Where Prairie and Water Meet:

A Wetlands Perspective

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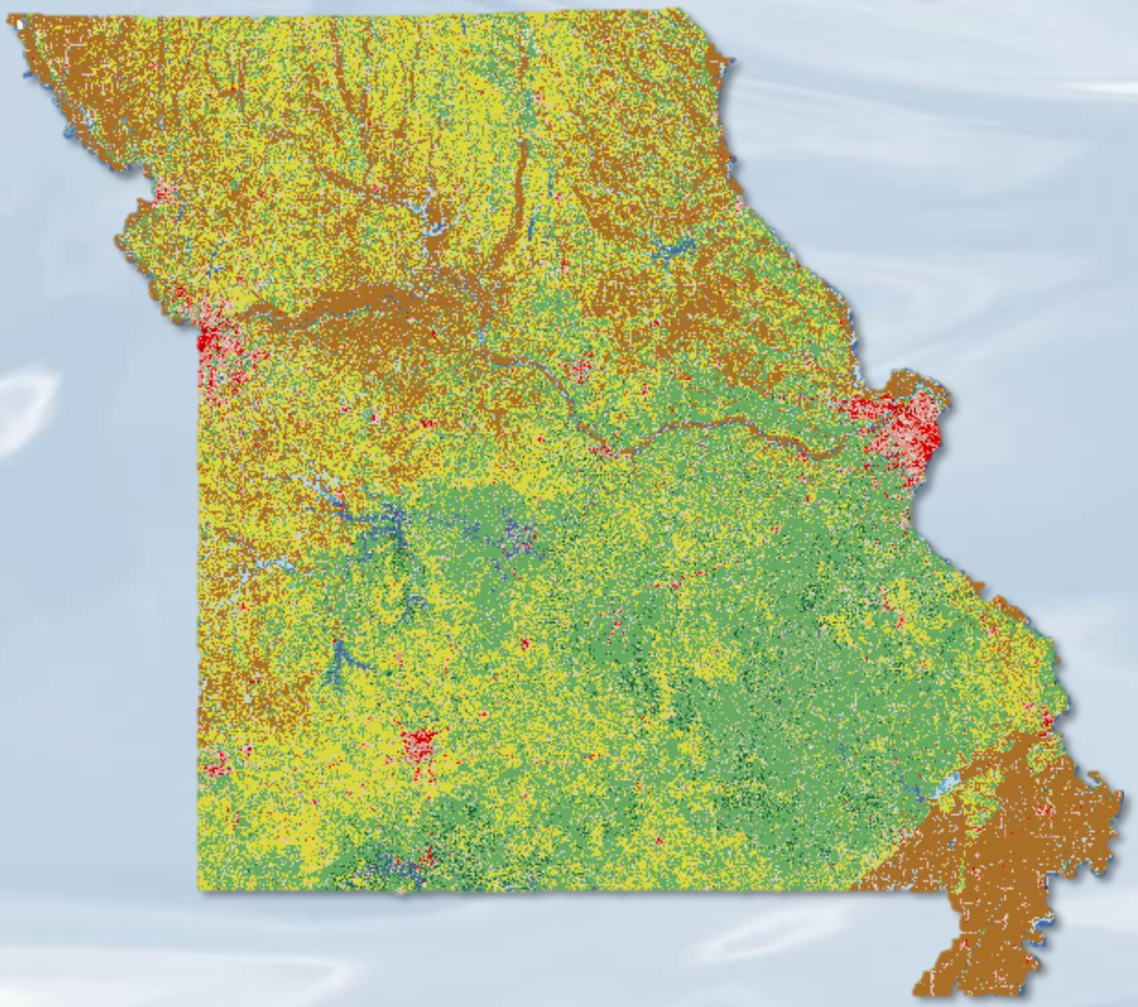
CONSERVATION DEPARTMENT MISSOURI

Serving nature and you

Outline

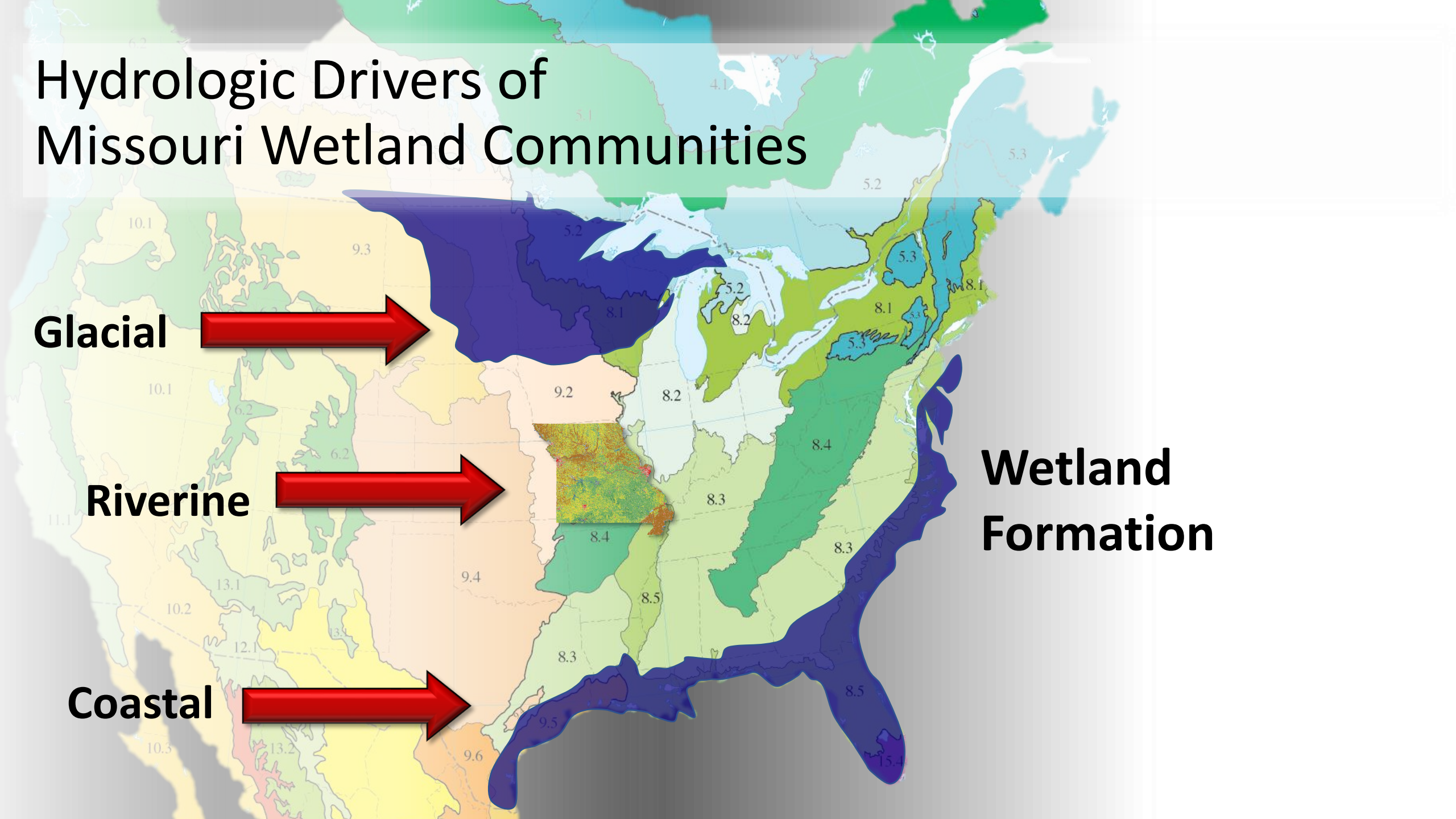
- Hydrologic Drivers and other Processes
- Network and Species Interactions
- Alterations and Isolation
- Reconnecting Pieces

Hydrologic Drivers of Missouri Wetland Communities

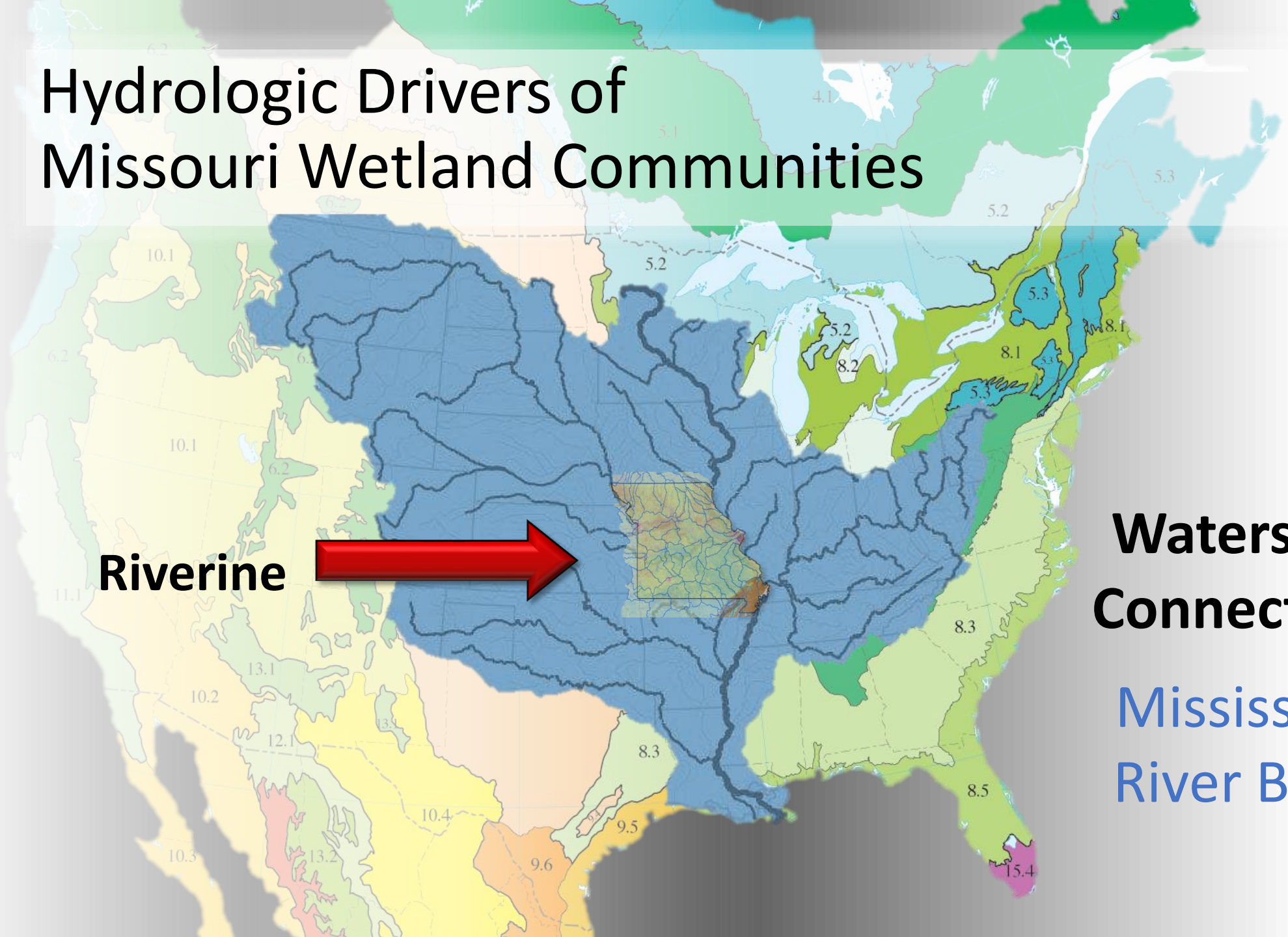


Before we think about local or regional characteristics…

Hydrologic Drivers of Missouri Wetland Communities



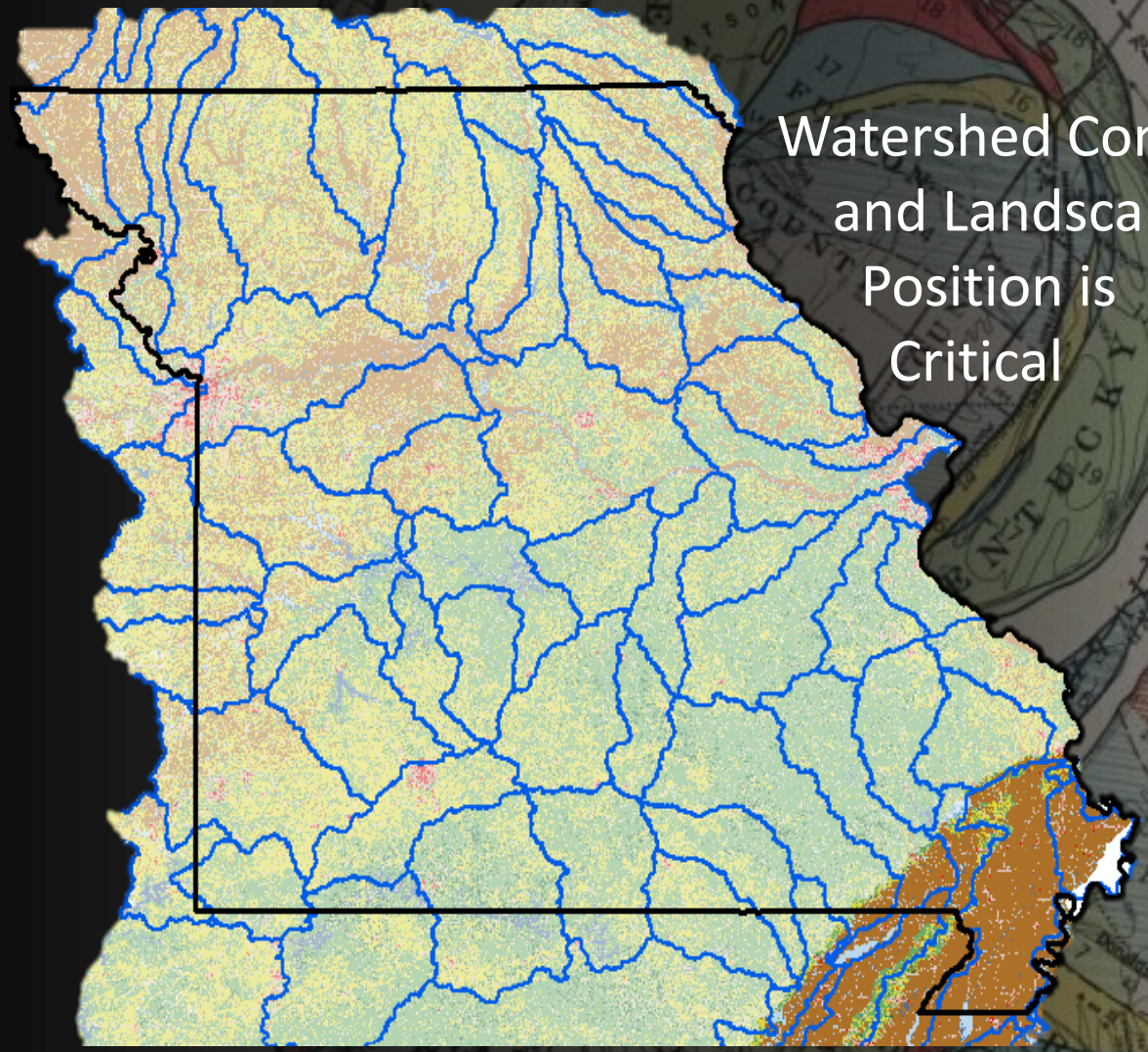
Hydrologic Drivers of Missouri Wetland Communities



Watershed Connections

Mississippi River Basin

Hydrologic Drivers of Missouri Wetland Communities



Watershed Context and Landscape Position is Critical

Hydrologic Drivers of Missouri Wetland Communities

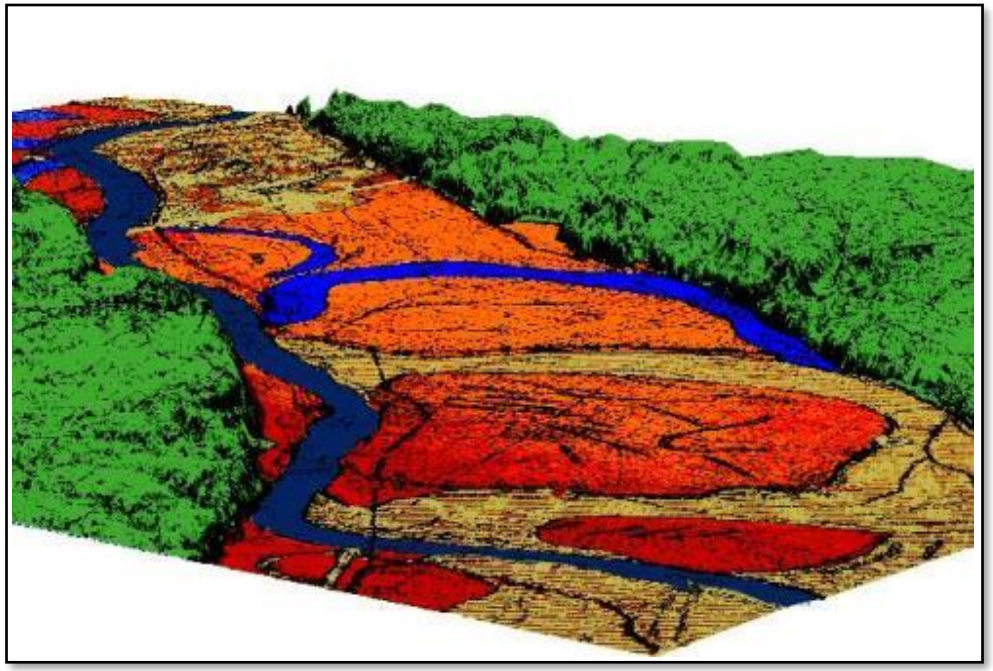
Floodplains are Inherently Diverse

Watersheds have been shaped over time

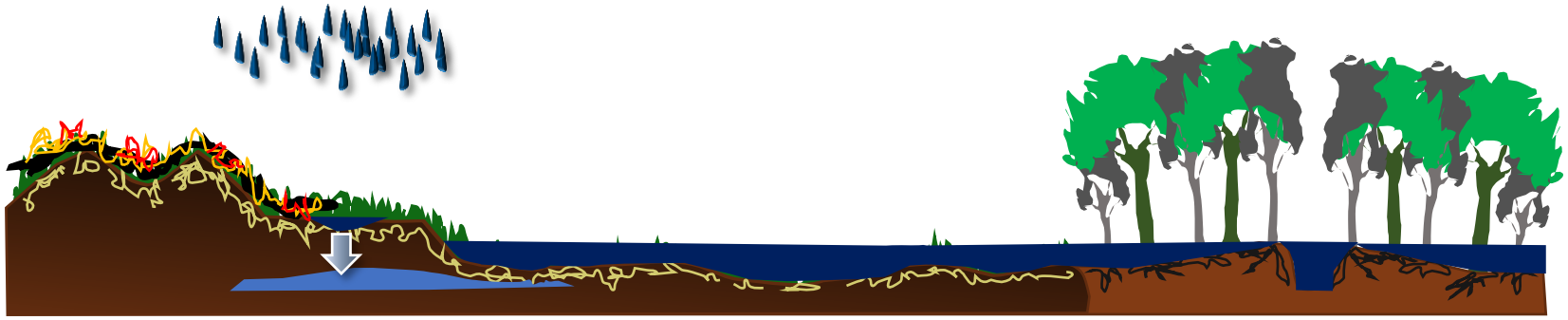
Upland Drainageways **Terraces** **High and Low Floodplain**

Landforms:

- Time
- Water
- Topography



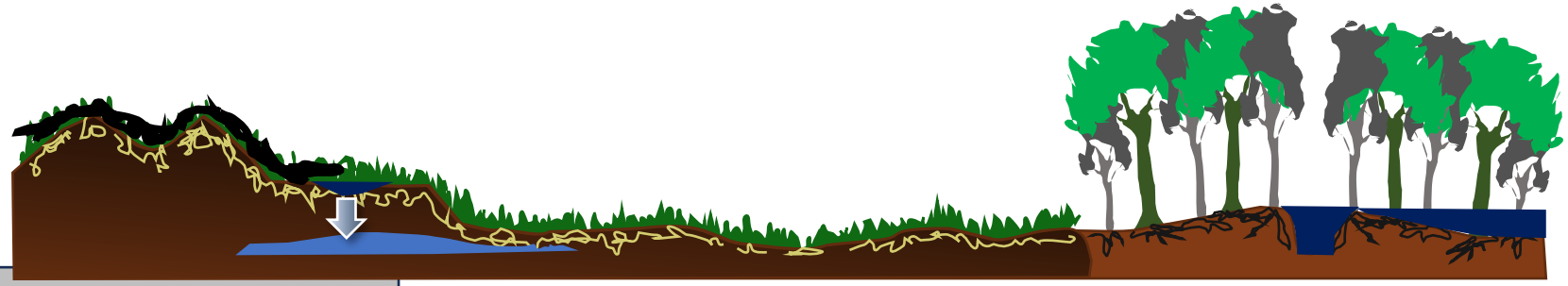
Creating a mosaic of floodplain conditions



Precipitation Groundwater Backwater Overland Flow

Hydrologic Differences Across Floodplains:

- Source of water
- Duration
- Frequency
- Water Chemistry
- Nutrient Availability
- Accounts for disturbance *(fire influences too…)*

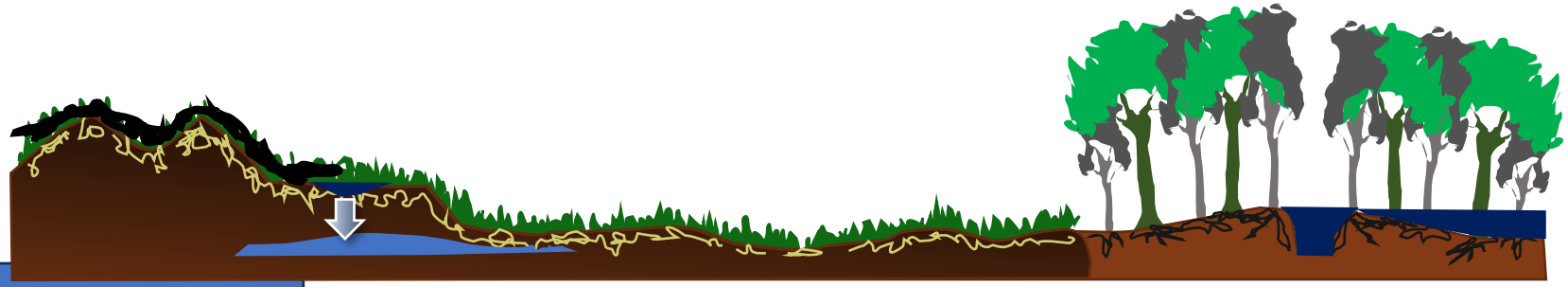


Precipitation

Terraces and Uplands

- Vernal pools
- Buffalo wallows
- Wet prairies

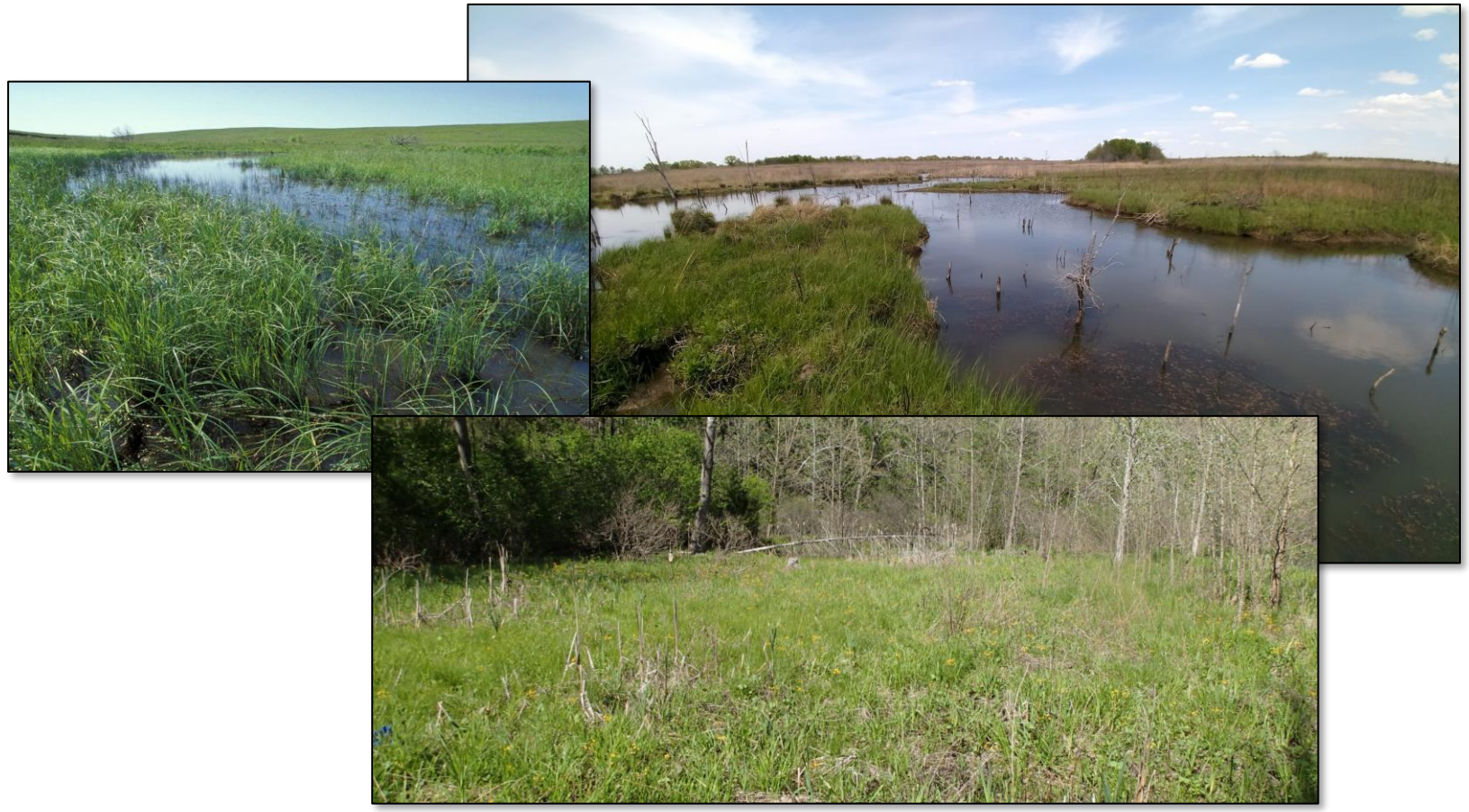
Hydrologic Differences Across Floodplains:



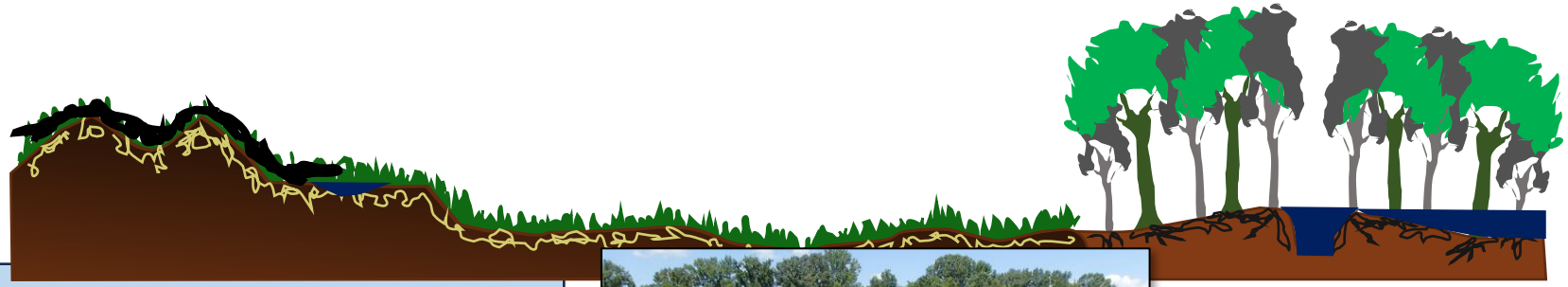
Groundwater

Drainageways and Foot Slopes:

- Springs
- Fens
- Prairie Swales
- Beaver Complexes



Hydrologic Differences Across Floodplains:



Riverine Flooding

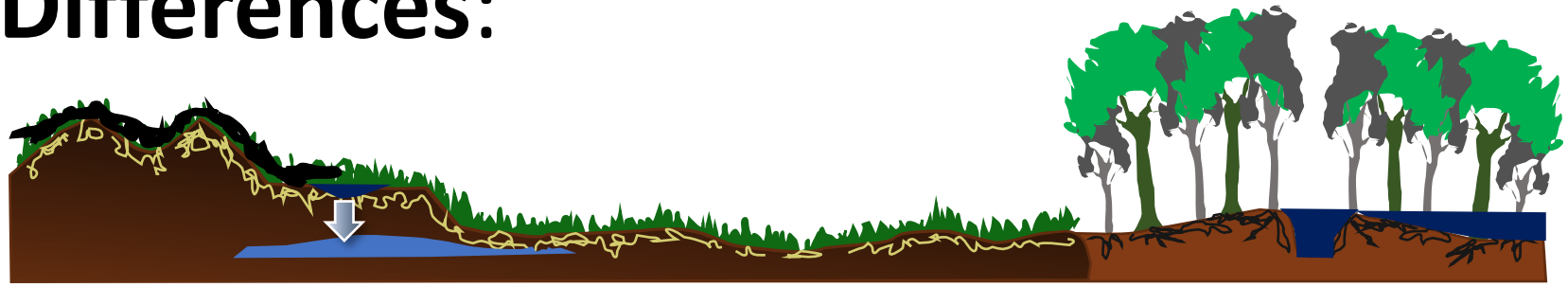
Backwater Overland Flow

Low and Broader Floodplains

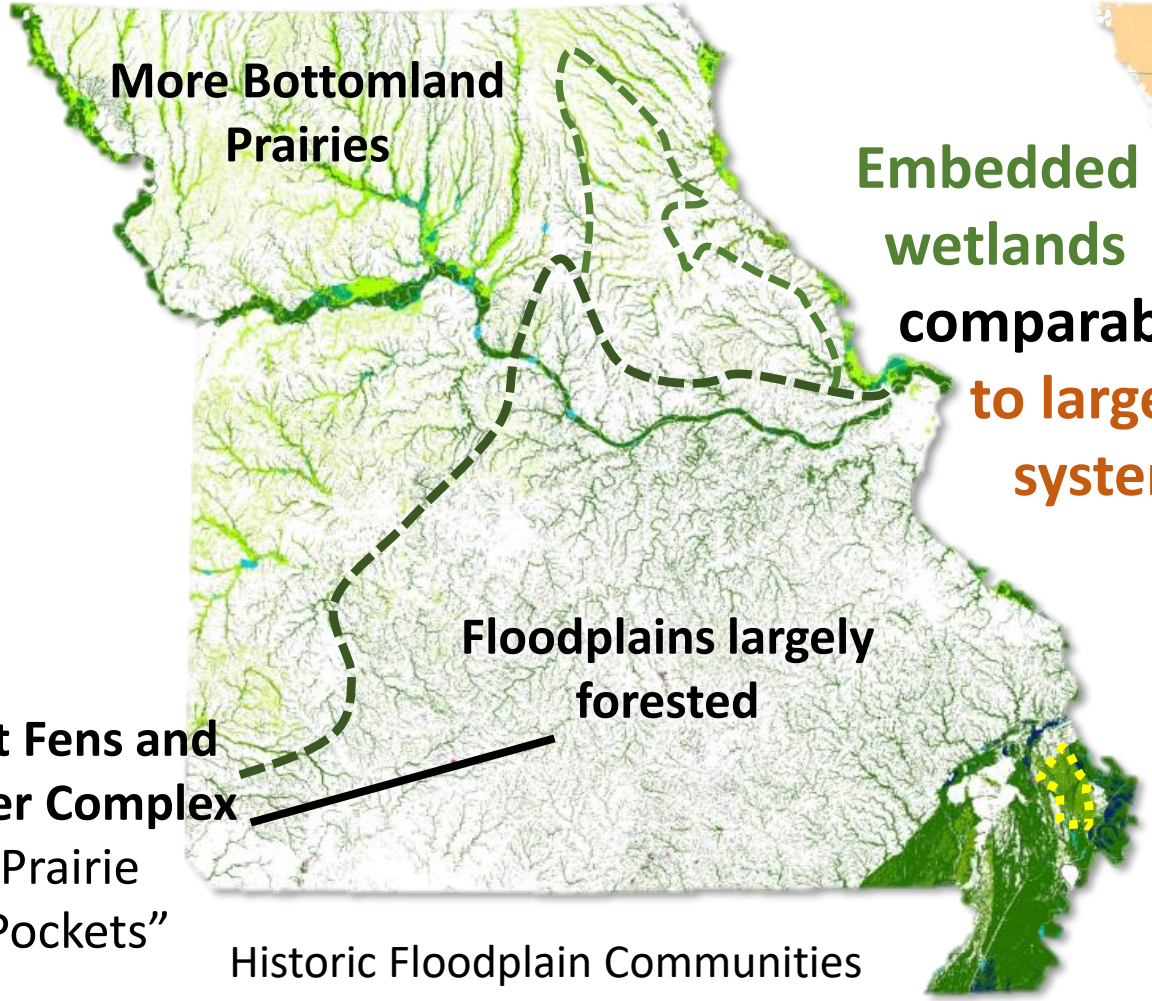
- Larger bottomland prairies
- Bottomland forests
- Oxbows and marshes

Hydrologic Differences Across Floodplains:

Regional Differences:

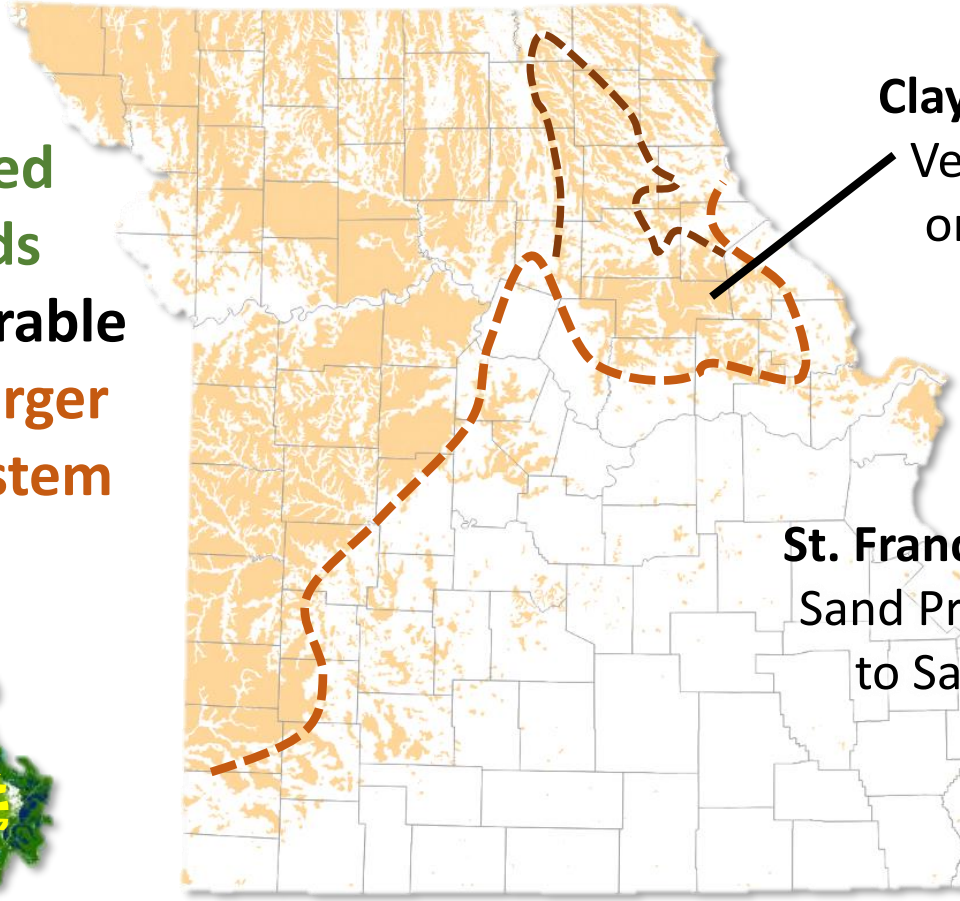


Claypan Prairie
Vernal pools
on uplands



Historic Floodplain Communities

Embedded wetlands comparable to larger system

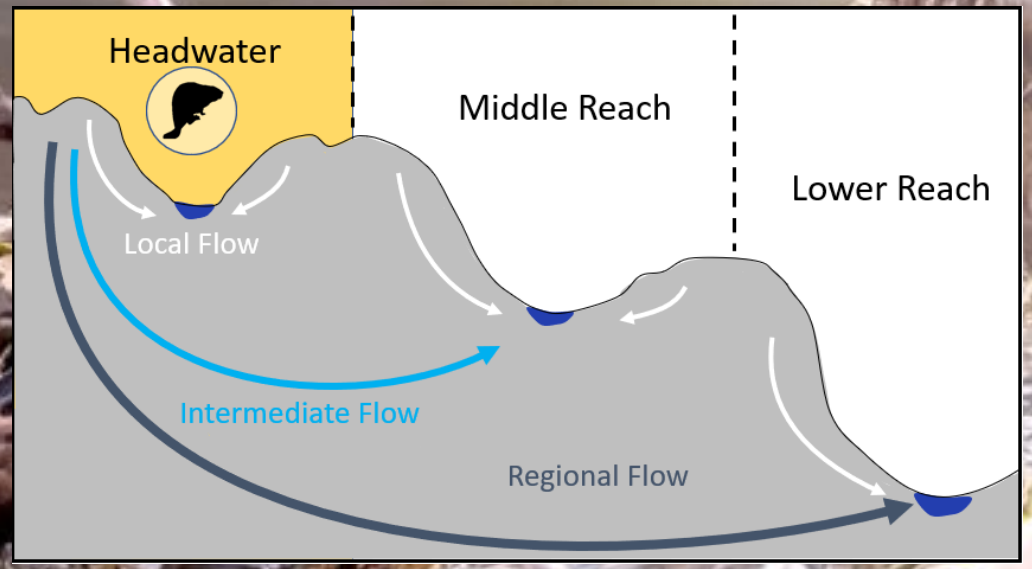


Historic Prairie Extent

St. Francis Valley Train
Sand Prairie adjacent
to Sandy Swales

Connected to MS River
thru Groundwater

Critter Contributions to Hydrology



Beavers: Ecosystem engineers

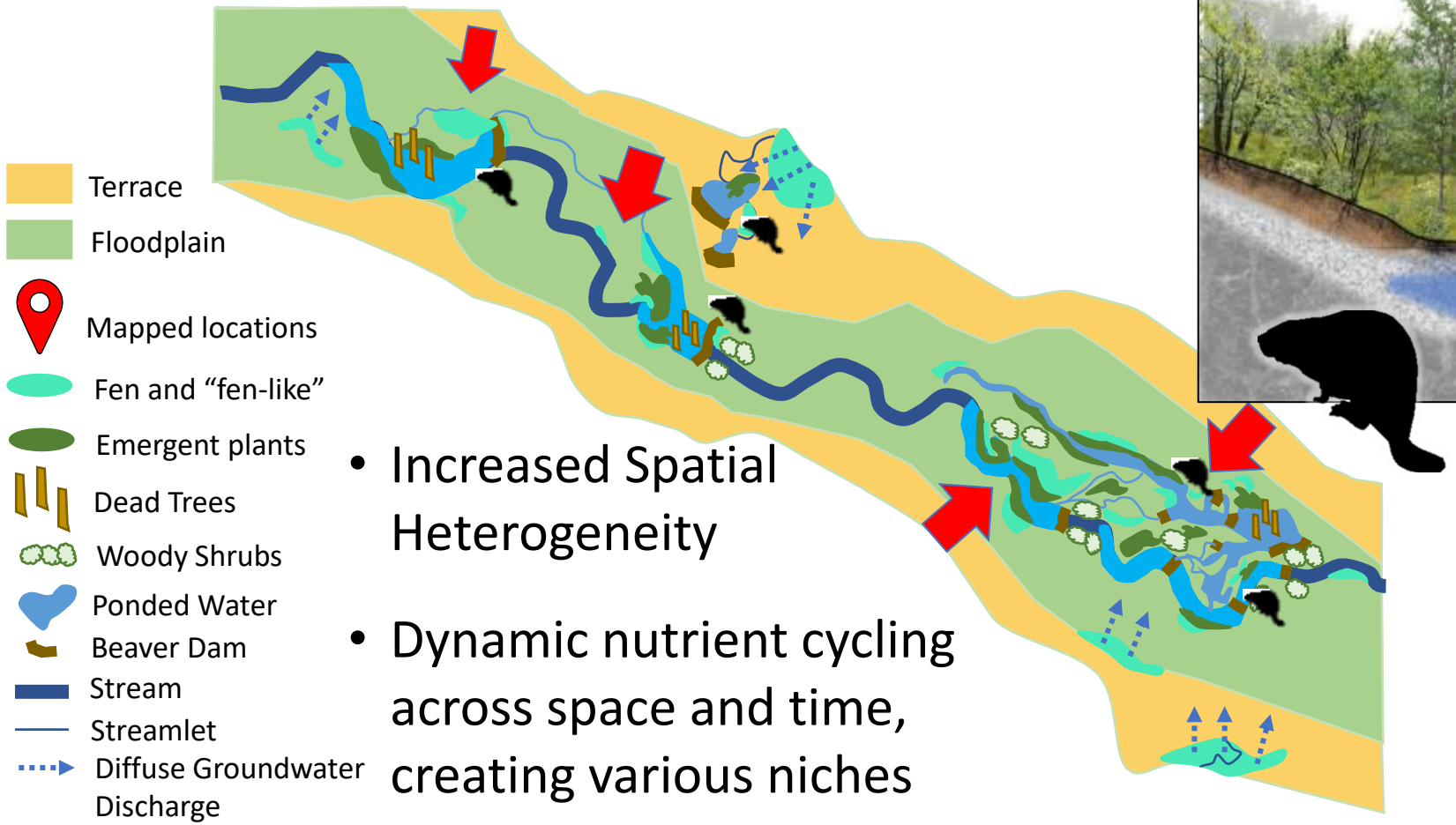
- Influence structure and nutrient dynamics
- Influential in 0-3 order streams, used larger rivers as drought refuge
- We suffer from “ecological amnesia” because of smaller population numbers than historically

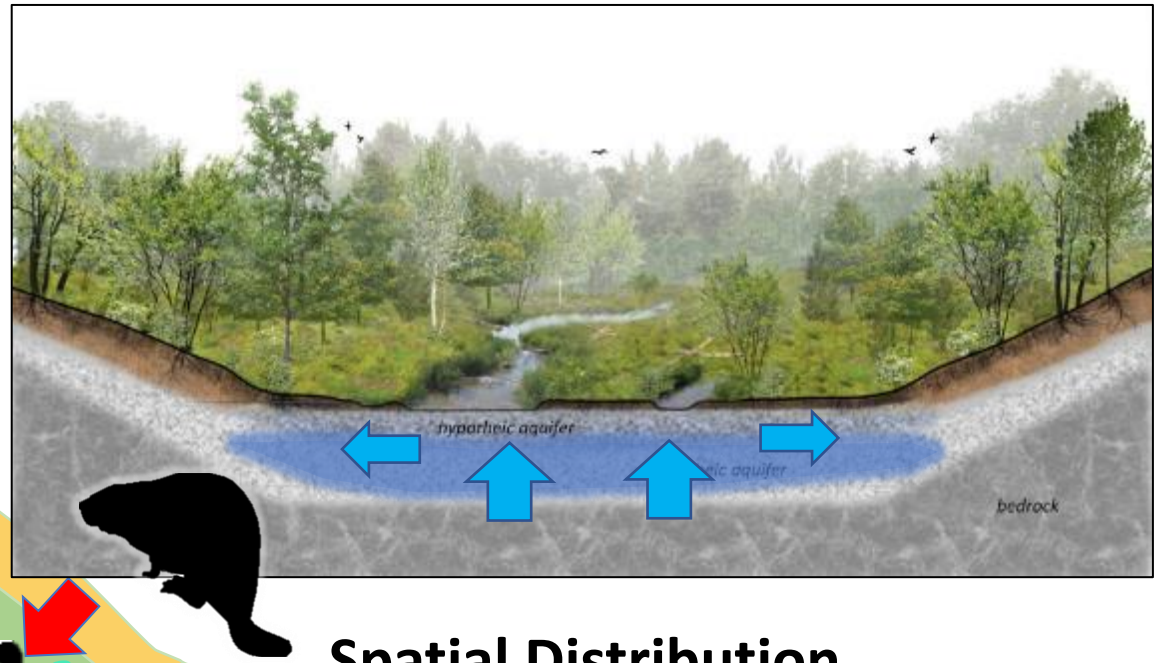
Photographer: Troy Harrison/Moment RF

Looking Backward Through Time

Upland Drainageways

Past Landscape





- Increased Spatial Heterogeneity
- Dynamic nutrient cycling across space and time, creating various niches

Spatial Distribution

- Beaver Activity=Dams
- Increased Water Table
- Anabranching Channels

Wohl, E., Castro, J., Cluer, B., Merritts, D., Powers, P., Staab, B. and Thorne, C., 2021. Rediscovering, Reevaluating, and Restoring Lost River-Wetland Corridors. *Frontiers in Earth Science*, *9*, p.511.

Examples Exist Today

- In both forested and grassland landscapes, beavers are quietly influencing habitat


Spring Creek Church Vicinity Fen, West Plains


Pawnee Prairie CA

Beaver Induced Wetland/Grassland Habitat in Forested System

Aquatic Perennial (Burreed)

Impacted Trees

Moist Soil Annuals

Shallow water

Mudflats

Resprouting

Adaptations to Herbivory: Willows, Alder, Cottonwood

Beaver Also Present in Prairie Systems

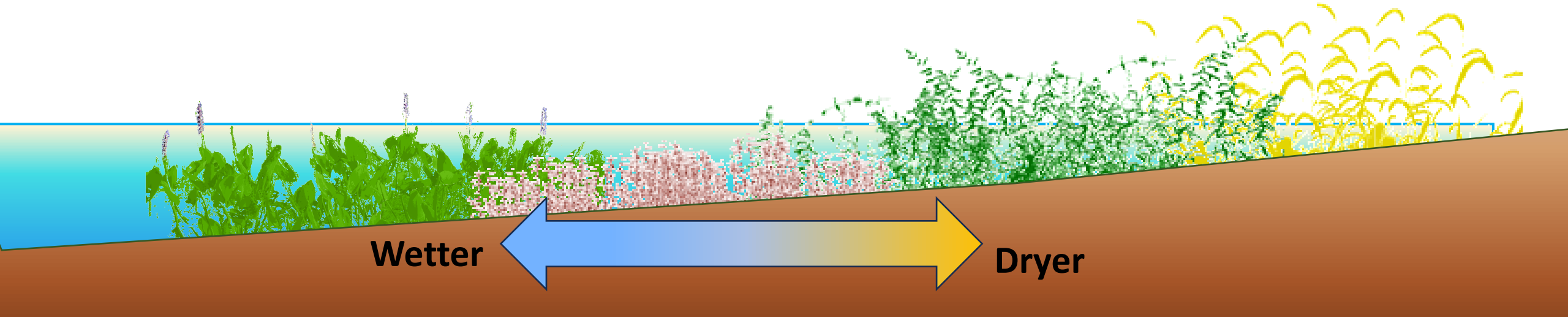
Created habitat heterogeneity up and down drainageways

Creating potential for wet prairies along the saturated fringe

Interaction of Water and Fire

Wet Prairies and Marsh Fringe

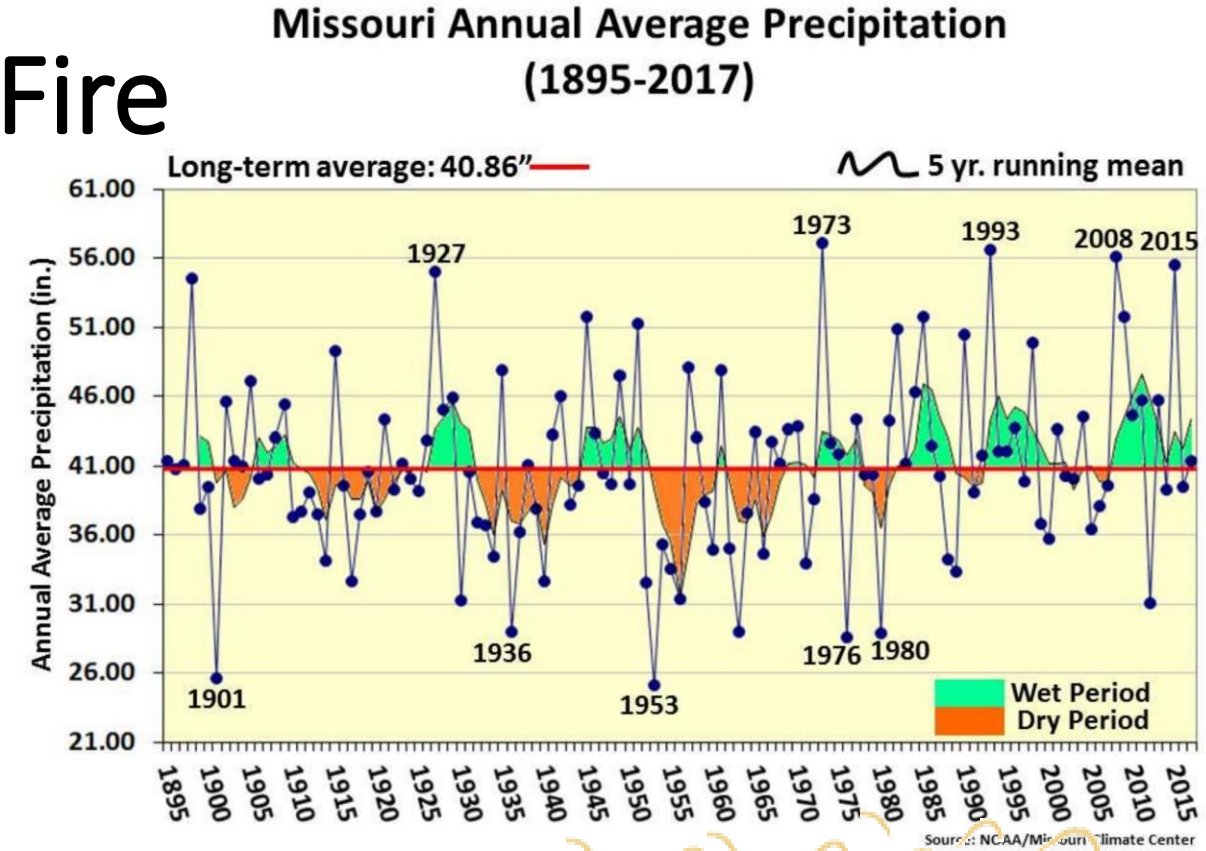
- Seasonally drying:
  - Summer temps and evapotranspiration
  - Wetland plants respond with germination and growth according to moisture regime

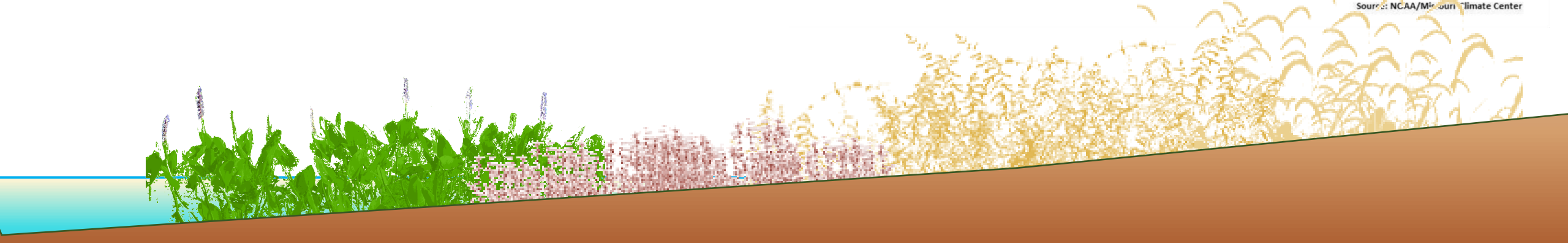


Interaction of Water and Fire

Wet Prairies and Marsh Fringe

- Seasonally drying:
  - Summer temps and evapotranspiration
- Periodic drought
  - Wet-dry cycles across years, 7-year avg
  - Bottoms more apt to burn sometimes





Climate of Missouri. (2021) Decker A. & Guinan P. ,Missouri Climate Center . https://solutionsfromtheland.org/wp-content/uploads/2021/04/MCC_climate_trends_Feb18.pdf

Lack of Water: Role of Fire

Wet Prairies and Marsh Fringe

- Seasonally drying:
  - Summer temps and evapotranspiration
- Periodic drought
  - Wet-dry cycles across years, 7-year avg
- Fires could cross small streams
- Rivers could act as fire break elsewhere

Lack of Water: Role of Fire

Wet Prairies and Marsh Fringe

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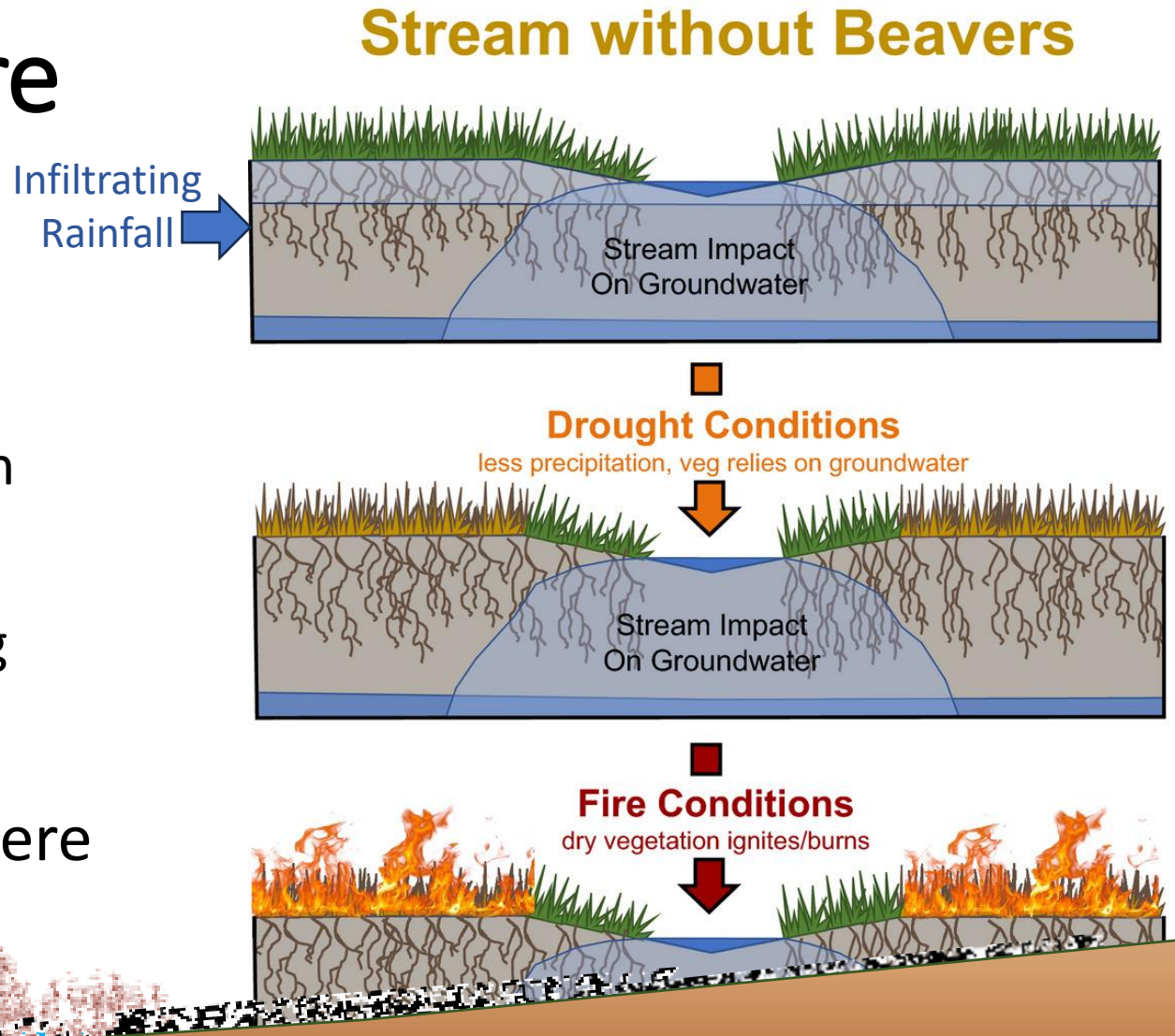
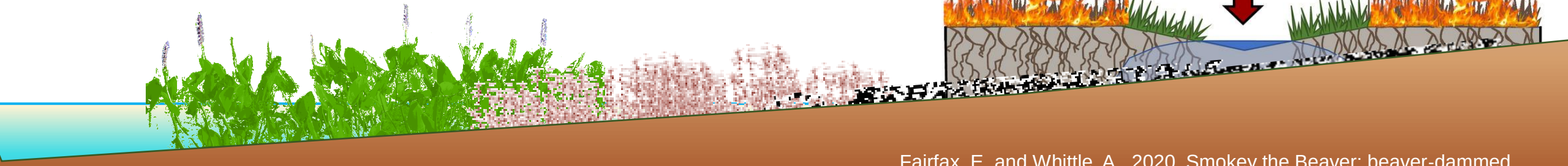




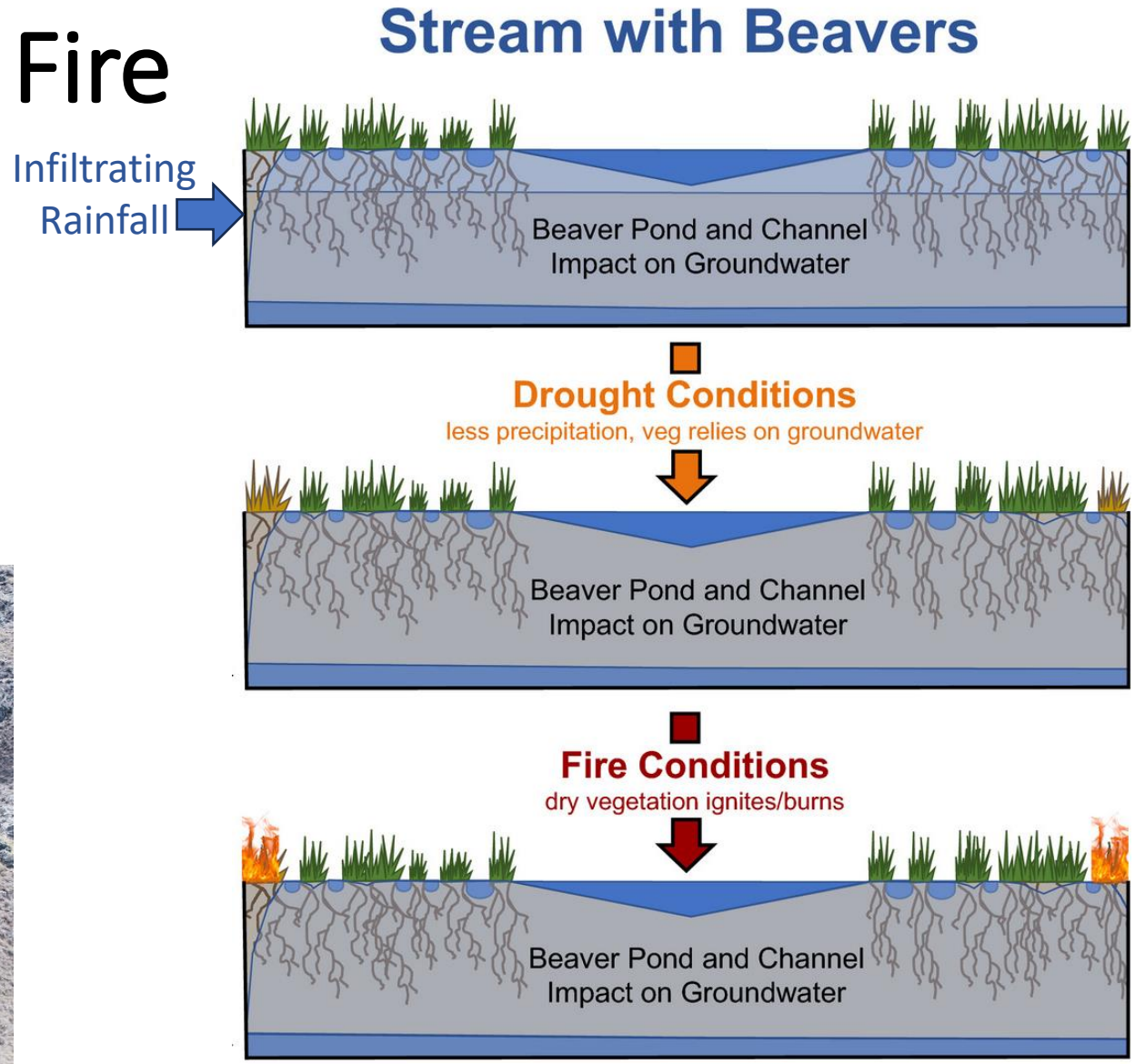
Fairfax, E. and Whittle, A., 2020. Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western United States. *Ecological Applications*, *30*(8), p.e02225.

Interaction of Water and Fire

Beaver Complexes and/or Fens

- High water table and saturated soils
- Green buffer when uplands are dry
- Fire breaks and refugia for critters

J. Wheaton/Utah State Univ.



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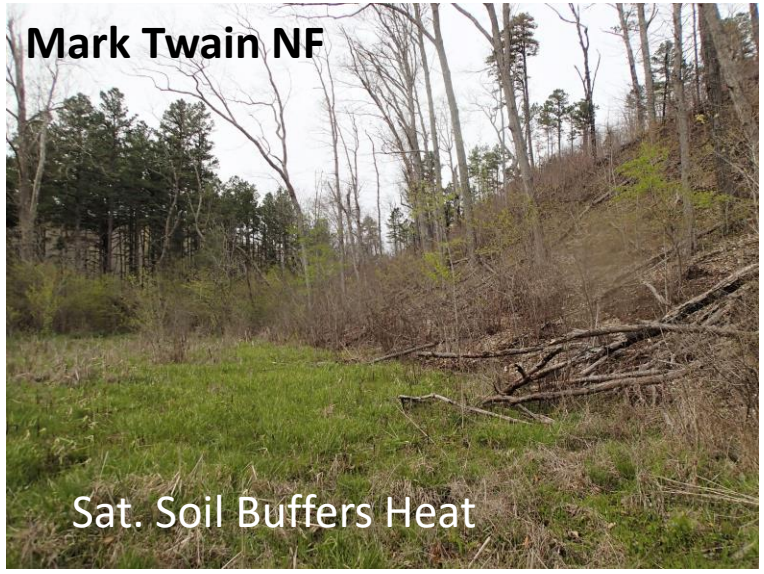
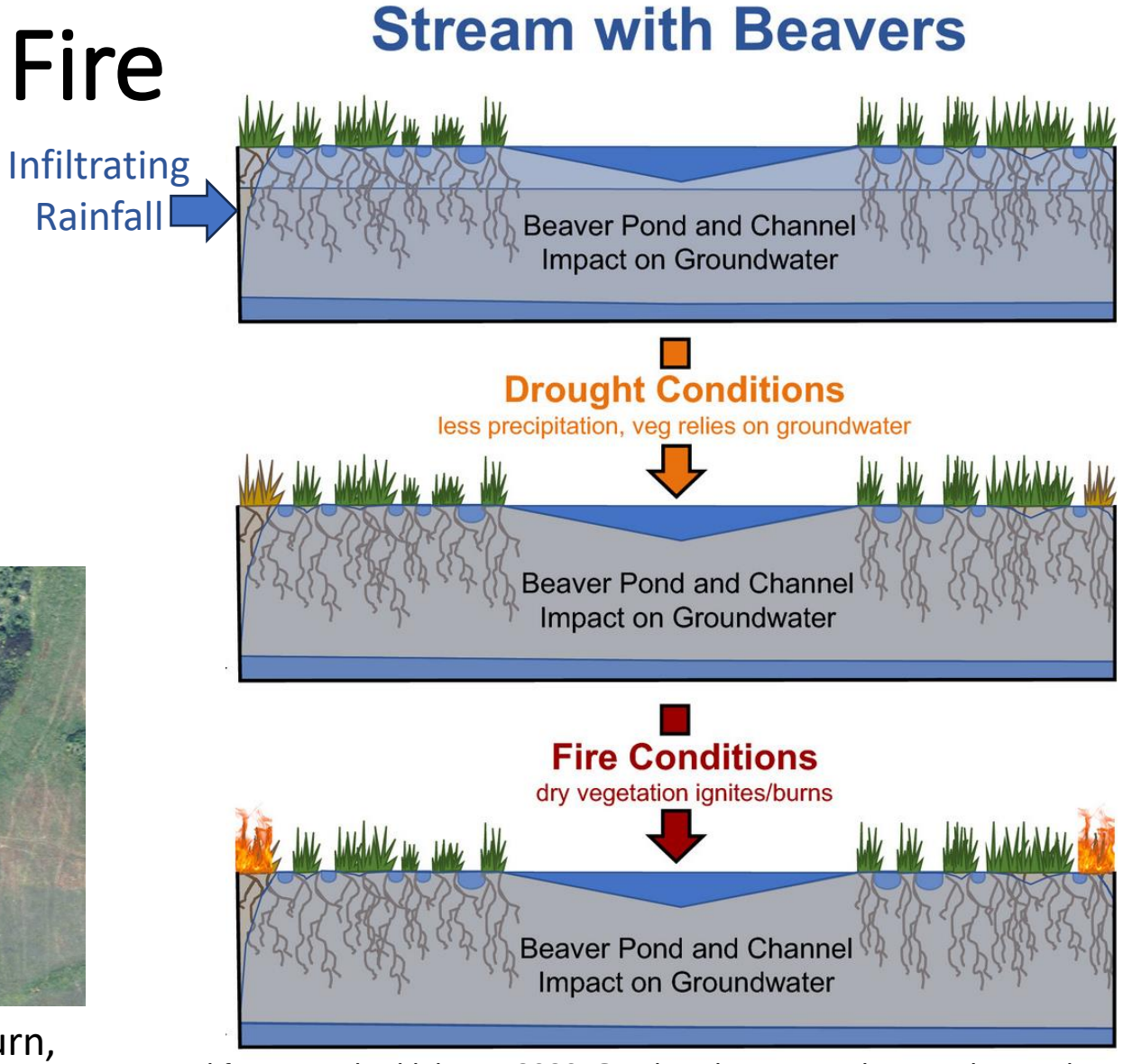


Some residual may burn,
Patchiness is fine and good.



Fairfax, E. and Whittle, A., 2020. Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western United States. *Ecological Applications*, *30*(8), p.e02225.

Critter Contributions to Succession

Grassland Diversity and Bison

- Fire extent and patchiness
- Influenced bison grazing patterns
- Bison grazing determine grassland structure and plant species richness
  - Diversity can create additional diversity through indirect linkages

Vinton, M.A., Hartnett, D.C., Finck, E.J. and Briggs, J.M., 1993. Interactive effects of fire, bison (Bison bison) grazing and plant community composition in tallgrass prairie. *American Midland Naturalist*, pp.10-18.

Joern, A., 2005. Disturbance by fire frequency and bison grazing modulate grasshopper assemblages in tallgrass prairie. *Ecology*, *86*(4), pp.861-873.

Critter Contributions to Succession

Possible Influence on Wetlands and Floodplain Habitat

- Seasonally grazing, browsing, trampling, and wallowing within marshes and wet meadows
  - Pulse of nutrients
  - Soil disturbance

Timoney, K., 2008. Factors influencing wetland plant communities during a flood-drawdown cycle in the Peace-Athabasca Delta, northern Alberta, Canada. *Wetlands*, *28*(2), pp.450-463.

Creating a vegetative mosaic

Structural Influence

- Bison grazing, browsing, trampling

- Decline in shrubs/woody cover, including willows and cottonwoods in places

Tall willows broken down by bison horning and breaking the branches

Painter, L.E. and Tercek, M.T., 2020. Tall willow thickets return to northern Yellowstone. *Ecosphere*, *11*(5), p.e03115.

Beschta, R.L., Ripple, W.J., Kauffman, J.B. and Painter, L.E., 2020. Bison limit ecosystem recovery in northern Yellowstone. *Food Webs*, *23*, p.e00142.

Creating a vegetative mosaic

Spatial Dynamics

Bison use of landscape

- Forage further from water than cattle
- Less time in low elevations and woody vegetation

Riparian Corridors Among Grasslands

- Allows for increased plant diversity and increased shrub cover within riparian areas

Boyce, A.J., Shamon, H. and McShea, W.J., 2022. Bison reintroduction to mixed-grass prairie is associated with increases in bird diversity and cervid occupancy in riparian areas. *Frontiers in Ecology and Evolution*, p.180.

Creating a vegetative mosaic

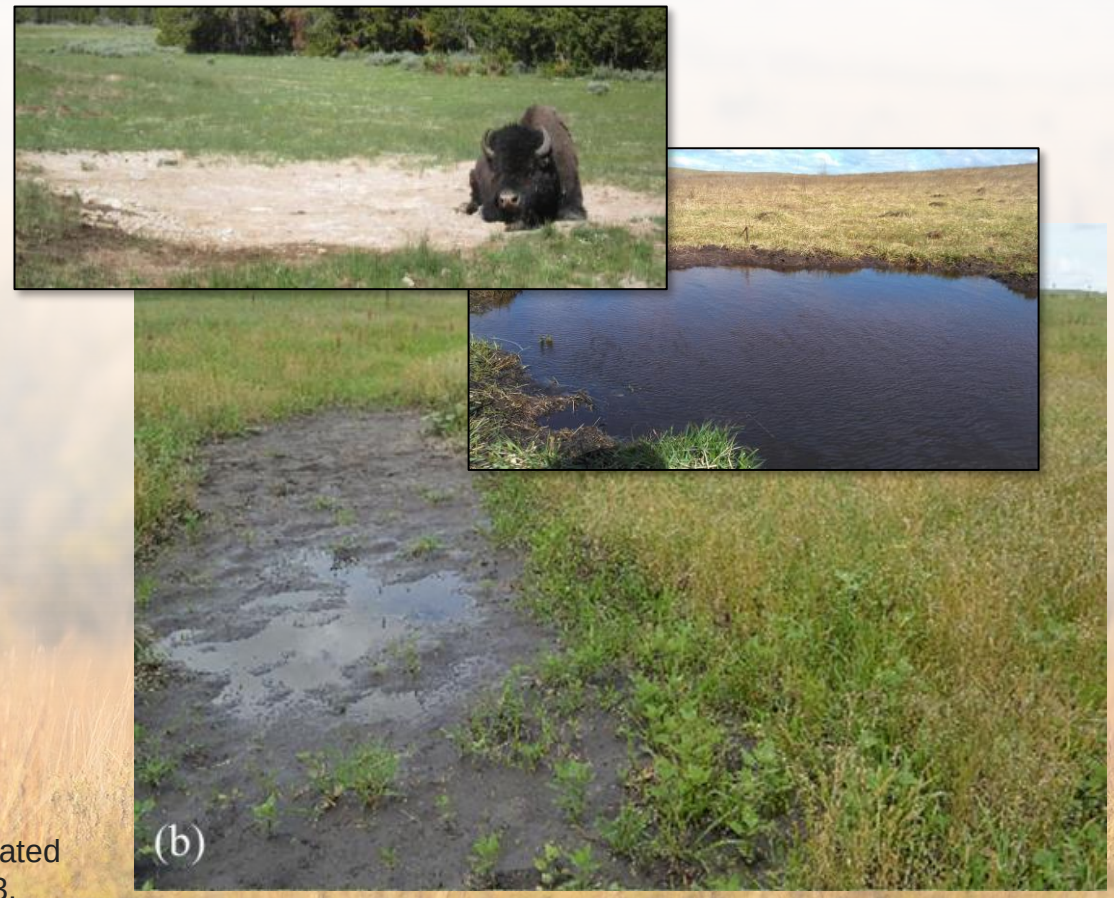
Bison Wallows: Soil Disturbance

- Bison create early successional habitats for annual forbs and grasses within tallgrass prairies

- Small scale disturbances that increase
  - light and nutrient availability
  - soil compaction and moisture

- Relict wallows have a dominance of sedges

Contributions to small isolated wetlands within upland matrix



McMillan, B.R., Pfeiffer, K.A. and Kaufman, D.W., 2011. Vegetation responses to an animal-generated disturbance (bison wallows) in tallgrass prairie. *The American Midland Naturalist*, *165*(1), pp.60-73.

Creating a vegetative mosaic

Bison Wallows: Dispersal and Use

- Annual plants would be dispersed by bison and germinate along the edges of bison wallows.

- Indigenous people following bison trails to water encountered annual plants that produce an abundance of small, nutrient rich, hard seeds …the “first crops”.
  - Goosefoot, *Chenopodium berlandieri*,
  - Marsh Elder, *Iva annua*,
  - Erect knotweed, *Polygonum erectum*

Mueller, N.G., Spengler III, R.N., Glenn, A. and Lama, K., 2021. Bison, anthropogenic fire, and the origins of agriculture in eastern North America. *The Anthropocene Review*, *8*(2), pp.141-158.

Creating a vegetative mosaic

Bison Trampling

- Grazing, wallows, and trampling at different intensities across prairies
- Trampled area (900 bison for two days before) was along the lake margin
- Looks a lot like a disked field

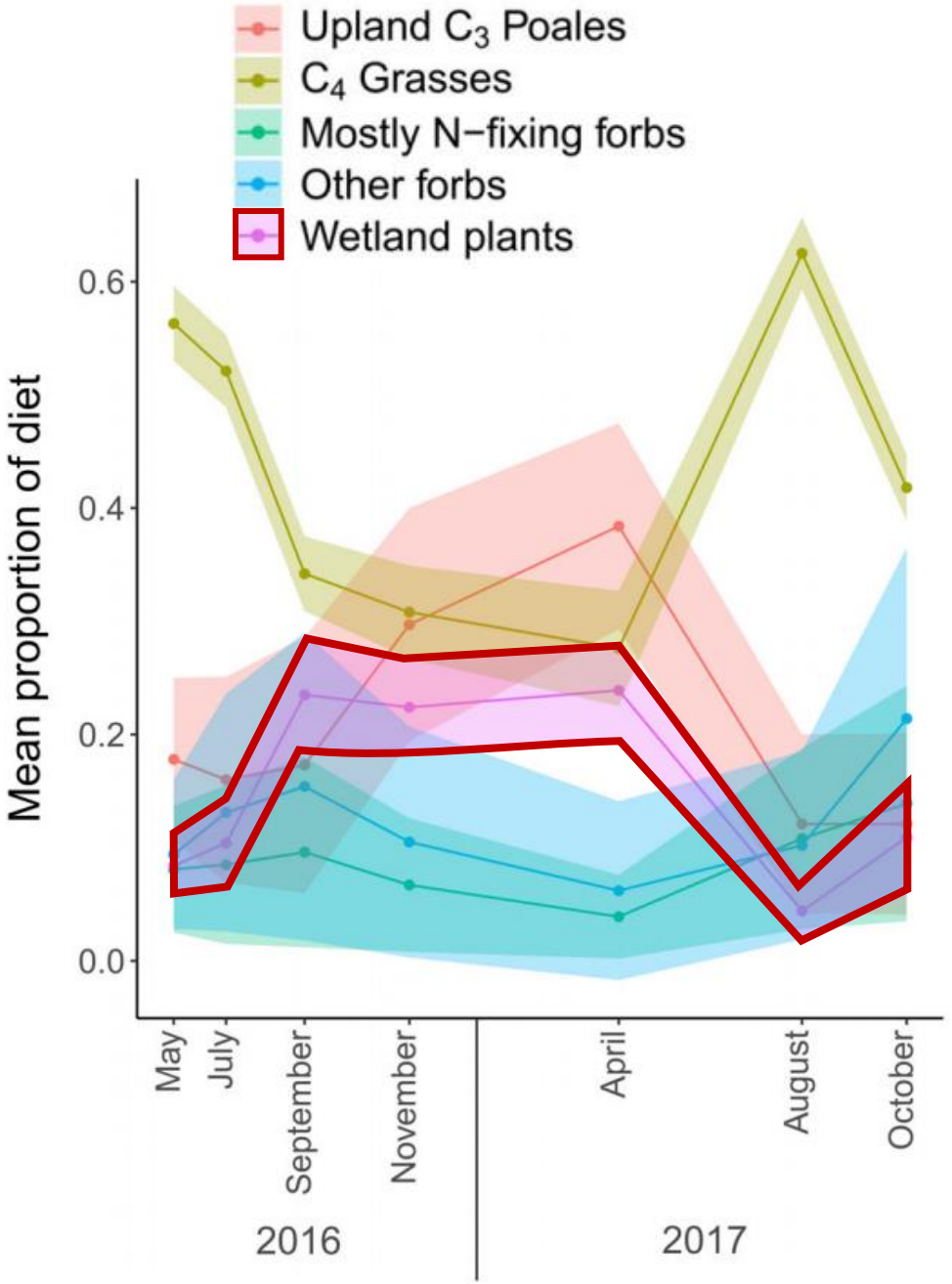
Bison create basking sites for turtles

Geluso, K., Kruse, C. and Harner, M., 2020. Wetland edge trampled by American Bison (*Bos bison*) used as basking site for Painted Turtles (Chrysemys picta).

Creating a vegetative mosaic

Temporal Dynamics

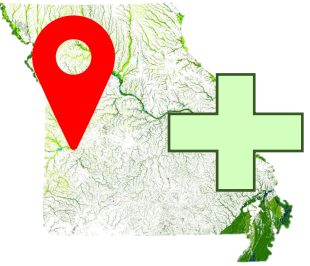
- Bison foraging on wetland species in **late summer and fall**
  - Wetland species and Upland C_3 Poales = over half of diet in fall
- Photosynthetically active, greener, with moisture at this point in year
- Higher protein for winter fat storage



Blackburn RC, Barber NA, Jones HP. Reintroduced bison diet changes throughout the season in restored prairie. Restoration Ecology. 2021 Apr;29:e13161.

Wetland Hydrology is Complex:

- Vary across space and time
- Involve abiotic and biotic processes
- What does this look like???



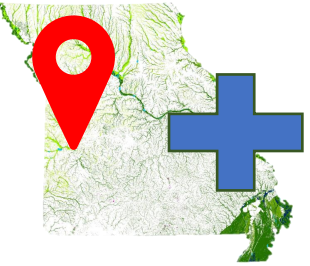
Upland Habitat

Prairie

Woodland

Glade

Upland Habitat with Streams



Prairie

Woodland

Glade

Stream Order

Upland Habitat with Streams and Bottomlands

- Prairie
- Woodland
- Glade

Stream Order

- Mesic BLF and Woodland
- Wet Mesic Woodland
- Prairie Swale
- Wet Bottomland Prairie
- Oxbows

Upland Habitat with Streams and Bottomlands

Prairie

Woodland

Glade

Stream Order

Mesic BLF and Woodland

Wet Mesic Woodland

Prairie Swale

Wet Bottomland Prairie

Oxbows

Spring rains would fill vernal pools and pond on wet prairies

Upland Habitat with Streams and Bottomlands

Prairie

Woodland

Glade

Stream Order

Mesic BLF and Woodland

Wet Mesic Woodland

Prairie Swale

Wet Bottomland Prairie

Oxbows

Overland flooding would seasonal spread out across the broader floodplain

Upland Habitat with Streams and Bottomlands

Prairie

Woodland

Glade

Stream Order

Mesic BLF and Woodland

Wet Mesic Woodland

Prairie Swale

Wet Bottomland Prairie

Oxbows

Springs, fens, and beaver complexes would slowly release water in specific locations

Upland Habitat with Streams and Bottomlands

- Prairie
- Woodland
- Glade

Stream Order

- Mesic BLF and Woodland
- Wet Mesic Woodland
- Prairie Swale
- Wet Bottomland Prairie
- Oxbows

Upland fires would carry across bottoms

But beaver complexes, rivers, and ponded areas would not

Upland Habitat with Streams and Bottomlands

Prairie

Woodland

Glade

Stream Order

Mesic BLF and Woodland

Wet Mesic Woodland

Prairie Swale

Wet Bottomland Prairie

Oxbows

Bison would follow the new growth creating wallows along the way

Upland Habitat with Streams and Bottomlands

- Prairie
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Stream Order

- Mesic BLF and Woodland
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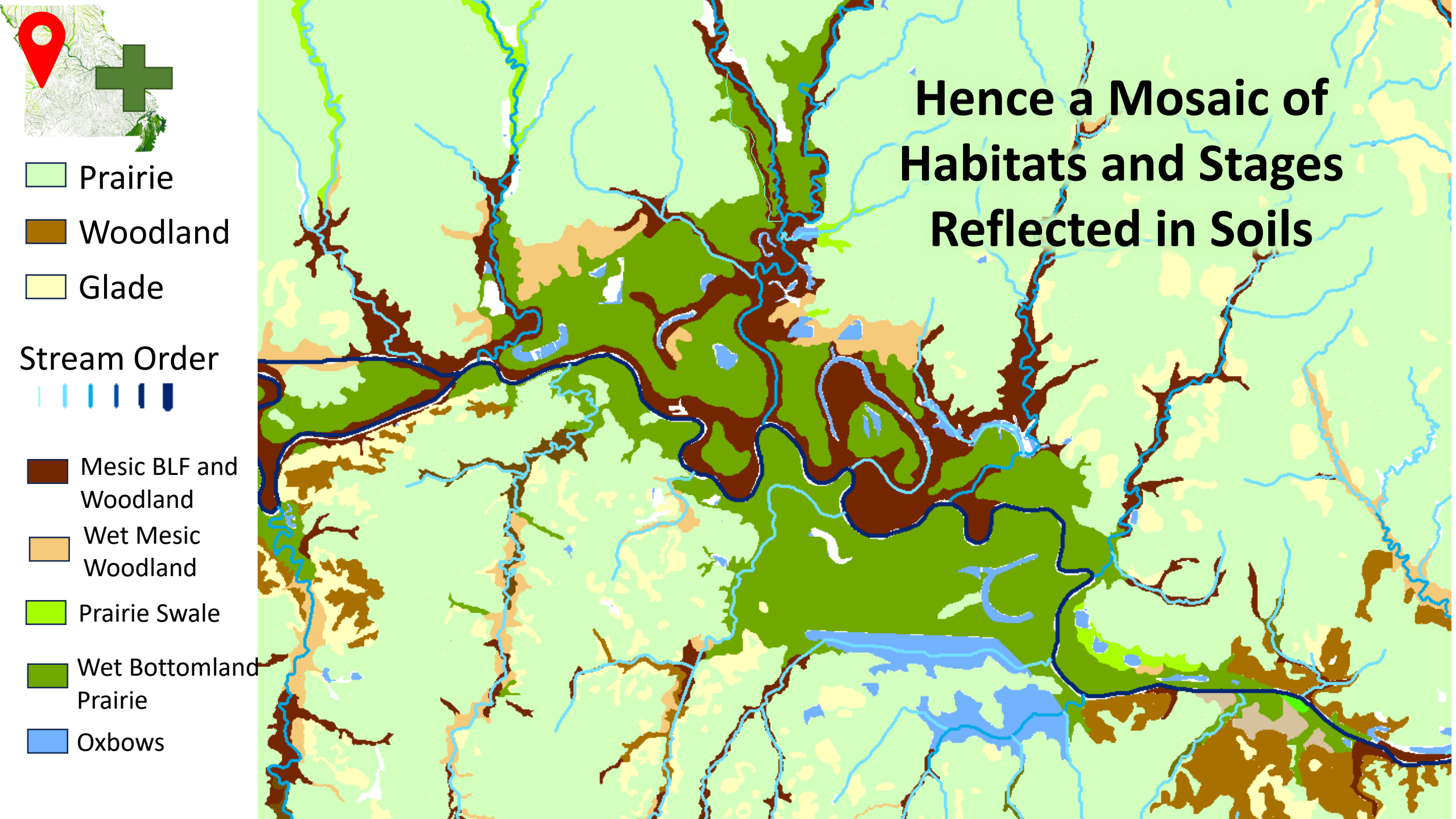
Bison would follow the new growth creating wallows along the way

Moving into the bottoms seasonally

Impacting trees and soil in locations


Prairie
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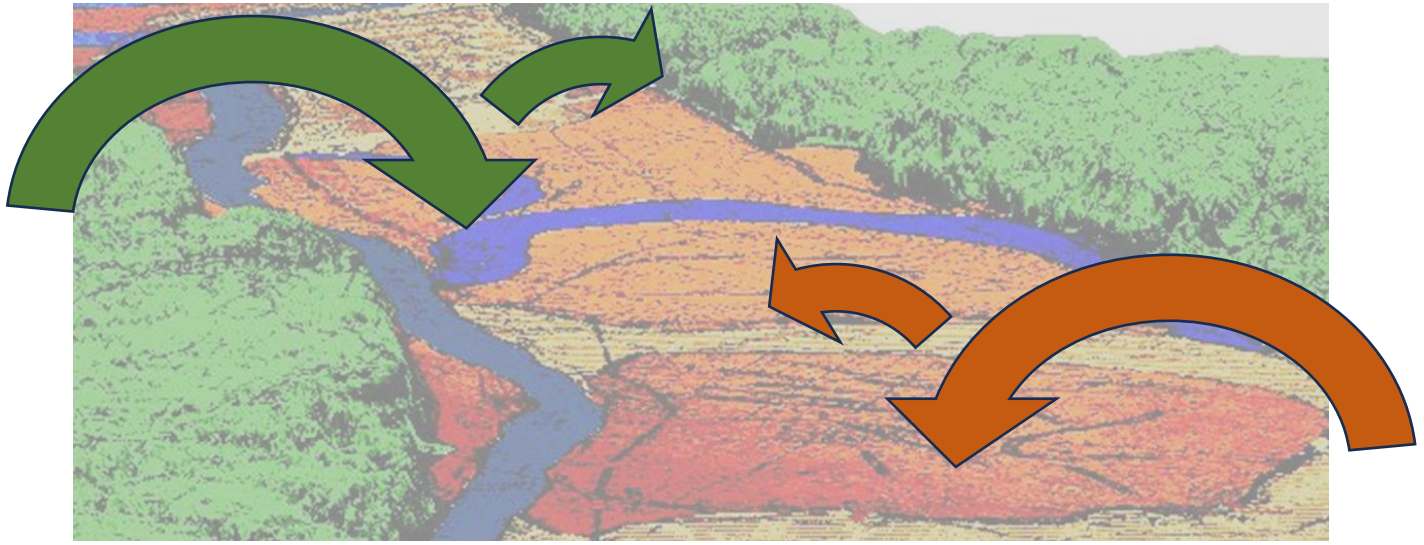
Stream Order
Mesic BLF and Woodland
Wet Mesic Woodland
Prairie Swale
Wet Bottomland Prairie
Oxbows
Hence a Mosaic of Habitats and Stages Reflected in Soils

Juxtaposition of Habitat Mosaics

- Migratory birds stop to refuel or breed to take advantage of seasonal resources



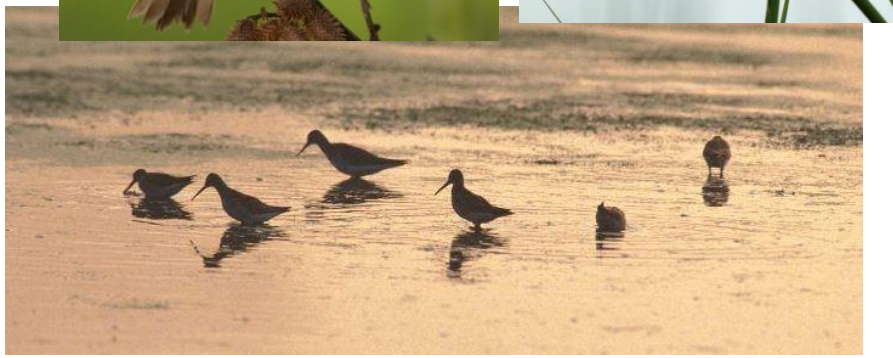
White Pelican

N. Pintail

Sora

Yellow Warbler

Dickcissel

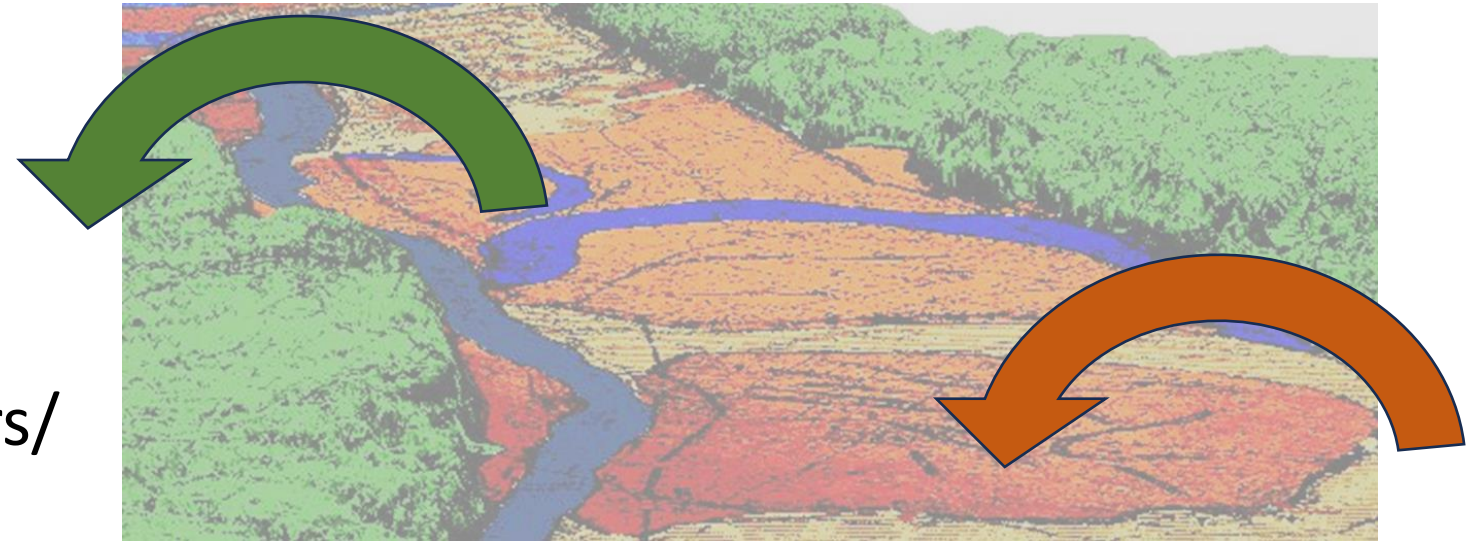


Sedge Wren

Sedge Wren

Juxtaposition of Habitat Mosaics

- Dragonflies emerge from floodplain wetlands and (fliers/ migratory) patrol uplands



Common Green Darner

Wandering Glider

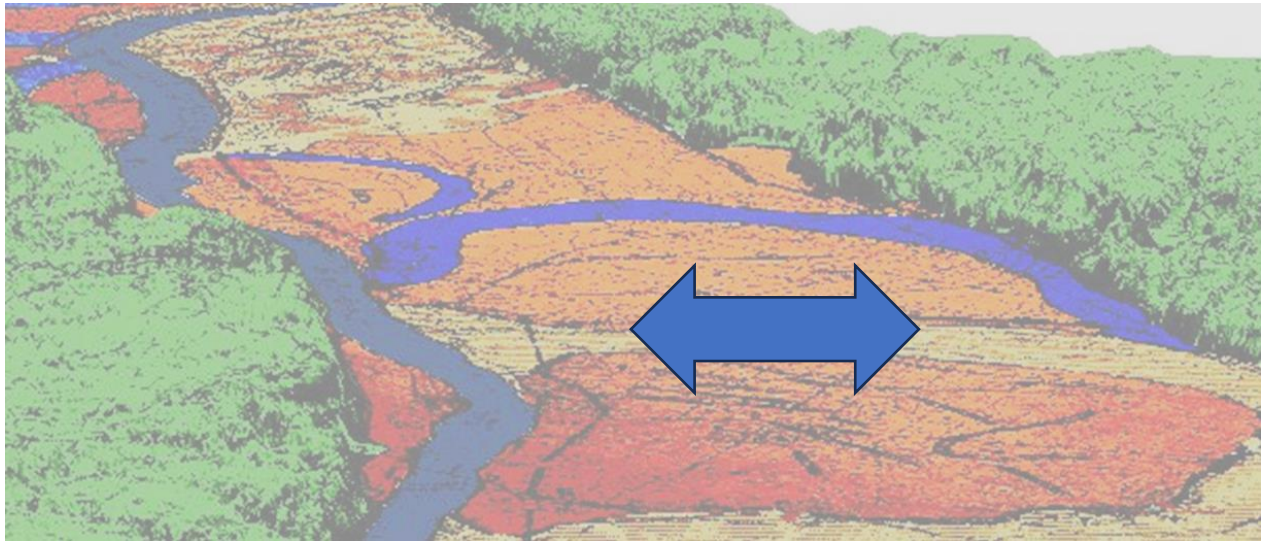
Photo: © Greg Lasley Nature Photography

Photo: © John C. Abbott/Abbott Nature Photography

Black Saddlebags

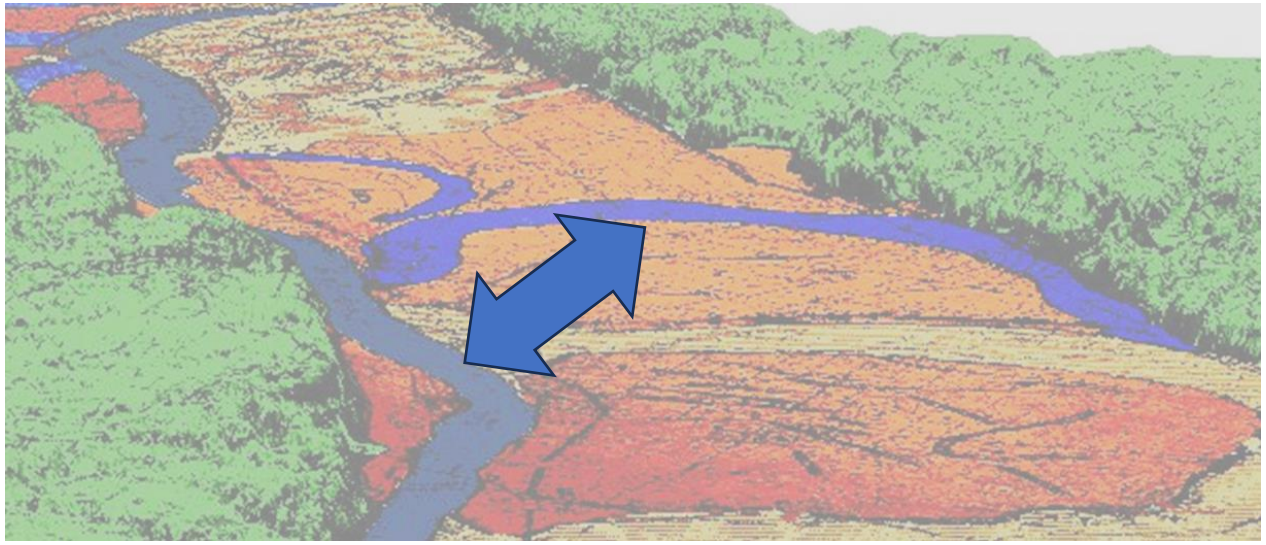
Juxtaposition of Habitat Mosaics

- Resident Species: moving locally and take advantage of various successional stages



Juxtaposition of Habitat Mosaics

- Aquatic species moving between the main channel and floodplain with flood connectivity



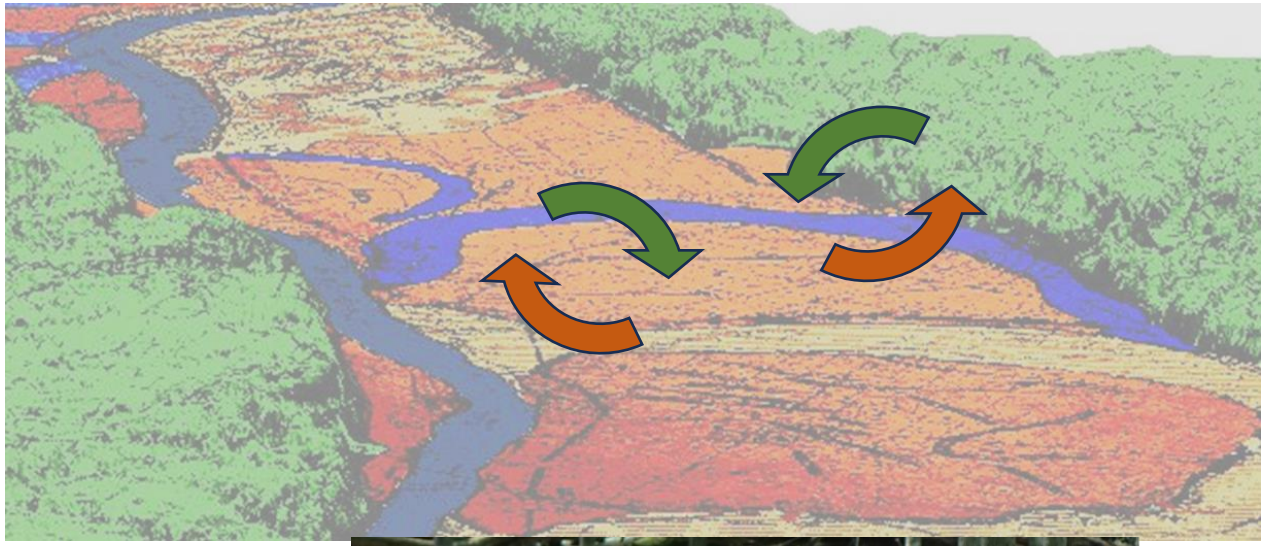
Black bullheads

Black Crappie

Paddlefish

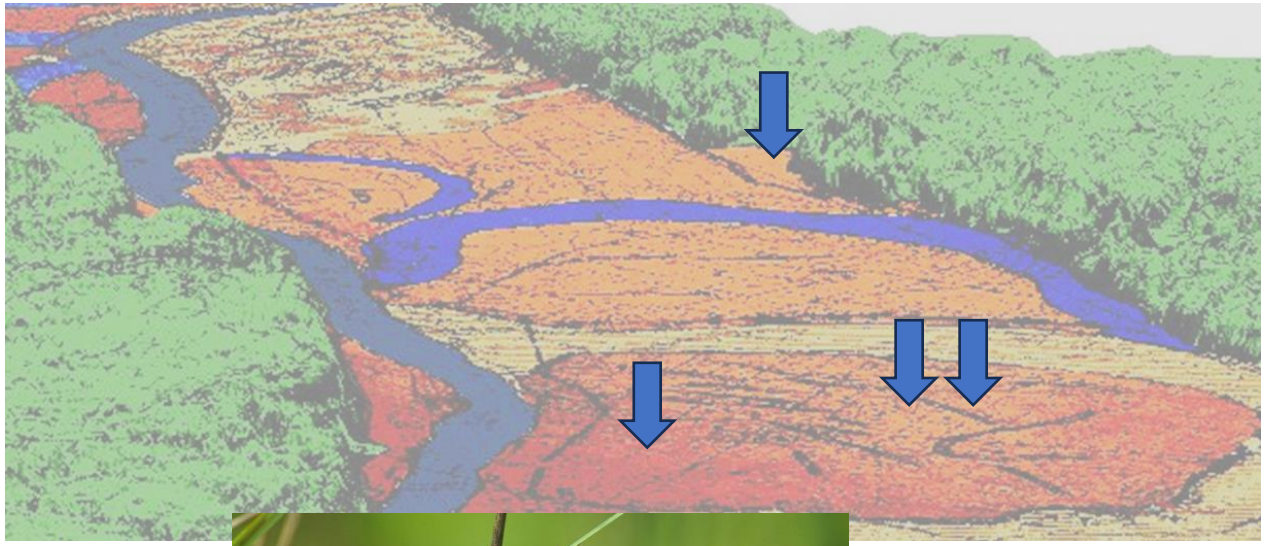
Juxtaposition of Habitat Mosaics

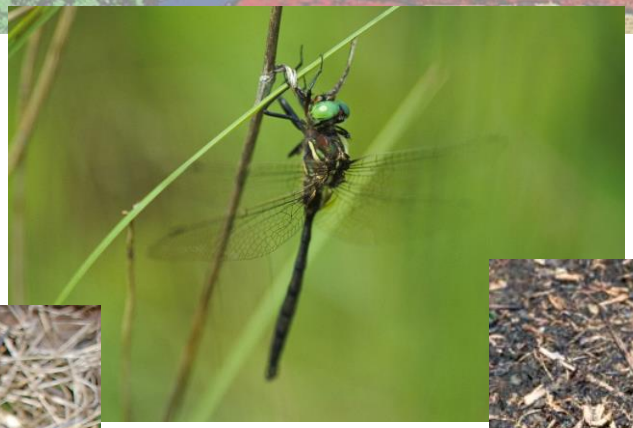
- Move between habitats for breeding, overwintering, egg-laying, larval development



Juxtaposition of Habitat Mosaics

- Ecosystem engineers creating habitat for other species





Hines Emerald Dragonfly

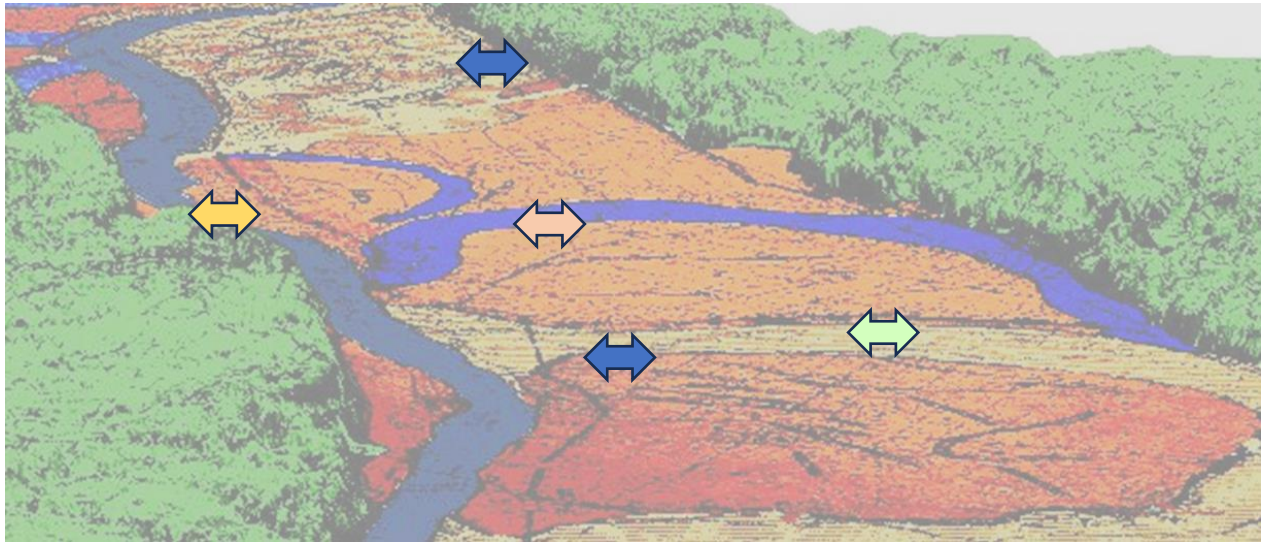
Burrowing Crayfish

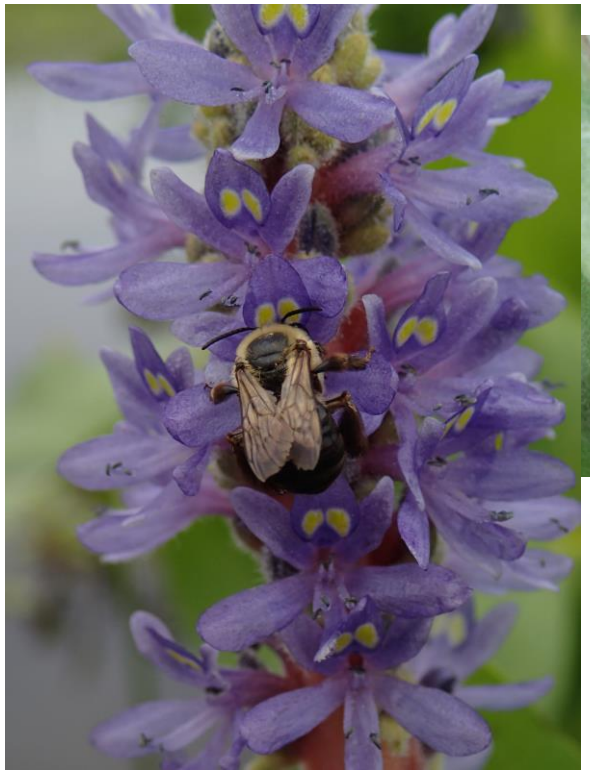
N. Crawfish Frog

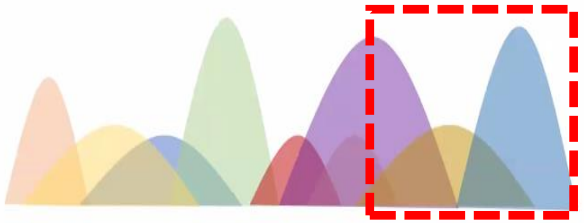
Prairie Massassauga Rattlesnake

Juxtaposition of Habitat Mosaics

- Reliance on seasonal and spatial availability of plants for nectar, pollen, leaves, or stems

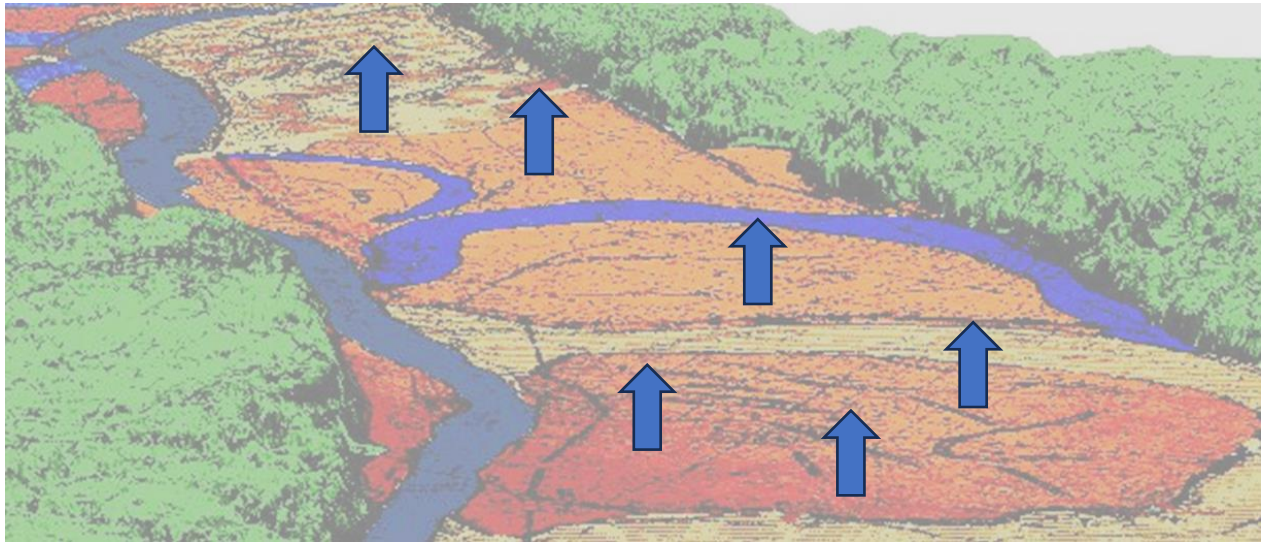


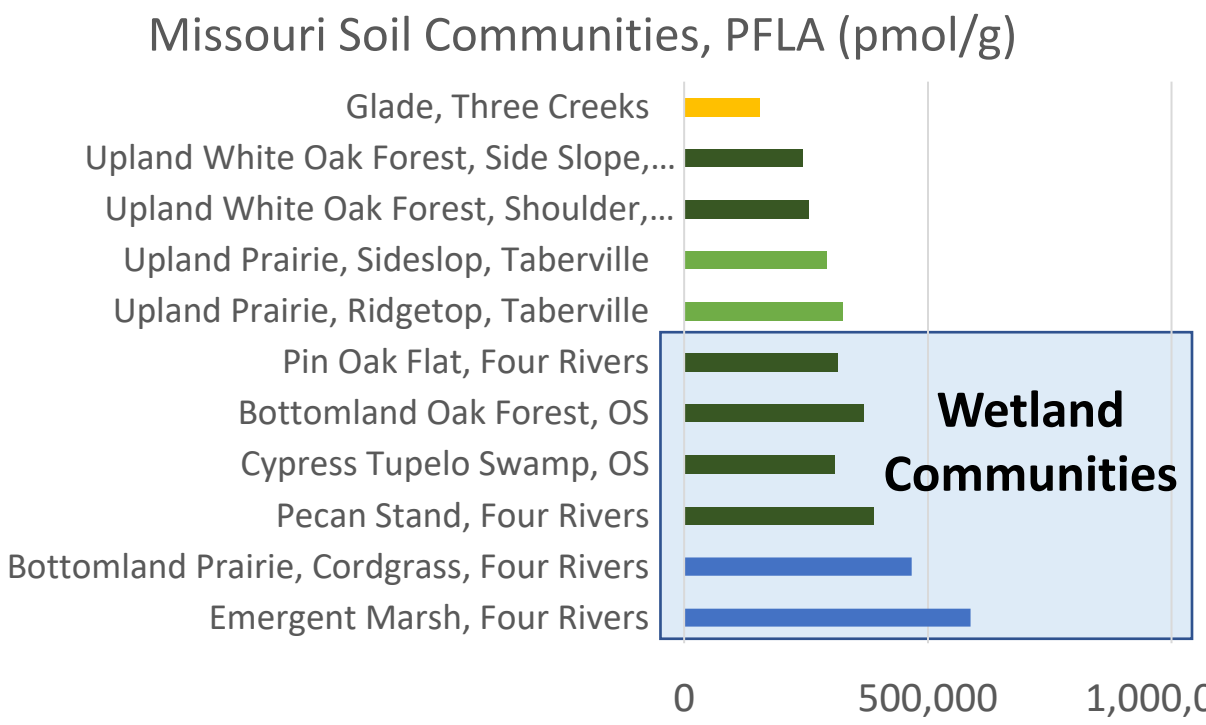


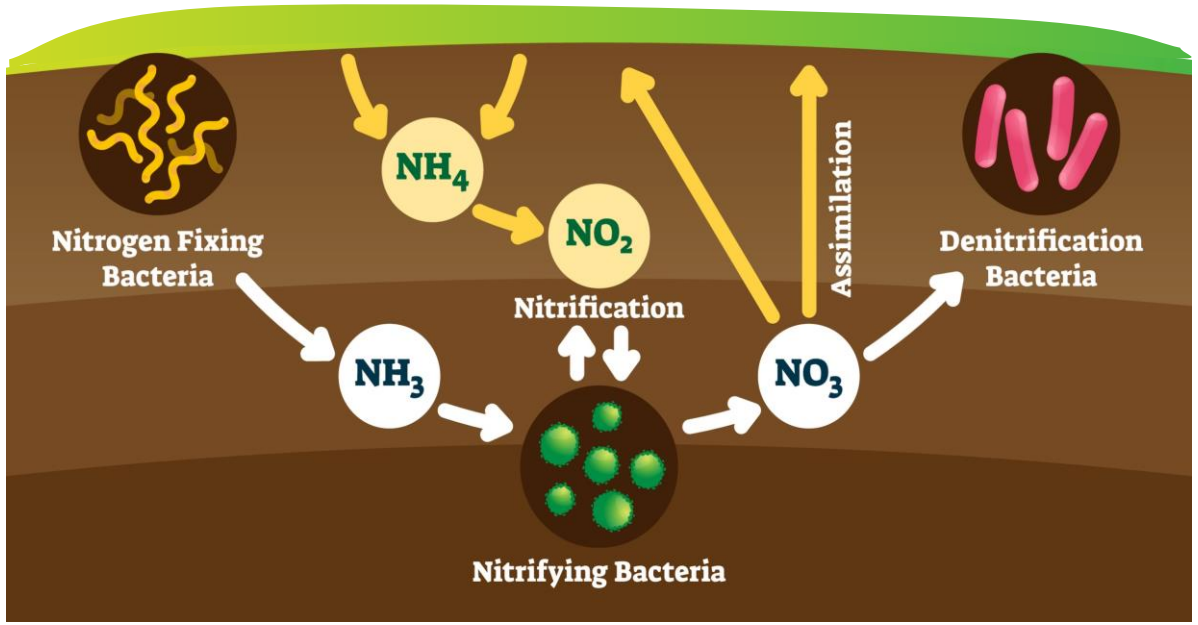


Juxtaposition of Habitat Mosaics

- Plants are interacting with soil nutrients via microbiome



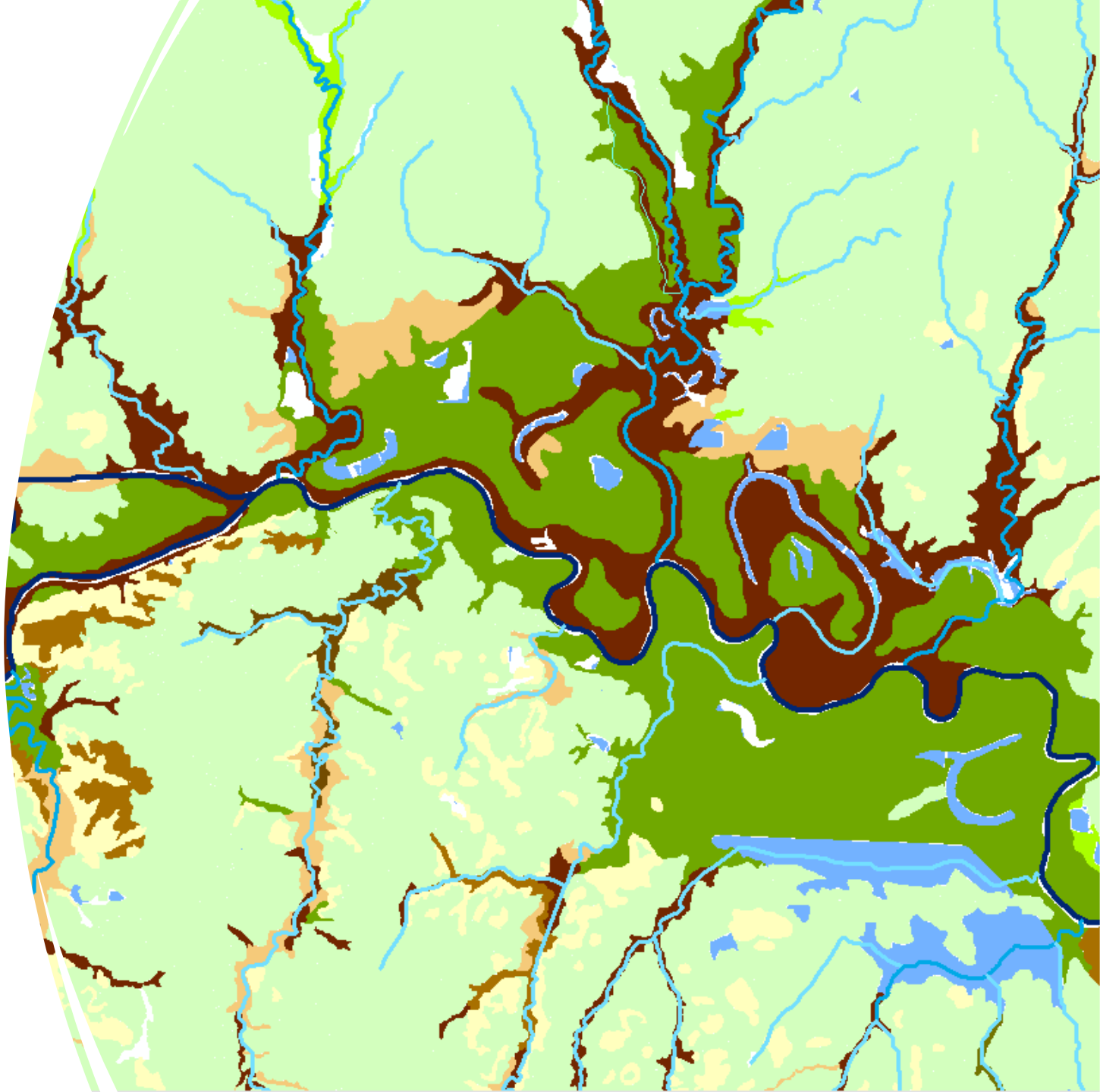




http://www.wetlands-initiative.org/nutrient-removal

Species Interactions Tied to Landscape Complexity

- Wetlands are Embedded in Watersheds and Prairie Matrix
- Play Many Different Roles
- Dependent on Spatial and Temporal Scales

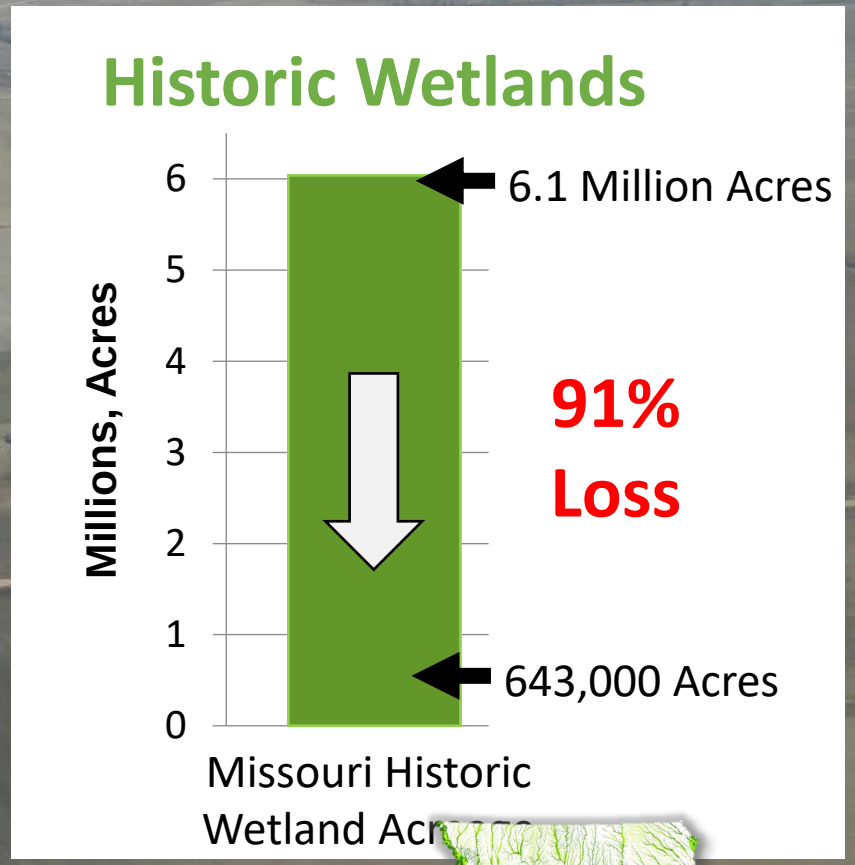


MO Historic Wetland Loss

- Floodplains were streamlined
- Wetlands were drained and diminished

MO Resulting Wetland Loss

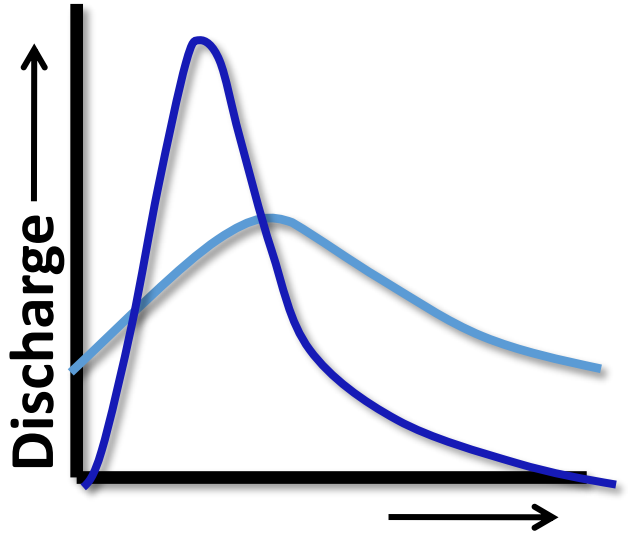
- Floodplains were streamlined
- Wetlands were drained and diminished

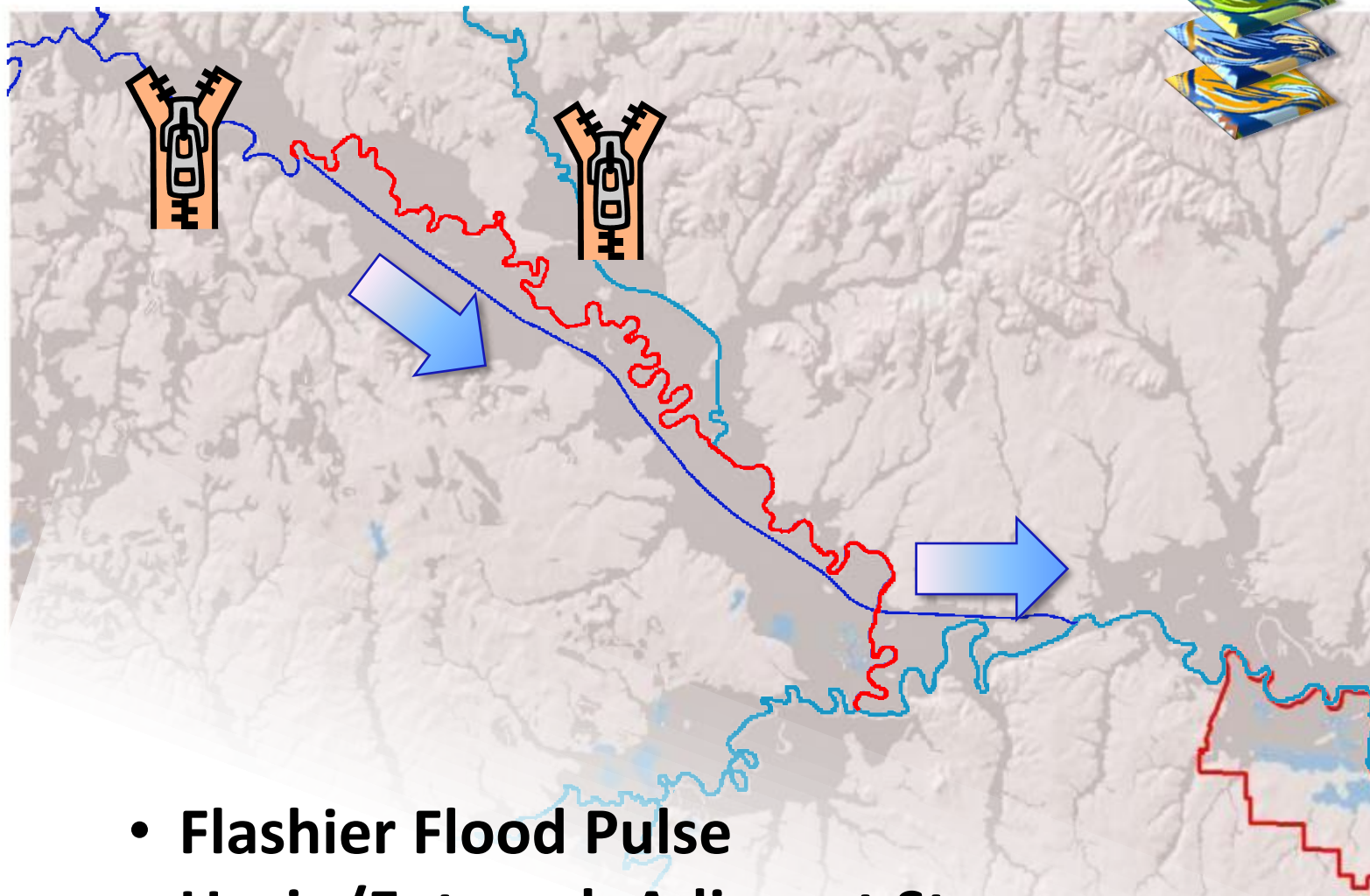


Alterations to Hydrology

Changing

- Magnitude
- Frequency
- Duration
- Timing





- **Flashier Flood Pulse**
- **Unzip/Entrench Adjacent Streams**
- **Lowering Water Table**

Alterations to Carbon Sequestration

Soil Organic Carbon

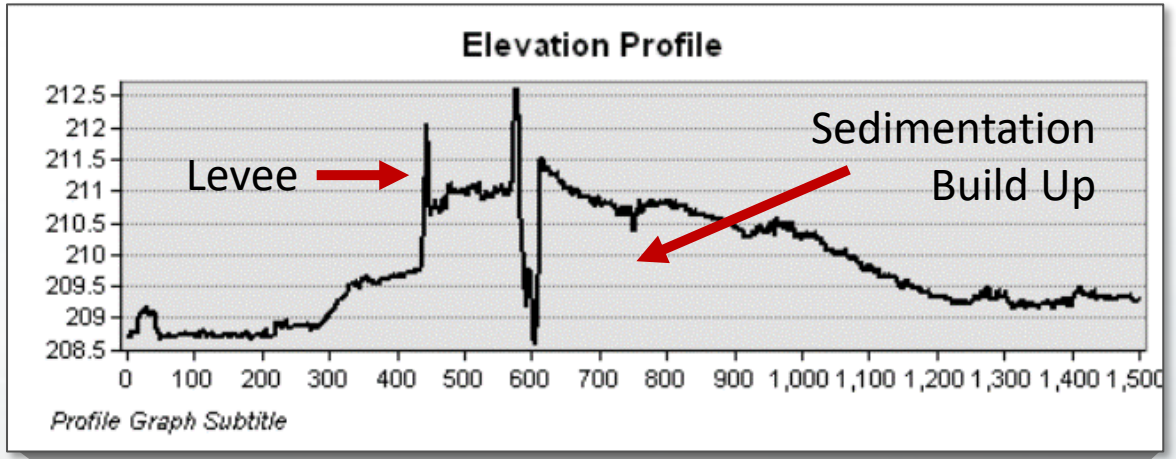
- Land conversion
  - Native prairie soils historically would have had 30-50% more carbon than cultivated fields today

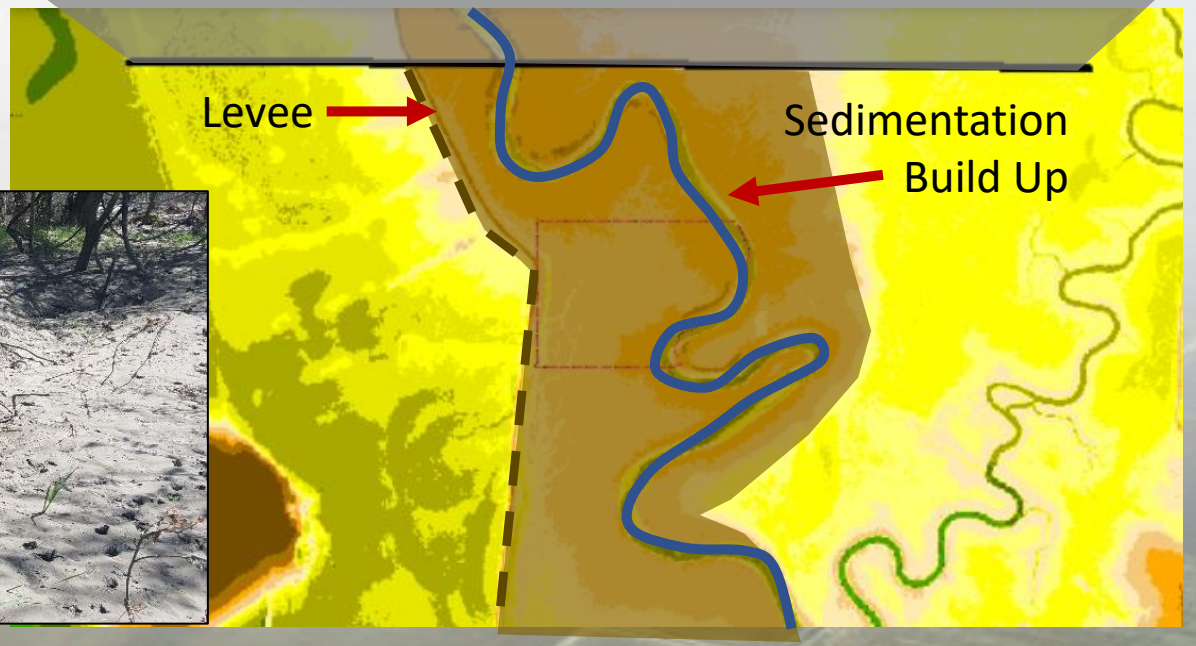
David, M.B., McIsaac, G.F., Darmody, R.G. and Omonode, R.A., 2009. Long-term changes in mollisol organic carbon and nitrogen. Journal of Environmental Quality, 38(1), pp.200-211

Alterations to Floodplain Connectivity

Influencing Sedimentation

- Levee constriction
- Confined space for higher sedimentation rates



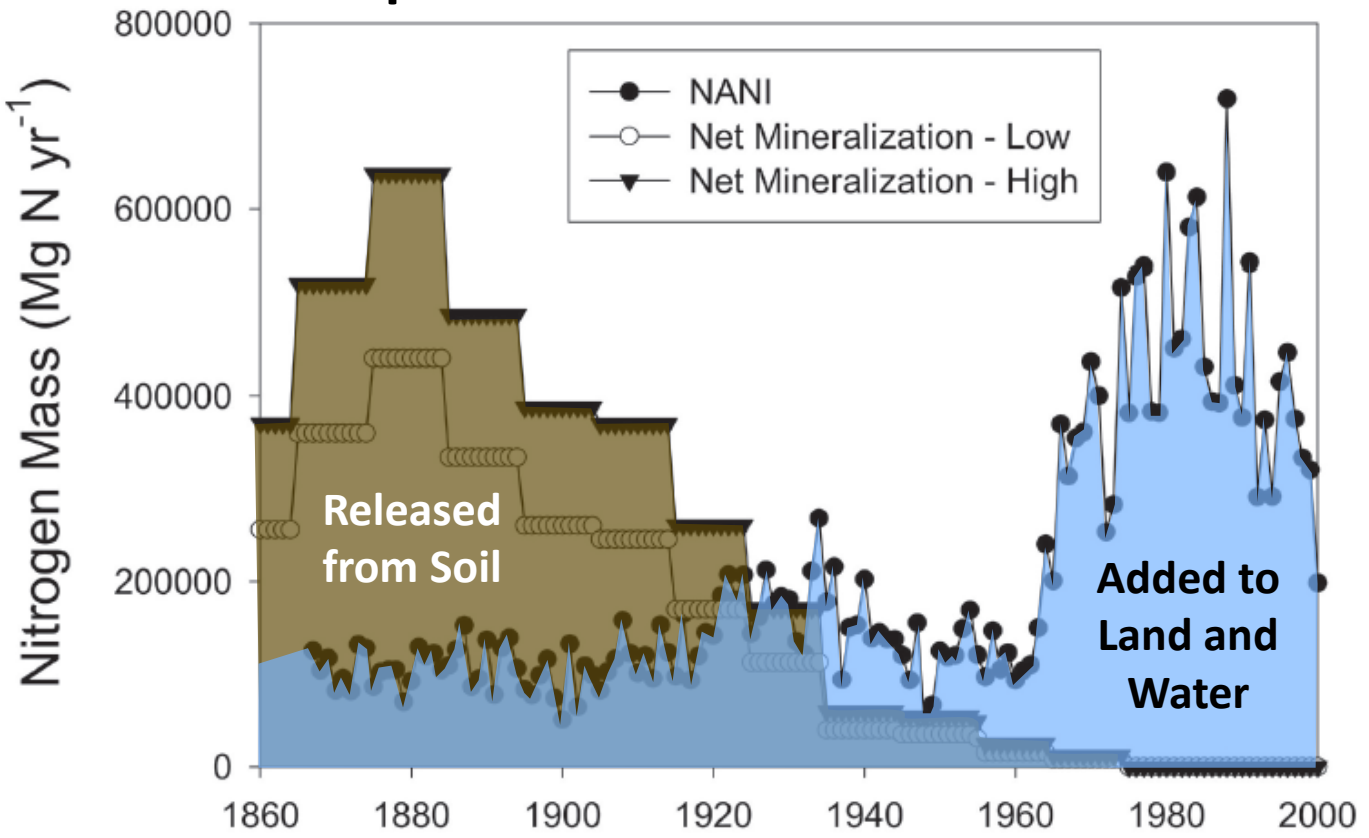


Alterations to Nutrient Cycling

Nitrogen Pulses

- Soils: Largest Pool of N (100 yr turnover rate)
  - Land Conversion: Mineralized soil organic N
- Anthropogenic Inputs
  - Second pulse of N

Availability of N following the plowing of prairie and forested soils in Illinois

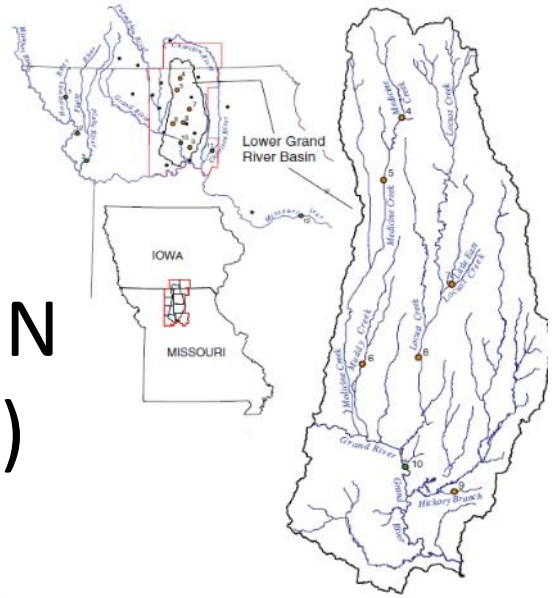


David M.B., McIsaac G.F., Royer T.V., Darmody R.G., Gentry L.E. 2001. Estimated historical and current nitrogen balances for Illinois. The Scientific World. 1(S2):597–604

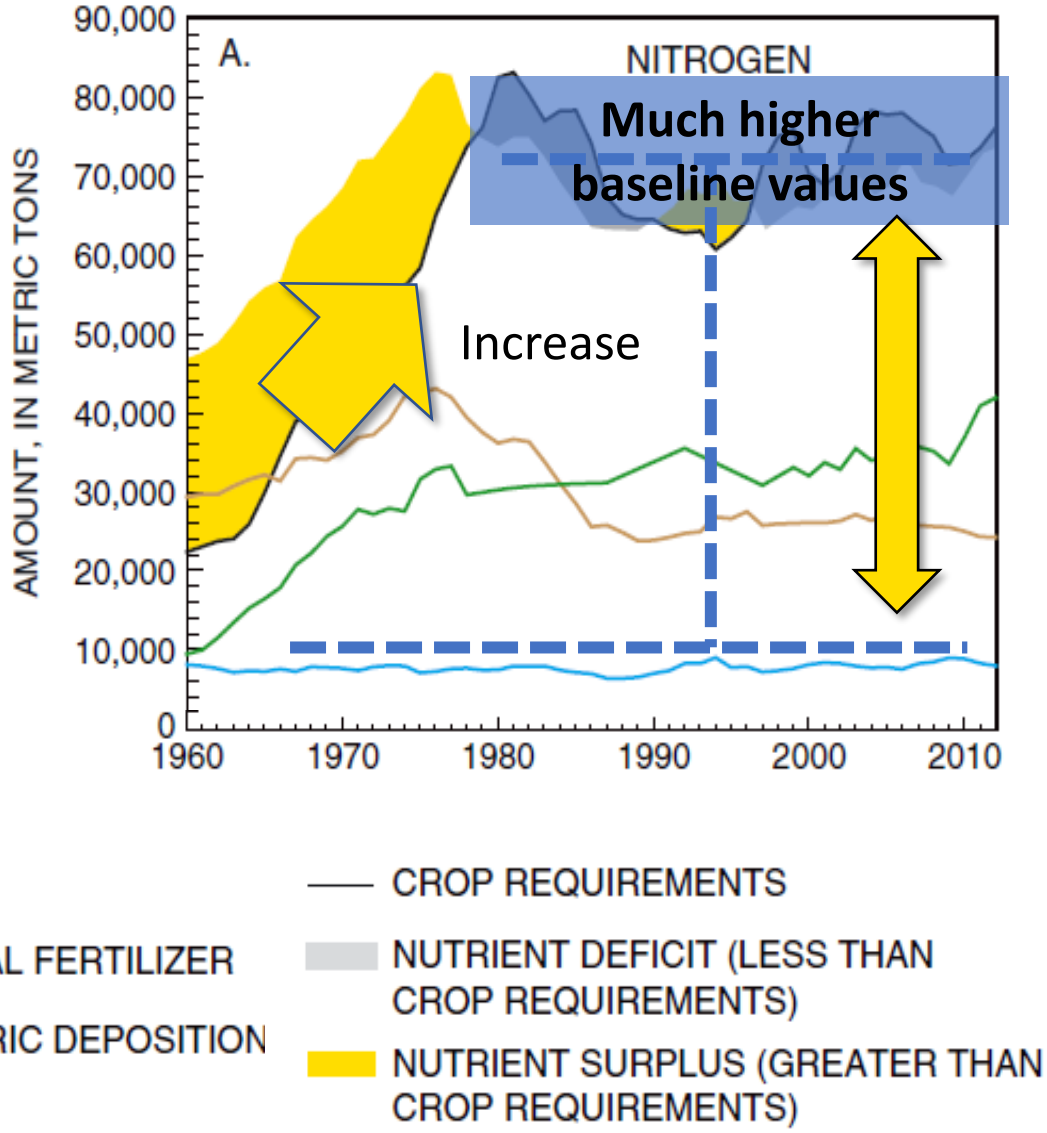
Alterations to Nutrient Cycling

Nitrogen Loading

- Soils: Largest Pool of N (100 yr turnover rate)
  - Land Conversion: Mineralized soil organic N
- Anthropogenic Inputs
  - Second pulse of N



Availability of N from Inputs within the Grand River Watershed



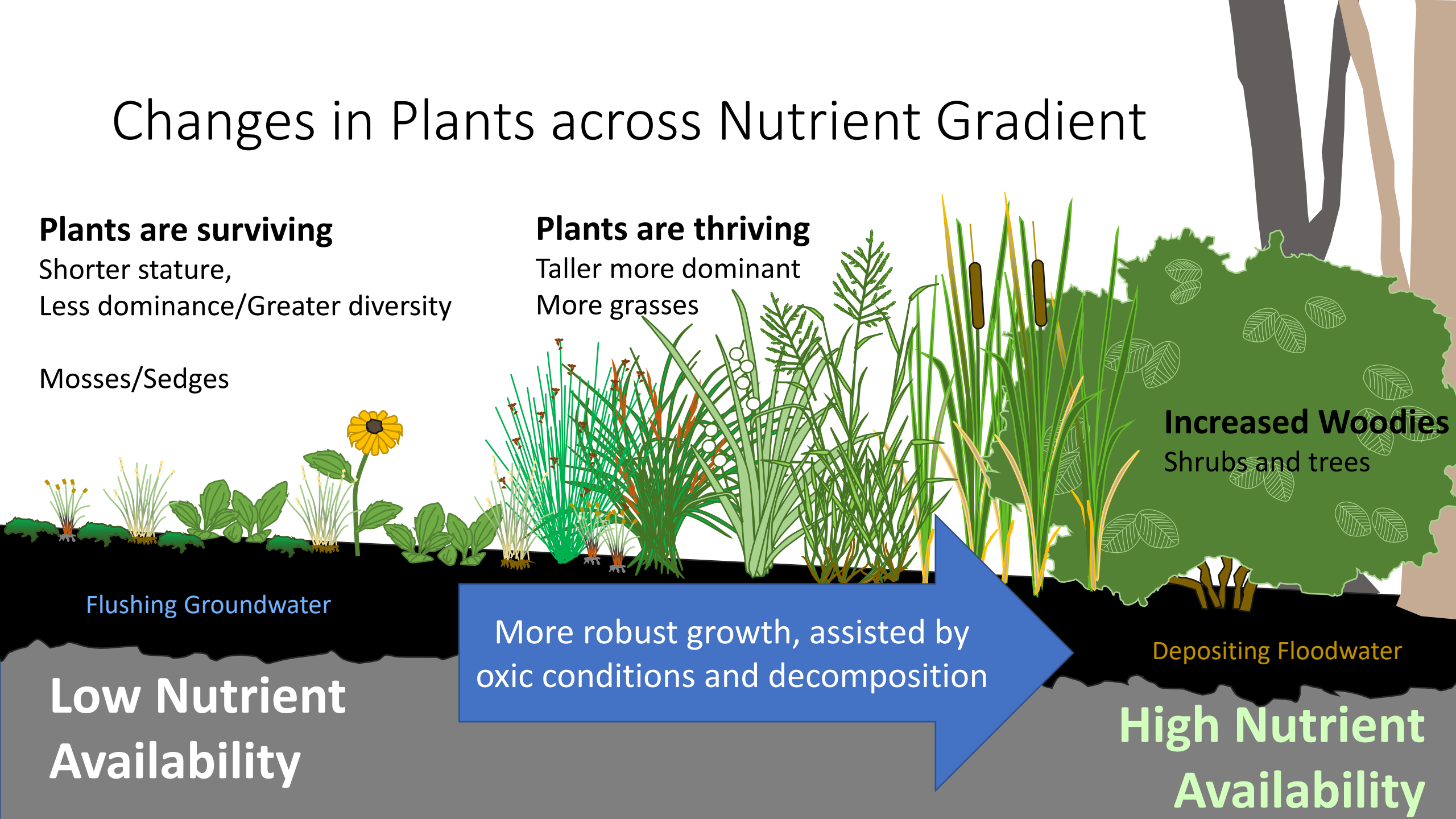
Wilkison, D. H., and Armstrong, D. J. 2015. Water-Quality Assessment of the Lower Grand River Basin, Missouri and Iowa, USA, in Support of Integrated Conservation Practices. River Res. Applic., 32: 583–596

Changes in Plants across Nutrient Gradient

Plants are surviving
Shorter stature,
Less dominance/Greater diversity

Mosses/Sedges

Plants are thriving
Taller more dominant
More grasses



Increasing N = Reduced Rare Plants

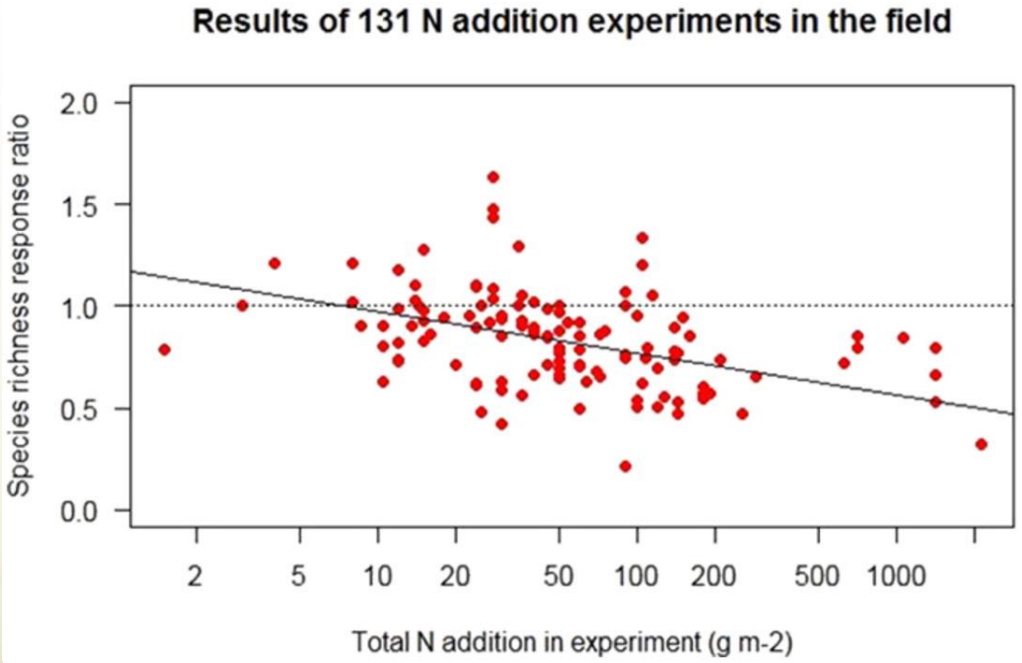
Shifting Plant Communities

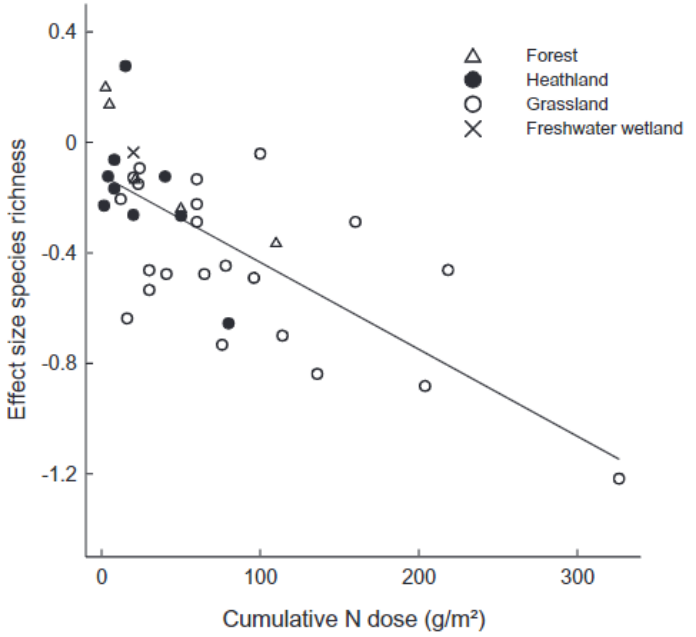
Multiple studies show a negative trend

- Rare species often lost
  - Attributed to >60% of loss

- More common and abundant species are less impacted
  - Attribute to 10% loss

- Soons, M.B., Hefting, M.M., Dorland, E., Lamers, L.P., Versteeg, C. and Bobbink, R., 2017. Nitrogen effects on plant species richness in herbaceous communities are more widespread and stronger than those of phosphorus. *Biological Conservation*, *212*, pp.390-397.
- De Schrijver, A., De Frenne, P., Ampoorter, E., Van Nevel, L., Demey, A., Wuyts, K. and Verheyen, K., 2011. Cumulative nitrogen input drives species loss in terrestrial ecosystems. *Global Ecology and Biogeography*, *20*(6), pp.803-816.
- Midolo, G., Alkemade, R., Schipper, A.M., Benítez-López, A., Perring, M.P. and De Vries, W., 2019. Impacts of nitrogen addition on plant species richness and abundance: A global meta-analysis. *Global ecology and Biogeography*, *28*(3), pp.398-413.
- Suding, K.N., Collins, S.L., Gough, L., Clark, C., Cleland, E.E., Gross, K.L., Milchunas, D.G. and Pennings, S., 2005. Functional-and abundance-based mechanisms explain diversity loss due to N fertilization. *Proceedings of the National Academy of Sciences*, *102*(12), pp.4387-4392.

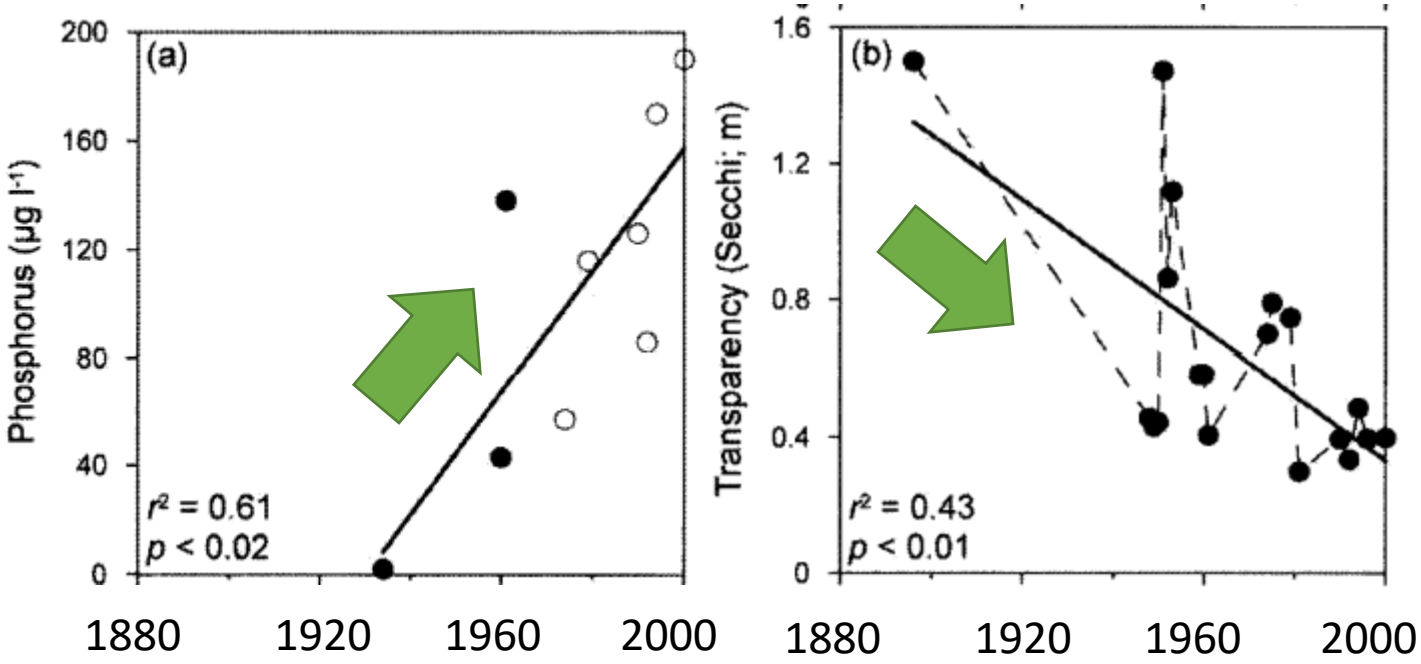


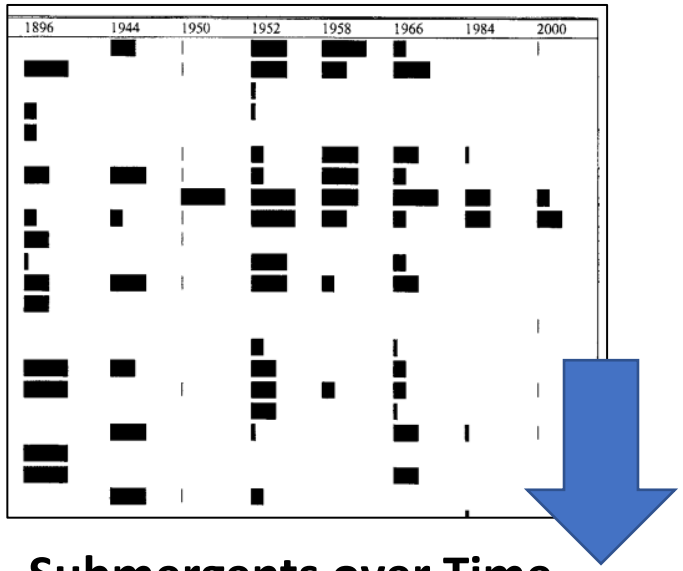


Increasing P = Reduced Rare Plants

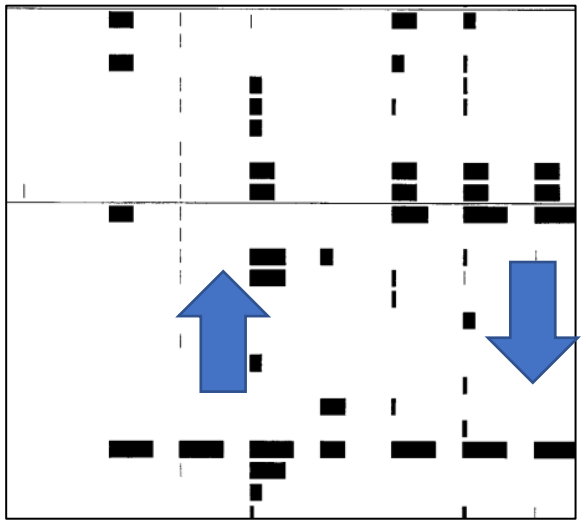
Shifting Aquatic Plant Communities

- Reduced submergents as P goes up and clarity goes down
- The number of floating and emergent move up and decline
- Only a few species can use the extra Phosphorous





Submergents over Time



Floating and Emergent over Time

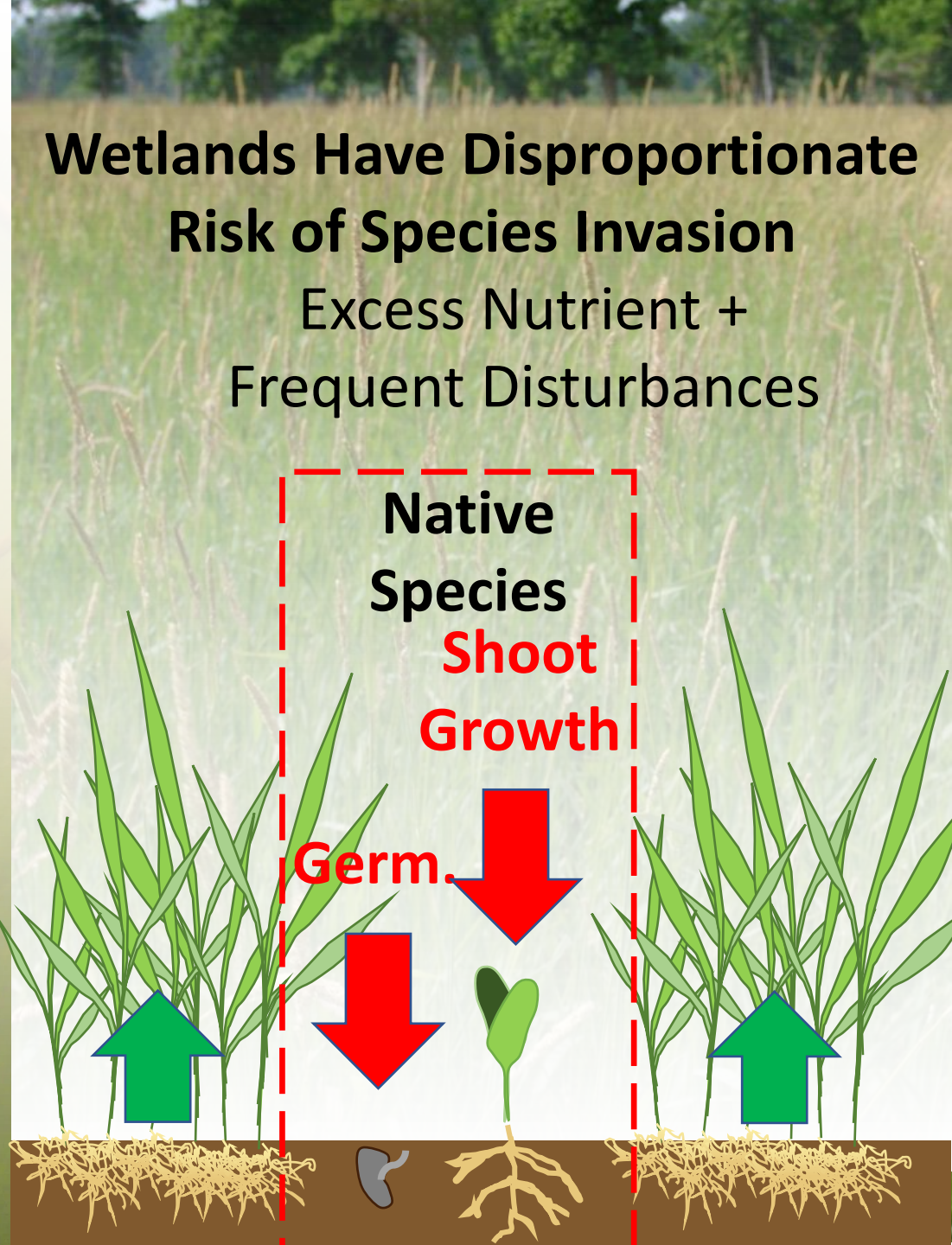
Egertson, C.J., Kopaska, J.A. and Downing, J.A., 2004. A century of change in macrophyte abundance and composition in response to agricultural eutrophication. *Hydrobiologia*, *524*(1), pp.145-156.

Increasing N = Increase of Invasives

Shifting Plant Communities

Invasive Synergies:

- Native wetland seedling germination can be lower with higher N loads
- Reduced shoot growth of native community by nearly half with excess N and Reed canary grass
- Reed canary grass can metabolize N, grow, and create own microclimate

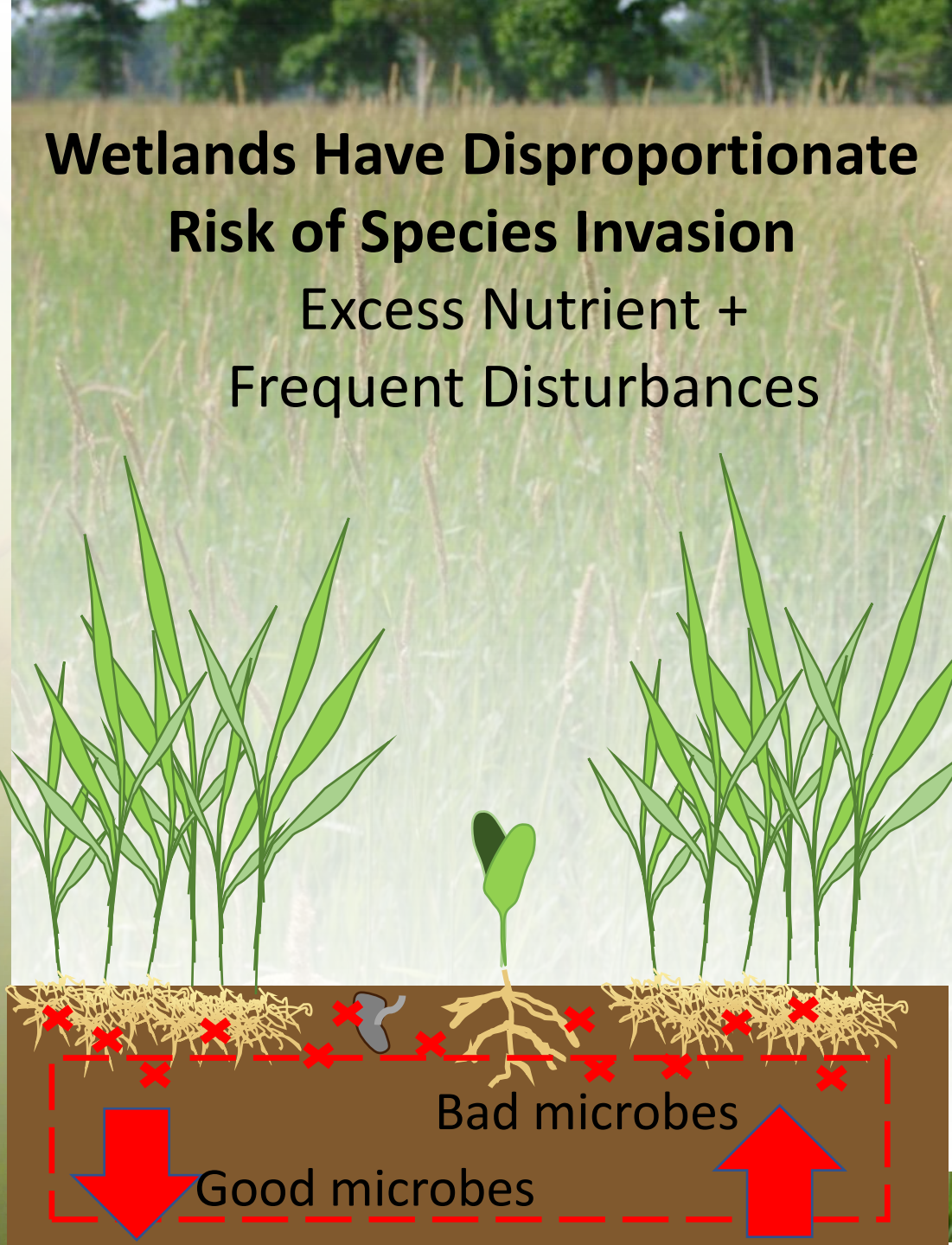


Alterations to Nutrient Cycling

Shifting Microbial Communities

Subsurface Threats with Excess N

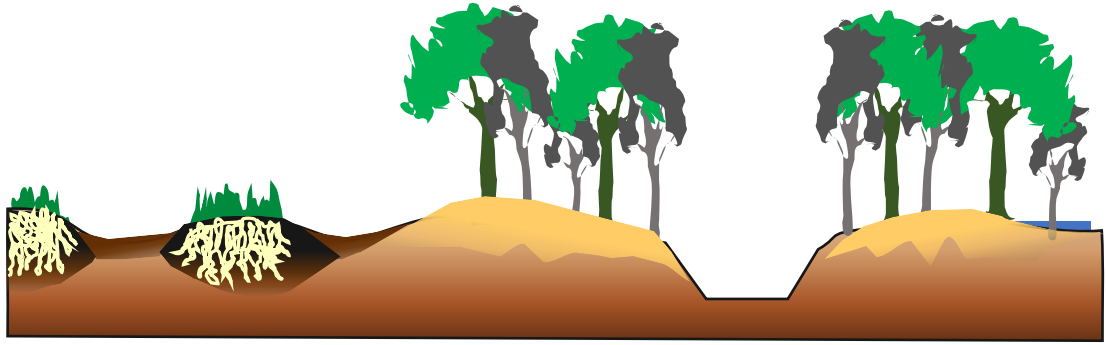
- Decrease microbial diversity, biomass, abundance (Wang et al. 2018, Ma et al. 2021)
- Plants hosted more virus (Blumenthal et al. 2009)
- Competitive plants hosted more than 4x fungi and viruses (Blumenthal et al. 2009)



Increase in Woody Encroachment

Implications of Climate Change

- Increasing CO_2 levels
- Increasing Temperatures
- Extended Growing Seasons
- Excess Nutrients



Early successional woodies
Changes the soil moisture and trajectory of soil carbon

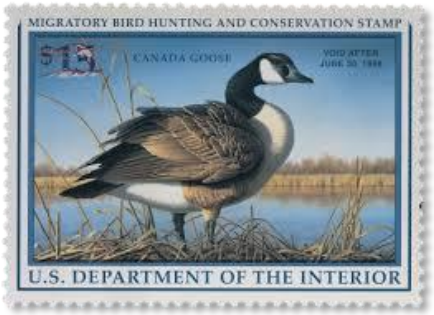
Heijmans, M.M., van der Knaap, Y.A., Holmgren, M. and Limpens, J., 2013. Persistent versus transient tree encroachment of temperate peat bogs: effects of climate warming and drought events. *Global Change Biology*, *19*(7), pp.2240-2250.

Dell, J.A., 2020. *The Effects of Willow Shrub Encroachment on Soil Organic Carbon Storage in a South Florida Herbaceous Wetland* (Doctoral dissertation, Florida Atlantic University).

Saintilan, N. and Rogers, K., 2015. Woody plant encroachment of grasslands: a comparison of terrestrial and wetland settings. *New Phytologist*, *205*(3), pp.1062-1070.

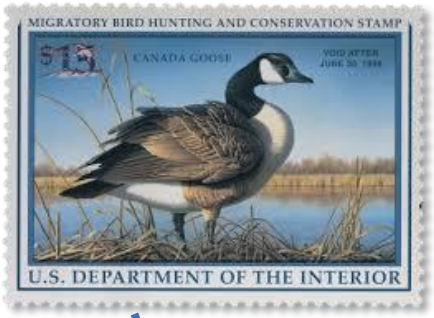
Historic Conditions:

Overlapping processes and habitats



Current Condition:

Fragmented landscape with isolated “postage stamps”



What's the Future

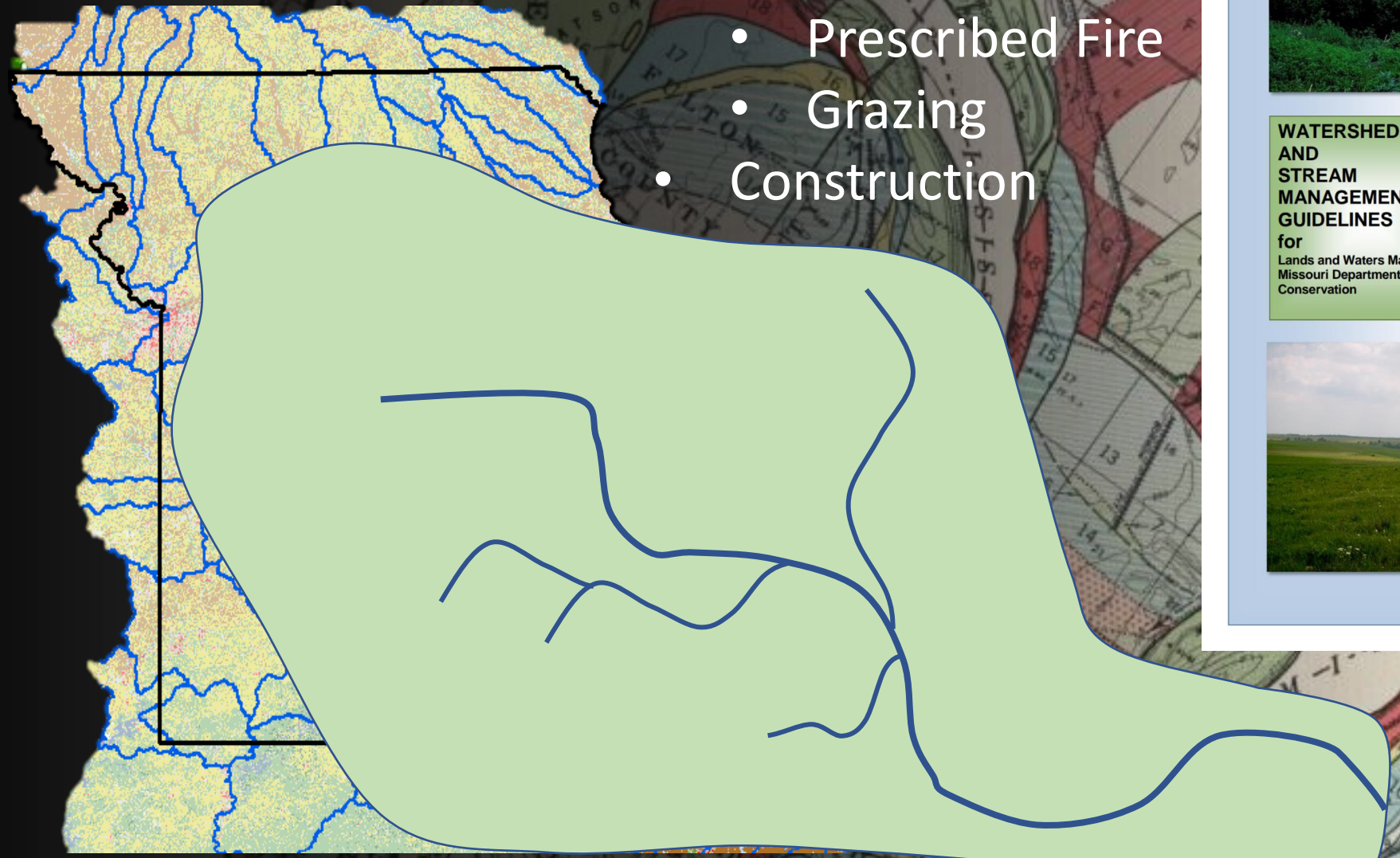
Fragmented landscape with isolated "postage stamps"

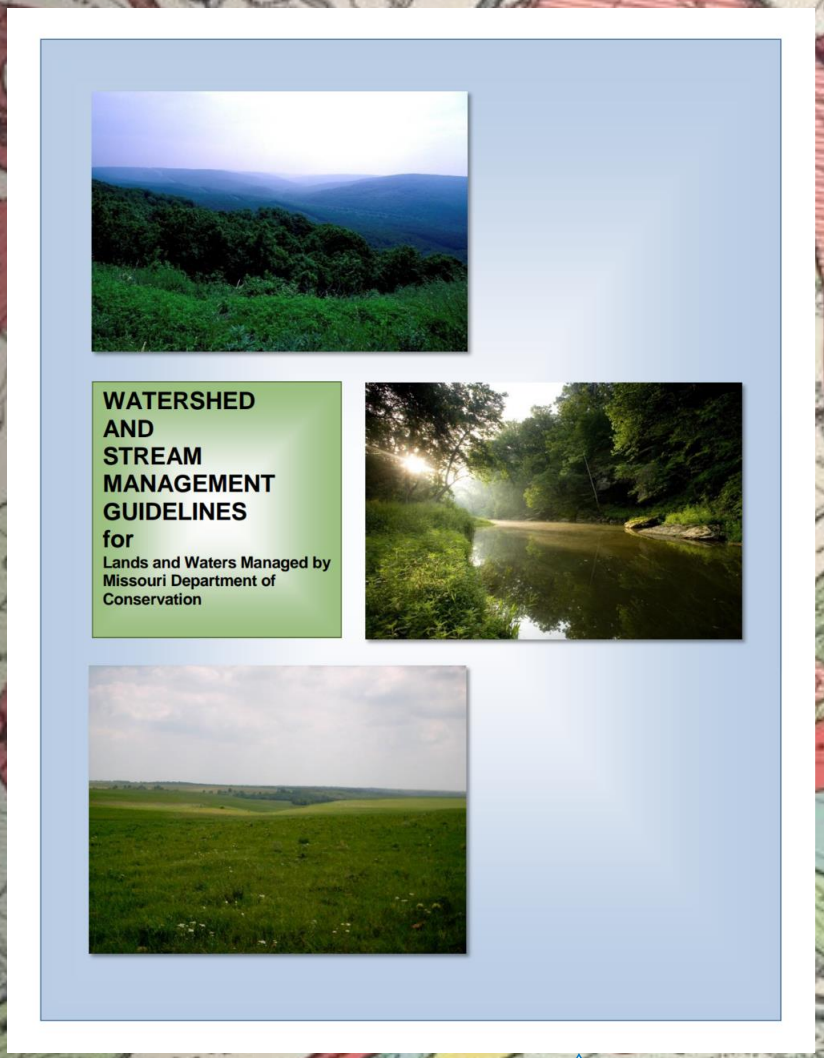
Broader Context and Connectivity

Stream Order, Watersheds, Adjacent Uplands

Incorporating Watershed and Stream Guidelines

- Veg. Management
  - Prescribed Fire
  - Grazing
- Construction

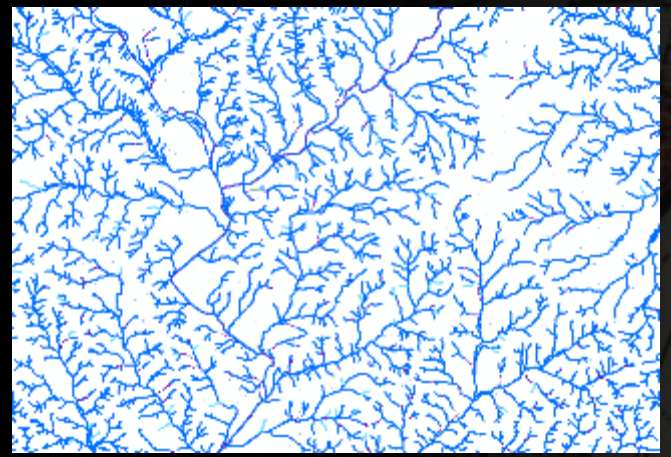




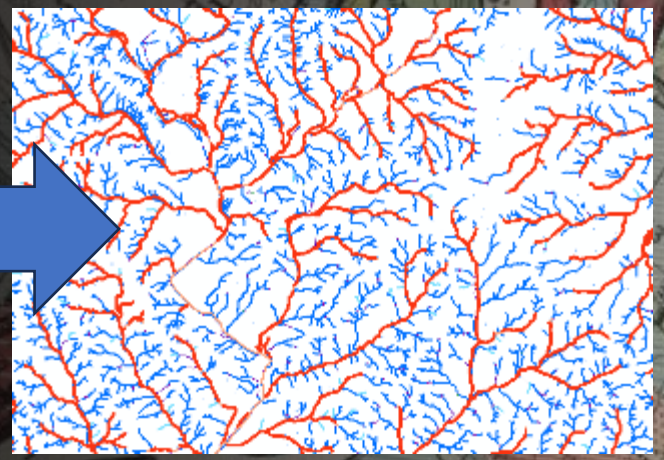
Collecting and Using Better Landscape Data: Streams

Old NHD

New EDH



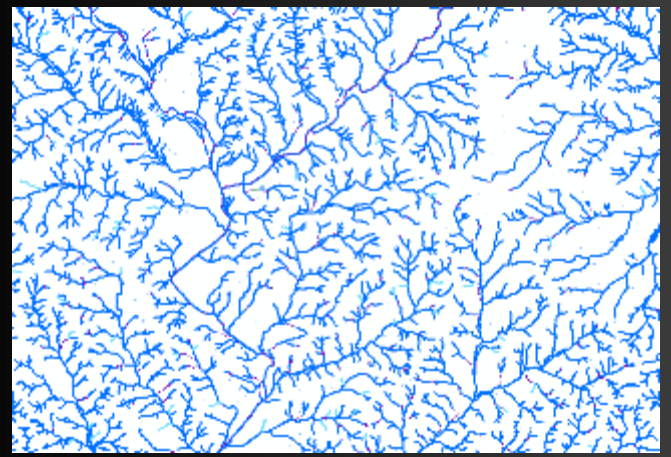
Better Stream Network



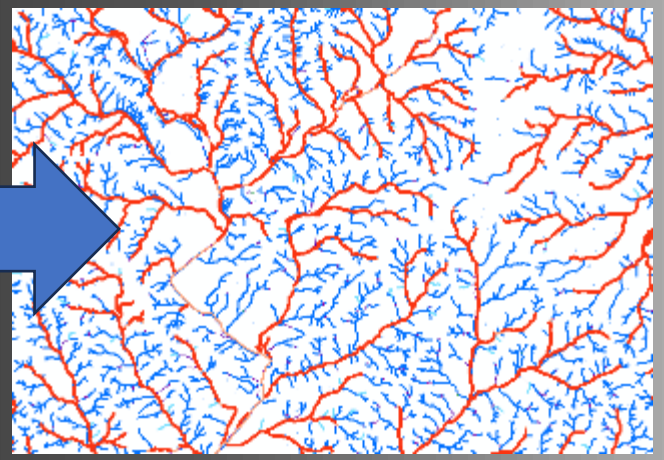
Collecting and Using Better Landscape Data: Streams

Old NHD

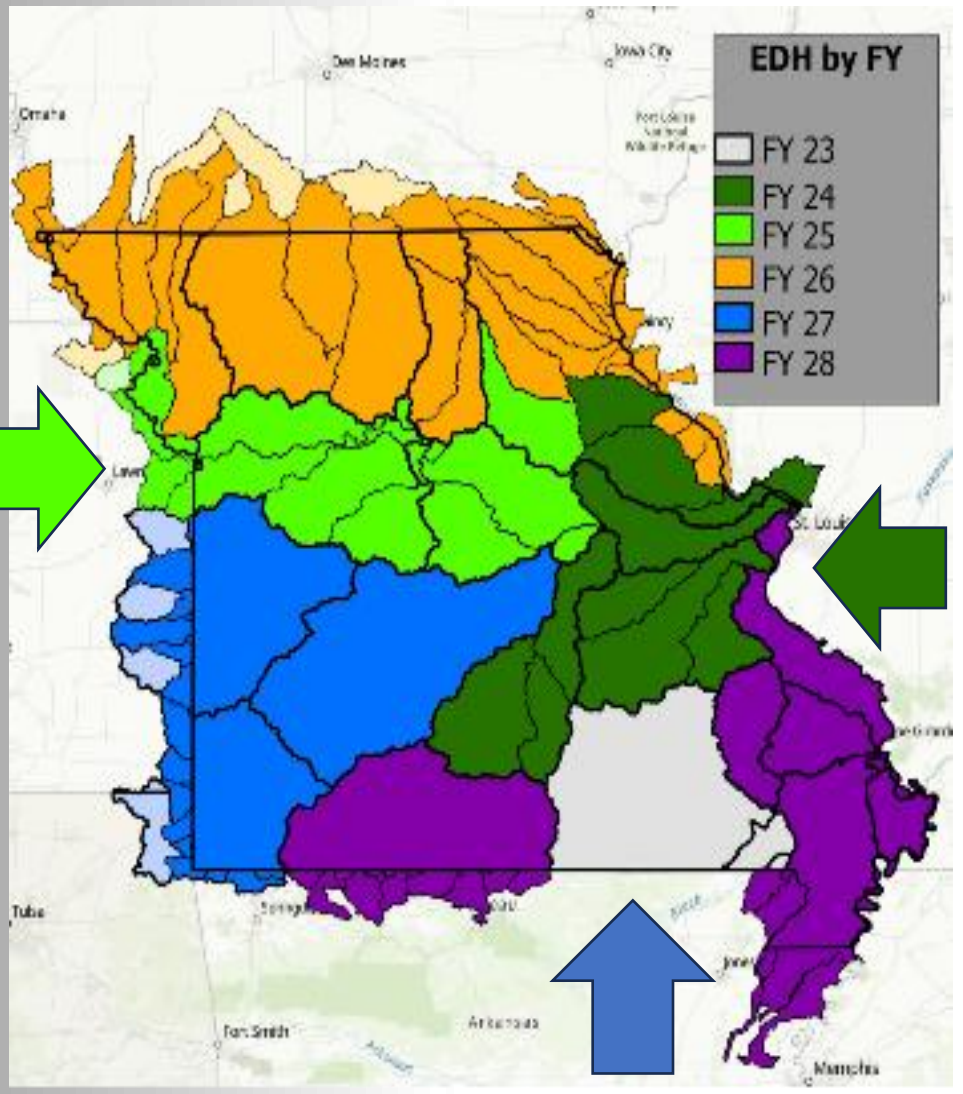
New EDH



Better Stream Network



Chipping our way around the state with stream networks



Collecting and Using Better Landscape Data: Wetlands

Mapping Embedded Habitats:

- Budgeted for FY24, this fall
- Preliminary pilot work in Bee Fork Watershed
- Leaf-off Imagery shows saturated soils

NWI

National Wetlands Inventory

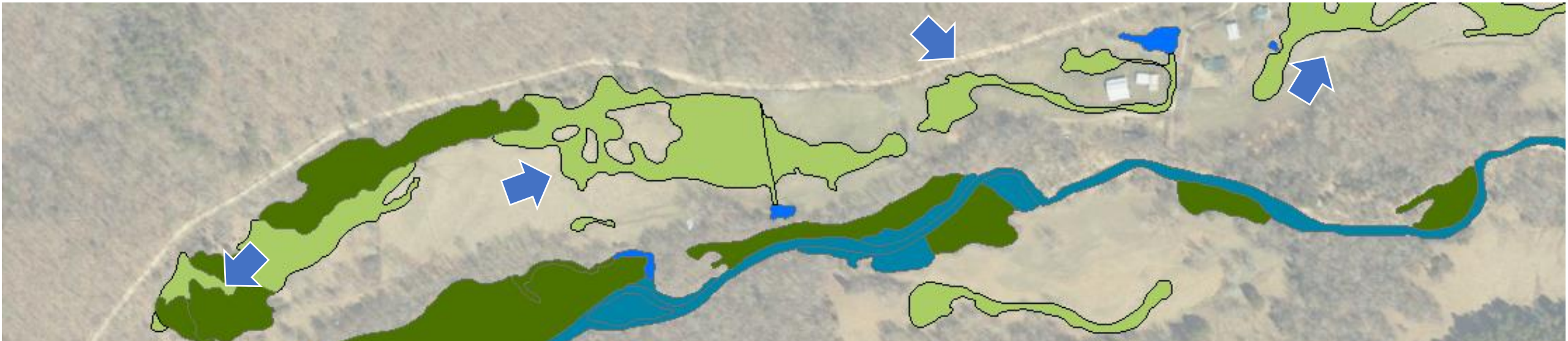
Collecting and Using Better Landscape Data: Wetlands

Mapping Embedded Habitats:

- Budgeted for FY24, this fall
- Preliminary pilot work in Bee Fork Watershed
- Leaf-off Imagery shows saturated soils
- Chipping our way around the state 5 yrs

NWI

National Wetlands Inventory



Hydrologic Interactions: Plants to Benefit WQ

Forested

Riparian Buffers

Restoring Native

Aquatic Plants

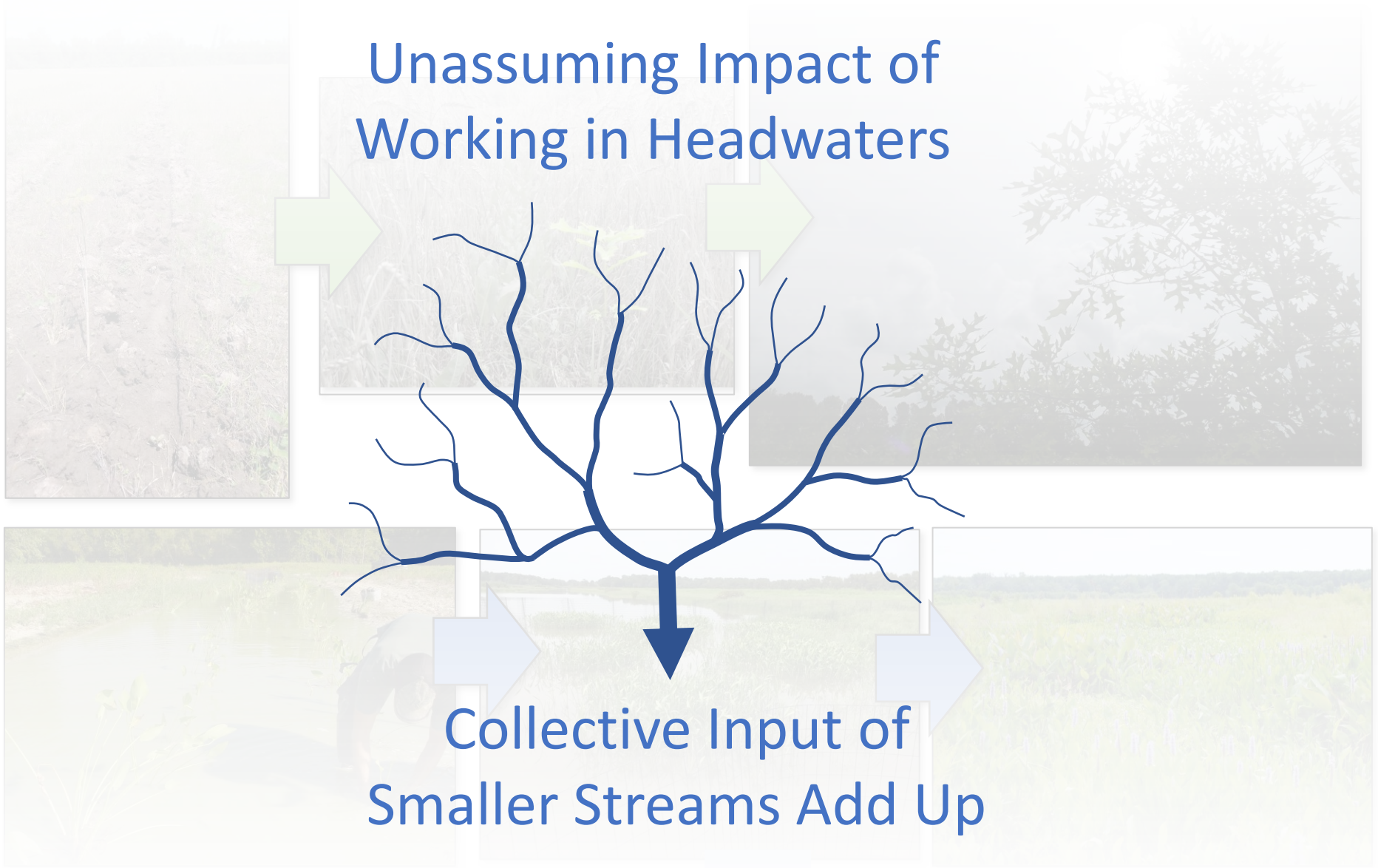
Hydrologic Interactions: Plants to Benefit WQ

Forested

Riparian Buffers

Restoring Native

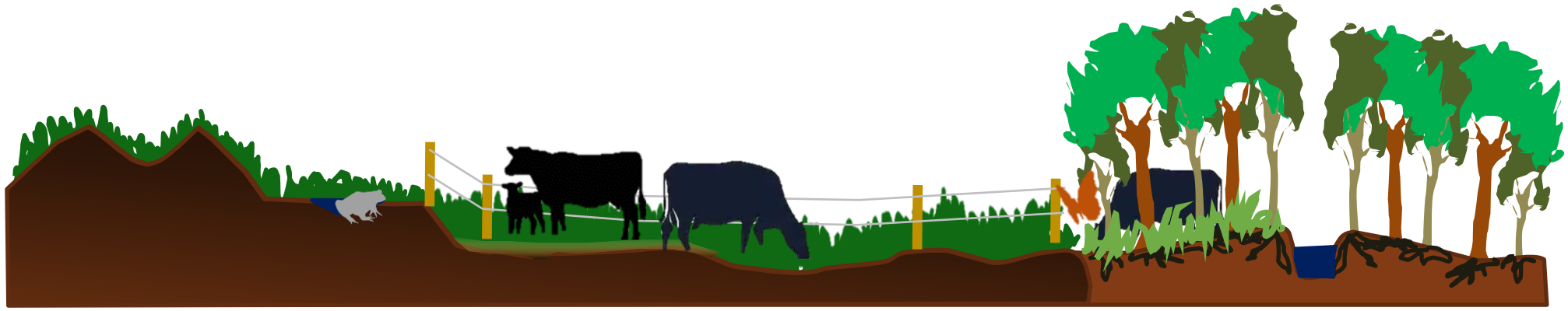
Aquatic Plants



Welcome/Mimic Critter Contributions

Shifting the mindset from maximization to sustainable integration

- Rotational Grazing: Mimicking Bison
  - Fencing out riparian corridors/sensitive habitats
  - Mixed species plantings/Pollinator plots
  - Periodic fallow paddocks for structural diversity and wildlife
  - Alternative water sources

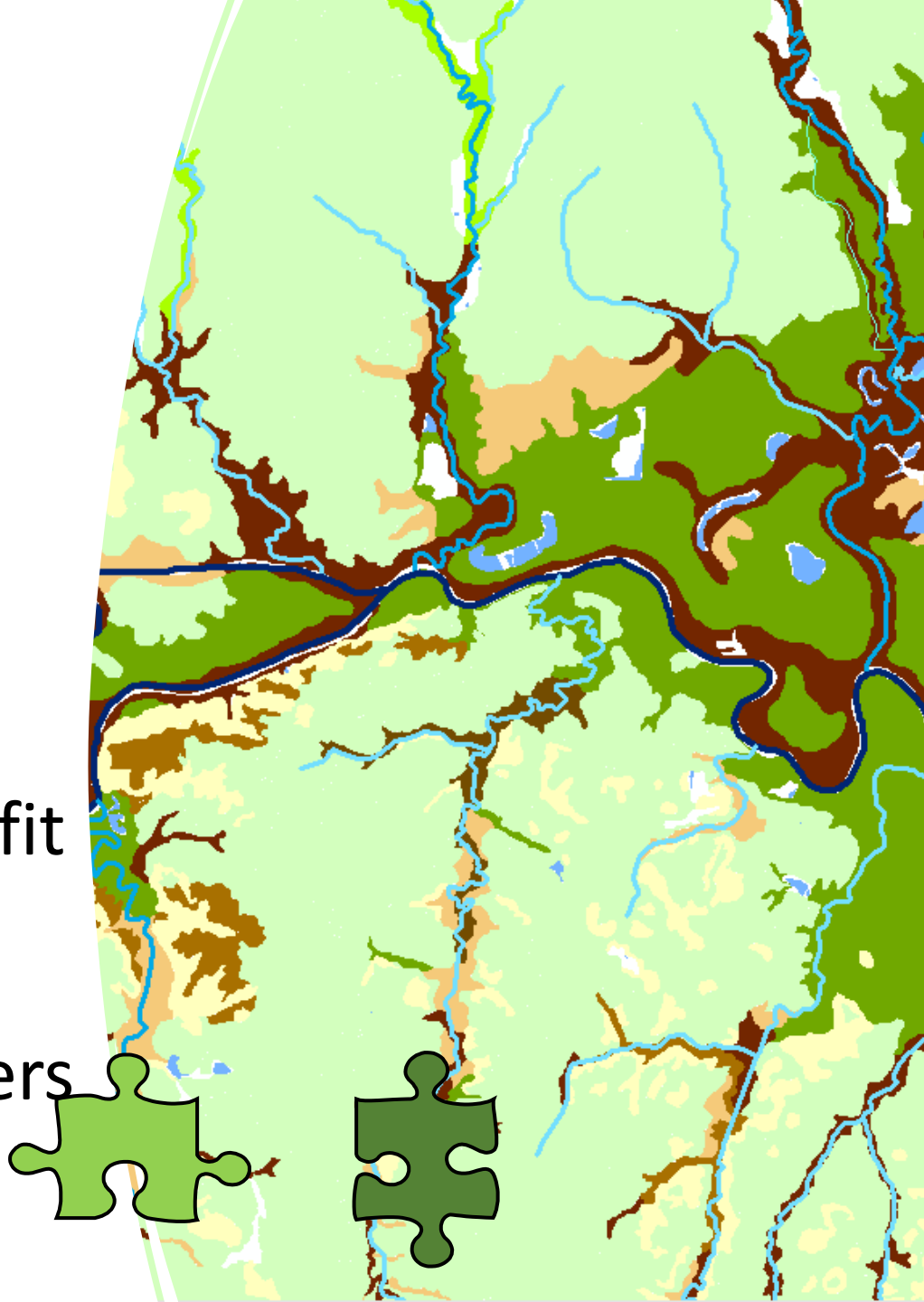


Integrating Habitat Adjacency and Interactions

Bundling Farm Bill Programs

- Potential Considerations
  - Extra points if prairie work benefits adjacent stream project or wetland easement
  - Priority if private land actions benefit public ground downstream
  - Incentive for neighboring landowners to sign-up together

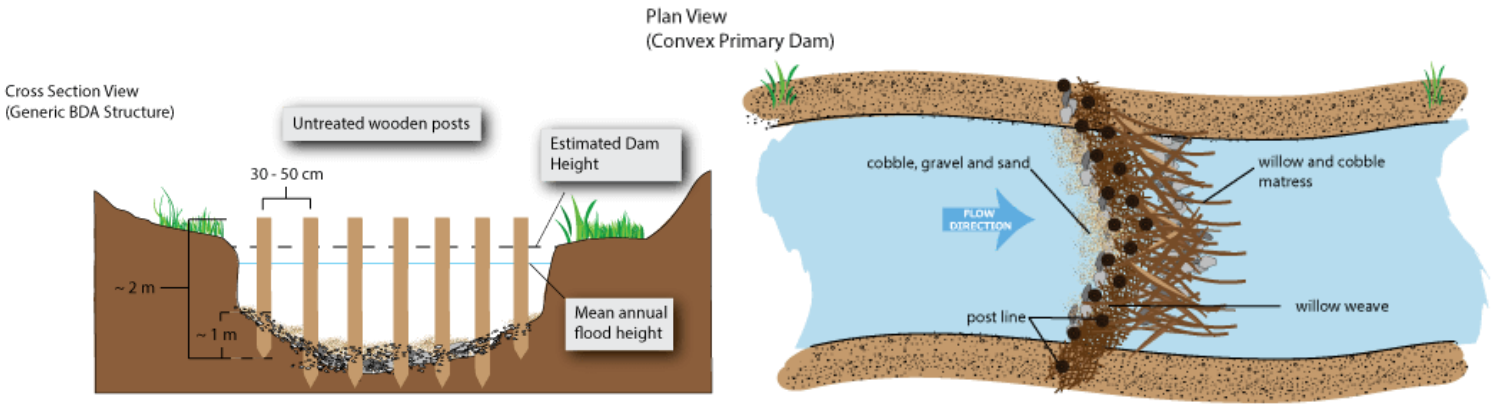
…bigger bang for your buck



Welcome/Mimic Critter Contributions: Headwaters

In headwaters where infrastructure is minimal

- **<u>Beaver Dam Analog (BDA):</u>** Low-cost structures that replicates beaver dam and encourages beaver activity



Welcome Critter Contributions: Urban Setting

Provide space for natural communities in built environments

Wet prairie and beaver complex used as green infrastructure to decrease flooding downstream and improve water quality

Osage Park, Bentonville AR

[OSAGE PARK | Ecological Design Group (ecologicaldg.com)]

Integrate Grey with Blue and Green Solutions

- Incorporating Nature Based Solutions with Native Plants:

https://www.ky3.com/content/news/New-storm-drain-coming-for-Fassnight-Creek-canal-near-Springfield-Art-Museum-570614301.html

Integrate Grey with Blue and Green Solutions

- Incorporating Nature Based Solutions with Native Plants

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Where Prairie and Water Meet:

A lot goes on at this intersection

Now and into the future we must be purposeful
to reconnect and maintain these interactions