Practical Approaches to Climate Resilience in Reclamation Projects

American Society of Reclamation Sciences 42nd Annual Meeting
Butte, MT
June 2025

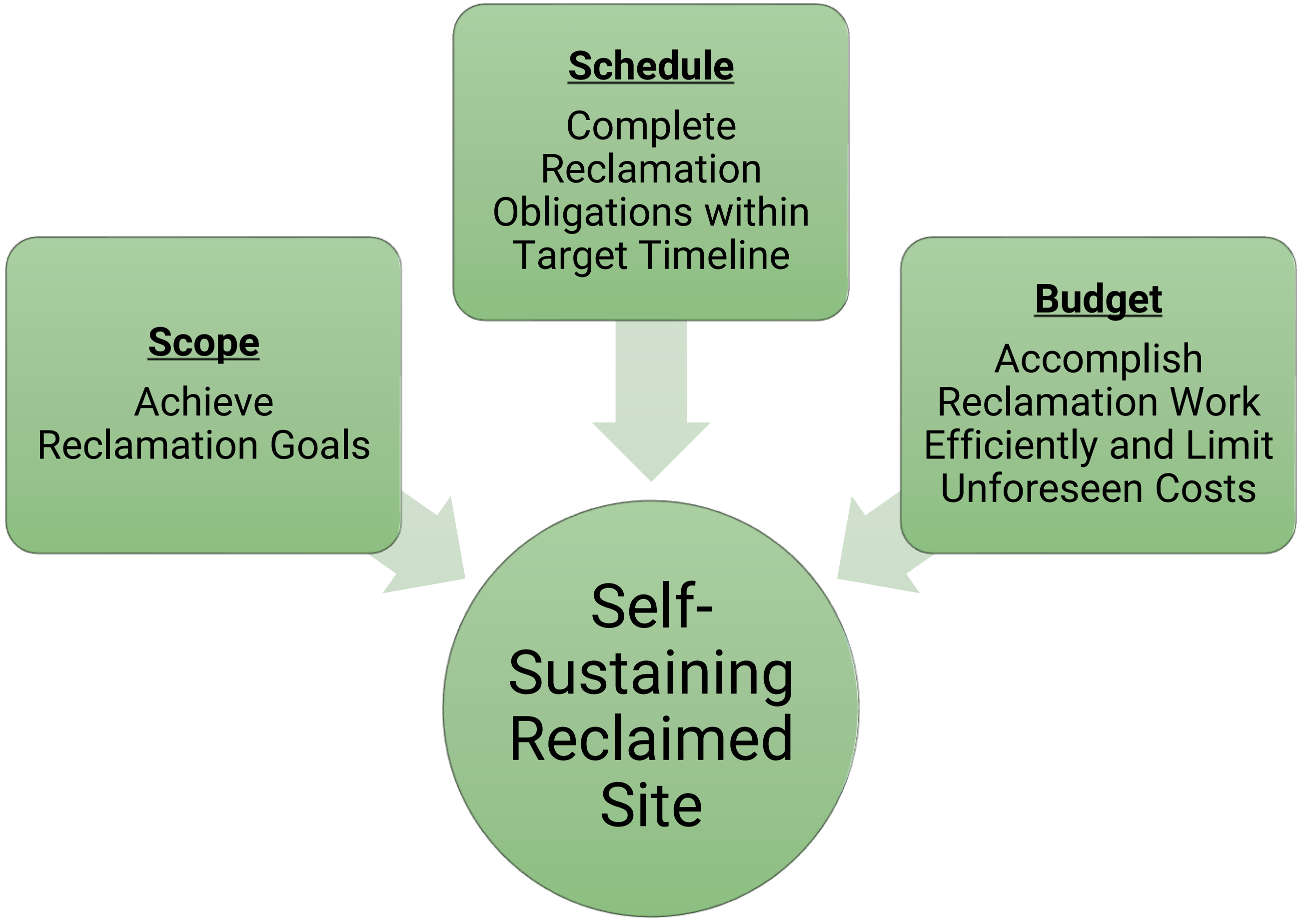
KC HARVEY ENVIRONMENTAL

Agenda

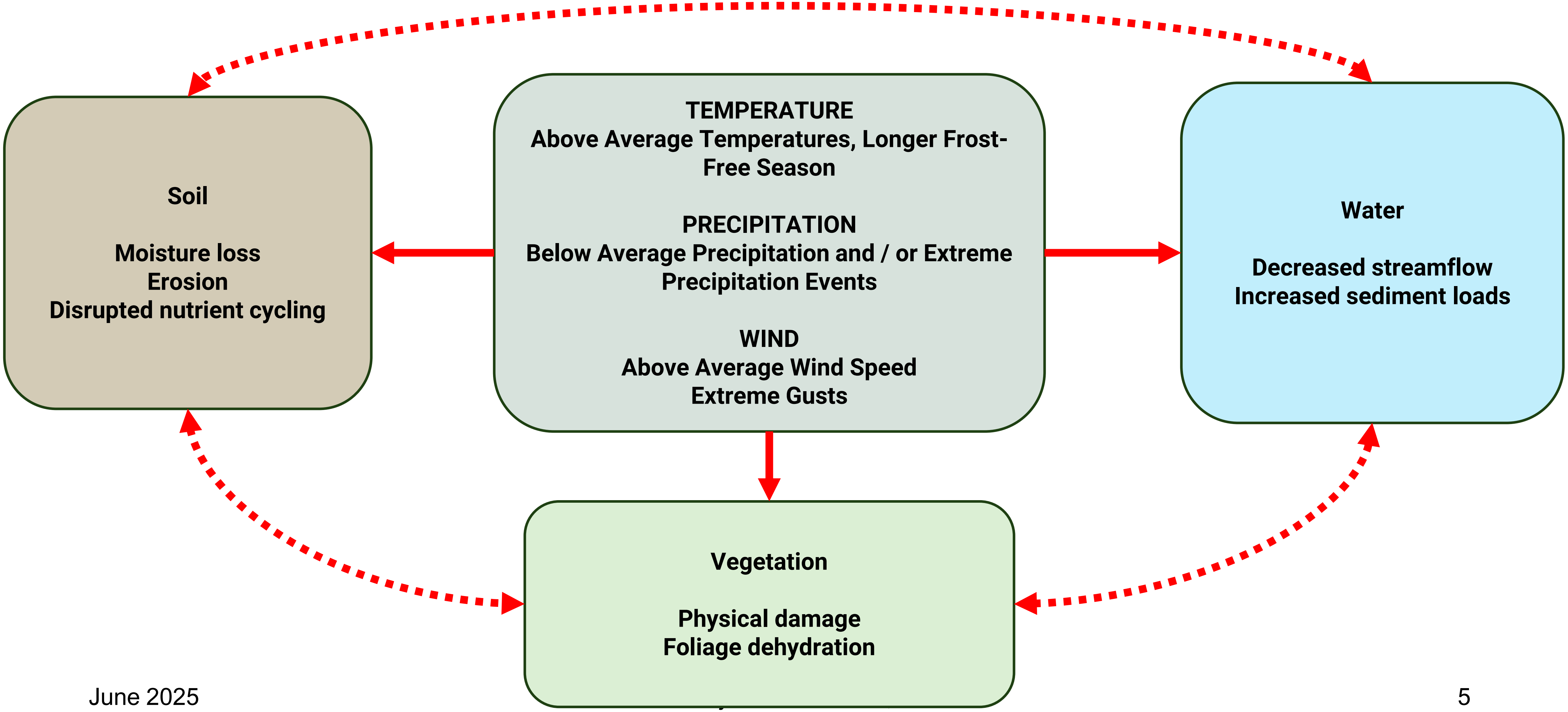
- Drivers for Building Climate Resilience into Reclamation Projects
- Soils
- Water
- Vegetation
- Planning Tools and References

Drivers for Building Climate Resilience into Projects

In a Word … Success



Weather Effects



Local Change – What Are We Adapting To?

WESTERN REGIONAL CLIMATE CENTER

Desert Research Institute

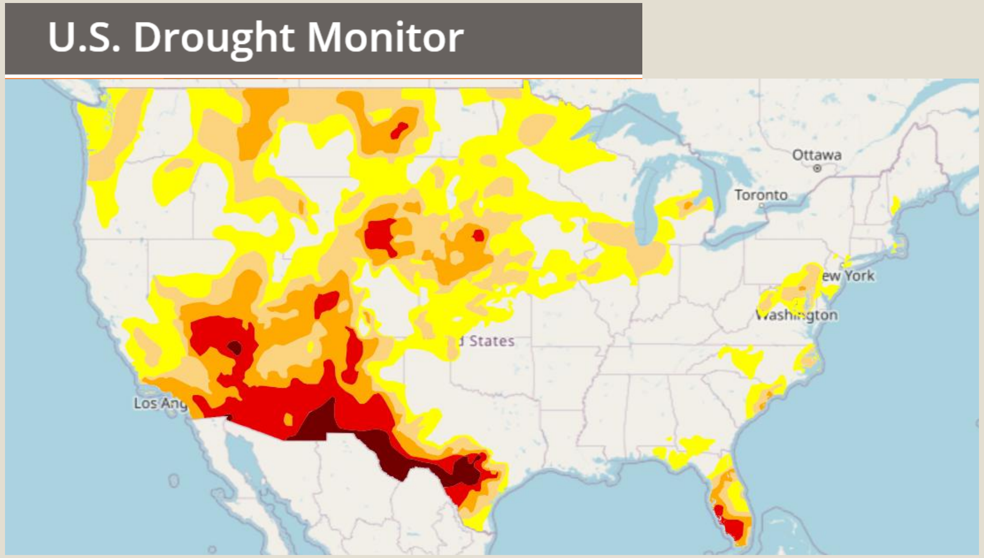
NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION

Terminology

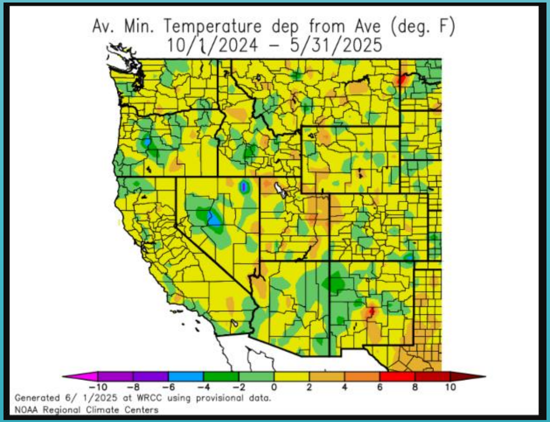
Climate: Average weather conditions over the long term

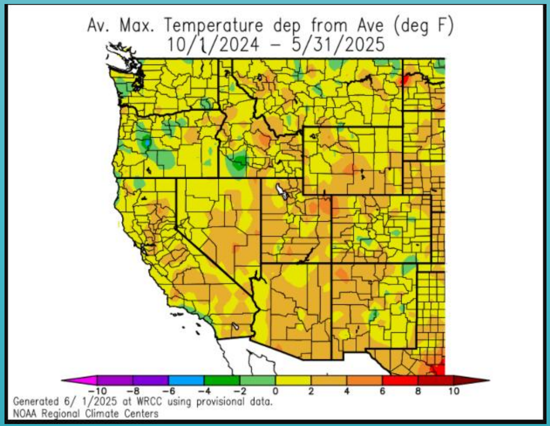
Weather: Atmospheric conditions at a specific time

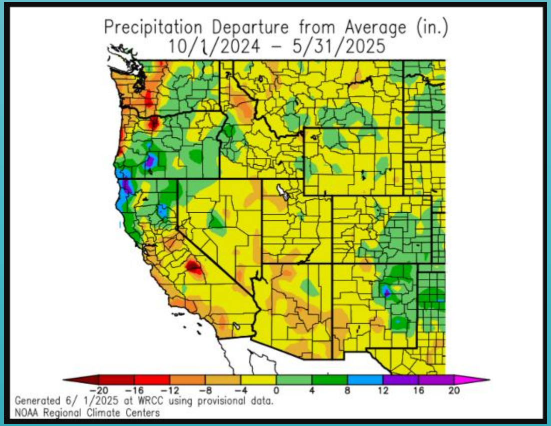
"Climate resilience" = Ability to withstand **changes in weather patterns** driven by climate change

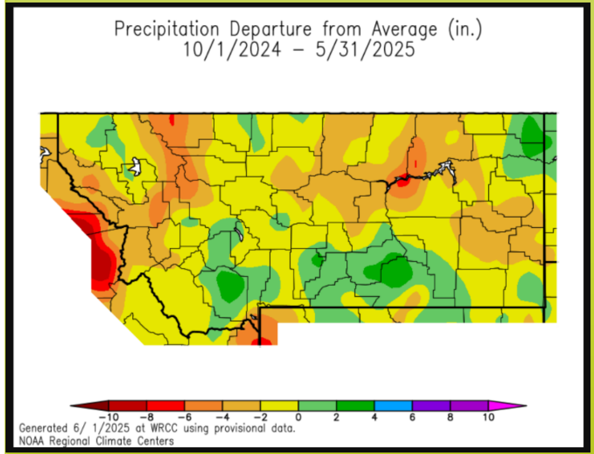


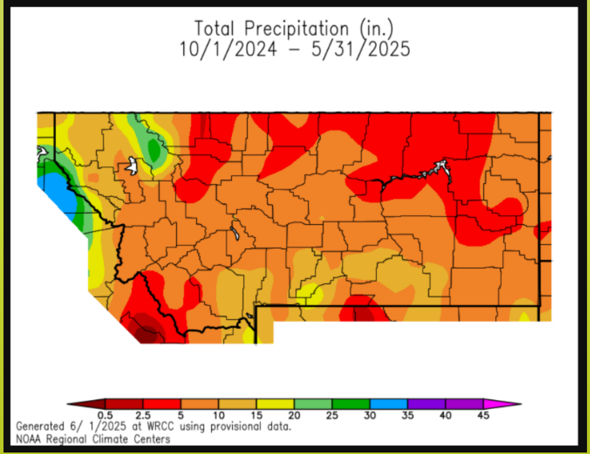
WRCC Example

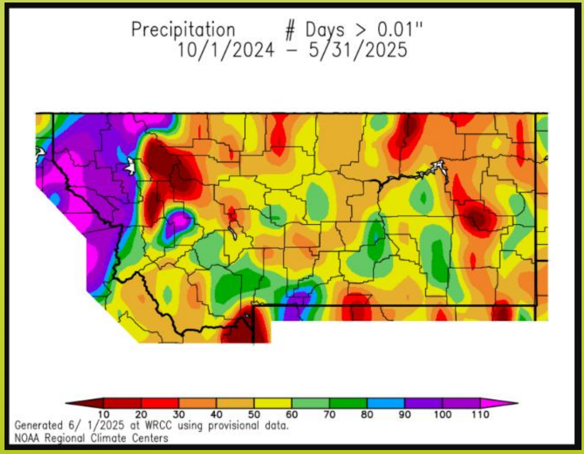


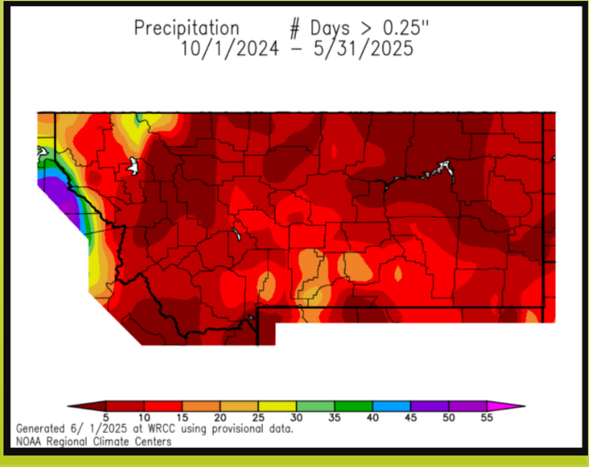




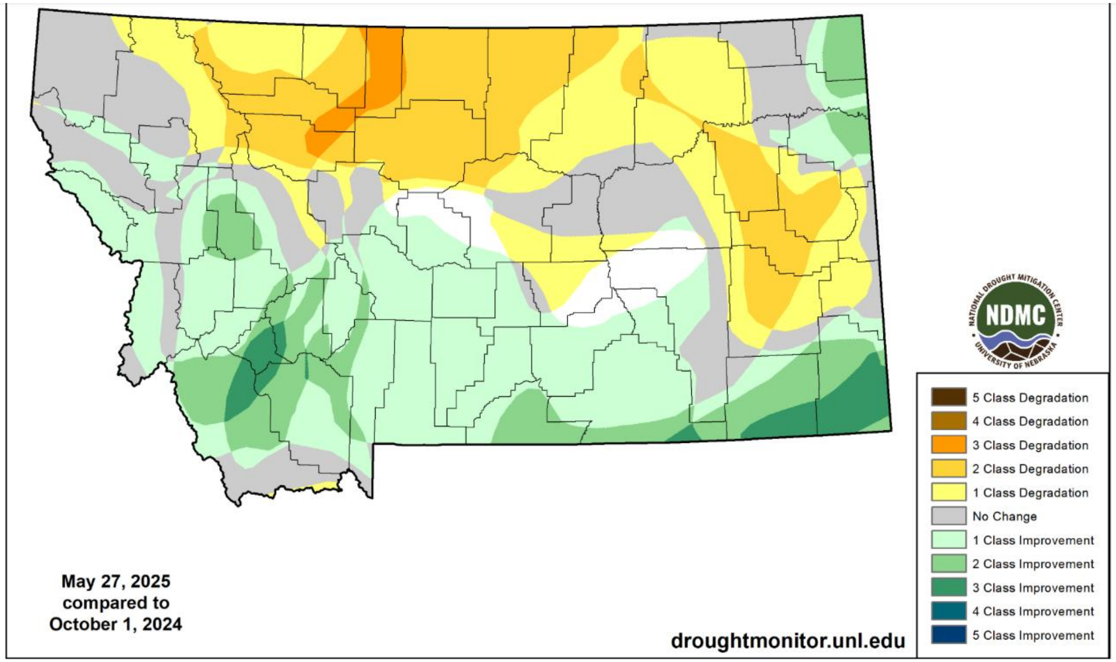




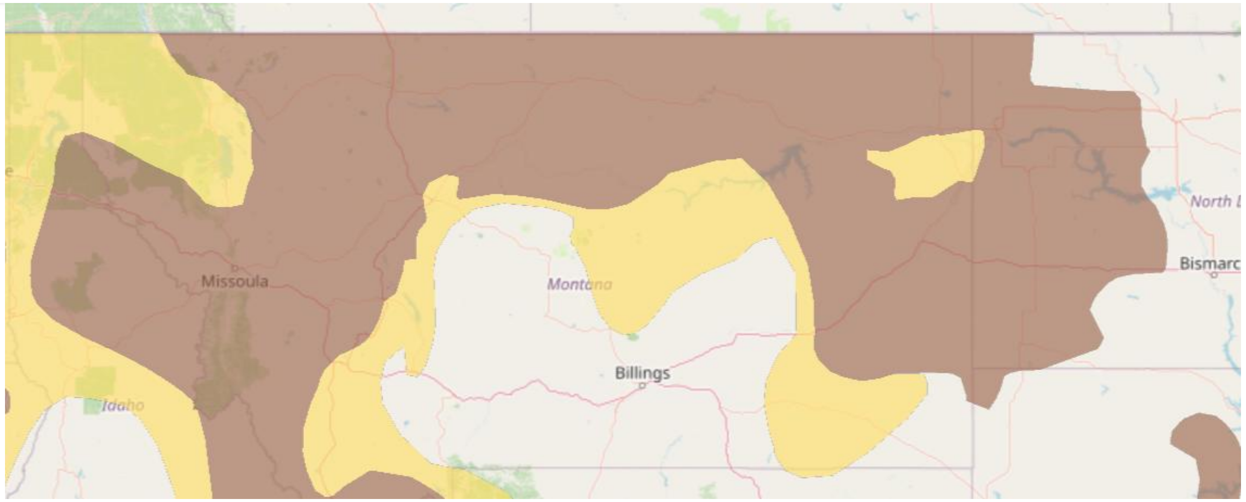




U.S. Drought Monitor Example



Water Year to Date



Seasonal Outlook

- Drought Persists
- Drought Remains but Improves
- Drought Removal Likely
- Drought Development Likely

Help to answer the key questions:
What's the current condition … and what should we be planning for?

Regulatory Drivers

Statutes, Rules, Codes, and Standards Commonly Relevant to Reclamation Projects

Federal

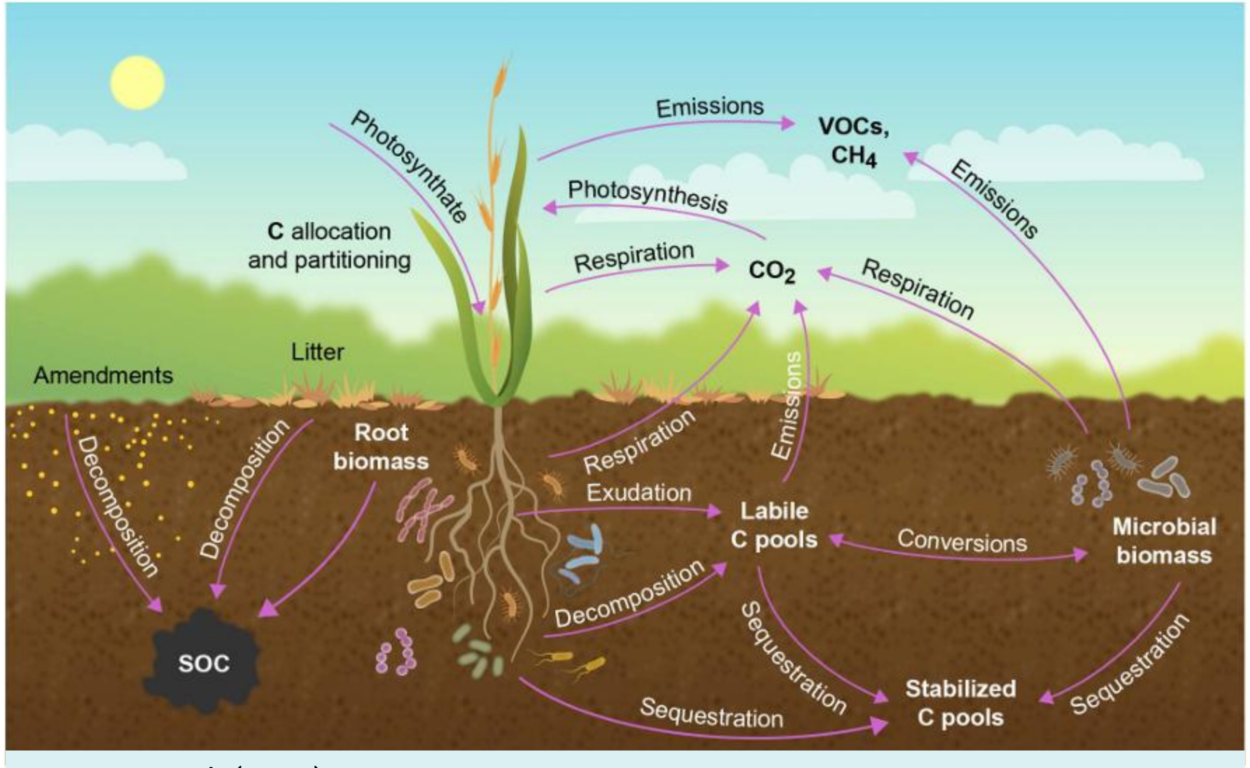
- National Environmental Policy Act
- Federal Land Policy and Management Act
- Forest Service Organic Administration Act
- Multiple-Use Sustained-Yield Act
- Forest and Rangeland Renewable Resources Planning Act
- National Forest Management Act
- Endangered Species Act
- Migratory Bird Treaty Act
- Bald and Golden Eagle Protection Act
- Clean Water Act
- Clean Air Act
- Federal Noxious Weed Act
- Federal Mining Laws
- Federal Agency Responsibilities to Federally-Recognized Tribes
- Executive Orders
- Secretarial Orders

State and Local

- Environmental Protection and Health Acts
- Water Quality Standards
- Groundwater Quality Standards
- Air Quality Rules
- Dam Safety Rules
- Surface Mining Acts
- Mined Land Reclamation Acts
- Planning and Zoning
- Flood Control
- Noxious Weed Control
- Fire Safety

Planning for Climate Resilience Either Explicitly or Implicitly Required

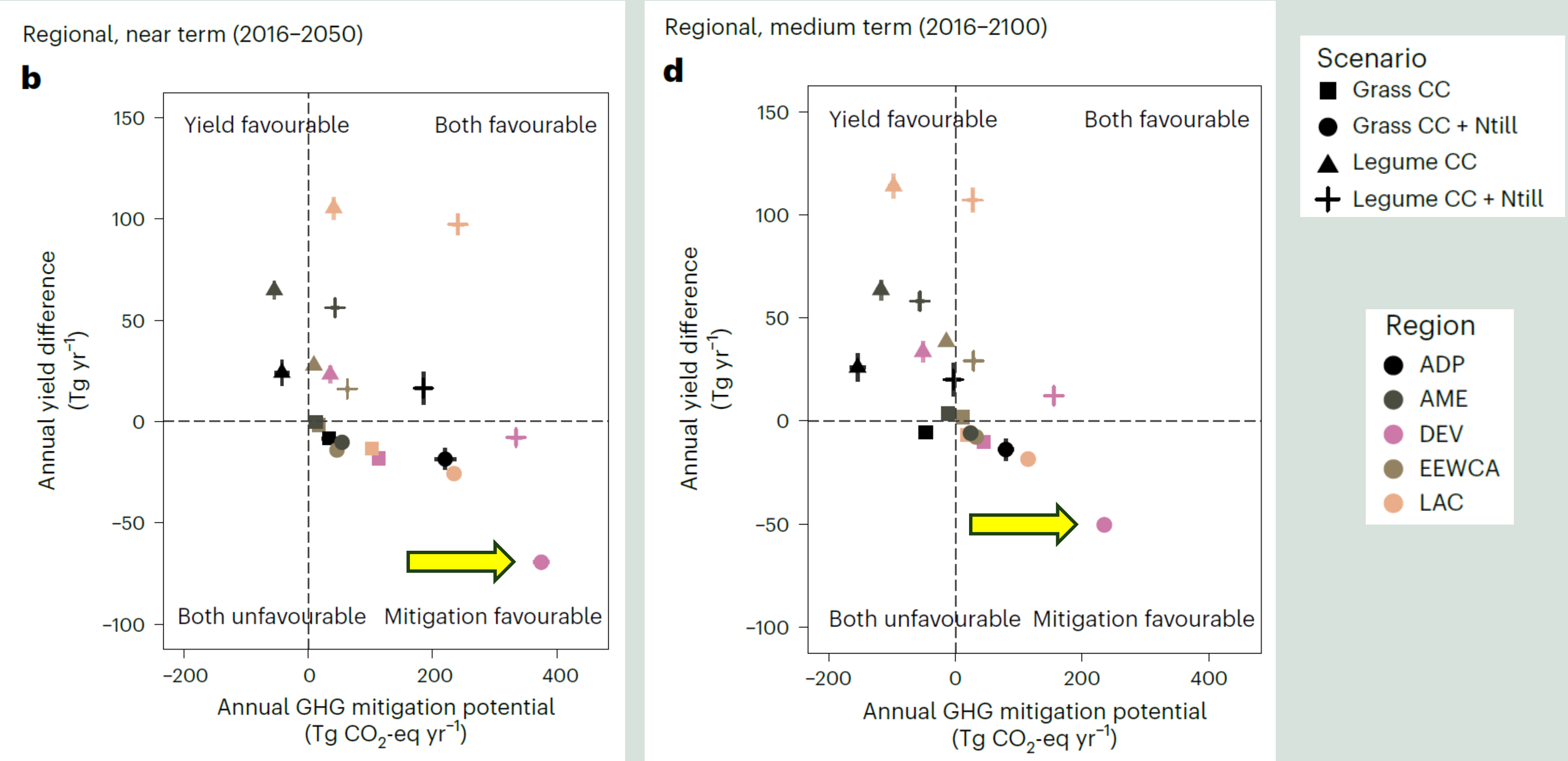
Soil Organic Carbon Sequestration



Jansson et al. (2021)

- Land-based GHG emission mitigation opportunities for reclamation sites
- Consider soil characteristics and site management needs / future land uses

Soil Organic Carbon Sequestration



McClelland et al. 2025. *Nature Climate Change*.

Soil

Soil Health

- USDA defines soil health as "*the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans*".

Key Functions of Soil:

Regulate water movement over land and to groundwater.

Provide structural support for plants.

Filter, buffer, immobilize and detoxify potential pollutants.

Cycle nutrients.

Soil Health

… To feed microbes in the rhizosphere.
… To improve water infiltration into the soil.

… To prevent disease and pest problems related to monocultures.
… To build a climate-resilient ecosystem.

Soil Management for Soil Health

Maximize the Presence of Living Roots…

Maximize Soil Cover…

Maximize Biodiversity…

Minimize Disturbance…

… To prevent soil loss due to wind and water erosion.
… To increase soil organic matter and nutrients.

… To minimize compaction and protect soil structure.
…To decrease stormwater runoff.

Minimize Disturbance?!

Minimize Soil Erosion

- **Erosion Control Measures**
  - Compost Blankets
  - Geotextiles, Matting and Netting
  - Land Grading
  - Mulching
  - Riprap
  - Permanent Seeding
  - Soil Retention
  - Soil Roughening
  - Temporary Slope Drains

USEPA National Menu of Best Management Practices (BMPs) for Stormwater (Construction and Post-Construction)

Grading + Soil Roughening + Hydroseeding + Matting

Grading + Compost Blanket + Matting

Grading + Soil Roughening + Straw Mulch

Minimize Sediment Loss

- **Sediment Control Measures**
  - Fiber Rolls
  - Filter Berms
  - Sediment Basins and Rock Dams
  - Sediment Filters and Sediment Chambers
  - Sediment Traps
  - Silt Fences
  - Storm Drain Inlet Protection
  - Straw or Hay Bales
  - Vegetated Buffers

USEPA National Menu of Best Management Practices (BMPs) for Stormwater (Construction and Post-Construction)

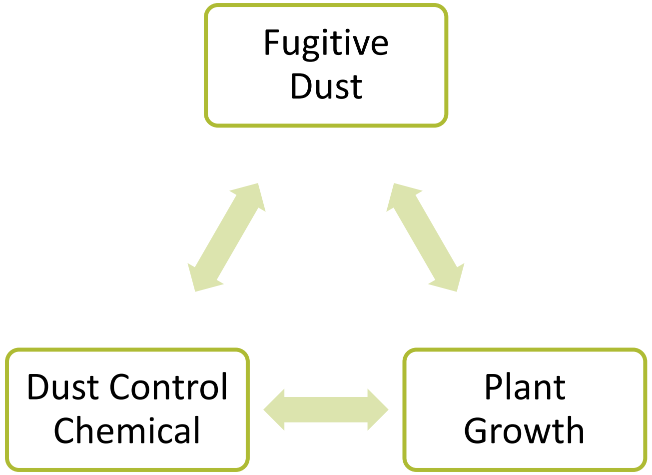
Channel + Riprap
Fiber Rolls + Matting

Channel + Matting + Riprap Check Dams
Fiber Rolls + Straw Mulch

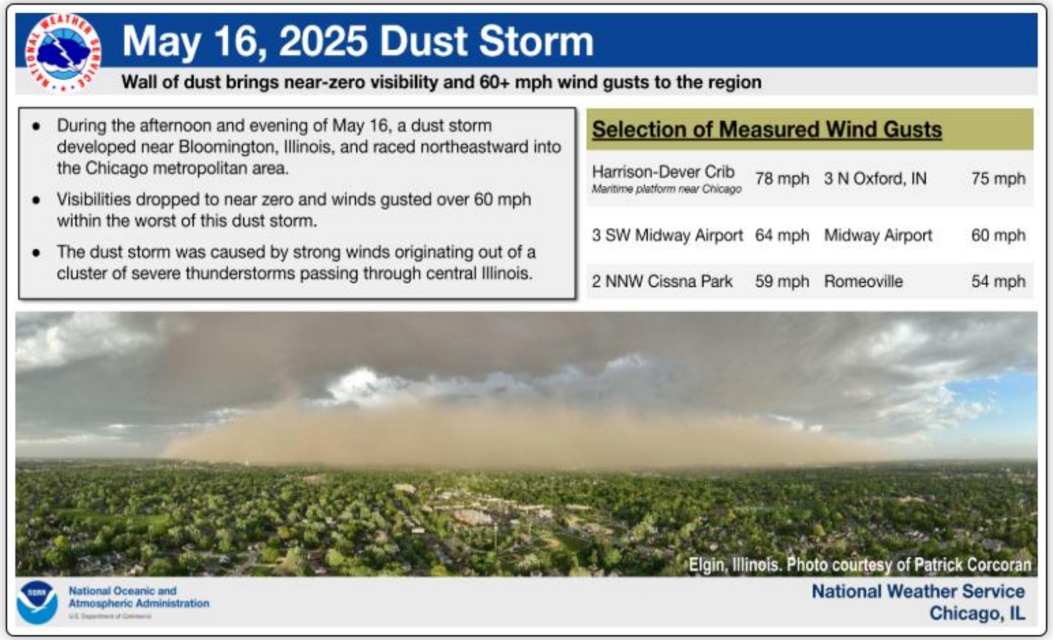
Riprap + Matting + Fiber Rolls + Silt Fencing

Minimize Fugitive Dust Emissions

- **Dust Control Measures**
  - **Revegetation areas**
  - **Site roads**



The huge Black Sunday storm — the worst storm of the decade-long Dust Bowl in the southern Plains — as it approaches Ulysses, Kansas, April 14, 1935. Daylight turned to total blackness in mid-afternoon. Sun-Times Media/Historic Adobe



Soil Health at Your Site

What type of ecosystem is the end goal?

- Restore native ecosystem
- Support other land uses (e.g. grazing)
- Develop mitigation wetlands
- Vegetative cover for evapotranspiration

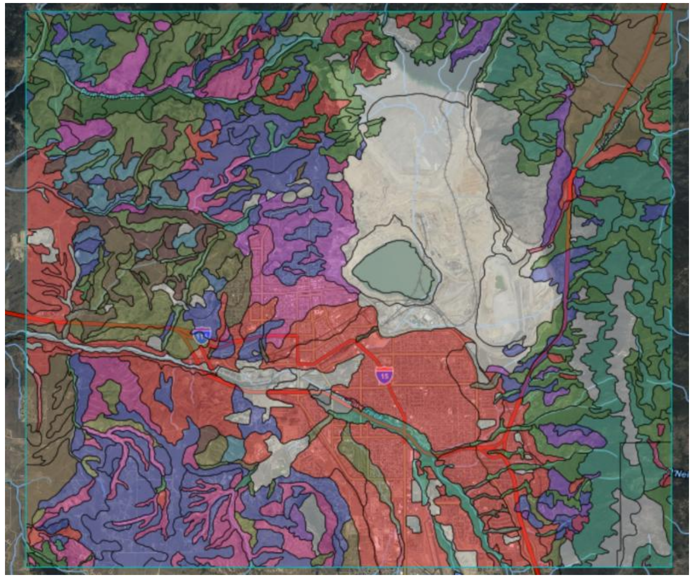
→ Plant species / Animal habitat

→ Requirements for healthy soil to support these

Soil Types

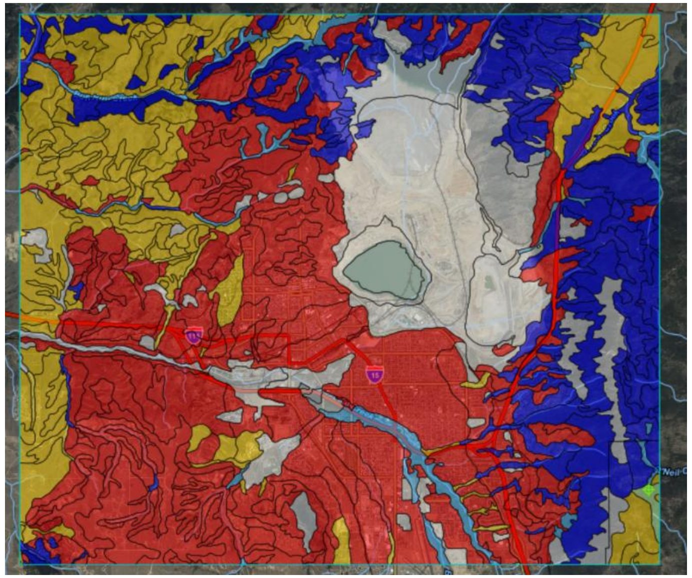
USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey



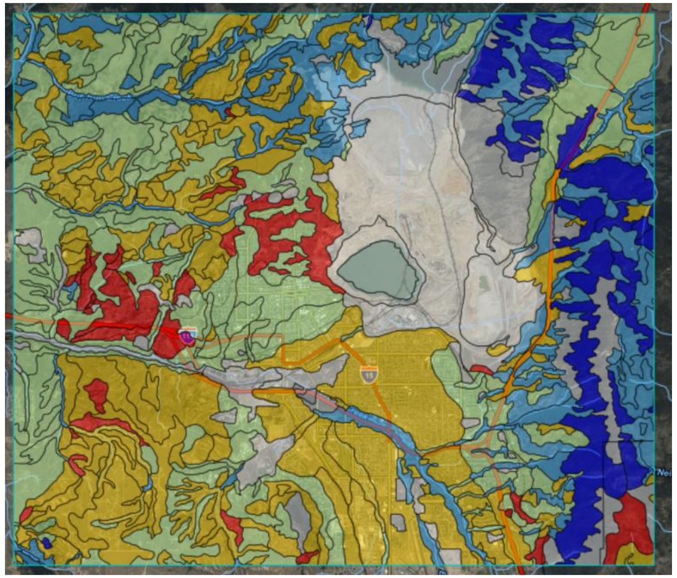
Texture

- Ashy loam
- Ashy sandy loam
- Channery loam
- Clay loam
- Coarse sandy loam
- Cobbly ashy sandy loam
- Gravelly ashy loam
- Gravelly coarse sandy loam
- Gravelly loam
- Gravelly loamy coarse sand
- Gravelly loamy sand
- Gravelly sandy loam
- Loam
- Moderately decomposed plant material
- Mucky peat
- Sandy loam
- Slightly decomposed plant material
- Stony coarse sandy loam
- Very channery sandy loam
- Very cobbly ashy loam
- Very gravelly sandy loam
- Not rated or not available



Organic Matter (%)

- <= 2.50
- > 2.50 and <= 4.00
- > 4.00 and <= 50.00
- > 50.00 and <= 70.00
- > 70.00 and <= 75.00
- Not rated or not available



Available Water Capacity (cm/cm)

- <= 0.08
- > 0.08 and <= 0.13
- > 0.13 and <= 0.19
- > 0.19 and <= 0.30
- > 0.30 and <= 0.45
- Not rated or not available

Water

Storm Water Management

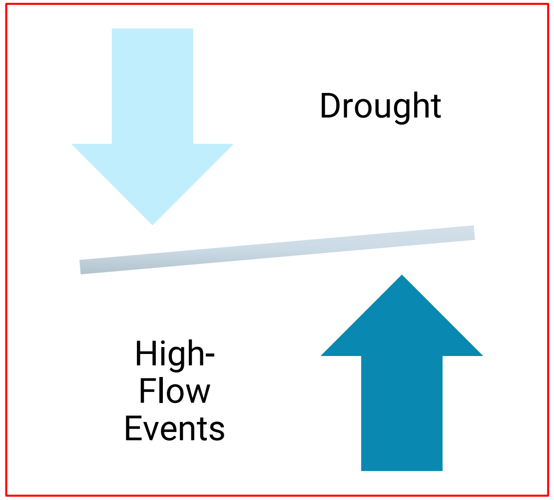
Runoff control measures for resilience to high-flow events include:

- Check Dams
- Grassed Swales and Channels
- Infiltration Basins
- Infiltration Trenches
- Land Grading

Detention / Retention measures for resilience to high-flow events include:

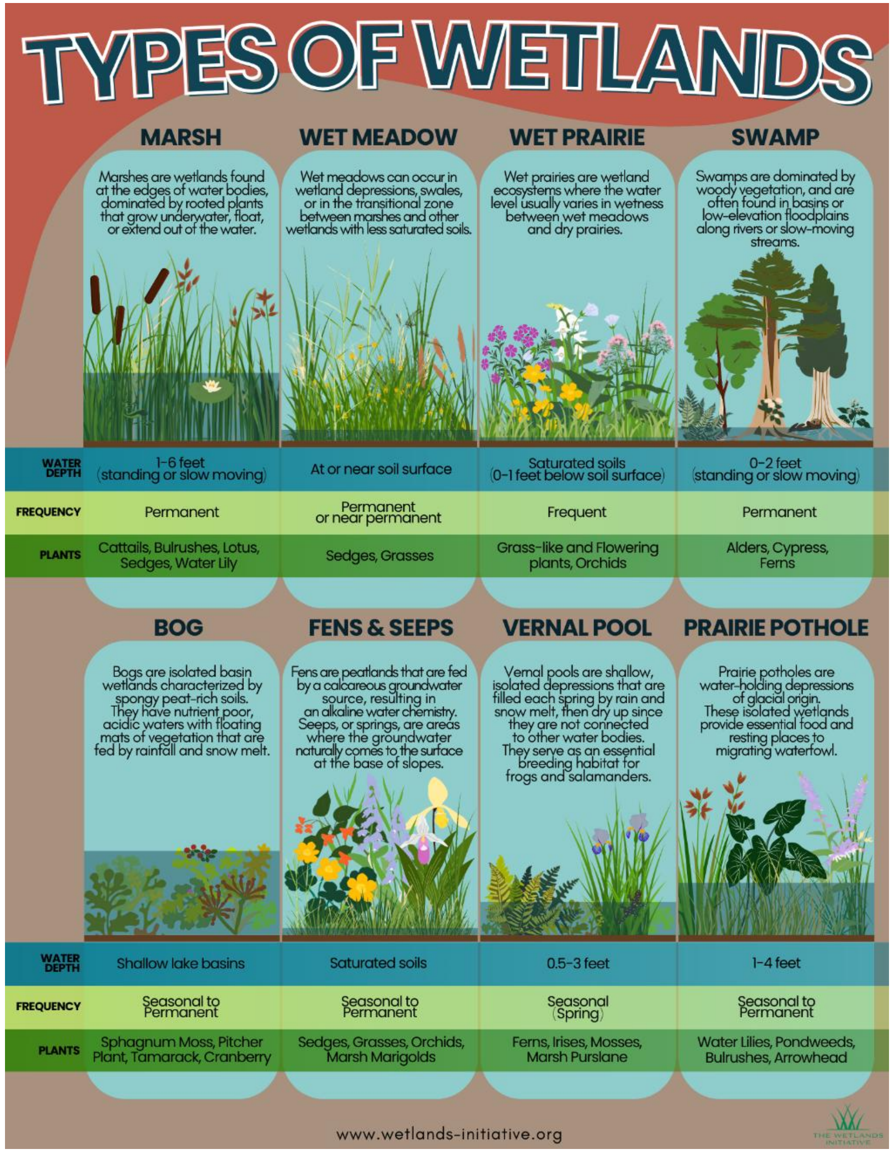
- Dry Detention Ponds
- Wet Extended Detention Ponds
- Constructed Wetlands

Retain for Onsite Use during Dry Periods

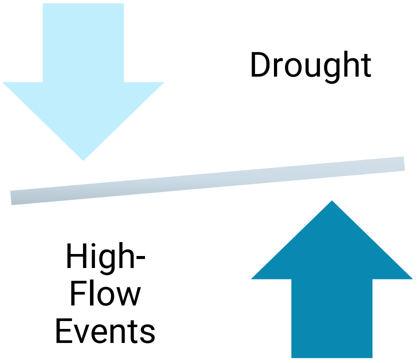


Wetlands

- **Habitat**
- **Water quality improvement**
- **Resilience to flooding**



THE WETLANDS INITIATIVE



Riparian Vegetation

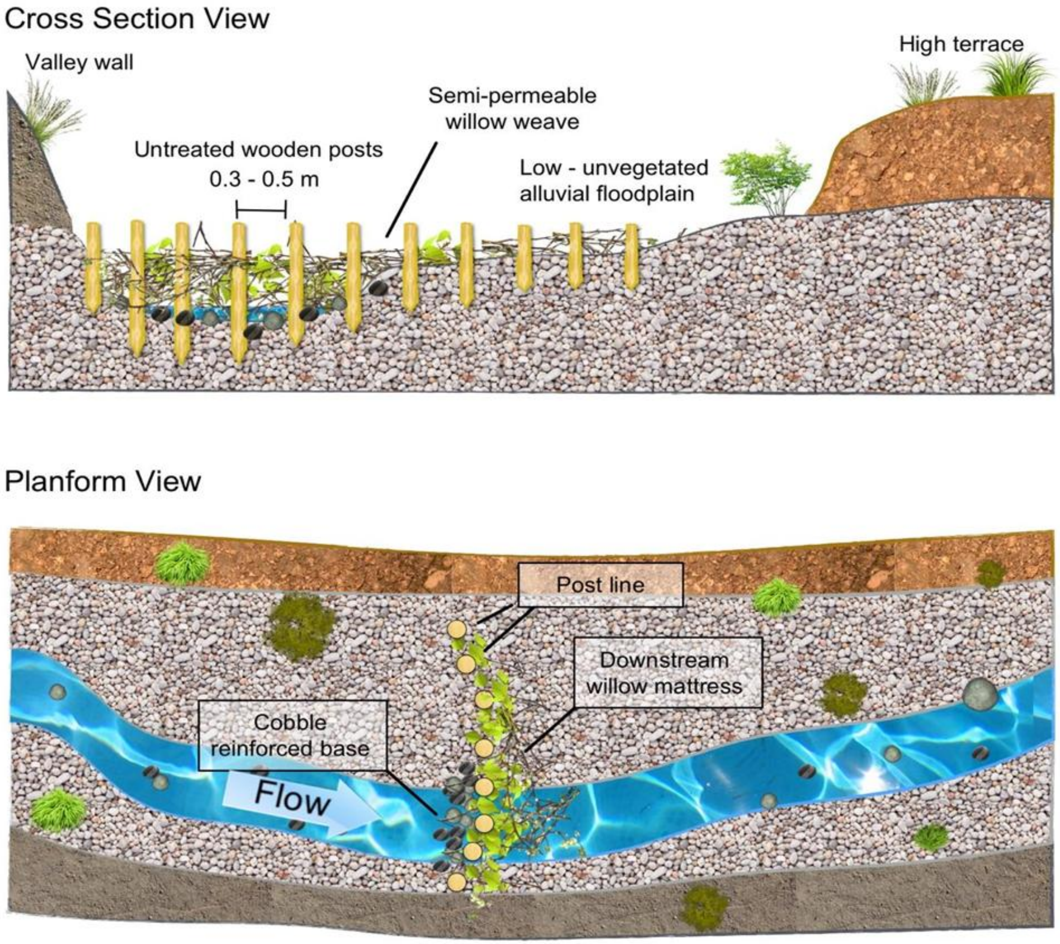
Steelhead

Chinook Salmon

Bull Trout

American Society of Landscape Architects (ASLA)

Beaver Dam Analogs



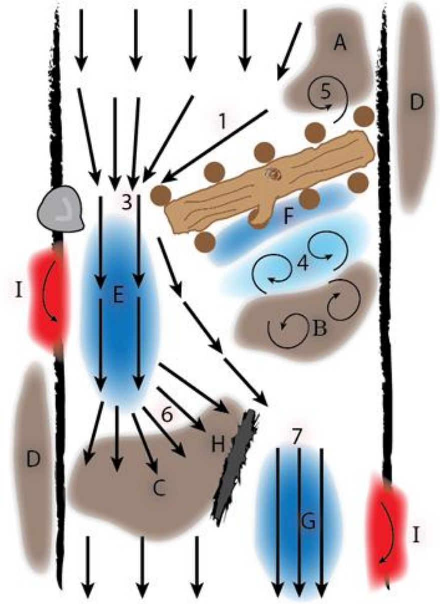
John Day River watershed, central Oregon.
Salmon habitat restoration.
Funded by Bonneville Power Administration.

Potential Improvements to:

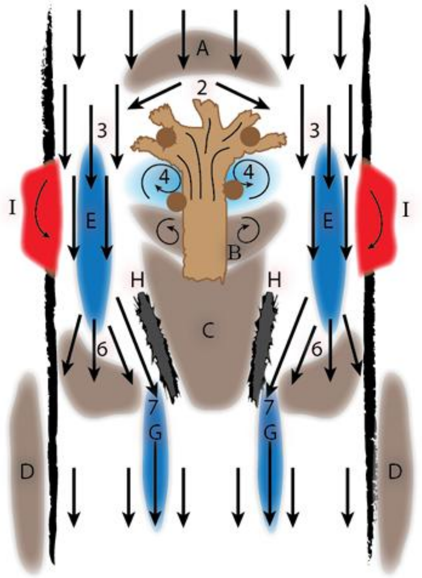
- Carbon sequestration
- Biodiversity
- Water quality
- Water temperature
- Water quantity
- Fire resiliency
- Drought resiliency
- Flood resiliency
- Erosion protection
- Fish habitat

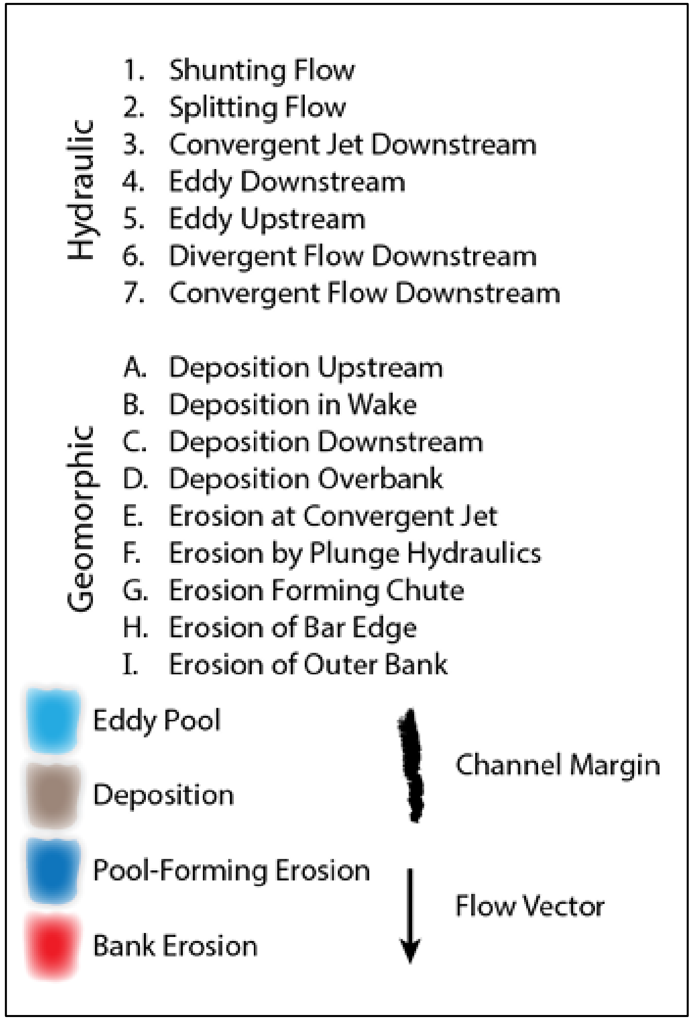
Post-Assisted Log Structures

PALS - Bank Attached



PALS - Mid Channel





Asotin Creek, southeast Washington.
Steelhead habitat restoration.
Supported by NOAA's Pacific Coastal Salmon Recovery Fund (PCSRF), Pacific States Marine Fisheries Commission (PSMFC), and Snake River Salmon Recovery Board (SRSRB).

Vegetation

granite SEED and erosion control

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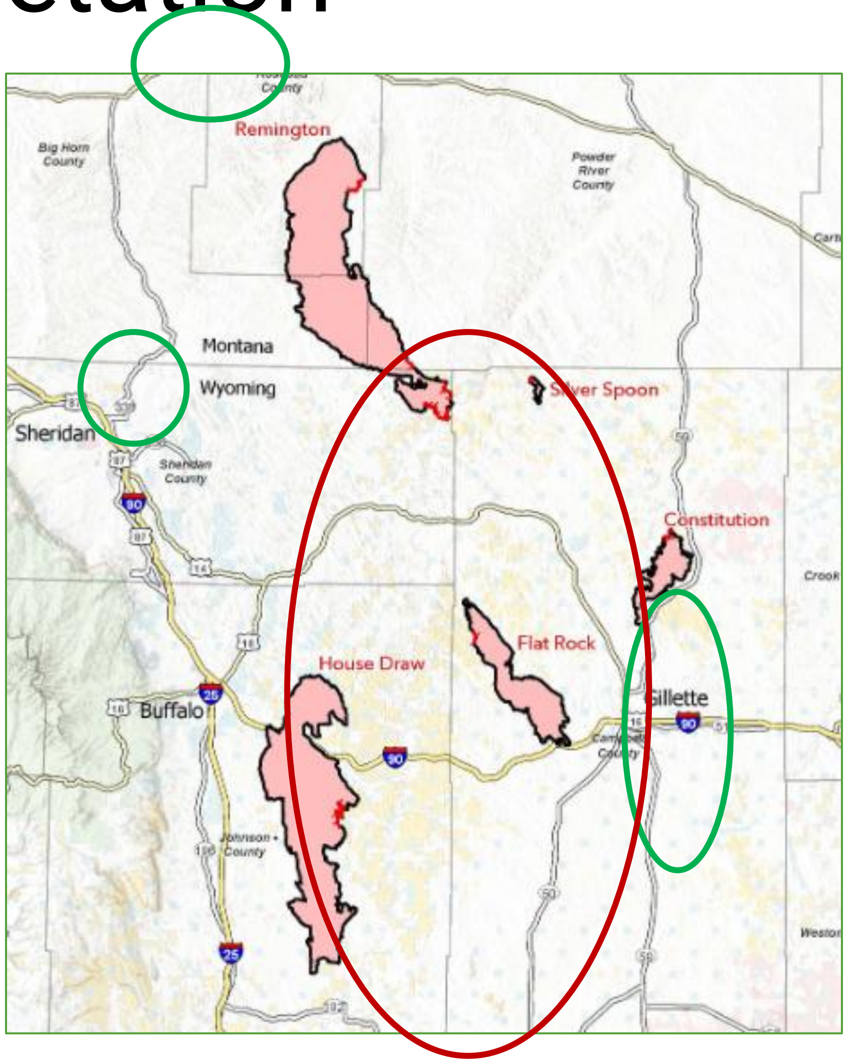
Seed Mix Design for Reclamation

- What species are we going to plant and how much of each?
- Reclamation goals supported by seed mix selection:
  - Return land to pre-disturbance land uses
  - Re-establish resilient, productive ecosystems
  - Meet regulatory standards
- Success depends on selecting species suited to site conditions and long-term resilience

Common Name	Scientific Name	Seeds/lb	Seeding Rate (PLS lbs/acre)	Seeds/ft^2	Percent of Seed Mix
Thickspike wheatgrass	*Elymus lanceolatus*	154,000	7.0	24.7	12.1%
Slender wheatgrass	*Elymus trachycaulus*	159,000	8.0	29.2	14.2%
Rough bentgrass	*Agrostis scabra*	113,000	0.1	0.3	0.1%
Mountain brome	*Bromus marginatus*	64,000	9.0	13.2	6.4%
Canada wildrye	*Elymus canadensis*	115,000	7.0	18.5	9.0%
Idaho fescue	*Festuca idahoensis*	450,000	2.0	20.7	10.1%
Annual ryegrass	*Lolium multiflorum*	227,000	8.0	41.7	20.3%
Canby bluegrass	*Poa secunda ssp. Canbyi*	926,000	2.0	42.5	20.7%
Yarrow	*Achillea millefolium*	2,770,000	0.1	6.4	3.1%
Lewis flax	*Linum lewisii*	170,000	1.0	3.9	1.9%
Silverleaf lupine	*Lupinus argenteus*	18,300	10.0	4.2	2.0%
		Total	**54.20**	**205.2**	**100%**

Climate Impacts to Revegetation

- Changing temperature and precipitation patterns affect seed germination and survival.
- Extreme weather events can disrupt early establishment.
- Long-term climate shifts may render traditional reclamation species less effective.
- Changing fire regimes to large, fast-moving fires

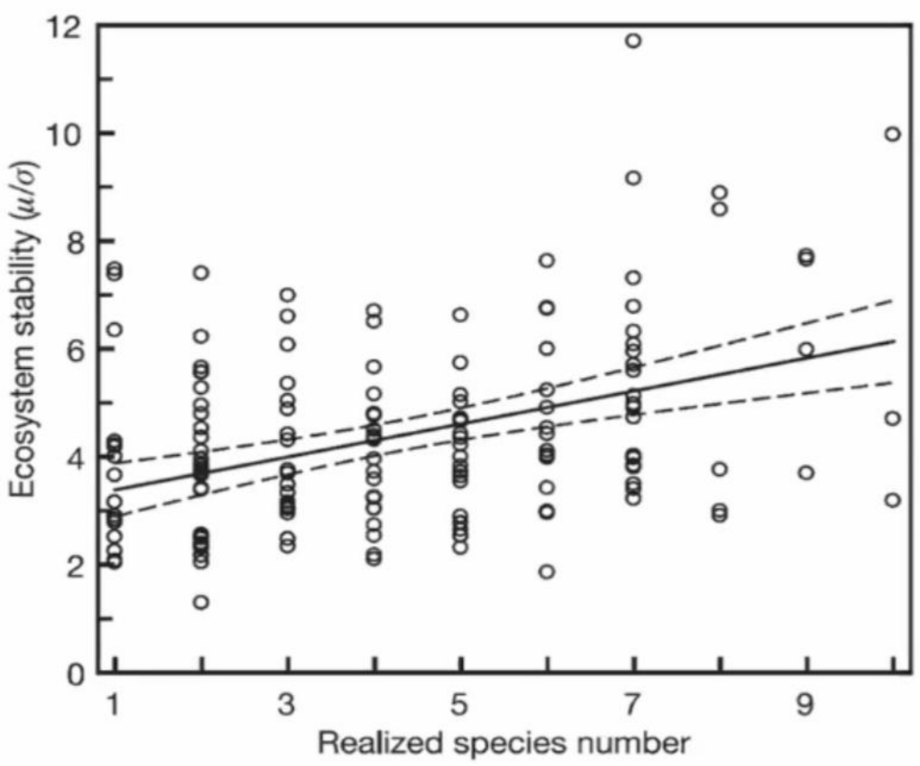


Challenges in the Commercial Seed Industry

- Native species often have narrow and unpredictable windows for seed maturation, which vary by region and year
- Early/late frosts affecting seed viability – both native and cultivated species
- Native species collection permits are difficult to acquire.
- Access and/or collection volume restrictions in harvest areas
- Requirements for species which are not commercially available
  - Low commercial incentive to grow species in low demand
- Seed mixes are often designed years or decades in advance of projects and do not build in flexibility
- Commercial availability and cost variable year to year

Reclamation Considerations

- Establishing diverse plant communities is key for long-term resilience
  - Invasives
  - Drought
  - High-precipitation events
- Increases in plant diversity have been shown to drive increases in diversity other life forms (Scherber et al. 2010. *Nature)*
- Use local seed sources when possible or varieties from similar environments
- Design mix for diversity, native species, etc. BUT ALSO climate anomalies to protect soil resources, etc.
  - Consider cover crops or non-natives for immediate stability
- If wildfire is a concern, prioritize natives adapted to post-fire recovery. Faster recovery equals more resilience to invasives.



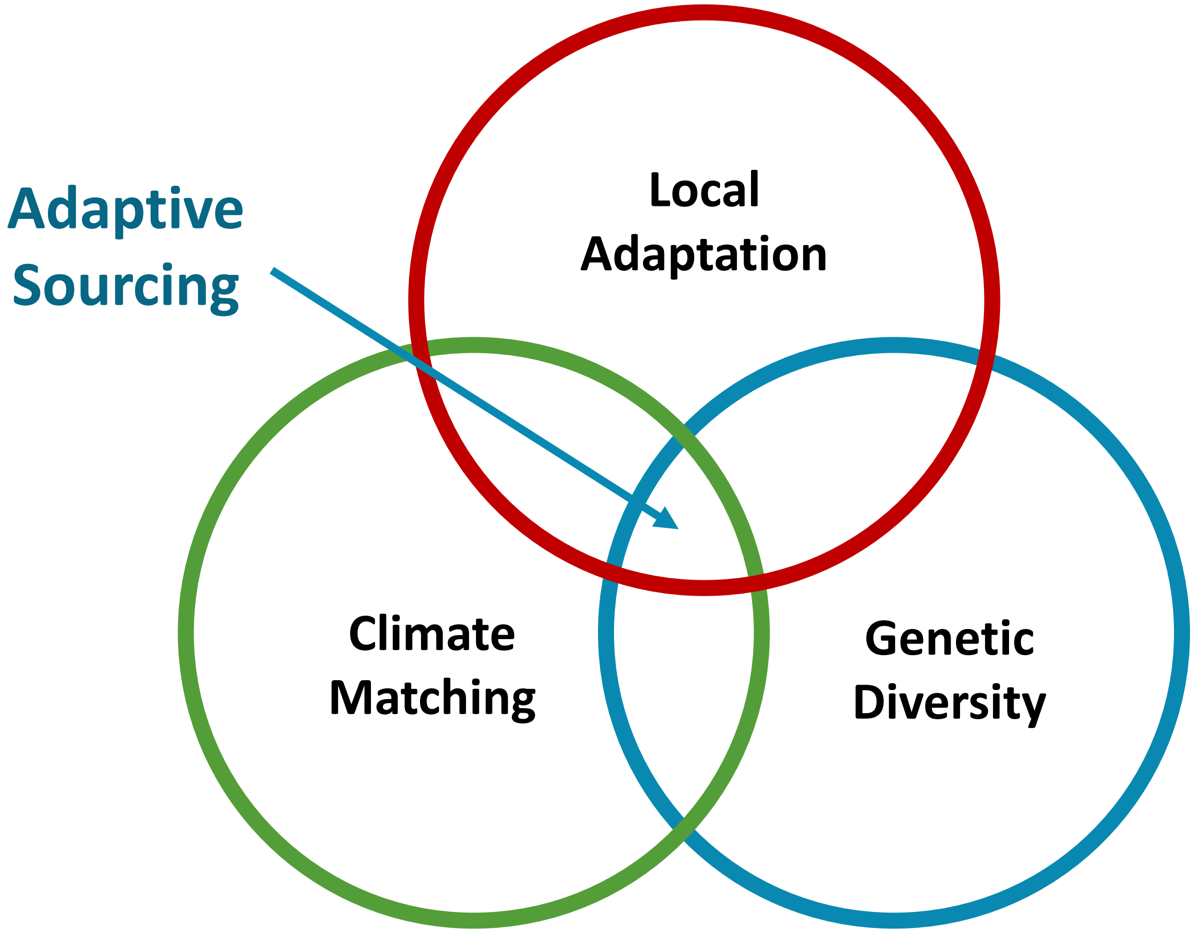
Tilman et al. 2006. *Nature*.

Adaptive Seed Sourcing

Local adaptations no longer local as climatic conditions change

Collect seed from:

1. Local sites for 'home site advantage'
2. Future climate-analog sites
3. Multiple sites to include genetic diversity



Planning Tools and References

Planning Tools Part 1

Western Regional Climate Center	• Climate anomaly maps. https://wrcc.dri.edu/
U.S. Drought Monitor	• Drought, temperature, precipitation, streamflow, and vegetation conditions. • Monthly and seasonal outlooks. • Agriculture-specific information. https://droughtmonitor.unl.edu/CurrentMap.aspx
USDA NRCS Web Soil Survey	• https://websoilsurvey.nrcs.usda.gov/app/
USEPA National Menu of Best Management Practices for Stormwater	https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater
Climate Mapping for Resilience & Adaptation	• https://resilience.climate.gov/

Planning Tools Part 2

U.S. Climate Resilience Toolkit	• Case studies, trainings, funding sources, guidance on vulnerability and risk assessment tools and applications (e.g. data analysis and mapping) https://toolkit.climate.gov/
USEPA Climate Change Adaptation Resource Center (ARC-X)	• Access to region- , topic- , and sector-specific EPA guidance https://www.epa.gov/arc-x
Utah State University Restoration Consortium	• Design manuals, workshops, learning modules focusing on low-tech restoration methods https://lowtechpbr.restoration.usu.edu/
USDA Climate Hubs U.S. DEPARTMENT OF AGRICULTURE	• Research and development, ag and forestry planning and risk assessment tools, webinars providing regional information on current drought status and impacts https://www.climatehubs.usda.gov/
esri | GIS for Climate Resilience	• Models, planning tools, siting, watershed analysis https://gis-for-climate-resilience-learngis.hub.arcgis.com/
Seedlot Selection Tool	• Match seedlots with planting sites based on climatic information (current and future). Focus on forestry. https://seedlotselectiontool.org/sst/

References

General

- McClelland, S.C., Bossio, D., Gordon, D.R. *et al.* Managing for climate and production goals on crop-lands. *Nat. Clim. Chang.* (2025).
- Jansson, C., Faiola, C., Wingler, A. *et al.* Crops for Carbon Farming. *Front. Plant Sci.* 12:636709. (2021)

Water

- **Riparian Shade:** Fuller, M.R., Leinenbach, P., Detenbeck, N.E., et al.. Riparian vegetation shade restoration and loss effects on recent and future stream temperatures. *Restoration Ecology* Vol. 30, No. 7, e13626 (2022).
- **PALS:** Bennett, S., Keksi, E. & Bouwes, N. (2020). Asotin Creek Intensively Monitored Watershed Annual Progress Report: 2020.
- **BDAs:** Wathen, G., Weber, N., & Bouwes, N. (2019). Evaluation of Steelhead Responses to Implementation of Beaver Dam Analogs in Bear Creek, OR. – 2019 Year - End Monitoring Report. Eco Logical Research, Inc., Bend, OR.

Vegetation

- Scherber, C., Eisenhauer, N., Weisser, W. *et al.* Bottom-up effects of plant diversity on multitrophic interactions in a biodiversity experiment. *Nature* 468, 553–556 (2010).
- Tilman, D., Reich, P. & Knops, J. Biodiversity and ecosystem stability in a decade-long grassland experiment. *Nature* 441, 629–632 (2006).

Comments and Questions

Thank you for your participation.

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