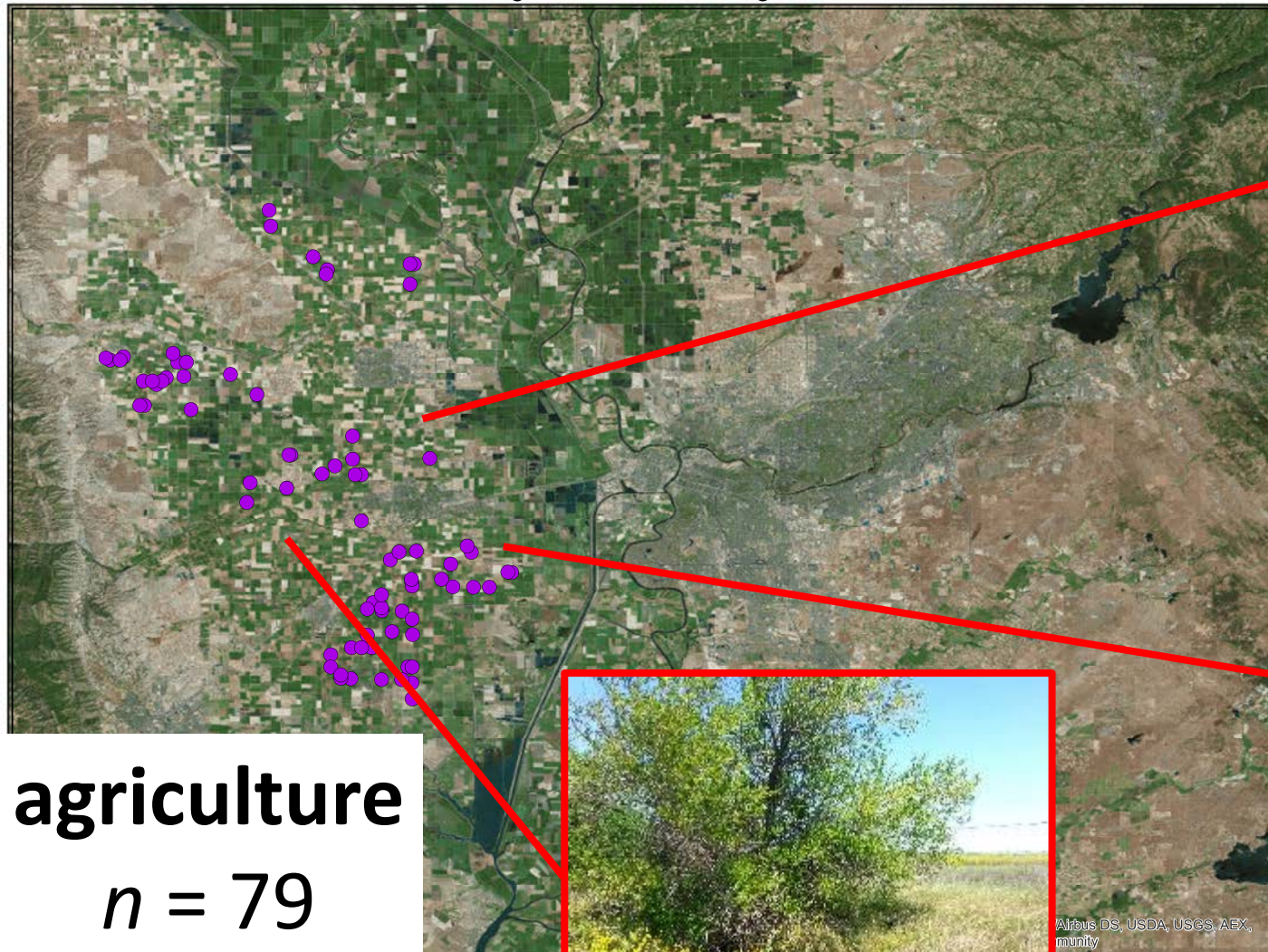
McConaghie 2016



Sacramento



20 km



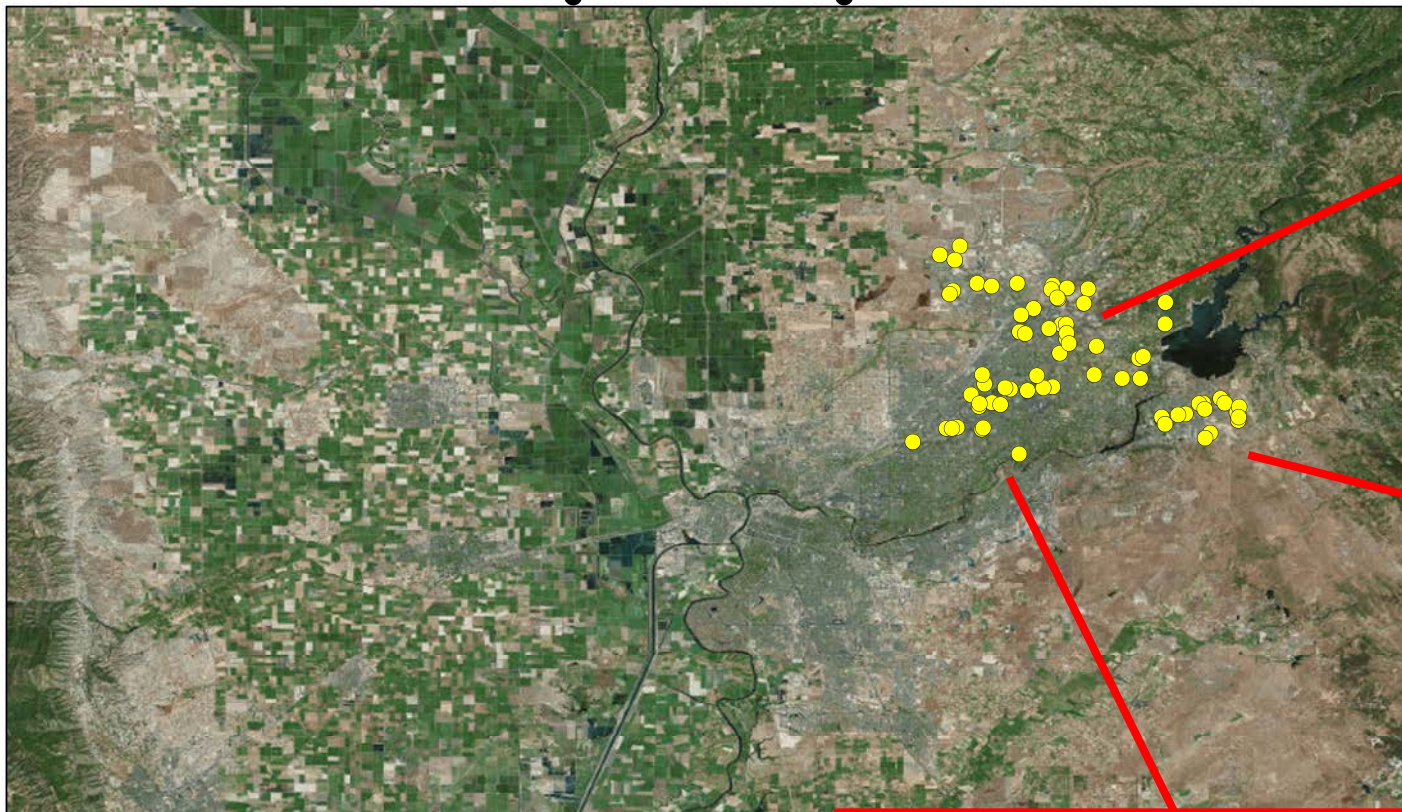
agriculture

$n = 79$



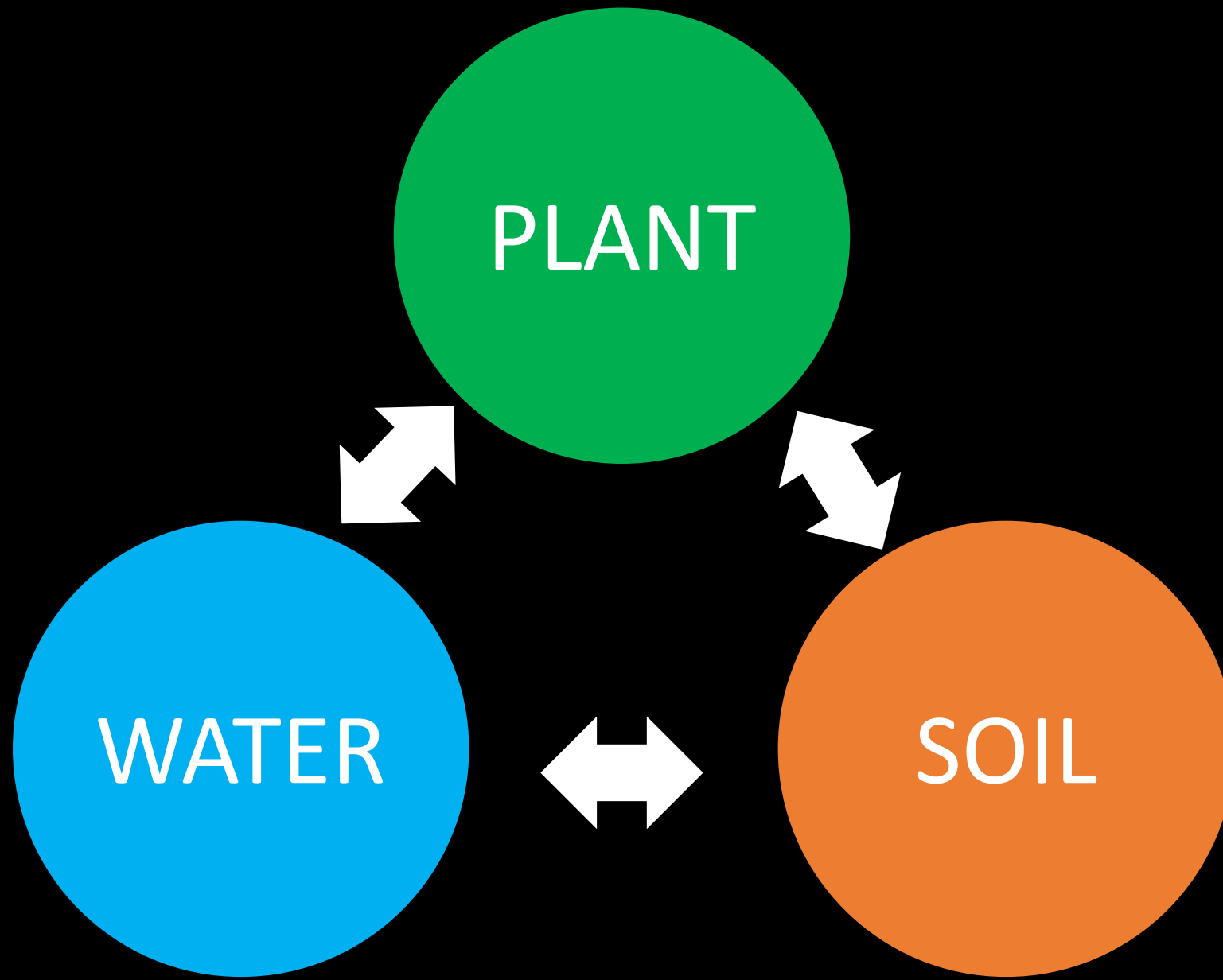
Airbus DS, USDA, USGS, AEX, munity

20 km



urban
 $n = 69$

Source: Esri, DigitalGlobe, GeoEye, Aero

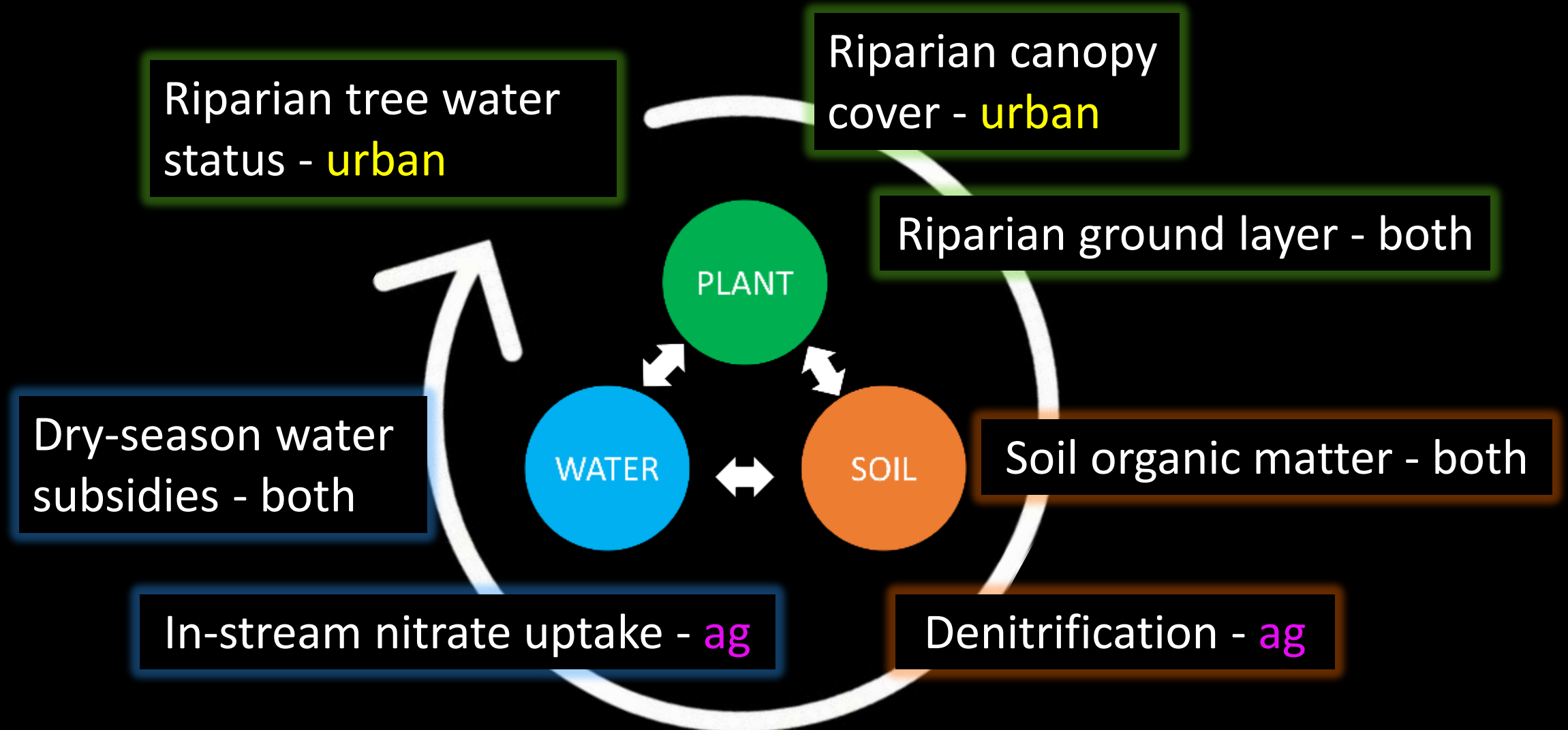


Ecosystem services of streams and riparian zones

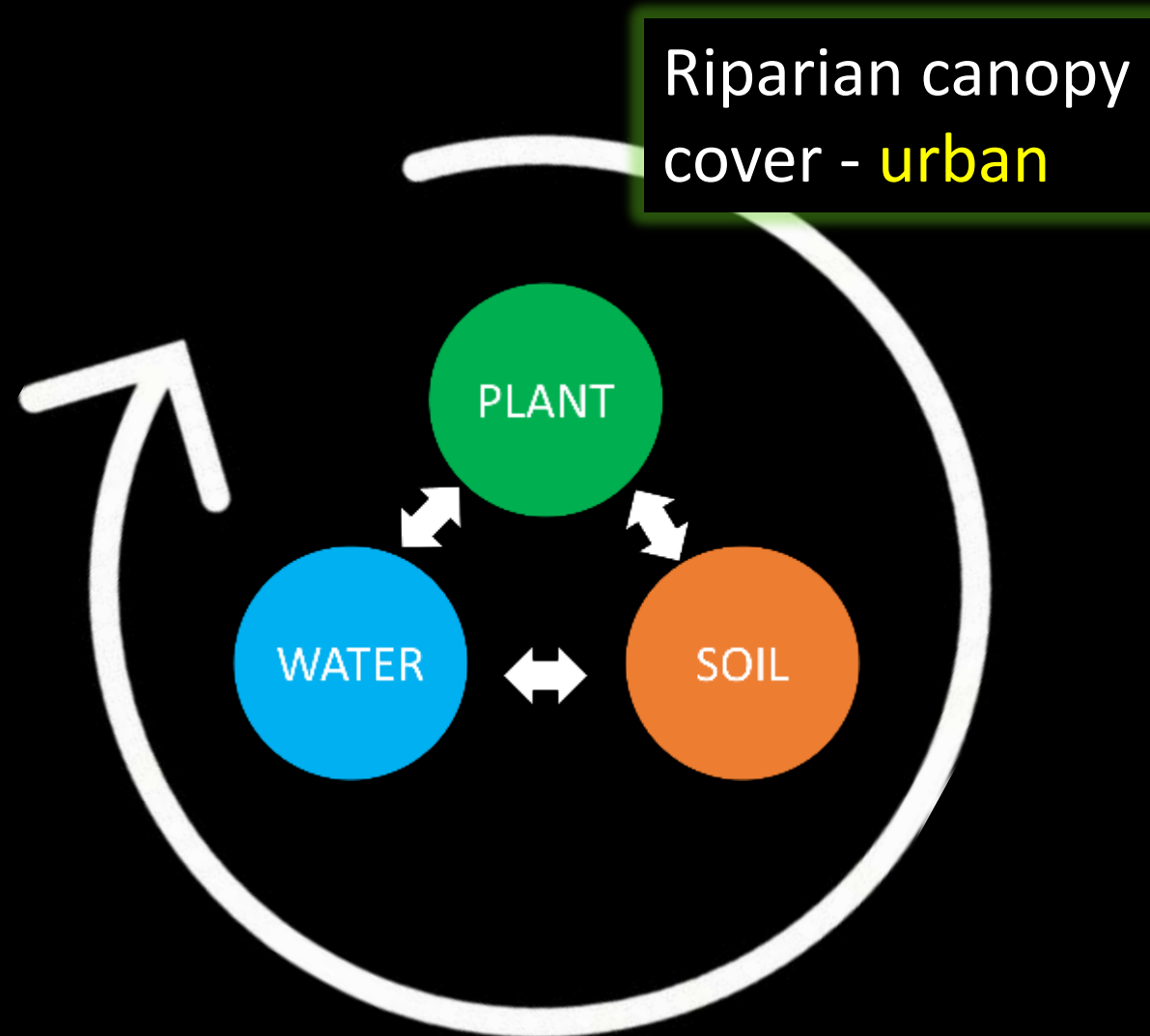
- Habitat
- Water quality
- Carbon storage

What influences the provision of these services, and how can we manage for them?

Roadmap to Ecosystem Services



Roadmap to Ecosystem Services

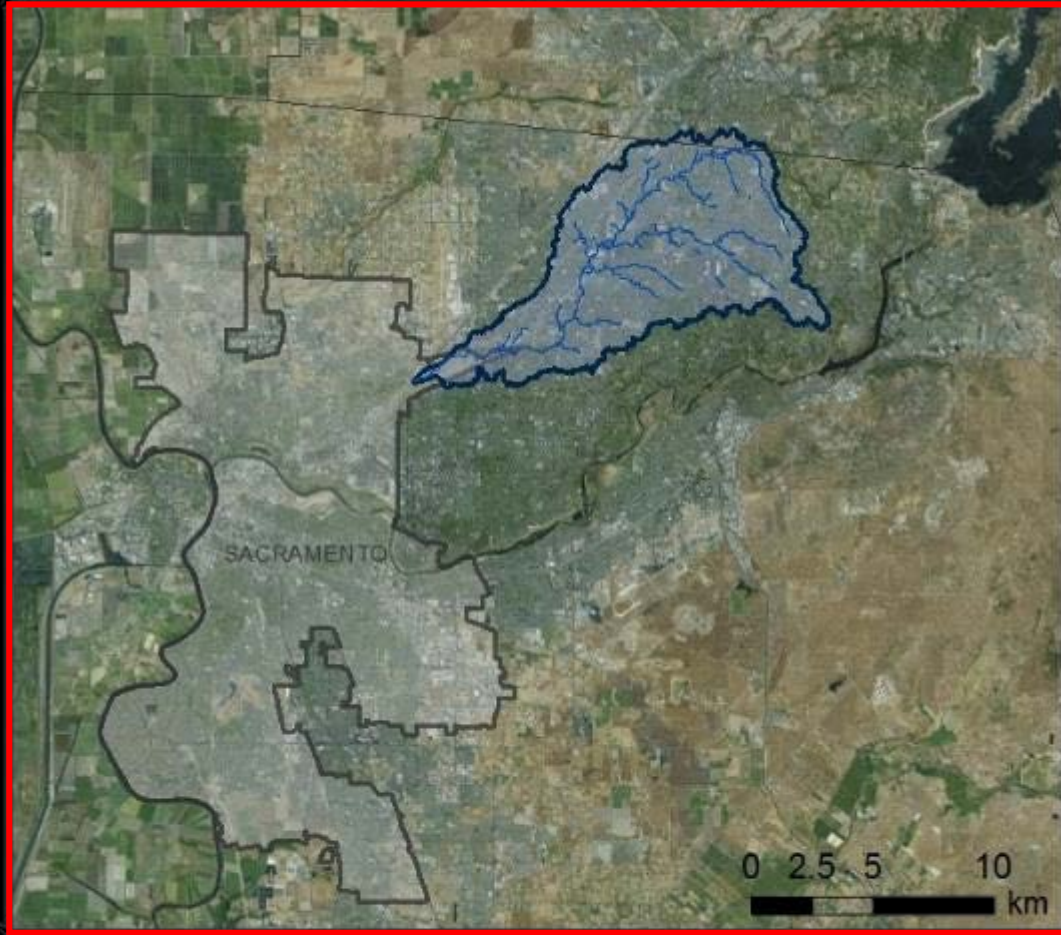




canopy cover

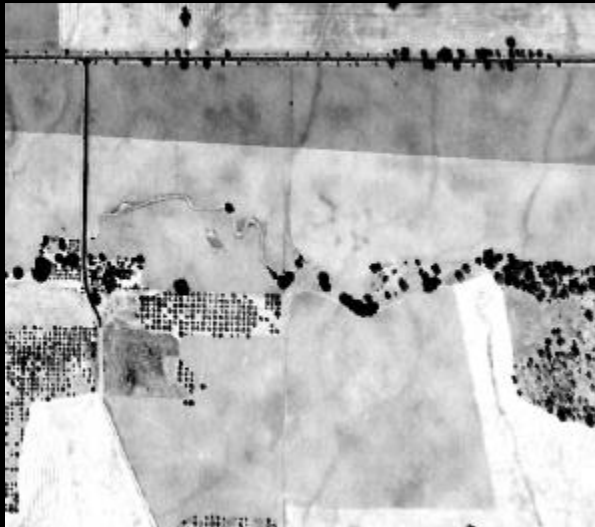
- light availability
- organic matter inputs

Arcade Creek Watershed



Time series approach using aerial imagery of the watershed

1937

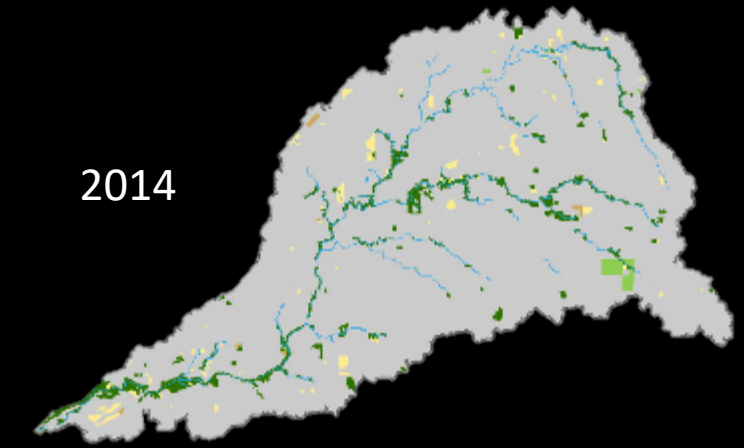
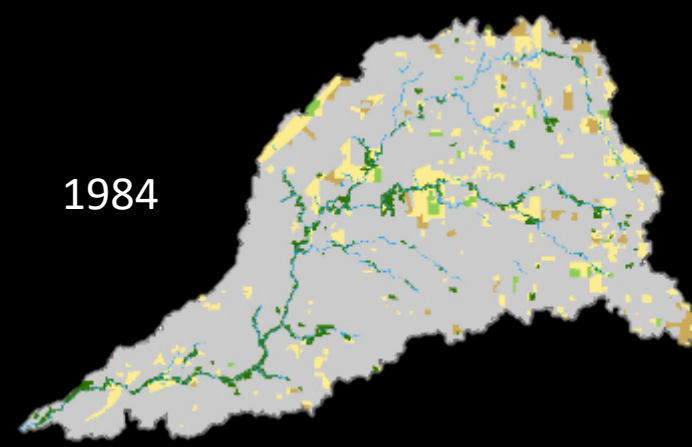
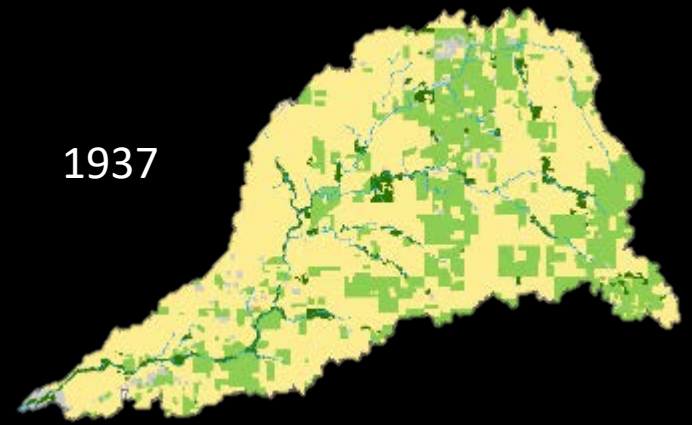


1984




2014

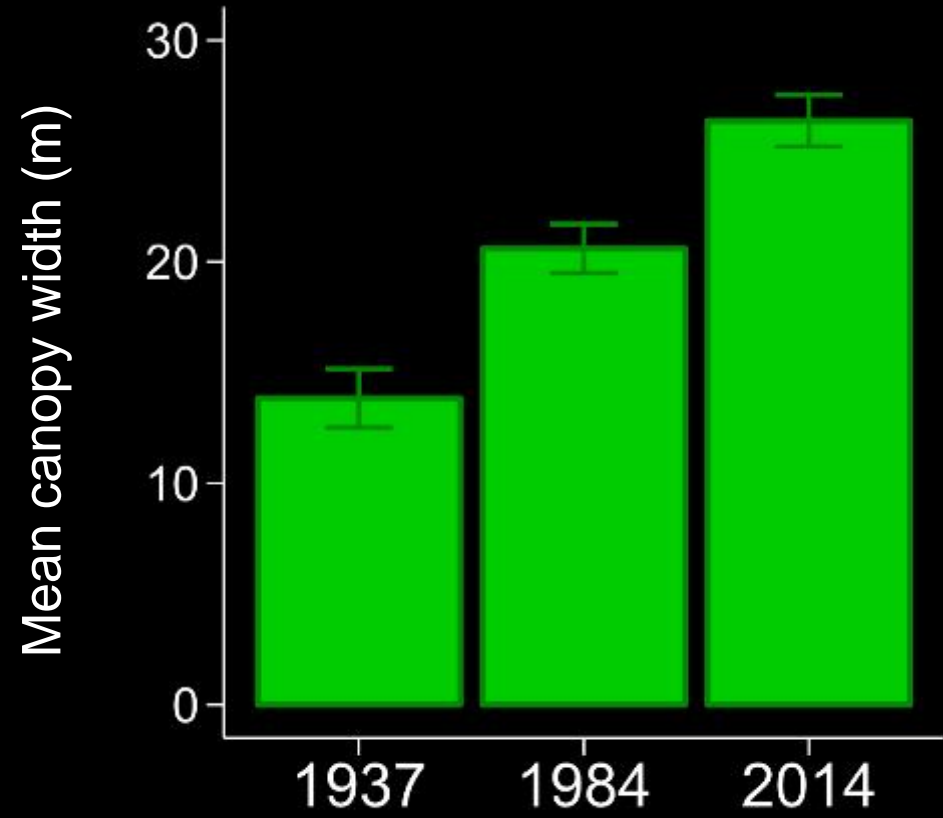
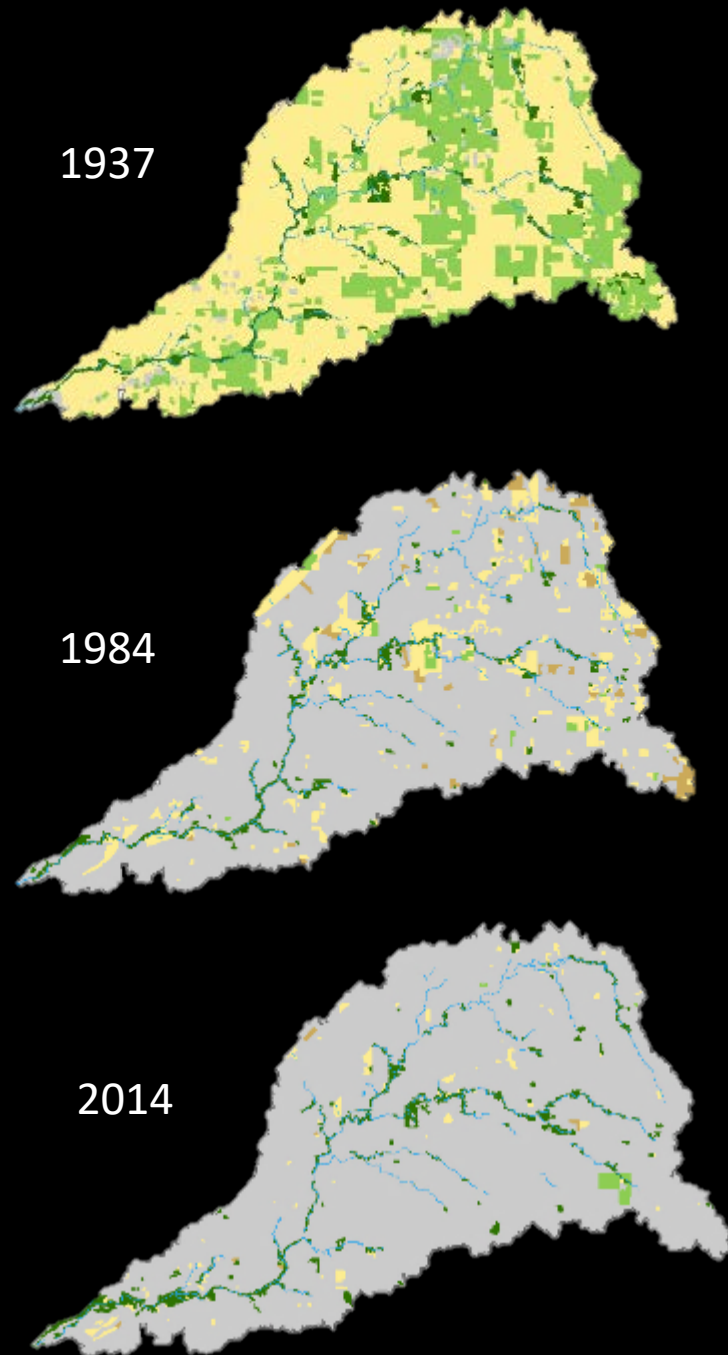




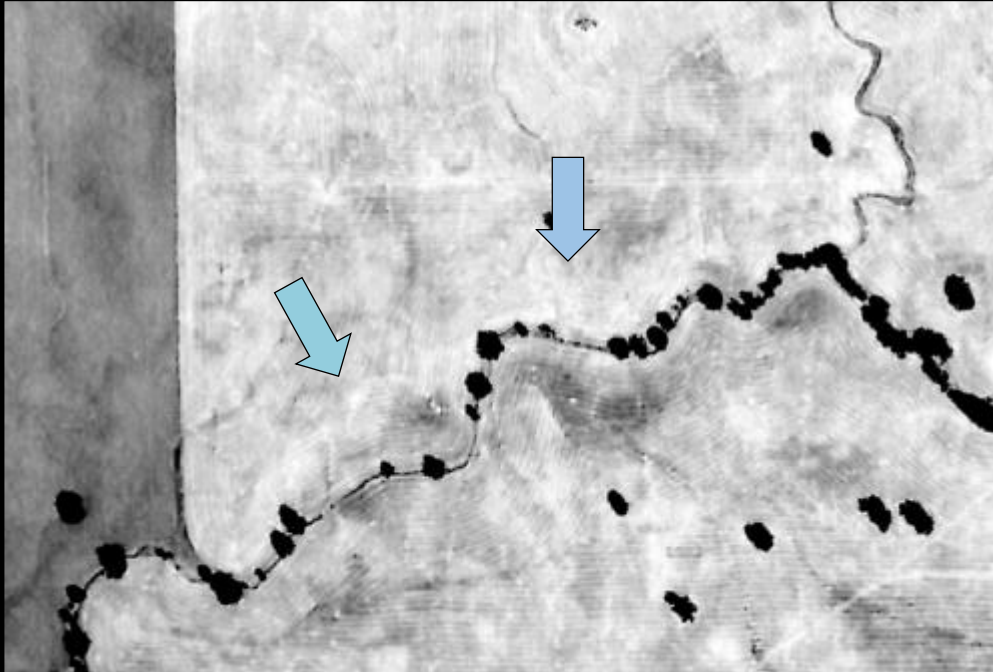
Dominant Cover

-  Bare
-  Crops
-  Developed
-  Pasture/grain
-  Tree canopy

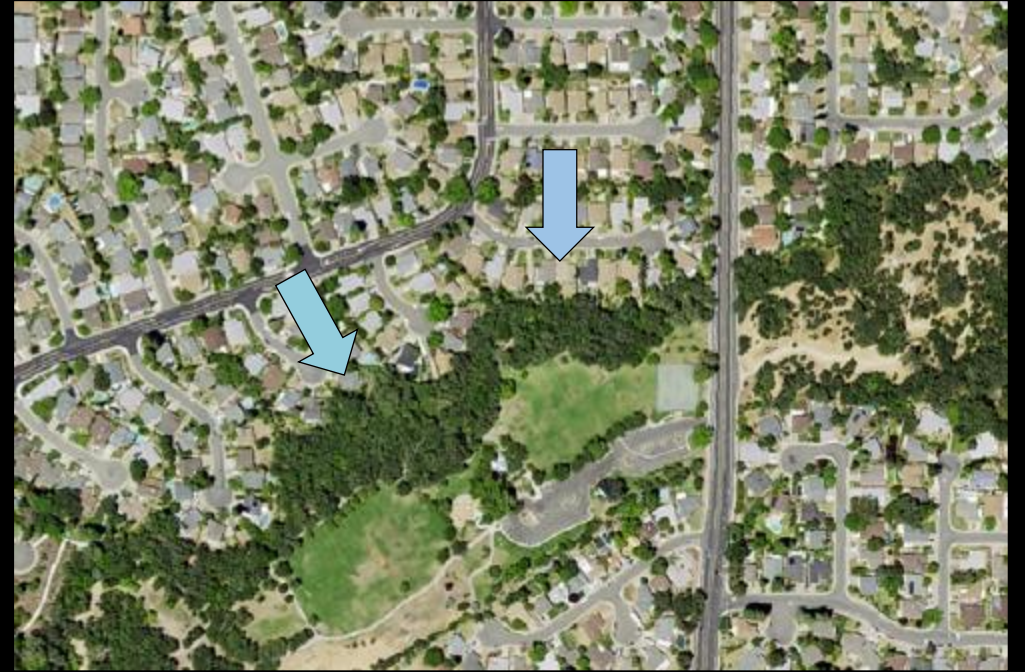
Increase in riparian tree canopy



Driver: release from agricultural pressures



1937



2014

Agricultural riparian canopy has not changed

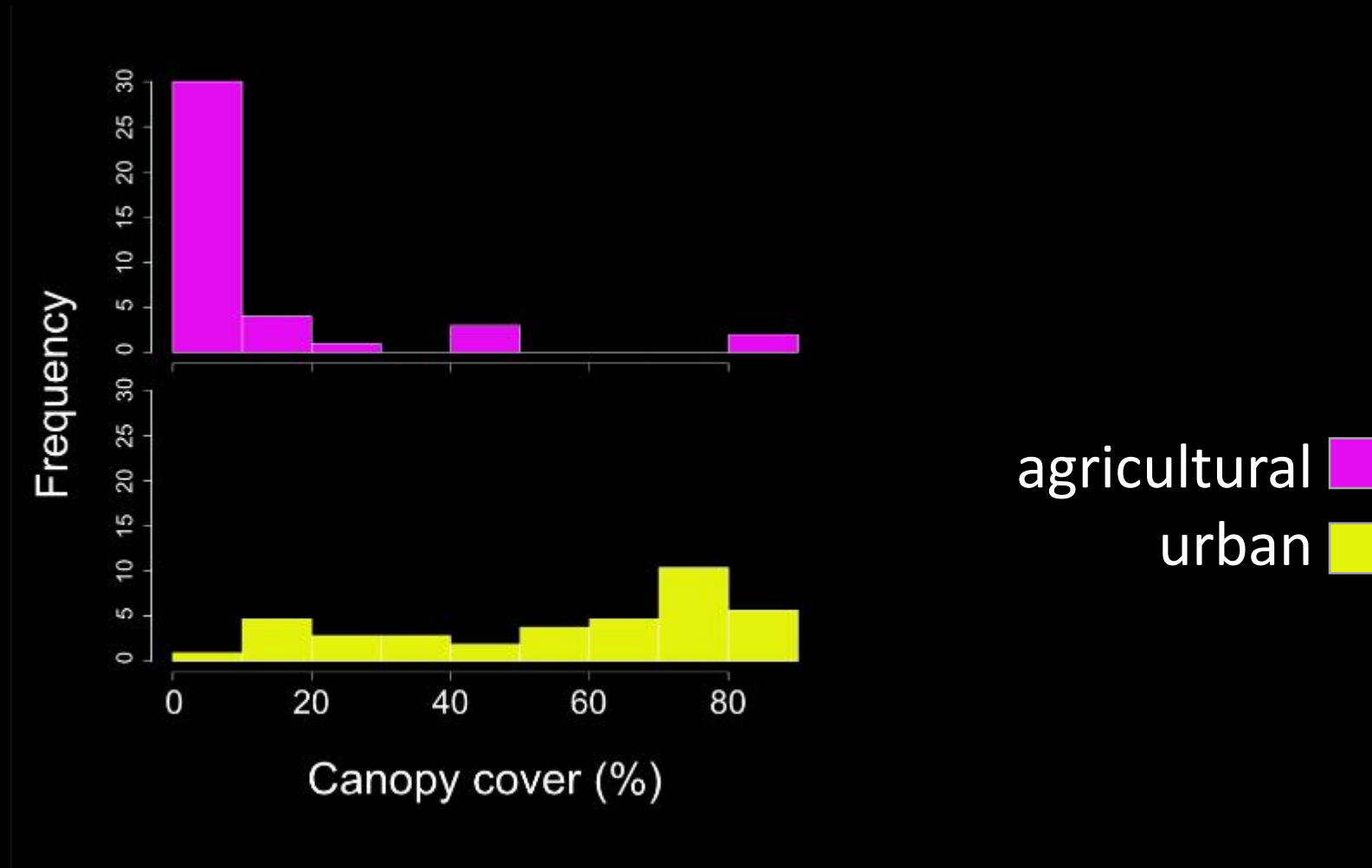


1937

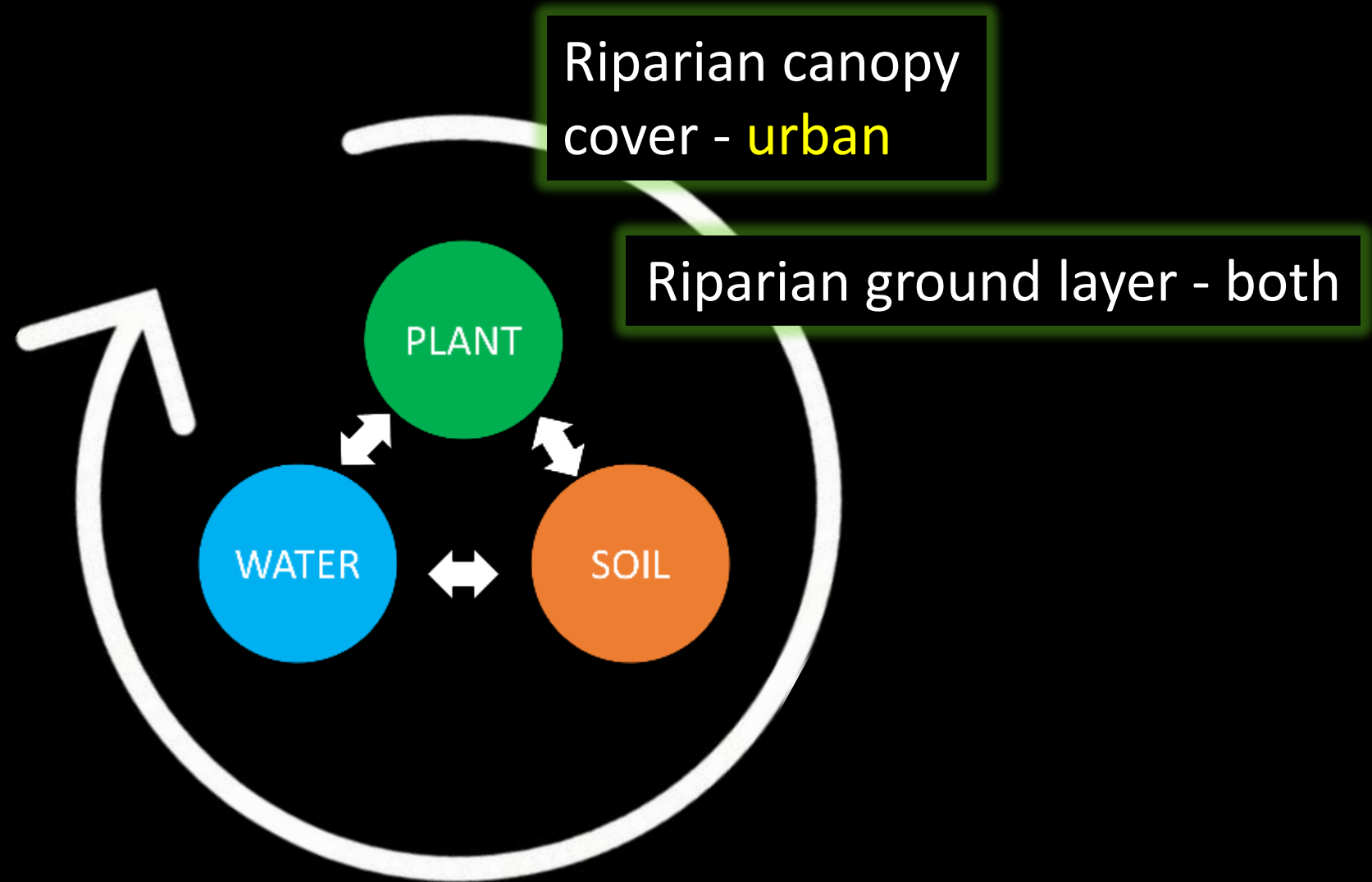


2014

Canopy cover in study stream reaches (2014)

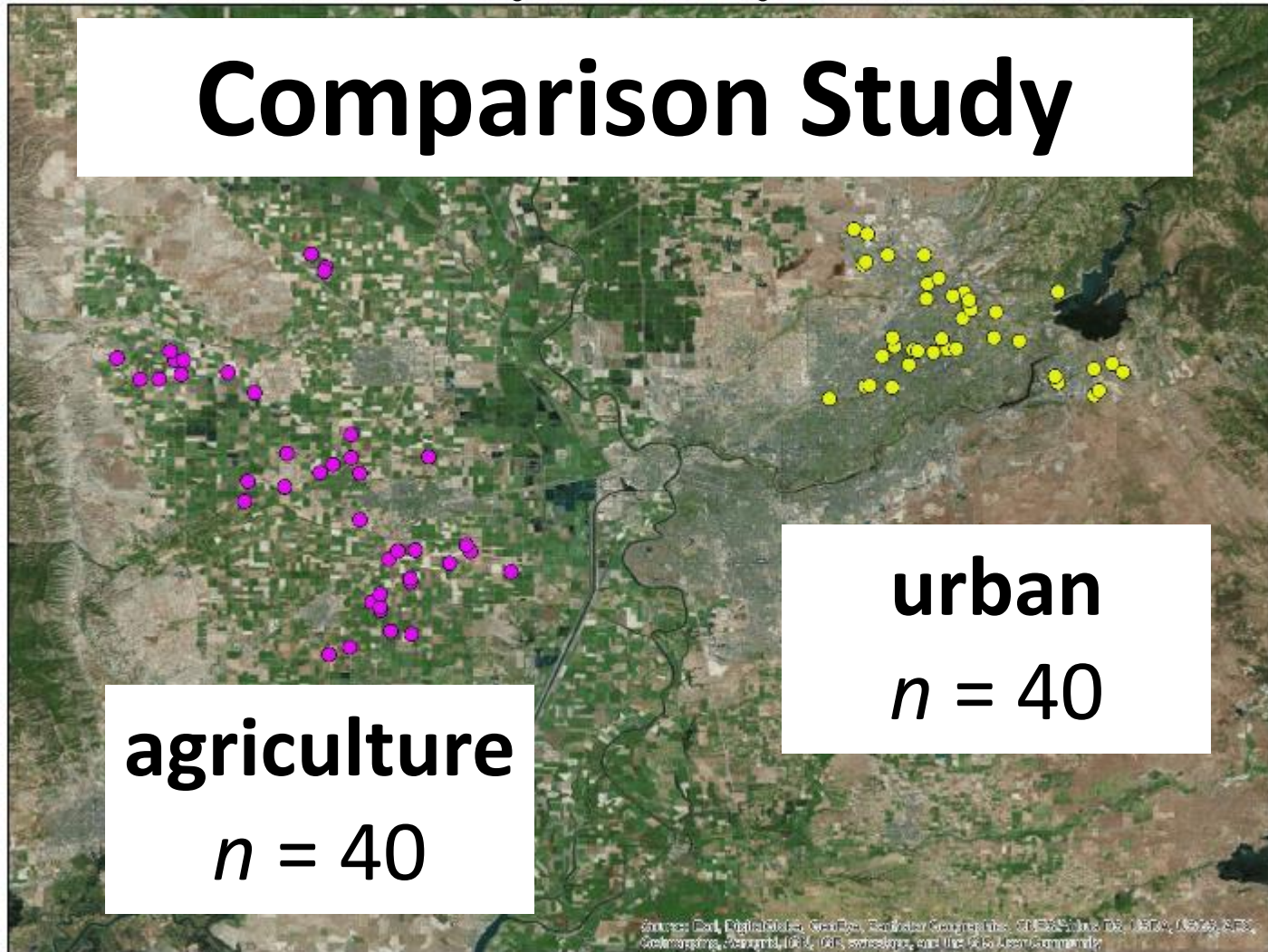


Roadmap to Ecosystem Services



20 km

Comparison Study



agriculture

$n = 40$

urban

$n = 40$



Sacramento

The stream margin ground layer (< 1 m height)

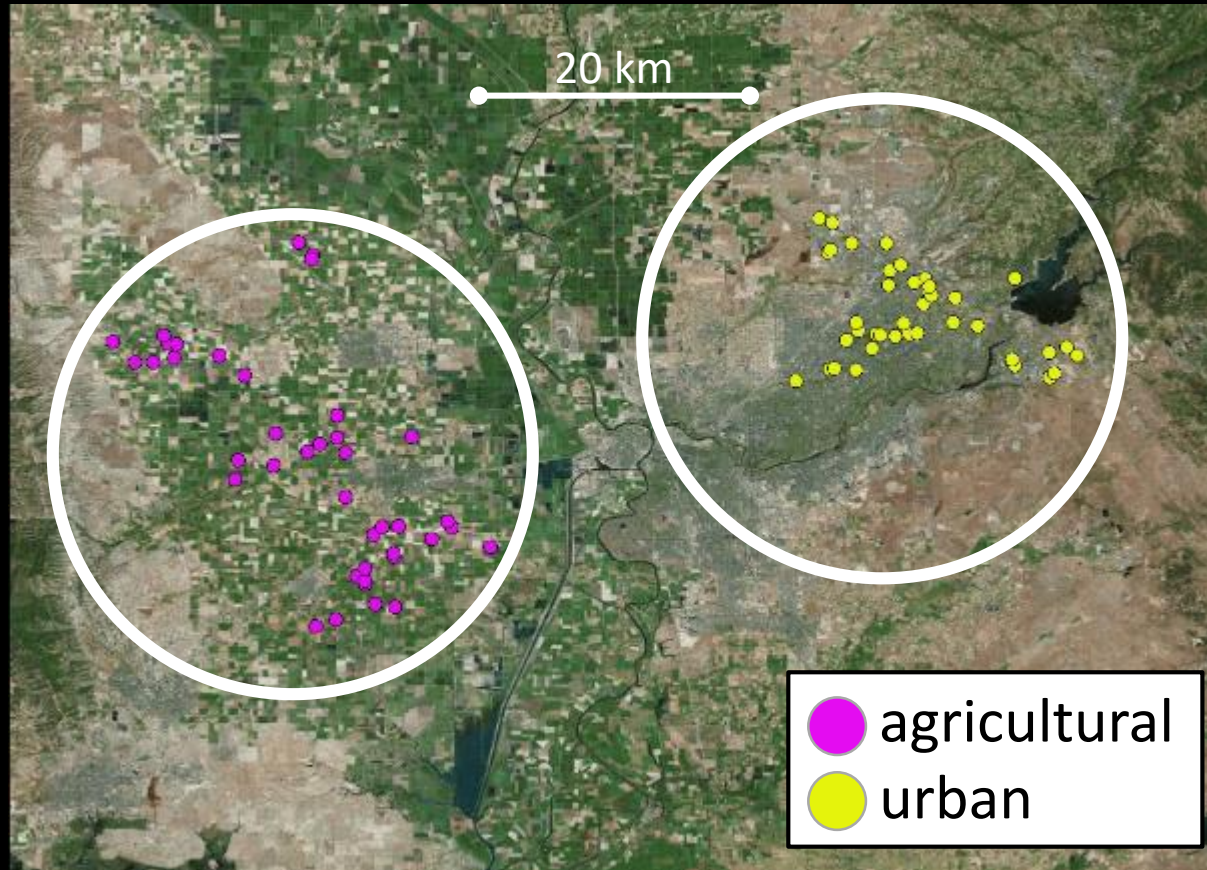
- Important for seedling recruitment, bank stability, nutrient cycling, biodiversity
- Exists on all study reaches



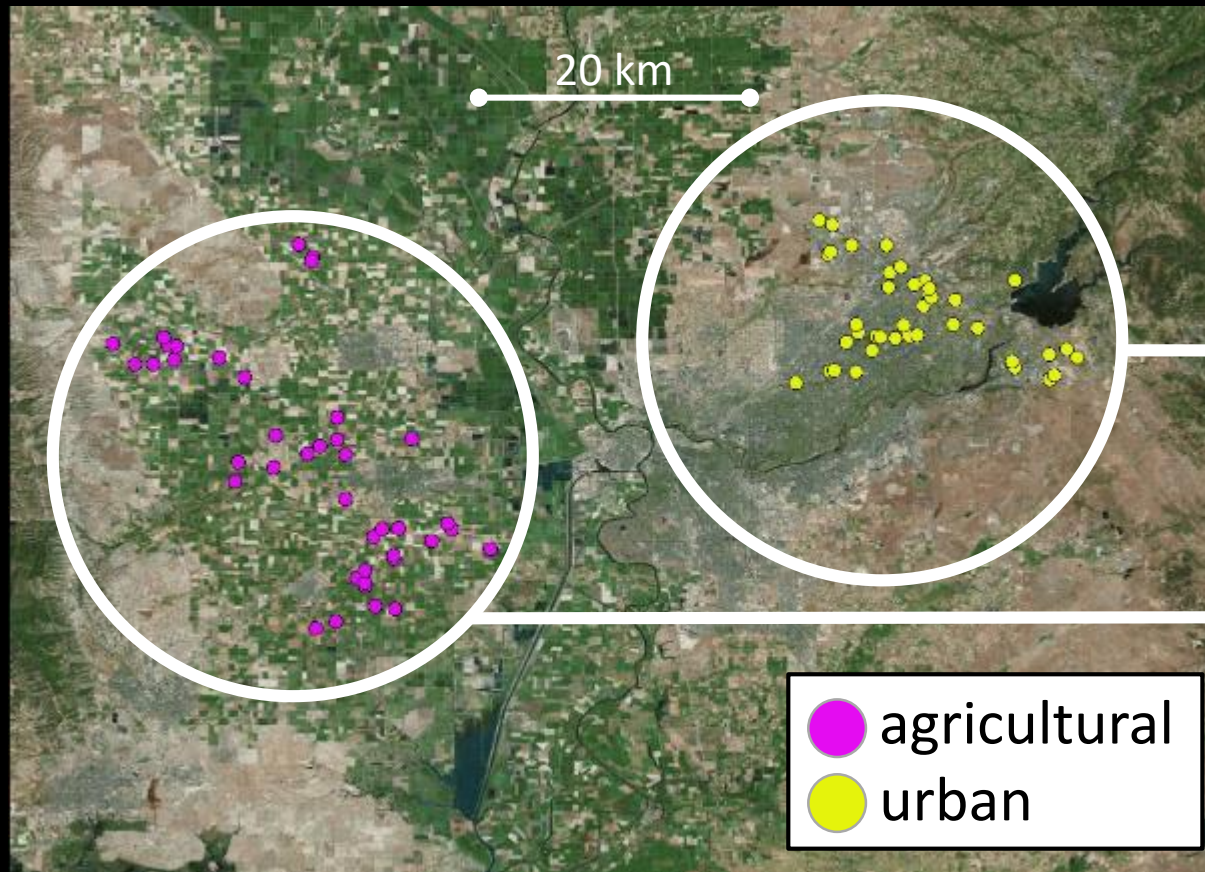
Research objectives

- Compare riparian stream margin vegetation between urban and agricultural land uses
- Assess factors shaping vegetation communities within and across land uses

Similarities in riparian vegetation across land uses

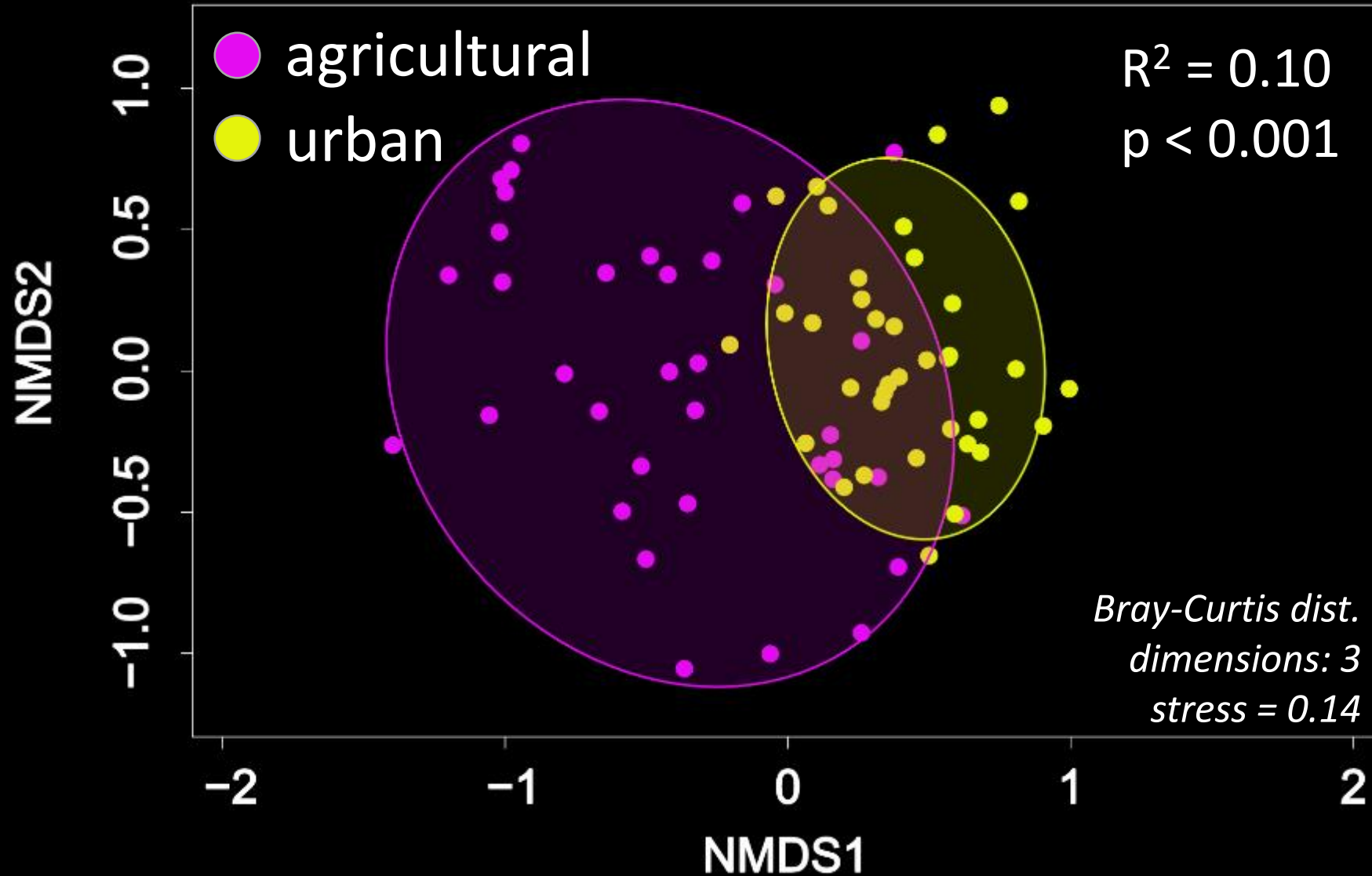


Similarities in riparian vegetation across land uses



- total cover
- native cover
- noxious weed cover
- alpha diversity
- native alpha diversity
- wetland prevalence index

Nonmetric multidimensional scaling



Generalist verses Unique Indicator species

Generalist verses Unique Indicator species

- Generalists all are **native wetland** species



Generalist verses Unique Indicator species

- Generalists all are **native wetland** species
- Unique indicators are mostly **noxious weed** species

urban



agricultural



Research objectives

- Compare riparian stream margin communities between urban and agricultural land uses
- Assess factors shaping these communities within and across land uses

Research objectives

- Compare riparian stream margin communities between urban and agricultural land uses
- Assess factors shaping these communities within and across land uses



canopy cover



bank height



bank slope



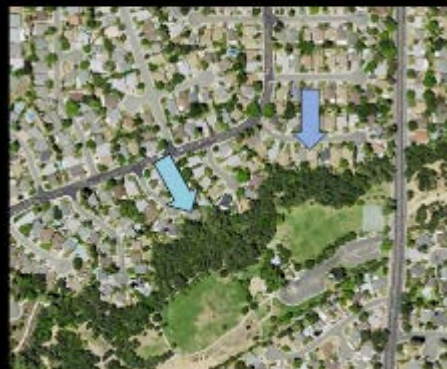
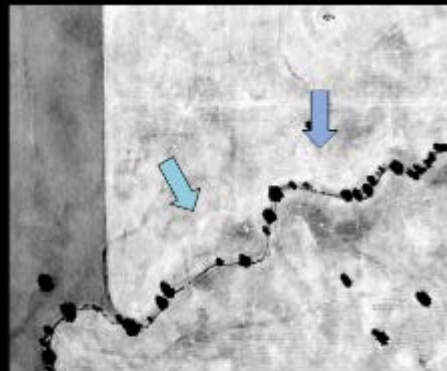
canopy cover



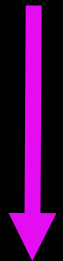
canopy cover

agricultural

urban



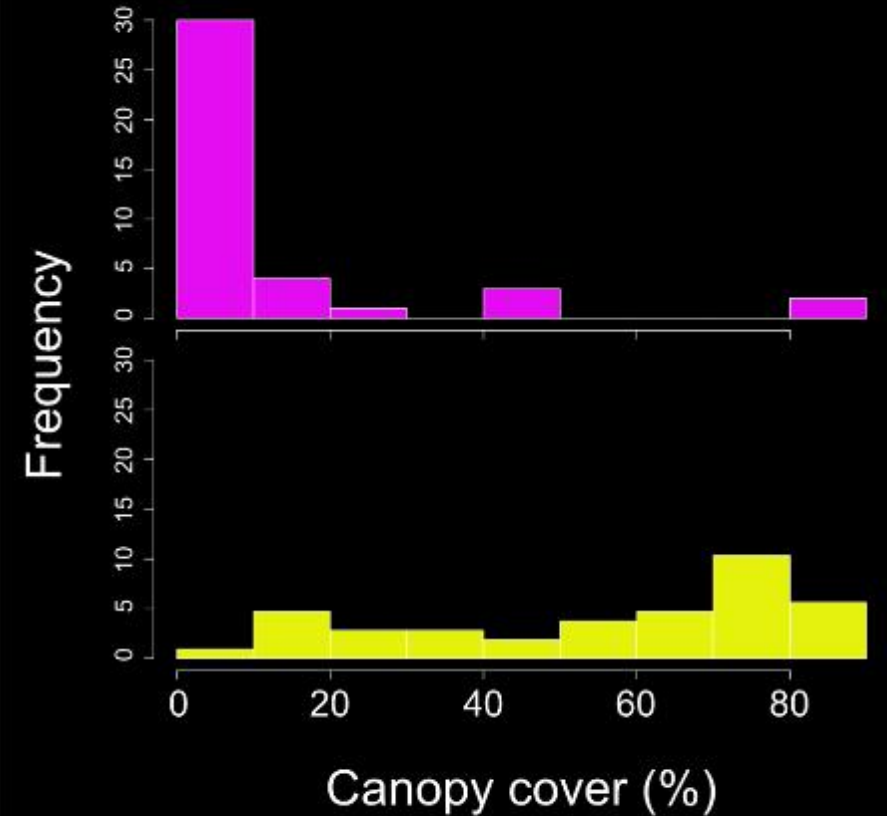
no
change



increasing
canopy



agricultural 
urban 



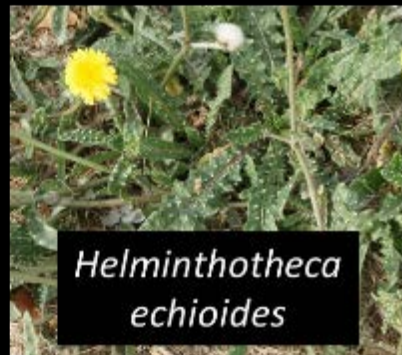


canopy cover

agricultural
indicator
species

grass and forbs

shade intolerant



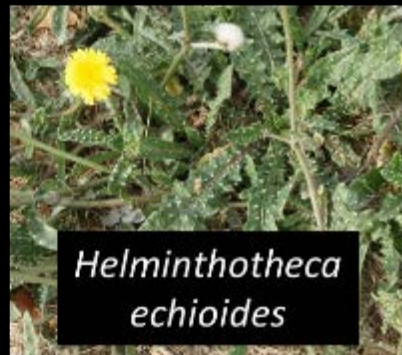


canopy cover

agricultural
indicator
species

grass and forbs

shade intolerant



urban
indicator
species

perennial
shrub and tree

shade tolerant



canopy cover



canopy cover

urban strongly associated with:

LOWER native cover and diversity

MORE noxious weeds



bank height

- incision
- other channel alteration



bank height

- incision
- other channel alterations

urban

associated with:

MORE bare ground

LESS perennial vegetation



bank height

- incision
- other channel alterations

urban

associated with:

MORE bare ground

LESS perennial vegetation

agricultural

strongly associated with:

LESS bare ground

MORE perennial vegetation

MORE native cover and diversity

MORE total cover and diversity

MORE noxious weeds



bank height

- incision
- other channel alterations

urban





bank height

- incision
- other channel alterations

urban



agricultural



decreasing
management
pressure?



bank height

- incision
- other channel alterations

urban



agricultural



decreasing
management
pressure?





bank height

- incision
- other channel alterations

urban



agricultural



decreasing
management
pressure?





bank slope

- micro-topography
- water availability

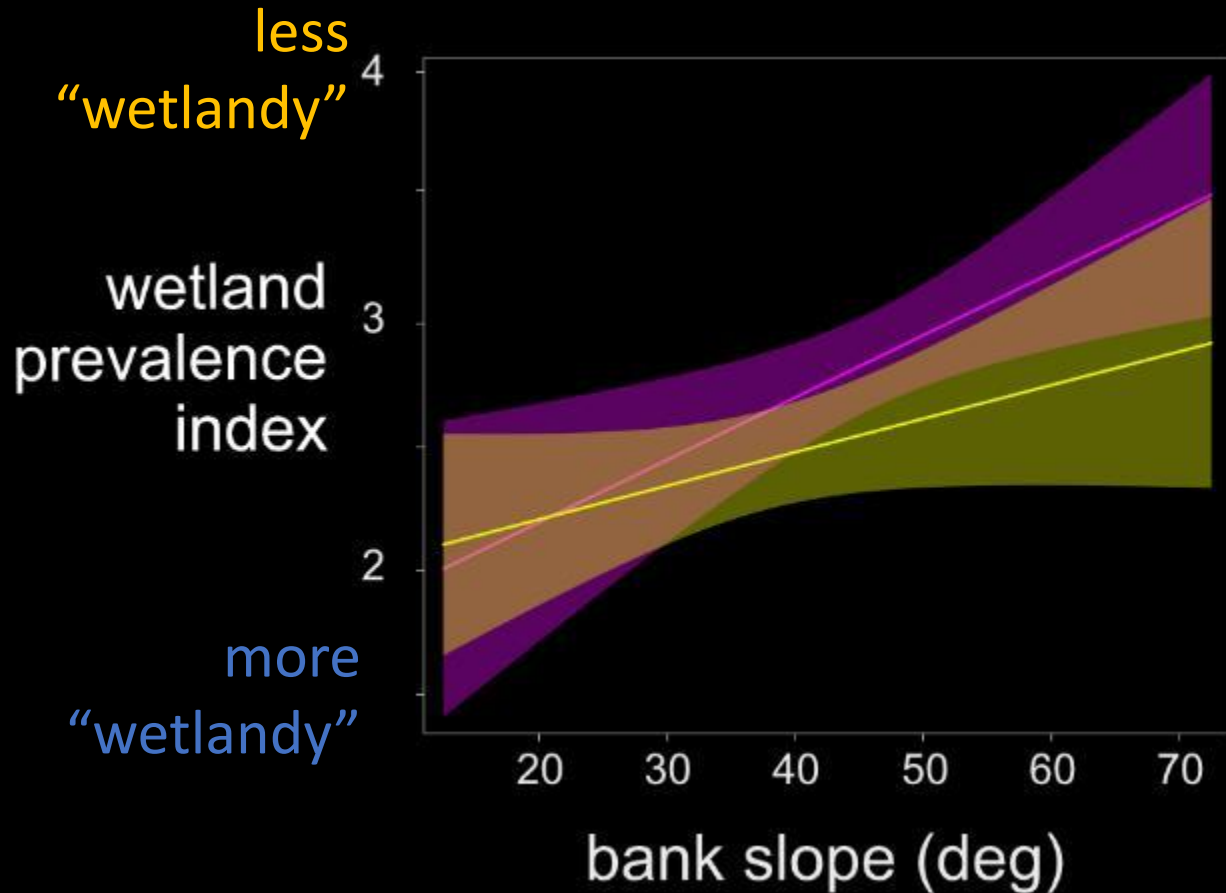


bank slope

- micro-topography
- water availability

■ agricultural

■ urban





bank slope

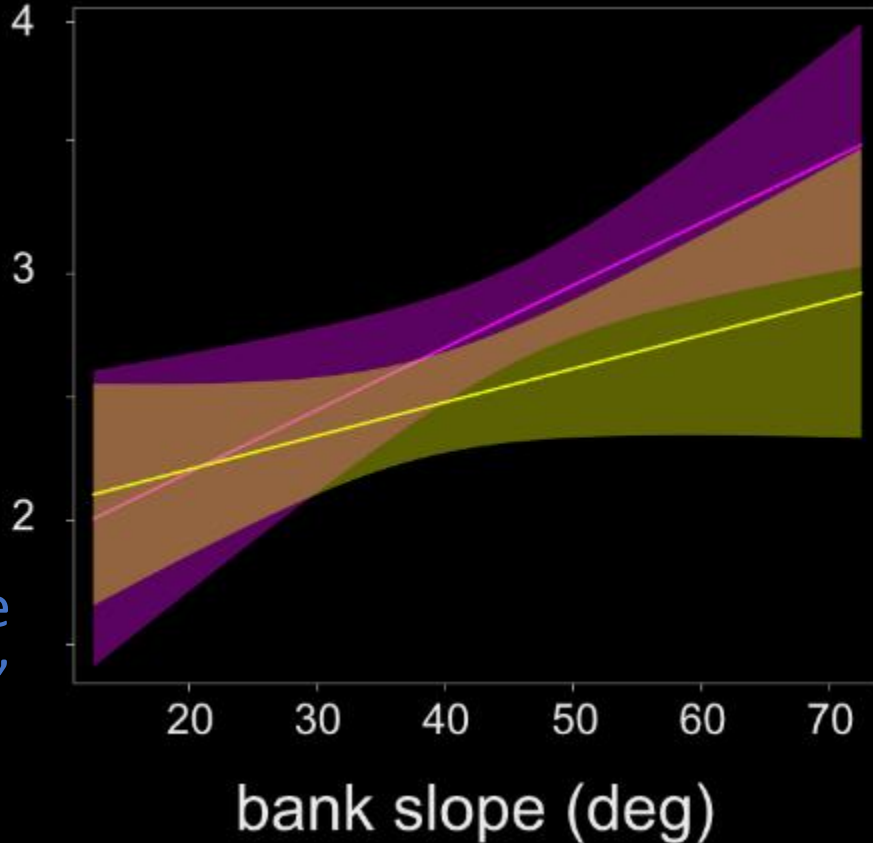
- micro-topography
- water availability

■ agricultural

■ urban

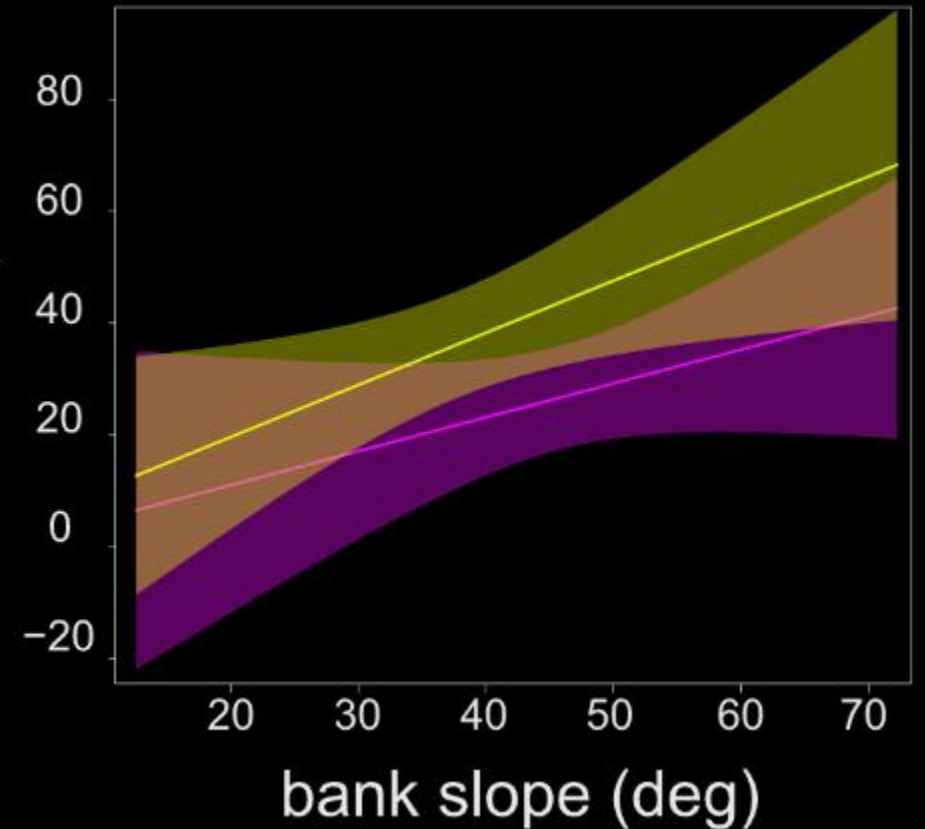
less
"wetlandy"

wetland
prevalence
index



more
"wetlandy"

cover
noxious
weeds
(%)



what characterizes existing riparian
vegetation communities?

agricultural and urban
small lowland streams:

what characterizes existing riparian vegetation communities?

agricultural and urban
small lowland streams:

- share a suite of common native
wetland species



what characterizes existing riparian vegetation communities?

agricultural and urban small lowland streams:

- share a suite of common native wetland species
- have contrasting exotic and noxious weed species



what characterizes existing riparian vegetation communities?

agricultural and urban small lowland streams:

- share a suite of common native wetland species
- have contrasting exotic and noxious weed species
- land use-associated weeds cause divergence in riparian habitat across landscape



what factors are shaping these communities?

what factors are shaping these communities?

shared

- steep bank slopes =
low wetland affiliation
high noxious weed cover

what factors are shaping these communities?

agricultural

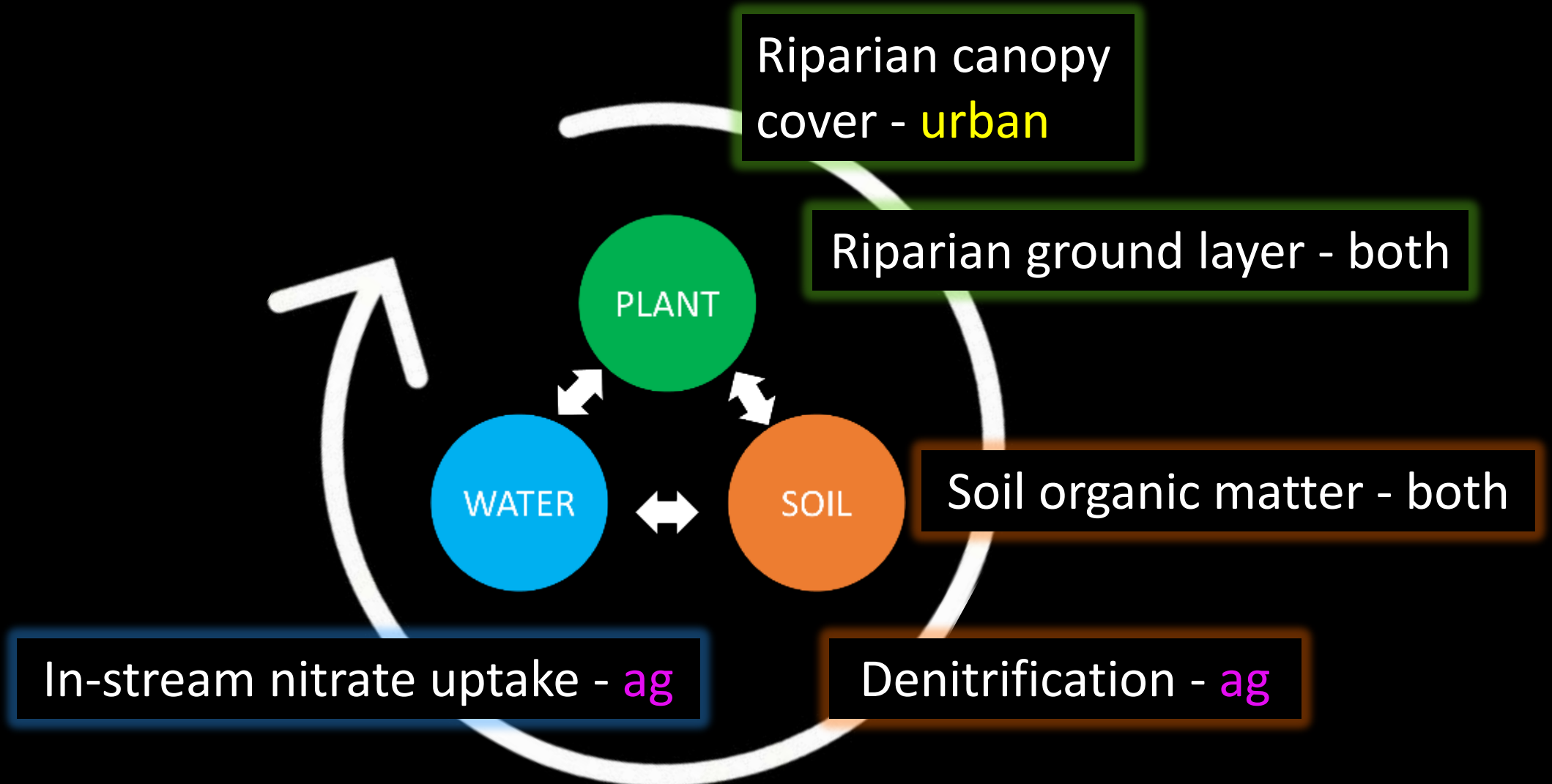
- high bank heights =
 - less bare ground
 - higher vegetation cover and diversity
 - escape from management pressure?

what factors are shaping these communities?

urban

- closed canopies =
 - low native cover
 - low diversity
 - high noxious weed cover

Roadmap to Ecosystem Services



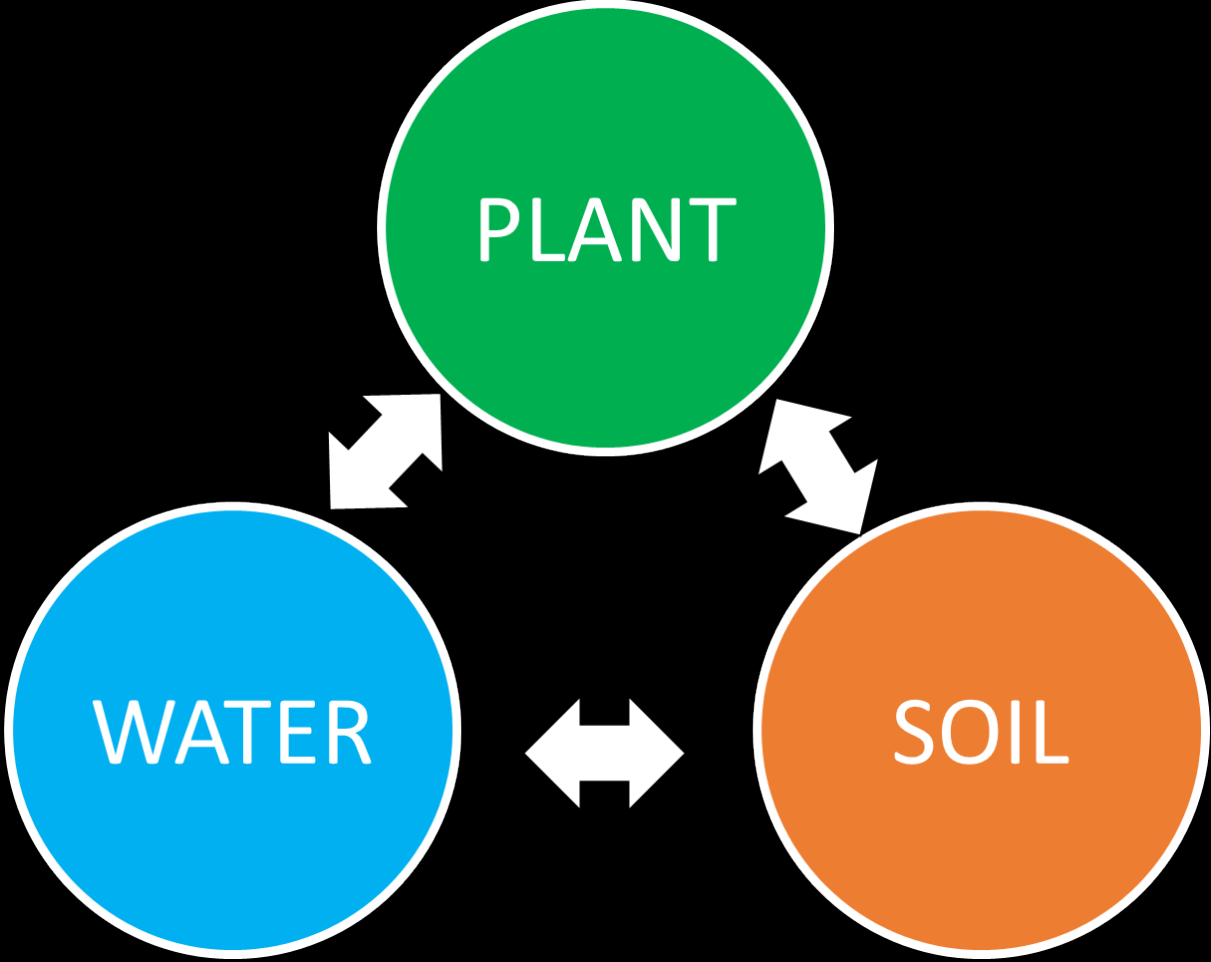
Soil organic matter



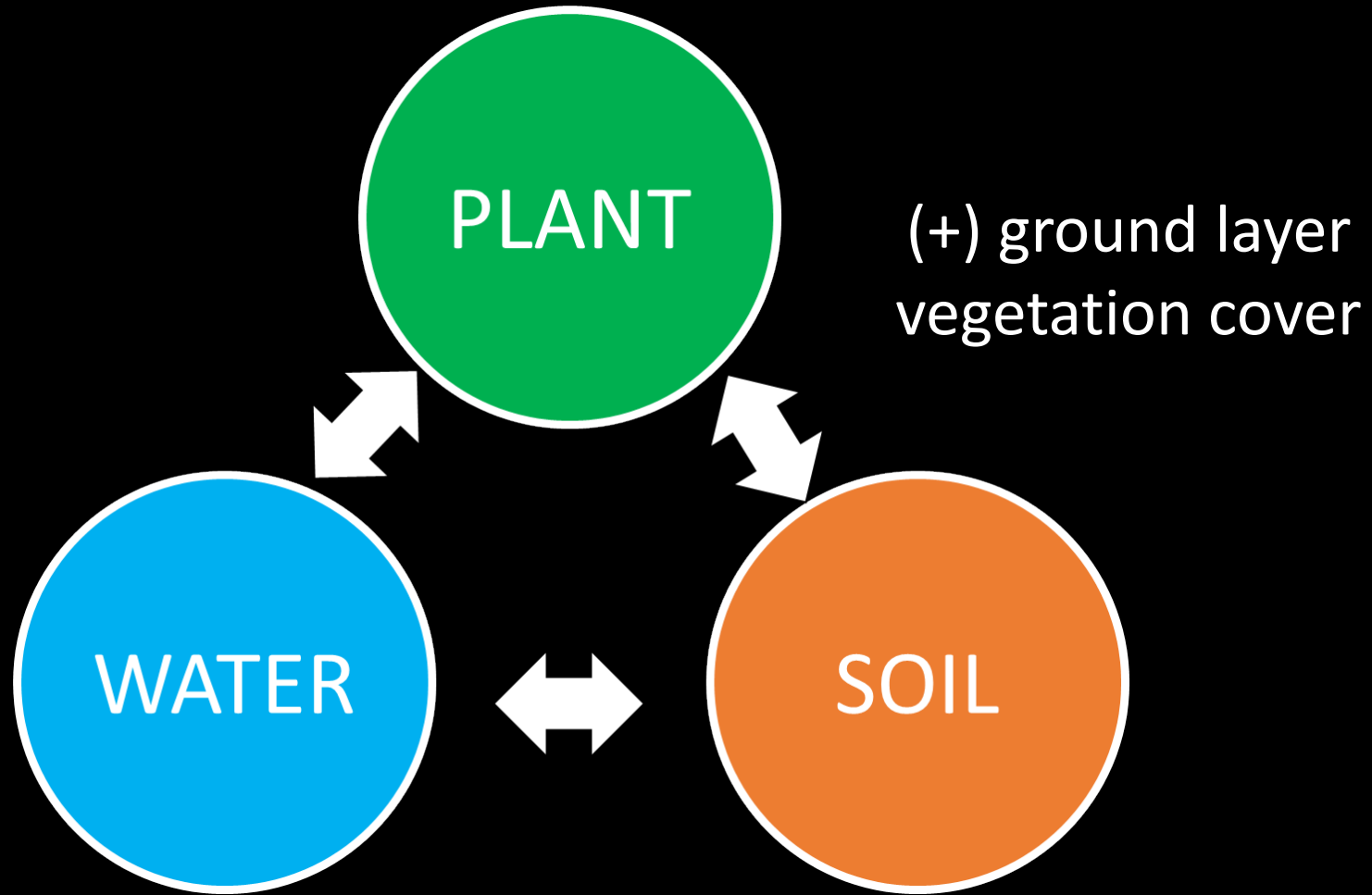
Soil organic matter

- No association with land use or canopy cover

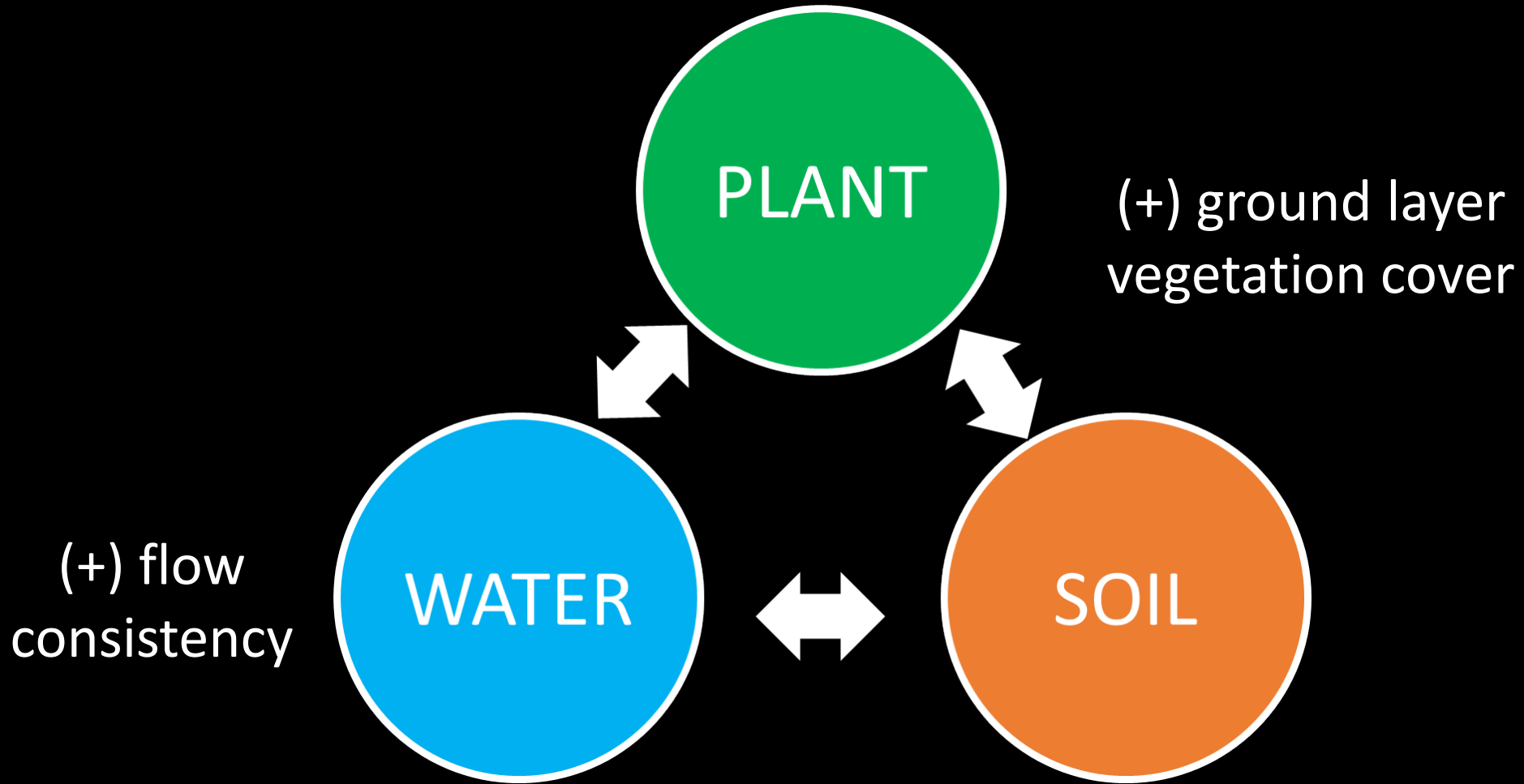
Soil organic matter



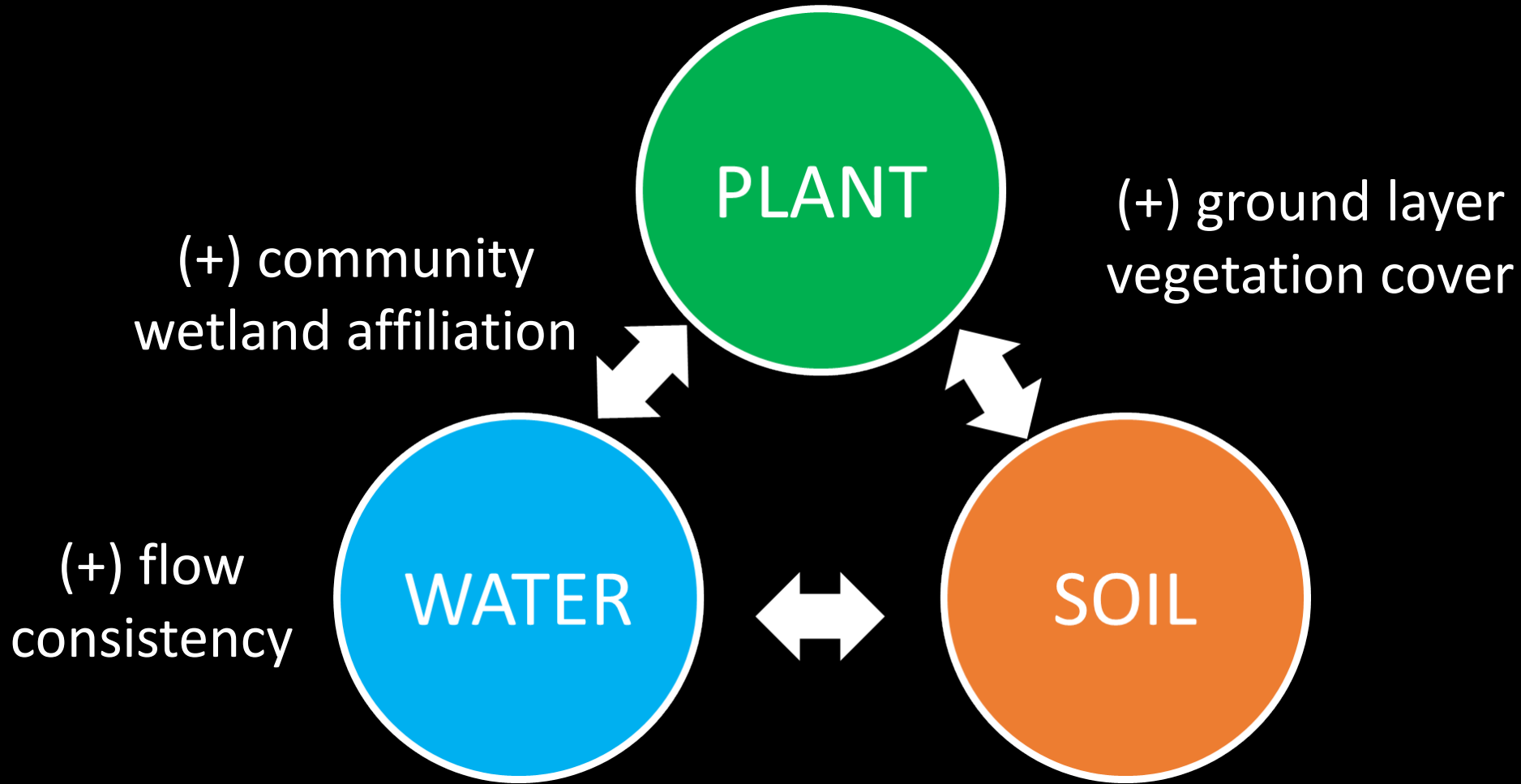
Soil organic matter is associated with...



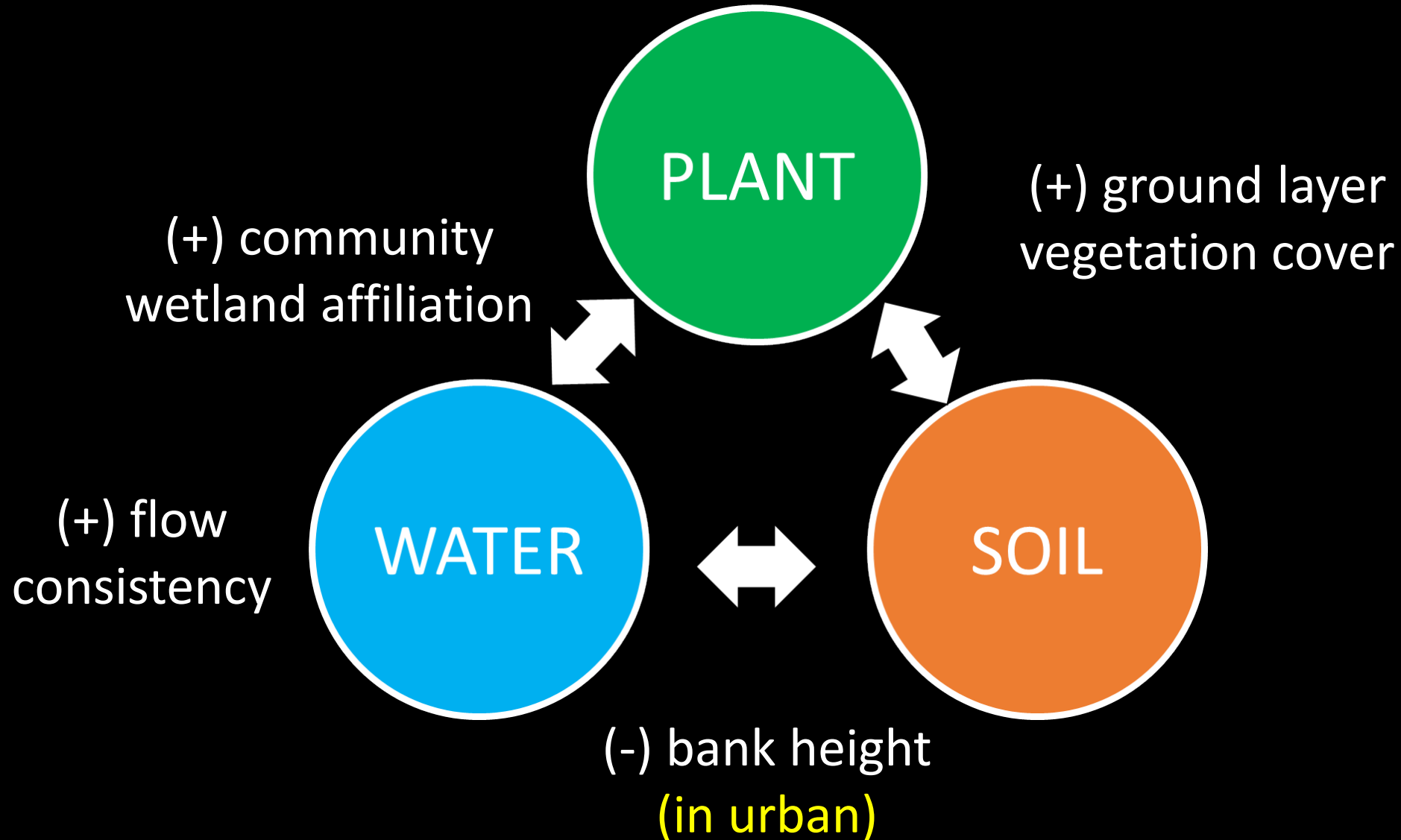
Soil organic matter is associated with...



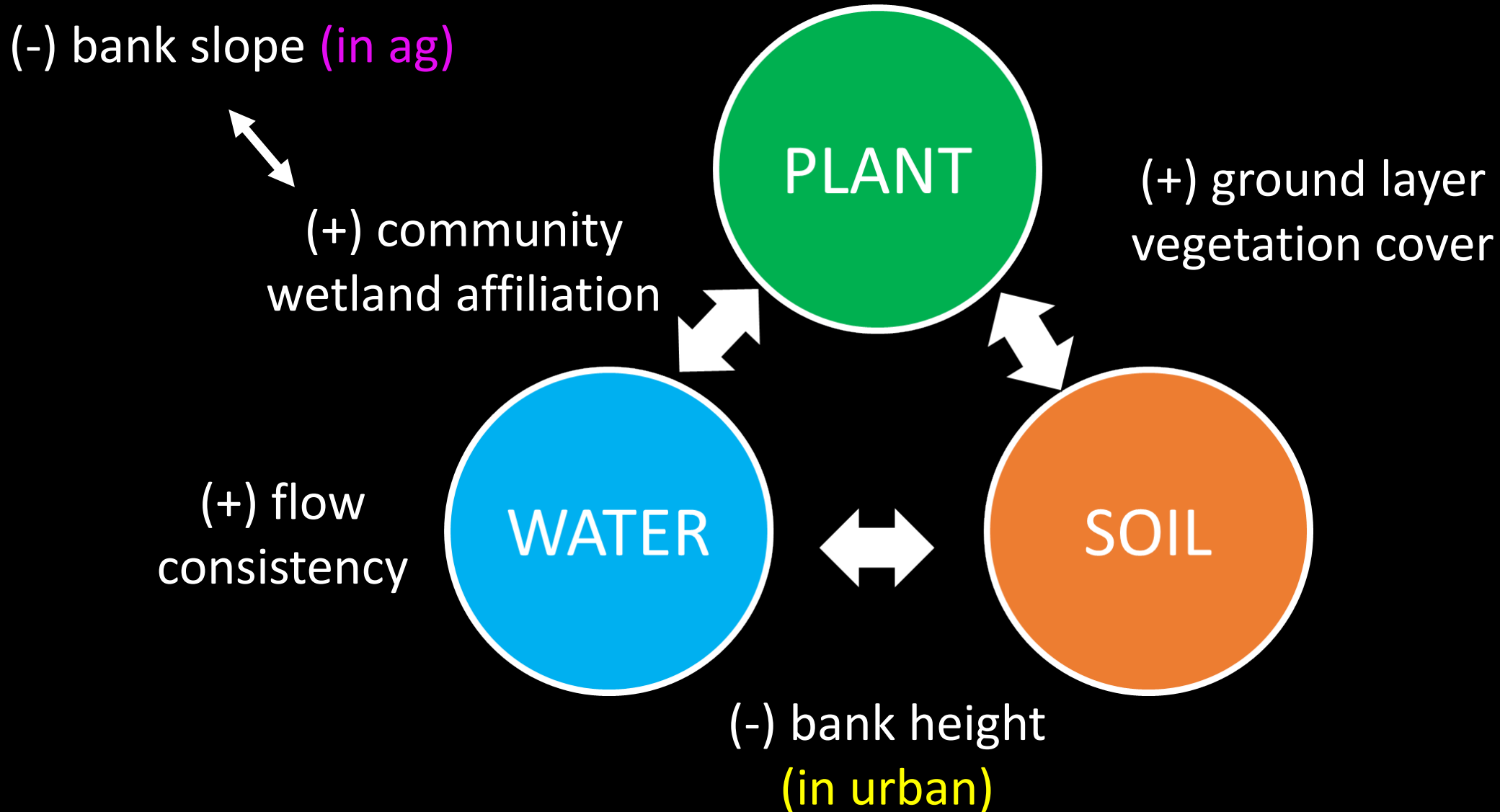
Soil organic matter is associated with...



Soil organic matter is associated with...



Soil organic matter is associated with...



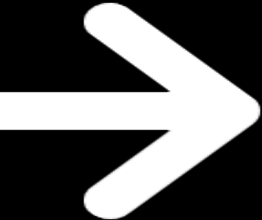
Soil organic matter



Soil organic matter



Excess
 NO_3



N_2 gas

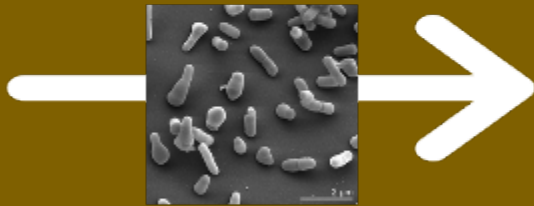
Denitrifying
microbes

- Riparian ecosystem function
- Water quality

Soil organic matter



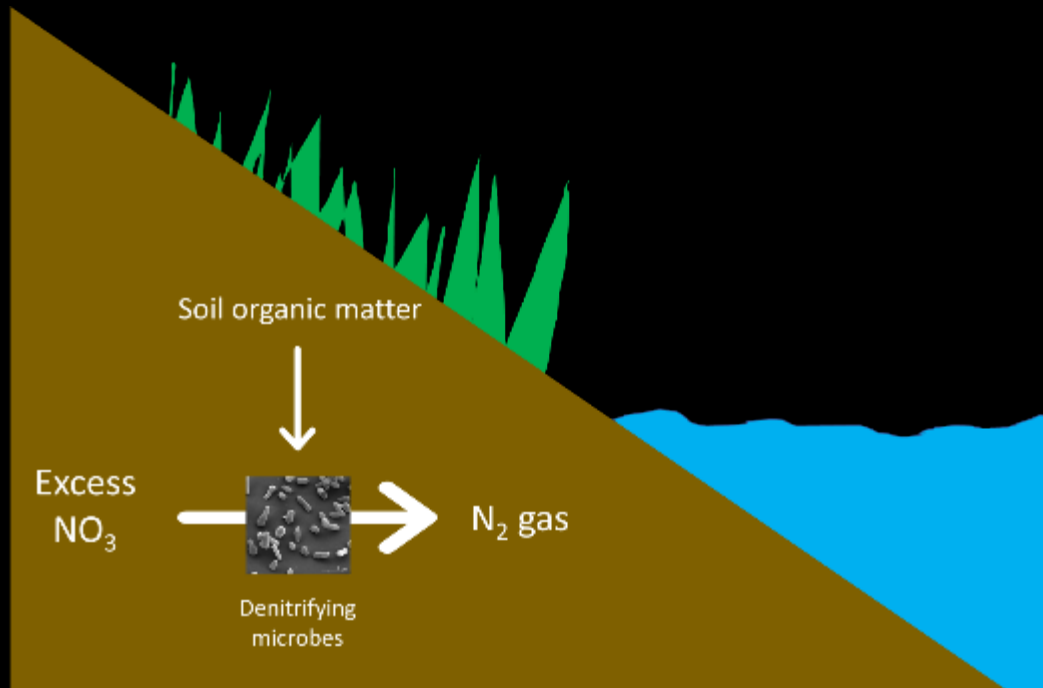
Excess
 NO_3



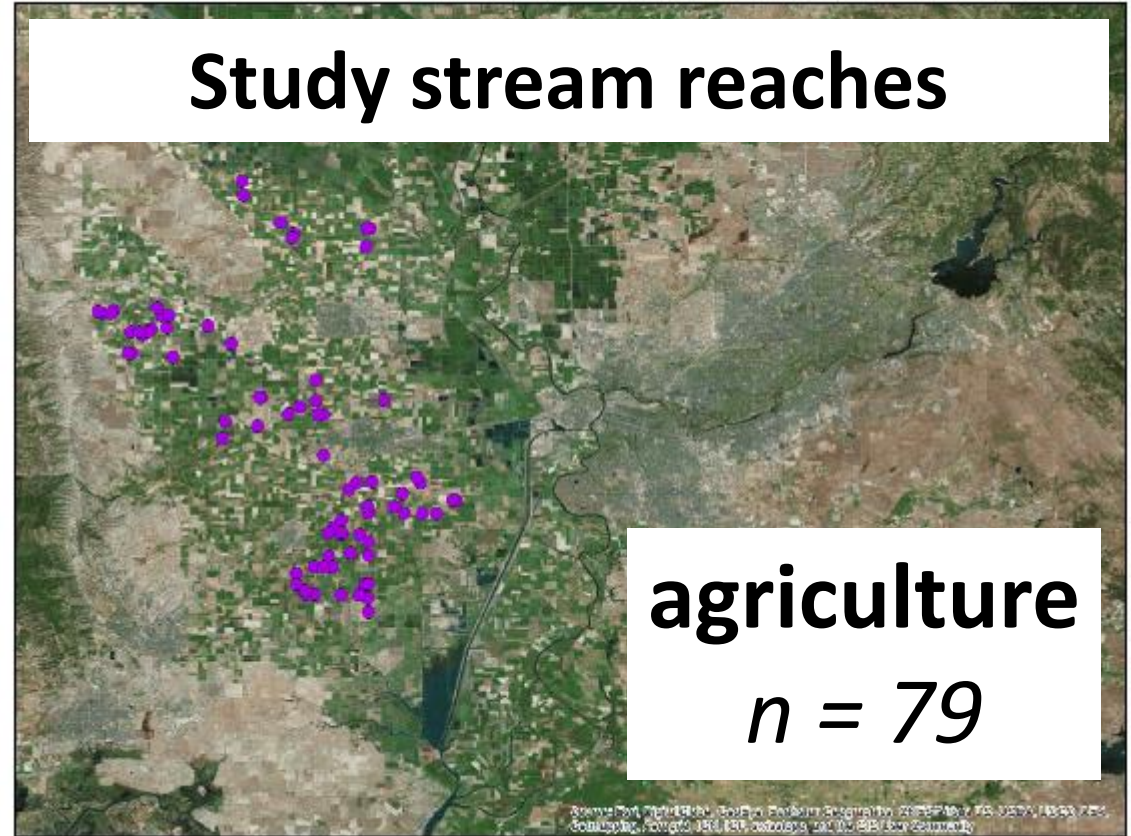
N_2 gas

Denitrifying
microbes

Denitrification

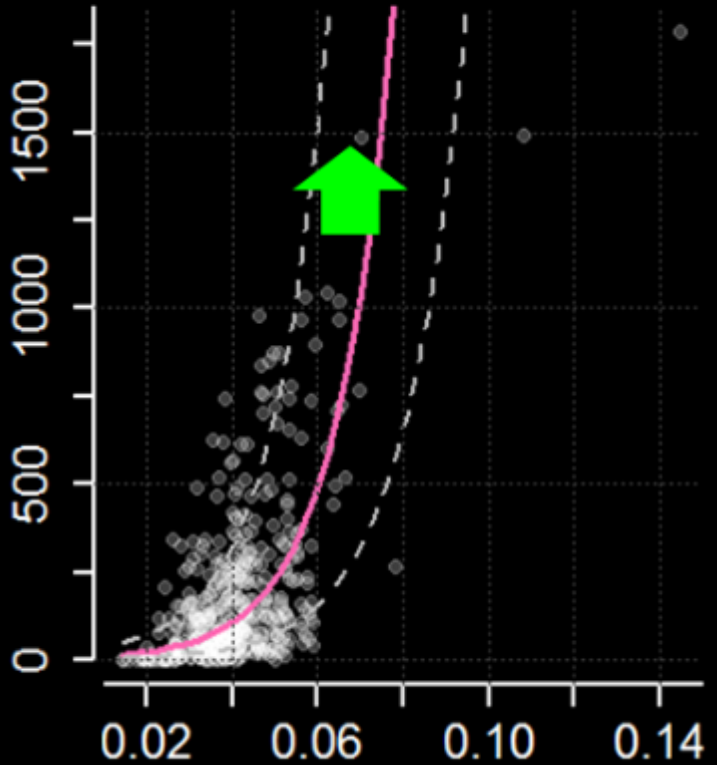


Study stream reaches



Denitrification
Potential

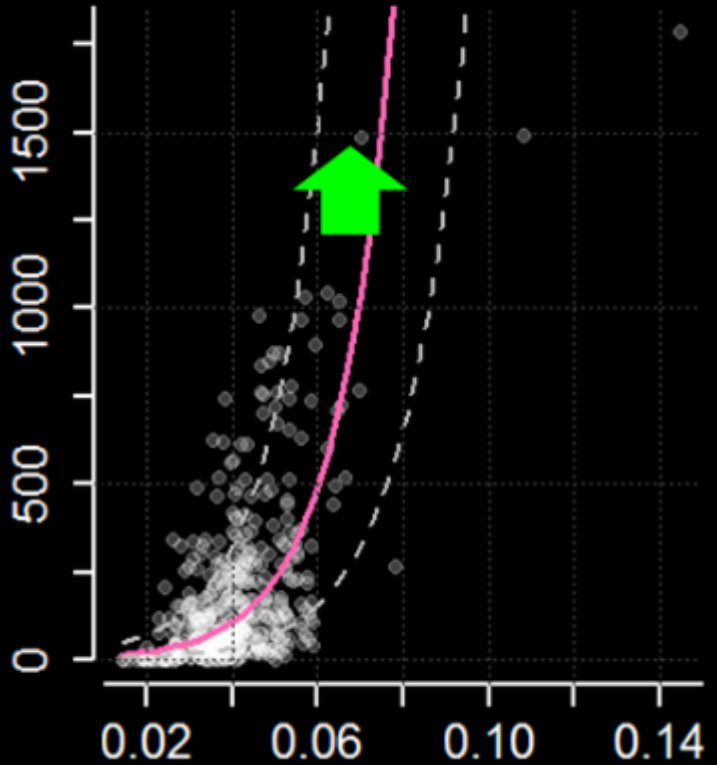
$$\left(\frac{\text{ng N}^{-1}}{\text{g dry soil}^{-1}} \right) \text{h}^{-1}$$



Soil Organic
Matter (%)

Denitrification
Potential

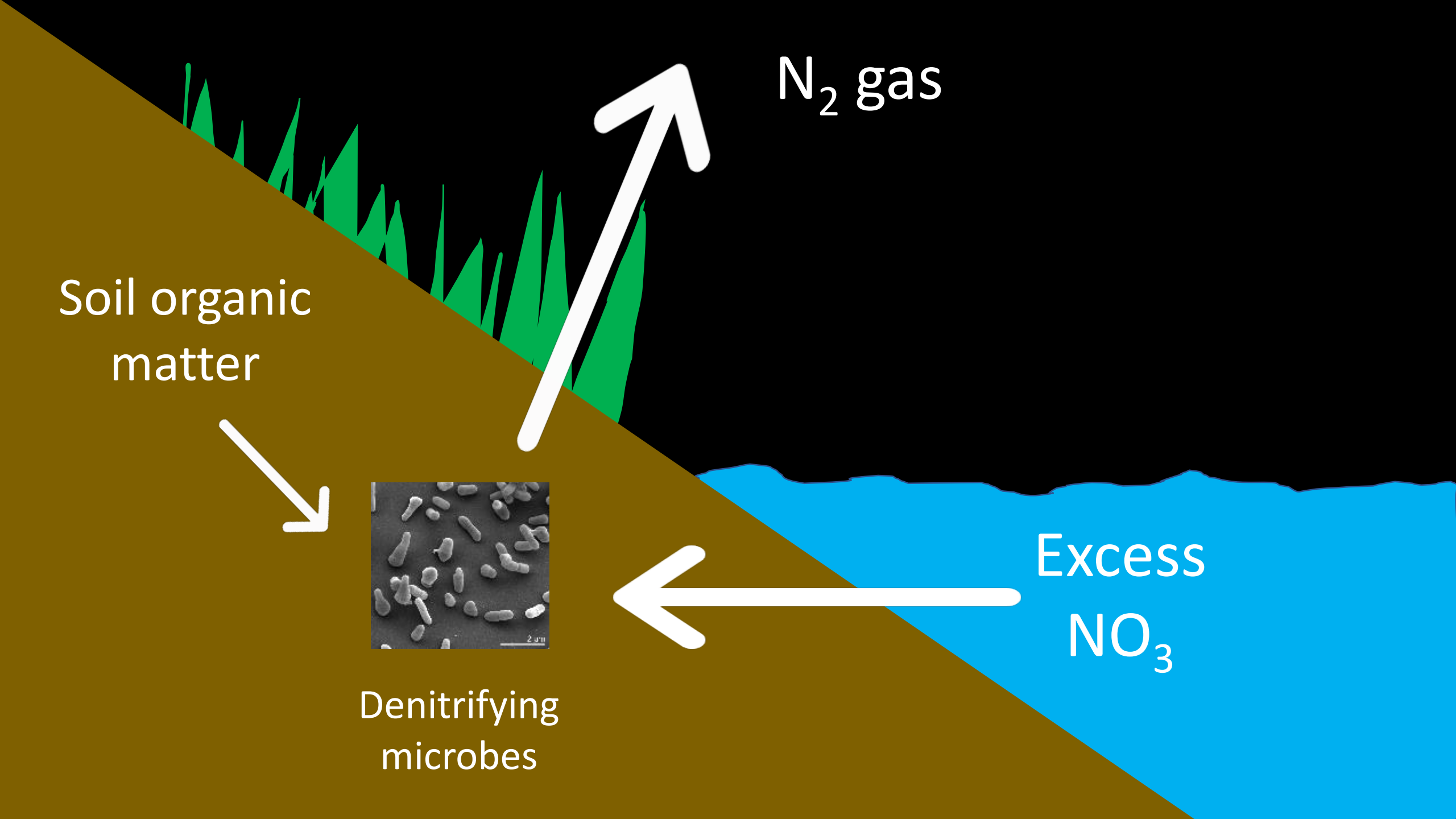
$$\left(\frac{\text{ng N}^{-1}}{\text{g dry soil}^{-1}} \right) \text{h}^{-1}$$



Soil Organic
Matter (%)

- (+) vegetation cover
- (+) community wetland affiliation
- (+) flow consistency
- (-) bank height (in urban)
- (-) bank slope (in ag)





N₂ gas

Soil organic matter

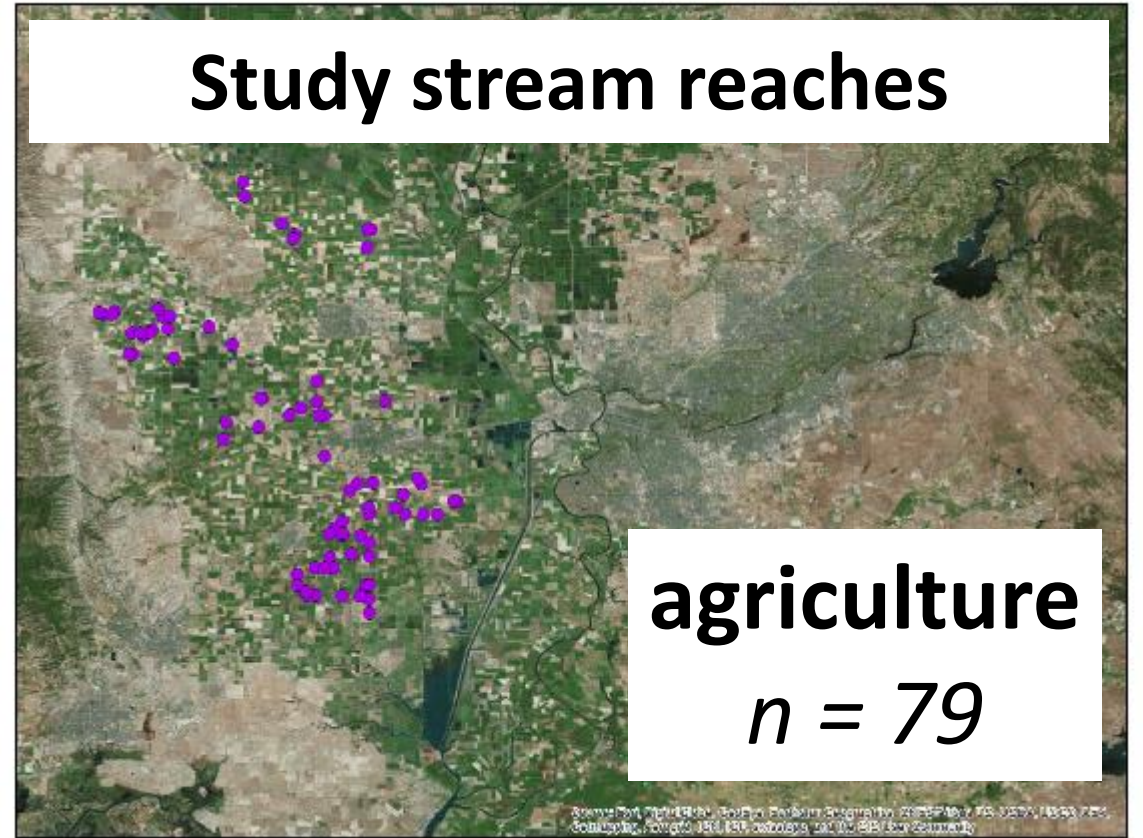
Excess NO₃

Denitrifying microbes

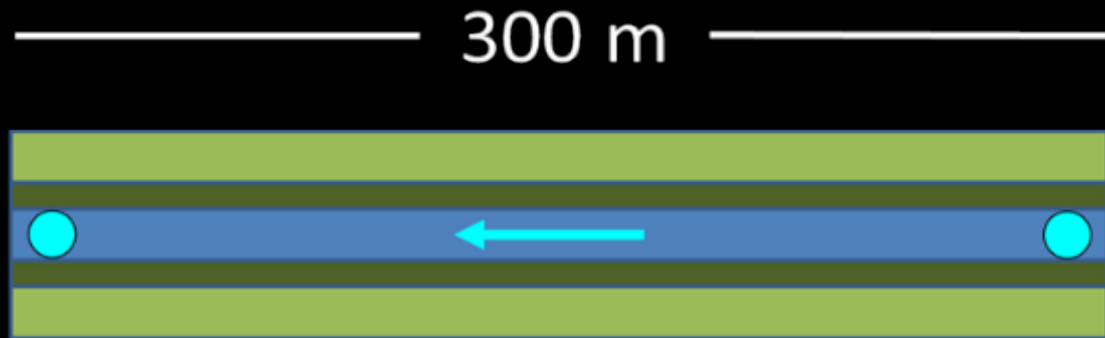


In-stream nitrate uptake

Study stream reaches

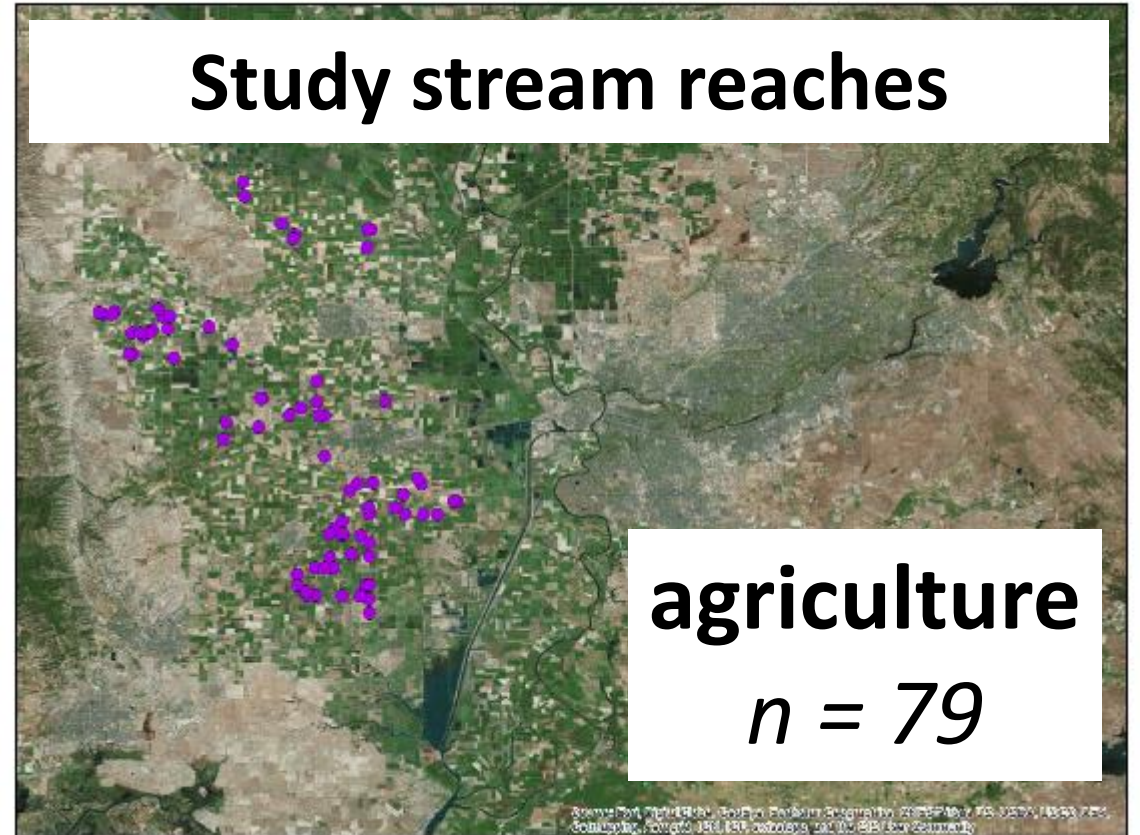


In-stream nitrate uptake



● Water Sample Point

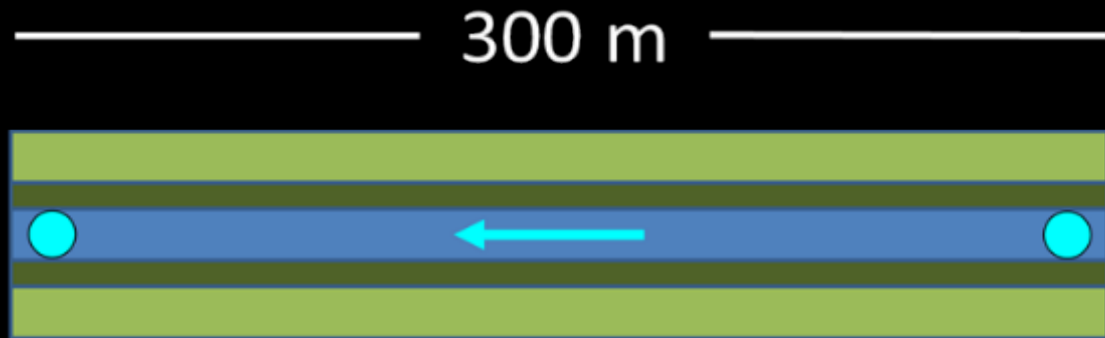
Study stream reaches



agriculture

$n = 79$

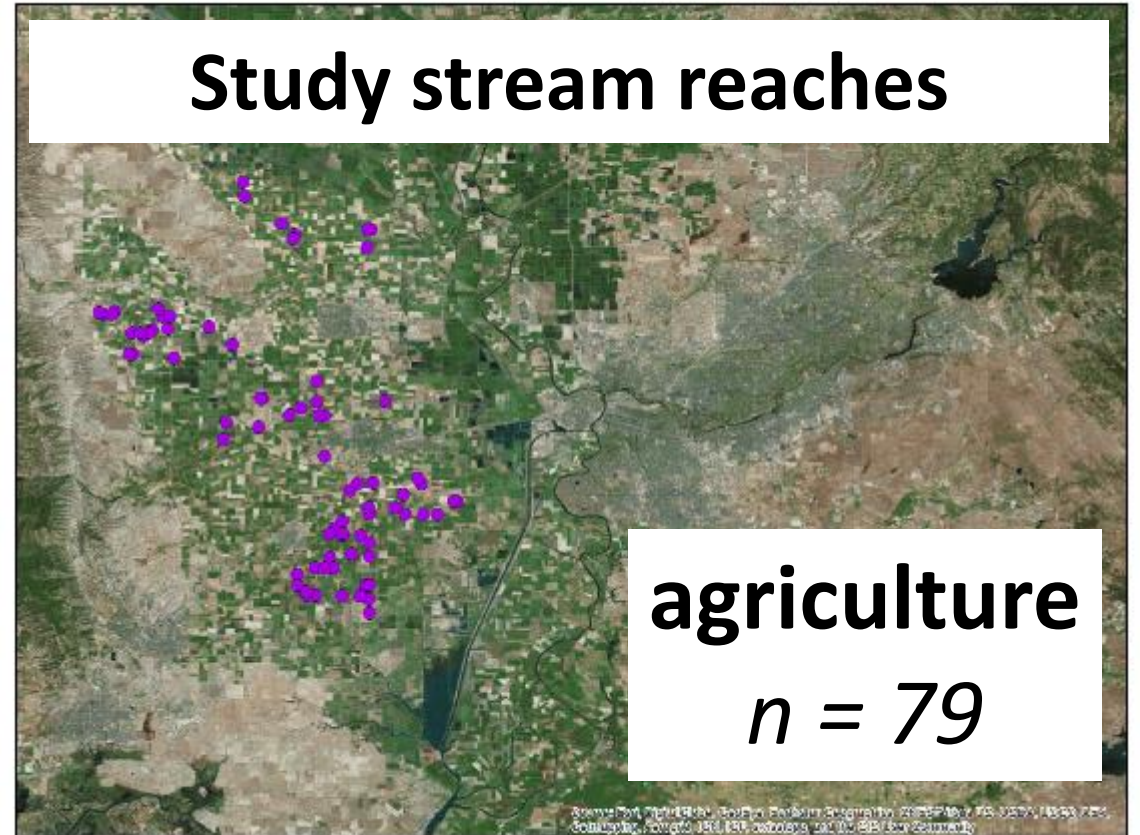
In-stream nitrate uptake



● Water Sample Point

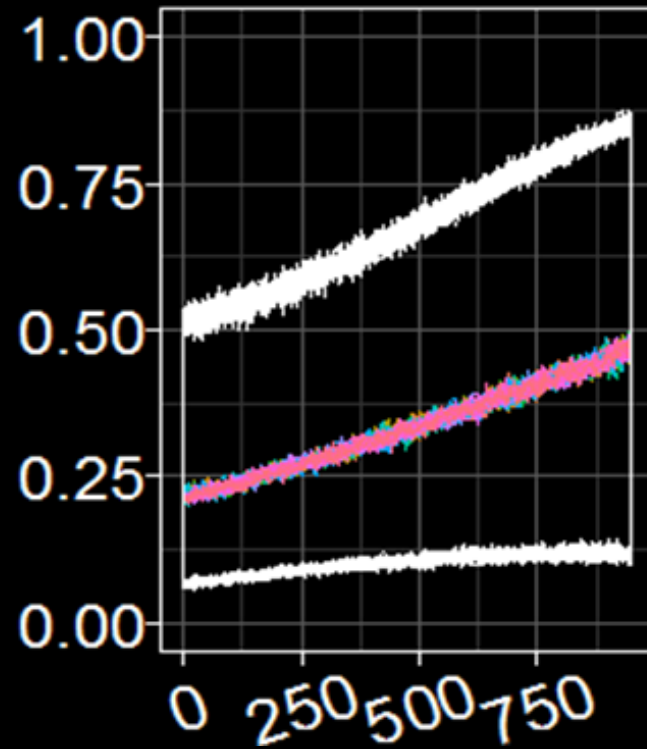
What predicts the probability of observing nitrate loss $> -5\%$?

Study stream reaches



In-stream nitrate uptake

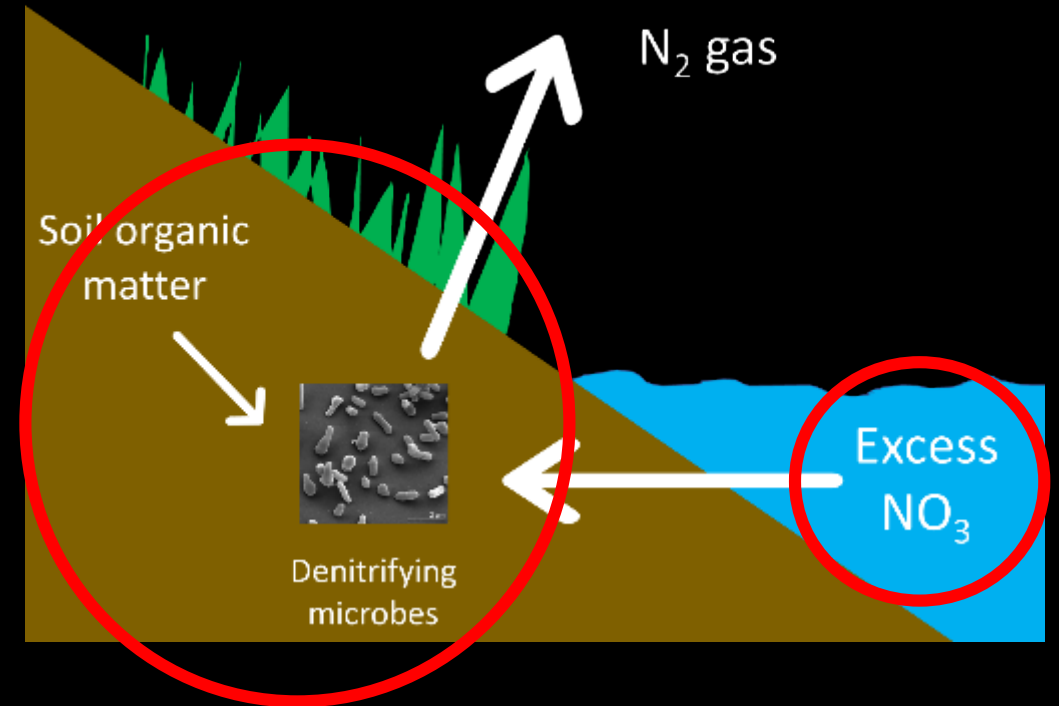
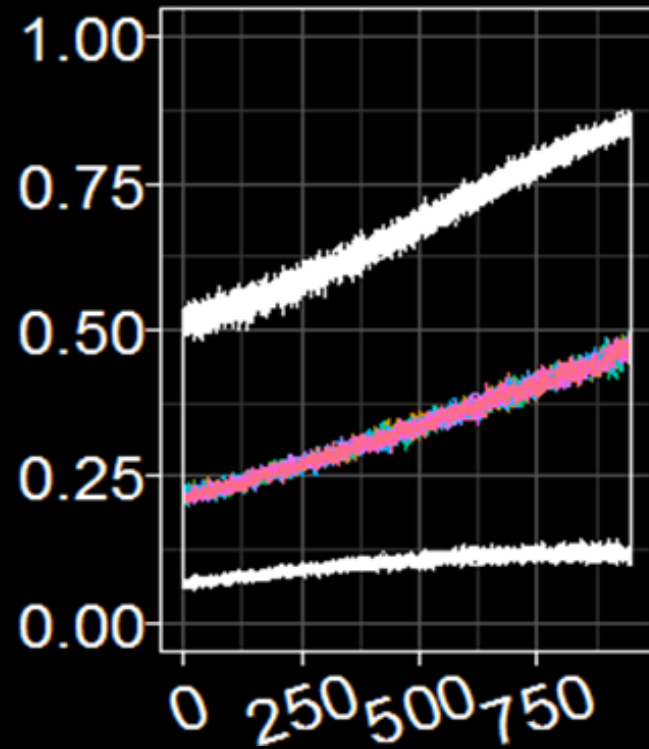
Probability
of Observing
Nitrate Loss
> -5%



Riparian denitrification
potential (ng N/g soil/hr)

In-stream nitrate uptake

Probability
of Observing
Nitrate Loss
> -5%

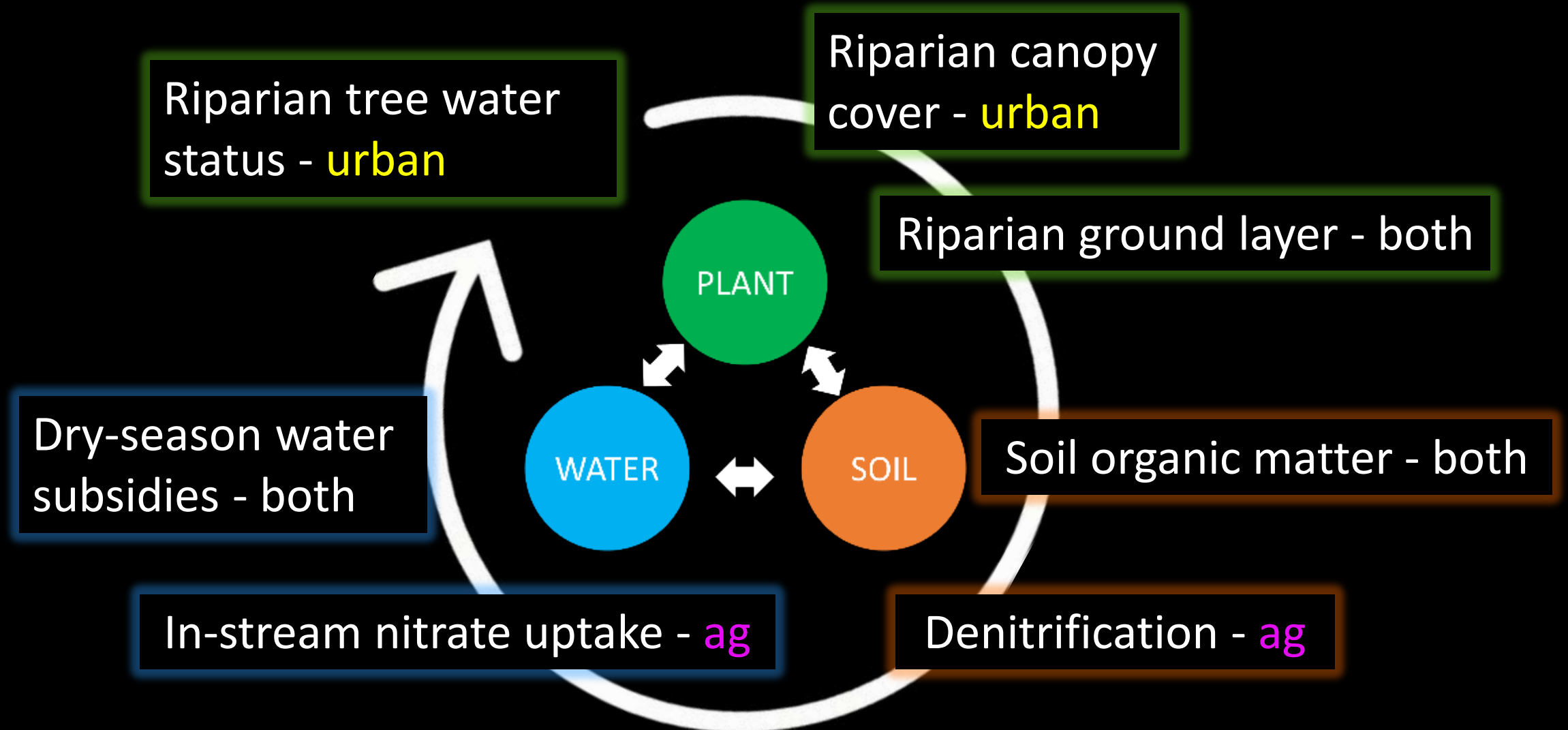


Riparian denitrification
potential (ng N/g soil/hr)

Water quality → Water quantity

Understory → Overstory

Roadmap to Ecosystem Services





Historically
intermittent streams

Dry-season water subsidies



Dry-season water subsidies



Contrasting impacts of urbanization:

Dry-season flow



Wetter riparian zones

Contrasting impacts of urbanization:

Dry-season flow



Wetter riparian zones

Channel incision



Drier riparian zones

Contrasting impacts of urbanization:

Dry-season flow



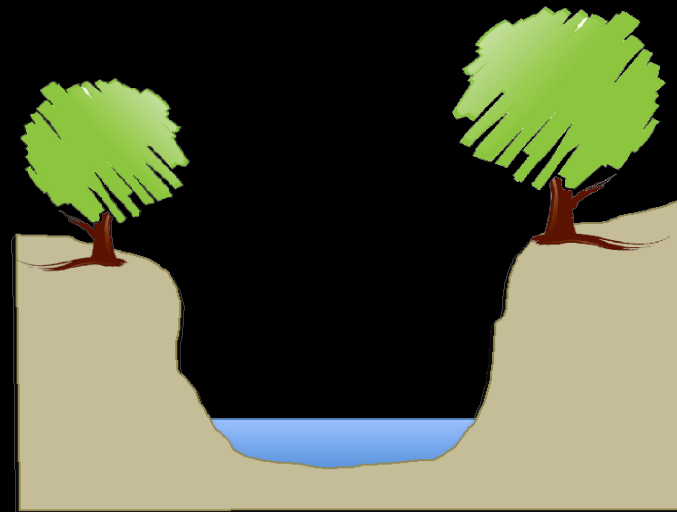
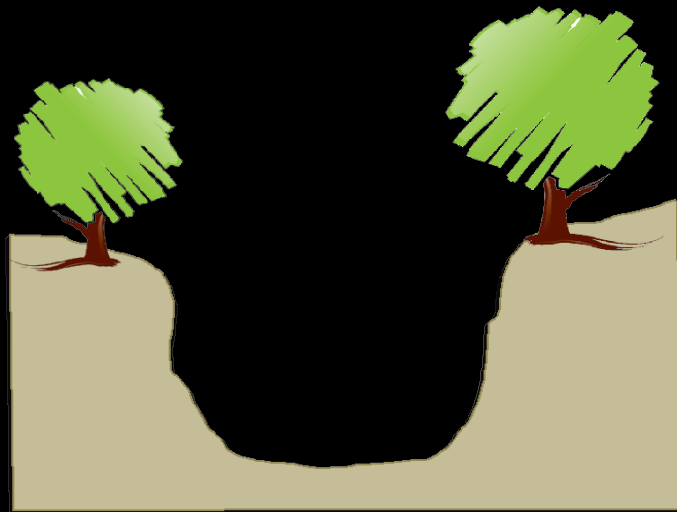
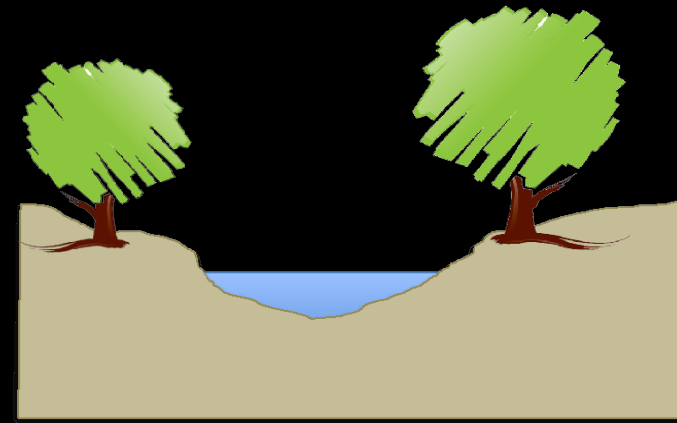
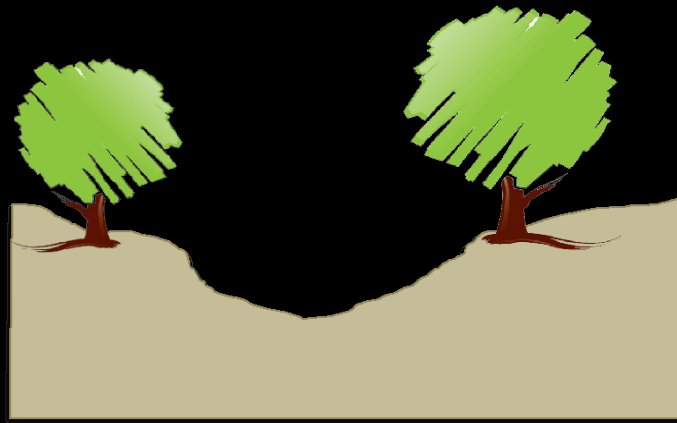
Wetter riparian zones

Channel incision

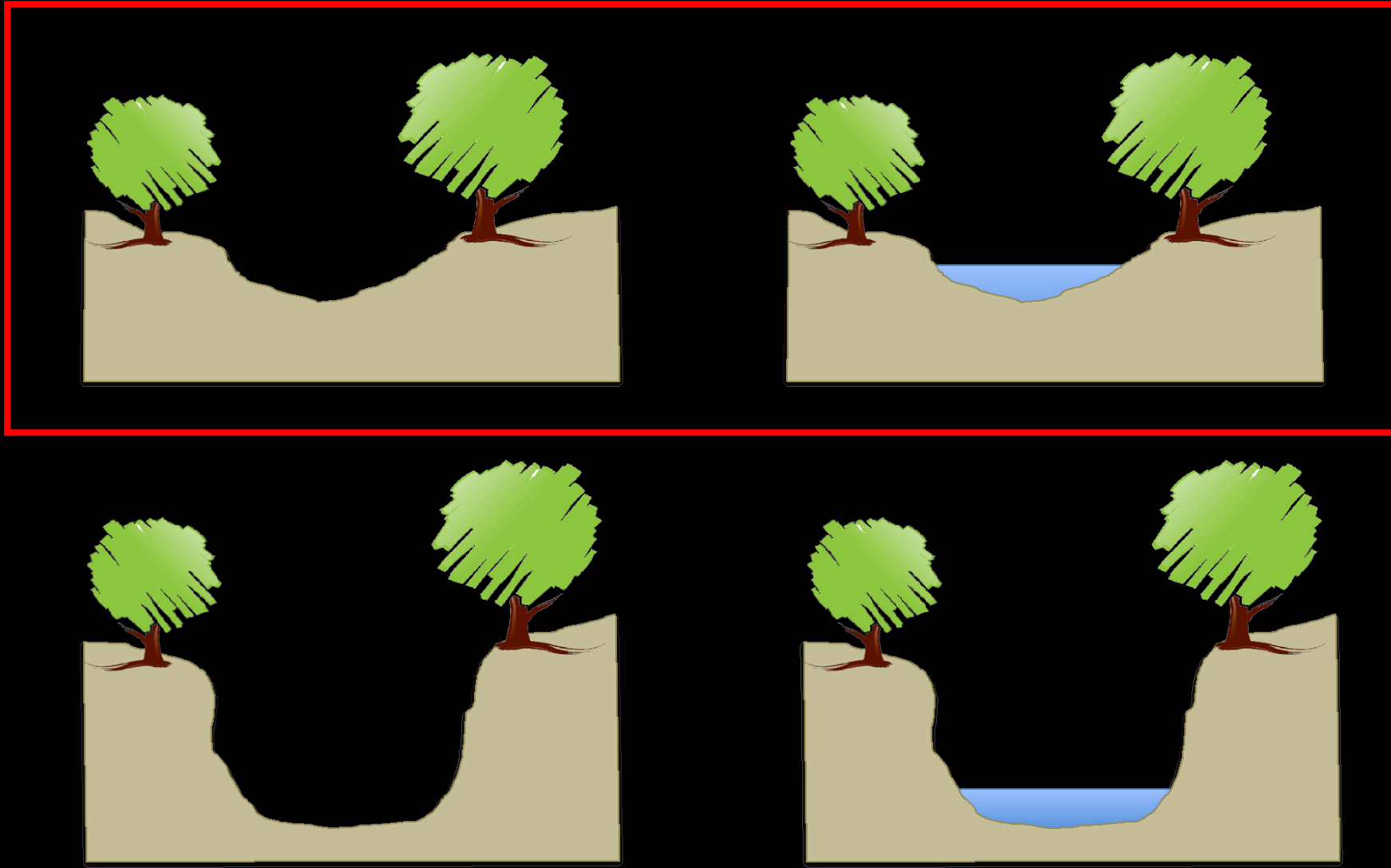


Drier riparian zones

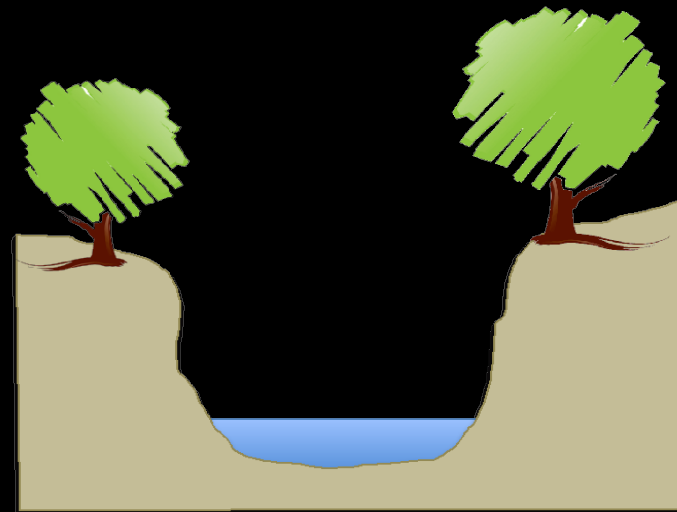
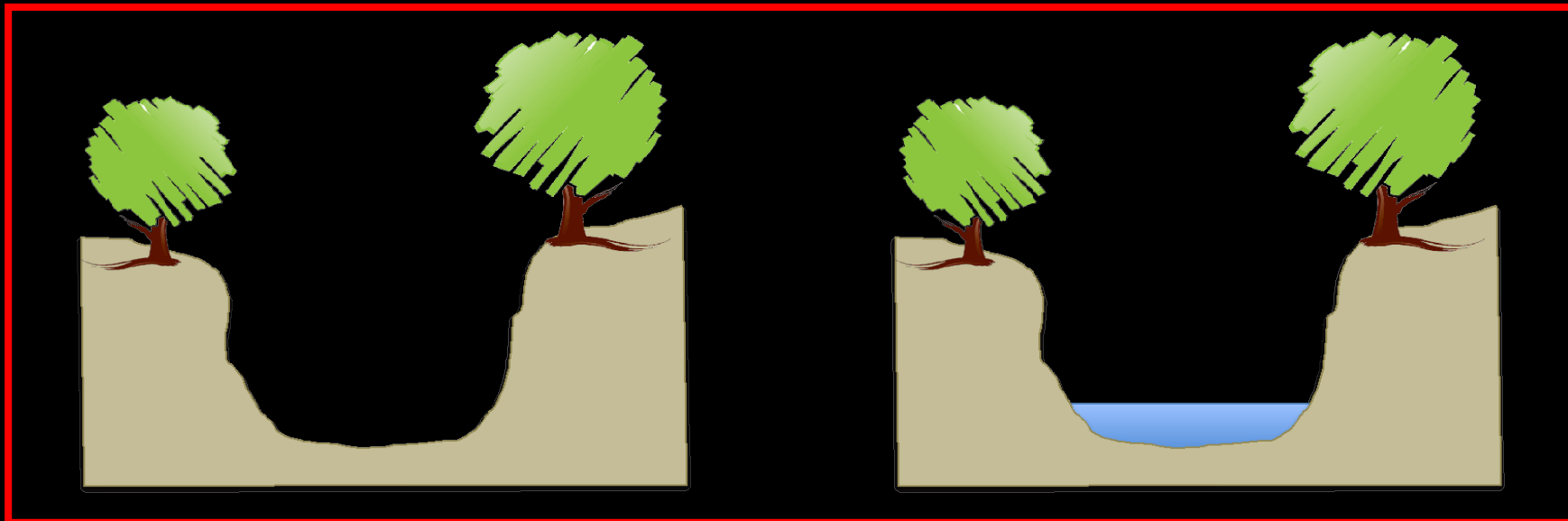
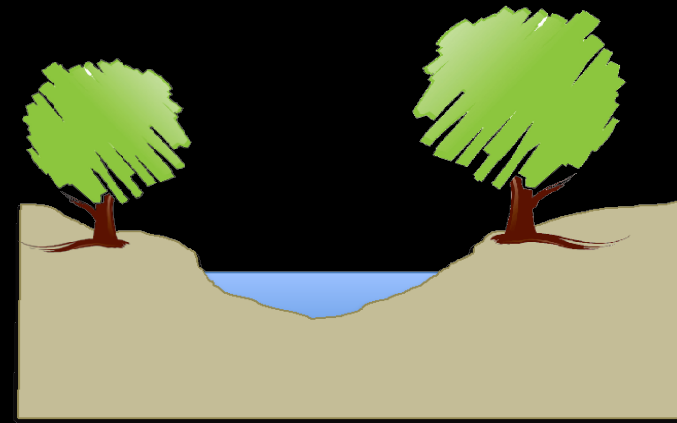
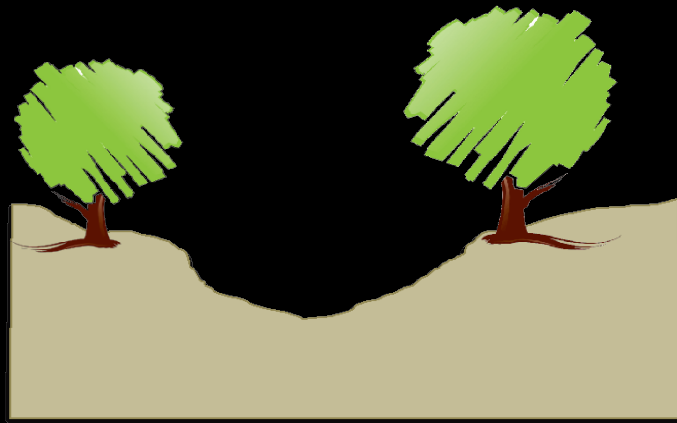
Interaction between channel incision and summer flow



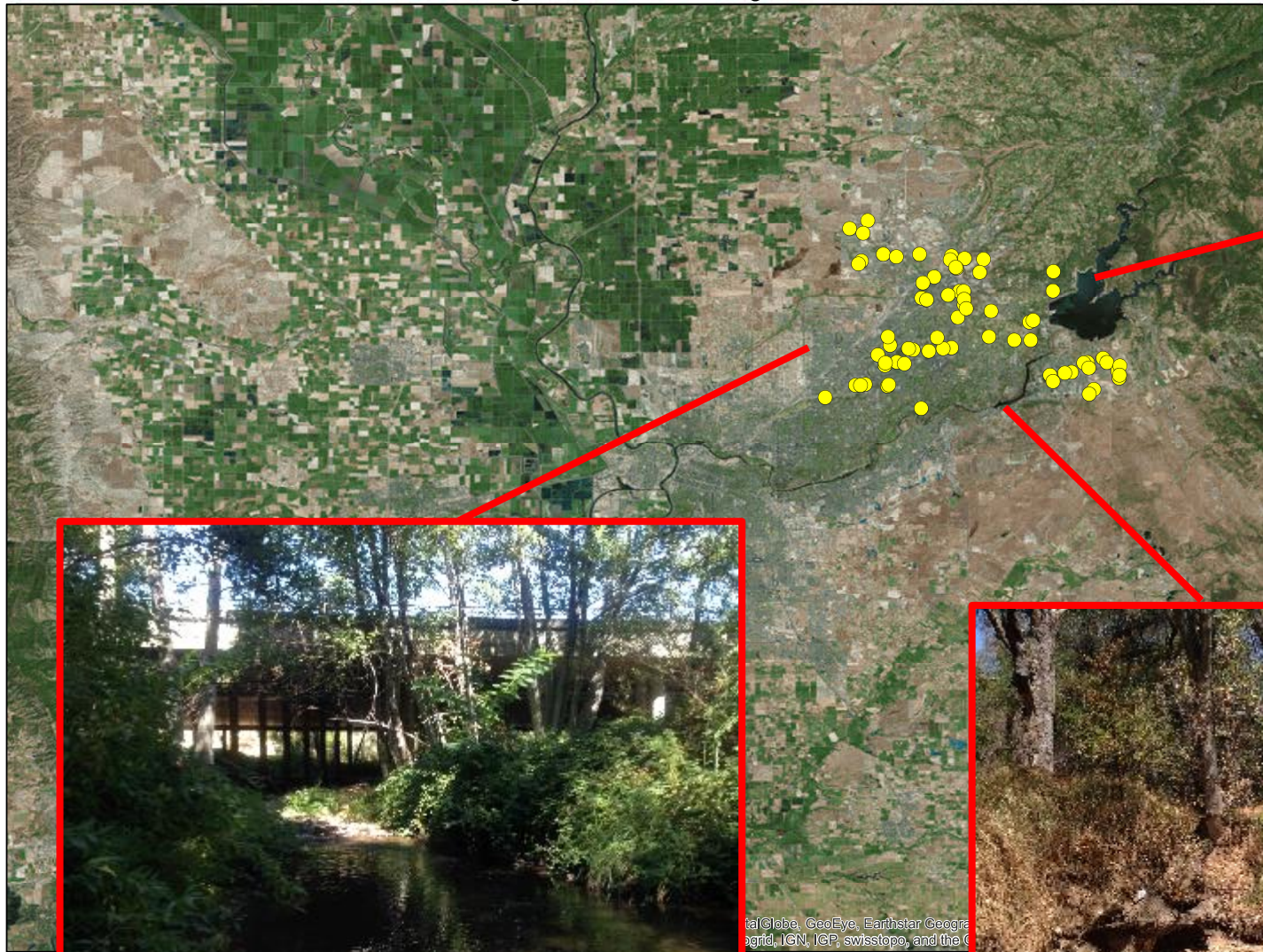
Interaction between channel incision and summer flow



Interaction between channel incision and summer flow



20 km



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grid, IGN, IGP, swisstopo, and the C

Water stress in riparian trees

Valley oak
(*Quercus lobata*)



$n = 48$

Water stress in riparian trees

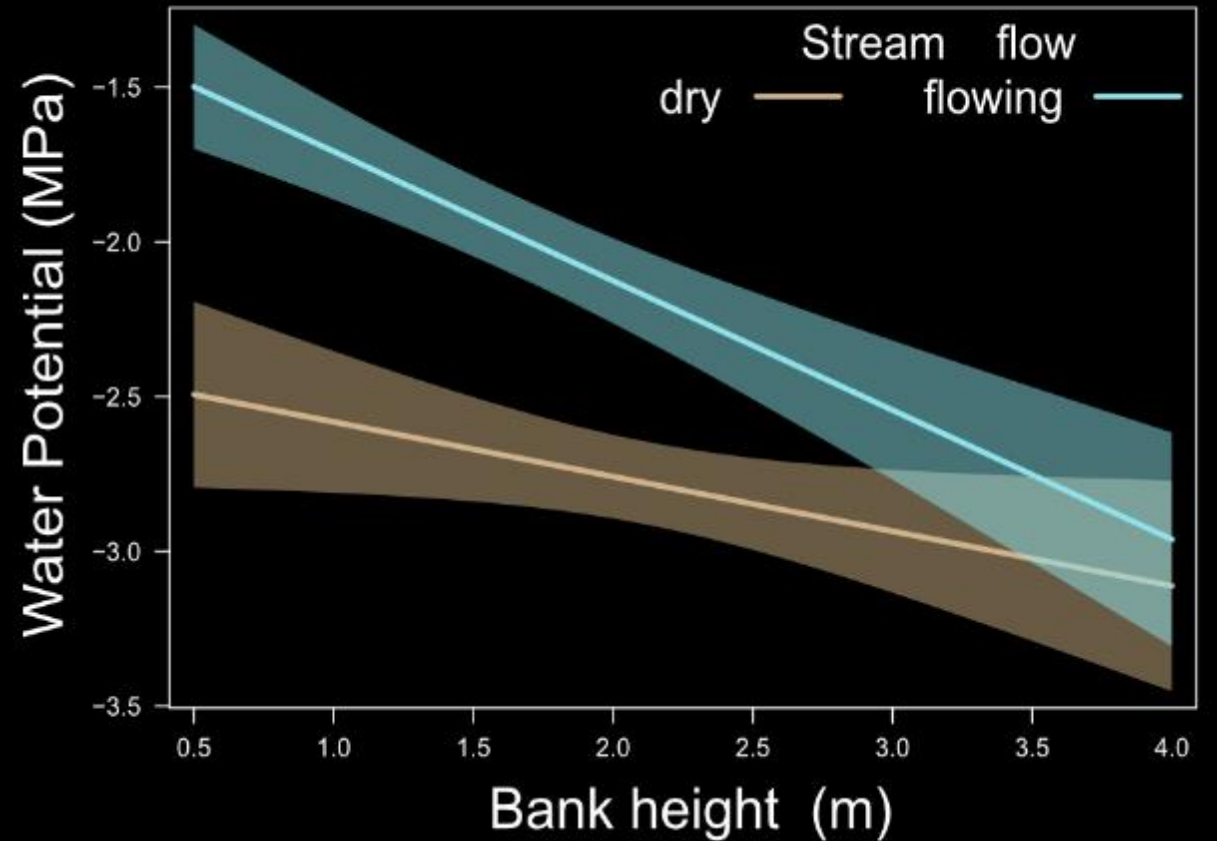
Valley oak
(*Quercus lobata*)



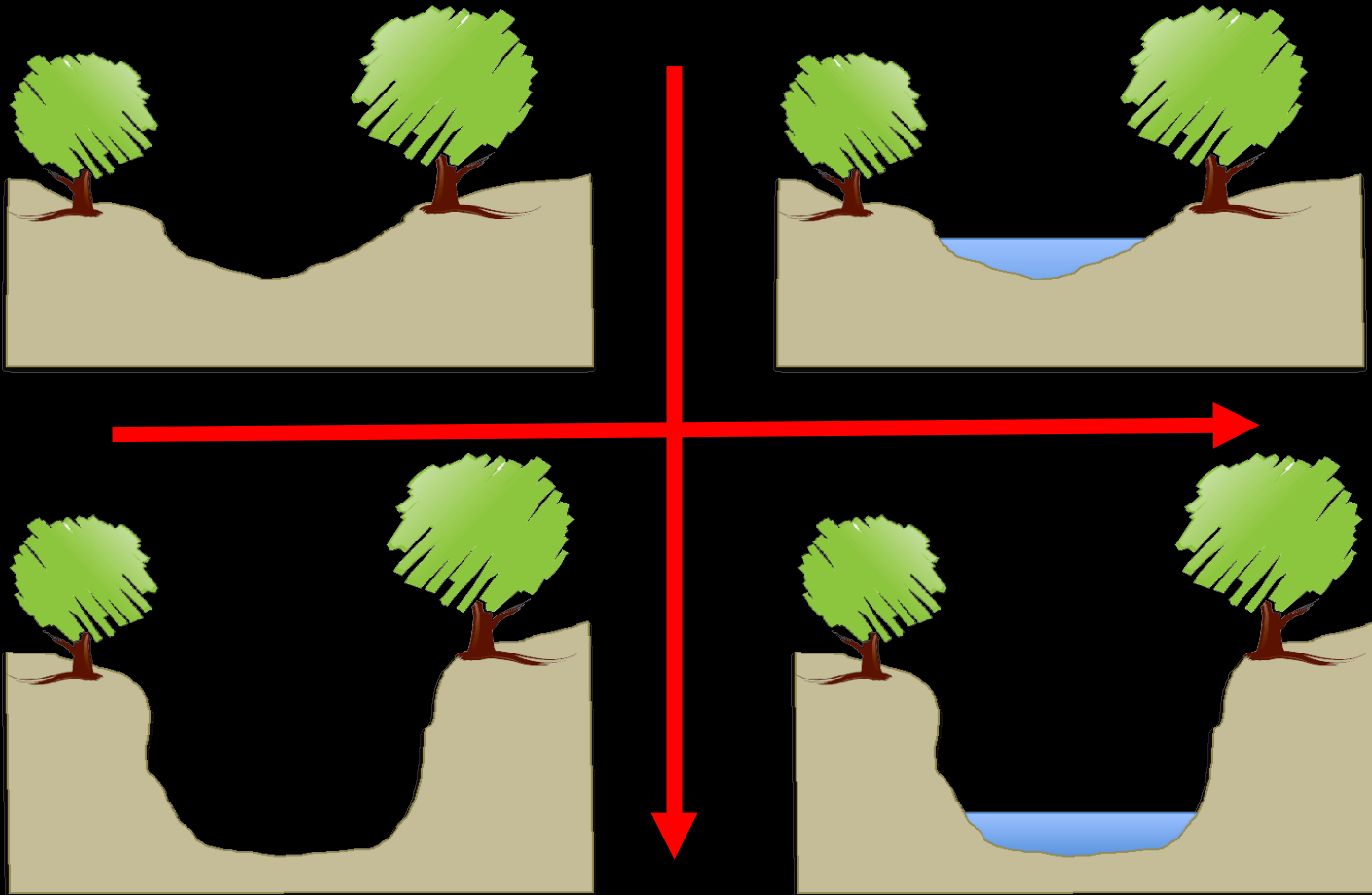
Less stressed



More stressed



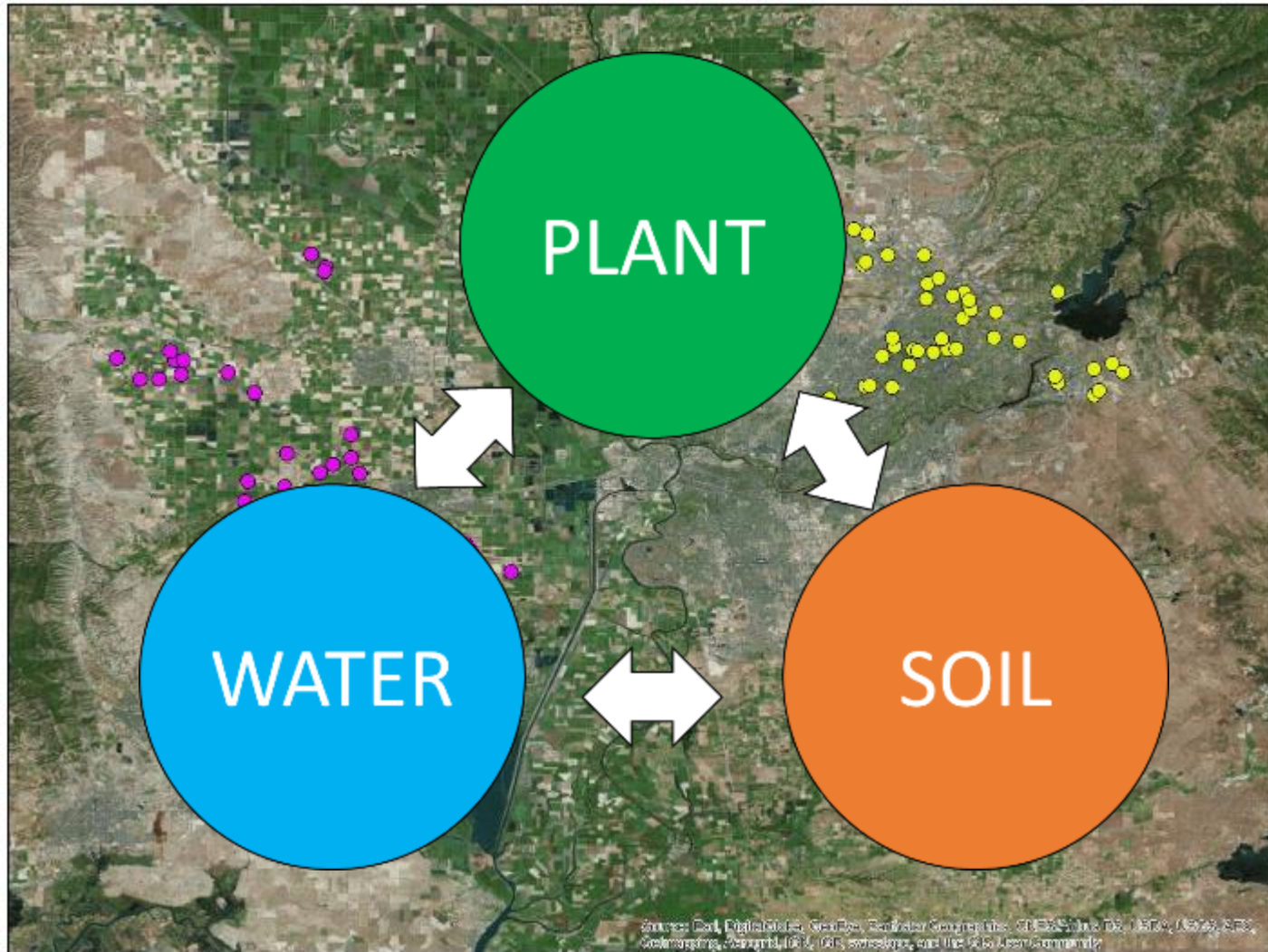
Interaction of incision and flow



- Water stress in riparian trees
- Riparian vegetation composition



- Carbon storage
- Habitat value



Ecosystem services

Habitat



- Structural and compositional differences driven by land use
- Similar levels of native wetland species in urban and agricultural stream margin ground layers
 - Potentially important for supporting wetland specialists

Ecosystem services

Water quality/aquatic habitat

- Evidence that riparian bank conditions affect N uptake via SOM



C storage

- More tree canopy in urban → more carbon storage
- SOM
 - Similar in both systems
 - Management opportunities



Management Implications

- Less management is beneficial in agricultural systems, more could be beneficial in urban
- Reduce slopes at stream channel margins
- Reduce or mitigate incision in urban systems
- Dry season flows promote some ecosystem services

Conclusions

Small lowland streams in the Sacramento Valley matter

- They're ubiquitous
- They do a lot
- Interesting scientifically – ecosystem processes, valuable study systems
- Need to integrate them into our understanding of freshwater/riparian ecosystems in the Valley

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thank you



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