USER GUIDE

Mesic Analysis Platform

A Tool to Identify, Prioritize, and Monitor Conservation and Restoration of the Sagebrush Biome's Mesic Resources

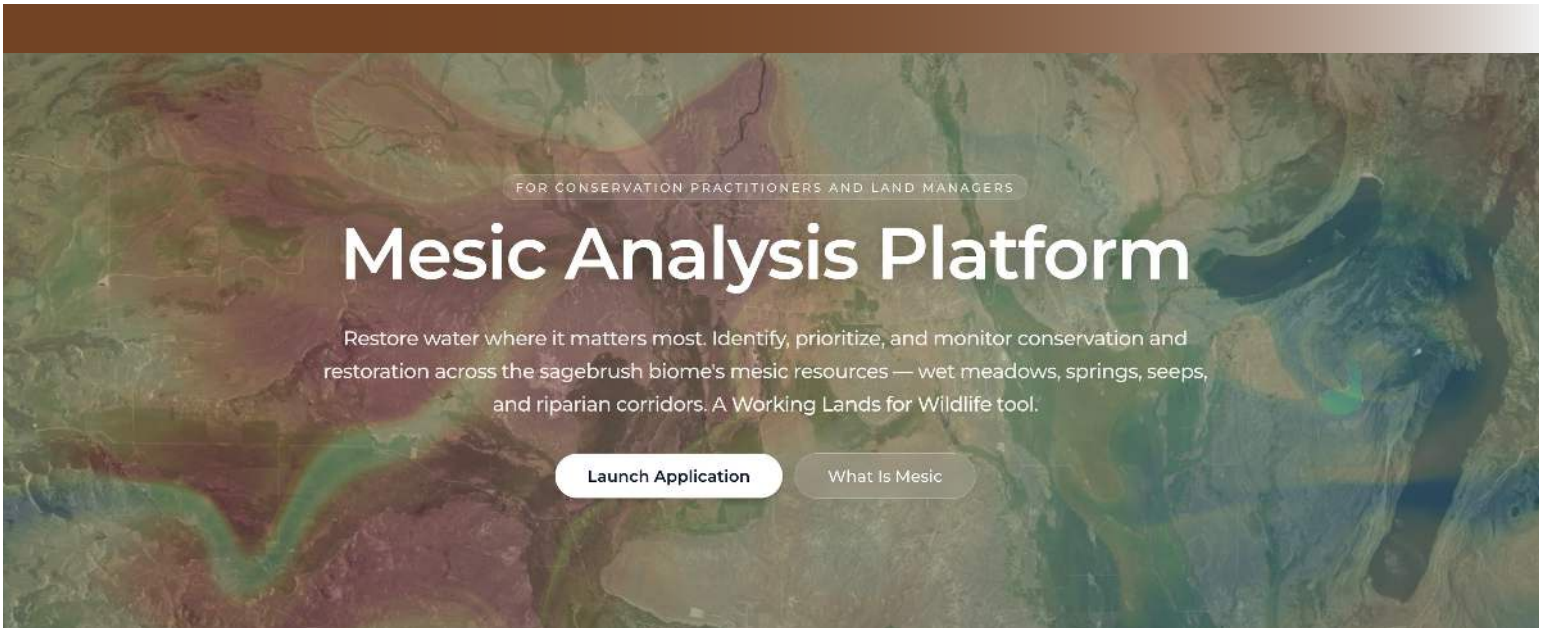
User Guide August 2026

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MESIC

UNIVERSITY OF MONTANA

WORKING LANDS FOR WILDLIFE



Purpose

In the West, water is life. Mesic resources—places where water meets land—represent a small fraction of the sagebrush biome but provide disproportionately important habitat, forage, water, and other ecosystem services. These productive areas support wildlife and livestock, sustain biodiversity, and help maintain watershed function and resilience. However, mesic resources are vulnerable to degradation from altered hydrology, channel incision, vegetation change, drought, and other disturbances. Effective conservation and restoration strategies require an understanding of where these resources persist, how consistently they function through time, and how they connect to surrounding upland habitats.

The Mesic Analysis Platform (MAP) provides an interactive, spatially explicit platform to help conservation planners and land managers identify, prioritize, and monitor mesic resources across the sagebrush biome. Using more than four decades of satellite imagery and complementary ecological, hydrologic, and landscape data, MAP highlights areas with persistent late-season productivity, identifies potential conservation and restoration opportunities, and provides context for evaluating mesic resources within their broader landscape setting. The platform is designed to complement the upland-focused Sagebrush Conservation Design (SCD; Doherty et al. 2022), providing conservationists with a more holistic perspective that couples efforts to defend and grow intact sagebrush cores with mesic resource conservation and restoration.

From entire watersheds to specific stream reaches, MAP supports conservation planners, land managers, and partners in making more informed decisions about mesic resource conservation and restoration. MAP is intended to complement local knowledge, field assessments, and other planning frameworks rather than replace site-specific evaluation or professional judgment. By combining long-term vegetation trends with information about hydrologic function, adjacent sagebrush habitat, land ownership, and restoration potential, the platform provides a common spatial framework for identifying priorities, communicating management opportunities, and tracking change through time.

Mesic resources are the wet, green places where water meets land. This includes riparian areas along streams and rivers, wet meadows, springs and seeps, irrigated fields, and high-elevation habitats. In these mesic areas, the soils have a well-balanced supply of moisture throughout the growing season, allowing plants to grow longer into the dry months.



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Acknowledgments

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Introduction

Mesic resources represent less than 2% of the sagebrush biome, yet they sustain a disproportionately high share of its biodiversity and productivity (Figure 1; Donnelly et al. 2016; Maestas et al. 2023; McKinstry et al. 2004). These patches function as ecological oases in an otherwise semi-arid landscape, providing critical forage, nesting, and brood-rearing habitat for numerous wildlife species, including the greater sage-grouse, mule deer, and a variety of migratory songbirds (Donnelly et al. 2016; Naiman et al. 1993; Thomas et al. 1979). These areas regulate hydrological processes, stabilize stream channels, and support riparian vegetation that buffers temperature extremes and stores groundwater (NRC 2002).



Wet Meadows

Open, grass-dominated systems fed by ground water or seasonal flooding — green well into later summer.



Streamsides & Riparian Corridors

Vegetation along streams and rivers, often the most visible mesic feature on the landscape.

Figure 1. Examples of mesic resources and landscape settings that can support late-season moisture and vegetation productivity across the sagebrush biome. These include wet meadows, streamside and riparian corridors, springs and seeps, groundwater-fed valley bottoms, north-facing slopes and high-elevation habitats, and wet swales and drainages. Although these features vary in size, hydrologic function, and landscape position, each can provide important sources of water, forage, and habitat during the dry season.



Springs & Seeps

Small, point-source systems where ground water surfaces — disproportionately important for wildlife and water quality.



Groundwater-fed Valley Bottoms

Broad valley floors where shallow groundwater keeps soils wet through the dry season.



North-Facing Slopes

Cooler, wetter aspects that retain moisture longer than south-facing terrain — often overlooked but ecologically significant.



Wet Swales & Drainages

Low-elevation drainage features that channel and hold runoff, supporting late-season productivity.

From an ecological perspective, mesic areas act as keystone resources, or patches that drive trophic and spatial linkages across the larger landscape (Kaufman et al. 2022). They serve as migratory stopovers, nesting habitats, and critical foraging grounds. For example, in dry years, sage-grouse broods move toward riparian zones that retain green vegetation longer into the summer, directly influencing chick survival and recruitment (Donnelly et al. 2018). Similarly, mesic meadows provide late-season forage for big game species such as elk and mule deer, maintaining body condition after fawning and calving (McCorquodale et al. 1986; Morano et al. 2019).

Mesic areas sustain critical ecosystem services with direct human benefits. In fact, Donnelly and colleagues (2016) demonstrated that nearly 75% of mesic resources used by sage-grouse occur on or immediately adjacent to private lands, underscoring the importance of cooperative, incentive-based approaches for sustaining these scarce habitats. Ranching operations rely on riparian and meadow systems for seasonal grazing, which can represent the most productive forage on public allotments (Kauffman and Krueger 1984). Springs and seeps provide livestock water and contribute to watershed-scale hydrologic balance. Beyond their agricultural role, these areas support recreation, hunting, and cultural values that tie communities to the landscape.

Recognizing the importance of working lands in conserving mesic resources, the USDA's Natural Resources Conservation Service (NRCS) Working Lands for Wildlife launched the "Water Is Life" campaign in 2017 to generate awareness about mesic resources in sagebrush country, train practitioners and landowners in effective techniques for restoration and management, and begin scaling up conservation efforts. Today, thousands of partners are engaged in mesic resource conservation efforts in communities across the biome. Conservation efforts on private lands are guided by WLFW's Frameworks for Conservation Action in the Sagebrush Biome and Migratory Big Game which identify mesic resource degradation on working lands as a primary threat to address. MAP empowers these partners to take mesic resource conservation to the next level by providing powerful new tools for prioritization and monitoring.

Shared Vision: Resilient Mesic Resources

The resilience of mesic systems (their capacity to recover following disturbance) depends on maintaining the physical and biological processes that regulate water retention, sediment transport, and vegetation succession (Kauffman et al. 2022). Functional connectivity between uplands and floodplains ensures that snowmelt and precipitation can be stored in soils rather than rapidly exported downstream. Maintaining critical eco-hydrologic processes, like beaver activity and healthy mesic plant roots, promotes natural feedbacks that reinforce hydrologic stability (Wheaton et al. 2019).

When natural feedbacks are lost through incision, overgrazing, or hydrologic alteration, mesic systems often transition into degraded states dominated by upland species or invasive annual grasses (Pilliod et al. 2017). These transitions reduce local biodiversity and increase landscape vulnerability to wildfire, erosion, and further invasion. Healthy riparian systems that maintain valley bottom moisture and support late-season green vegetation are resistant to upland wildfires and can serve as a natural fire break. Remaining intact areas spared from fire provide wildlife and livestock refugia, critical for post-fire recovery.





Figure 2. Healthy mesic areas are more resilient to drought, fire, and flooding. Expanding and maintaining mesic areas increases natural water storage, supporting greater soil moisture, vegetation productivity, and ecosystem resilience. In essence, healthy mesic areas act like sponges or a piggy bank—storing water, sustaining green vegetation, and providing more "green groceries" for wildlife and livestock.

Maintaining and restoring the function and resilience of the West's precious mesic resources is a shared vision benefiting both agricultural producers and wildlife. In Figure 2, the picture on the left shows an incised and degraded stream that has lost its green mesic vegetation and now serves as a drainage ditch that rushes water off the land as soon as it falls. Compare that condition to the picture on the right of a healthy and functioning mesic area. When we can maintain or restore mesic resources to conditions like those pictured on the right, we increase the natural storage capacity of the soil to retain moisture. It's like a piggy bank for those leaner times during the year when water is highly limited. Retaining more water in the soil increases vegetation productivity and ultimately improves the resilience of the land to stresses like drought, fire, and flooding. WLFW-supported science shows that mesic restoration can boost vegetation productivity by 25%, keep resources greener longer during the growing season, and make mesic areas less sensitive to drought (Silverman et al. 2019).

While there are many important ecosystem services and values provided by mesic resources that we could manage for and measure, focusing on the foundational capability of mesic areas to retain soil moisture, grow productive green vegetation, and be resilient to disturbances is a shared vision that rallies diverse stakeholders to mesic conservation.

Measuring Mesic Resources from Space

MAP leverages four decades (1984-2025) of satellite imagery to identify and map mesic resource persistence across western landscapes. This platform visualizes late-season (July 15 - September 30) mesic vegetation productivity within the sagebrush biome, during dry summer periods when differences in soil moisture are most apparent.

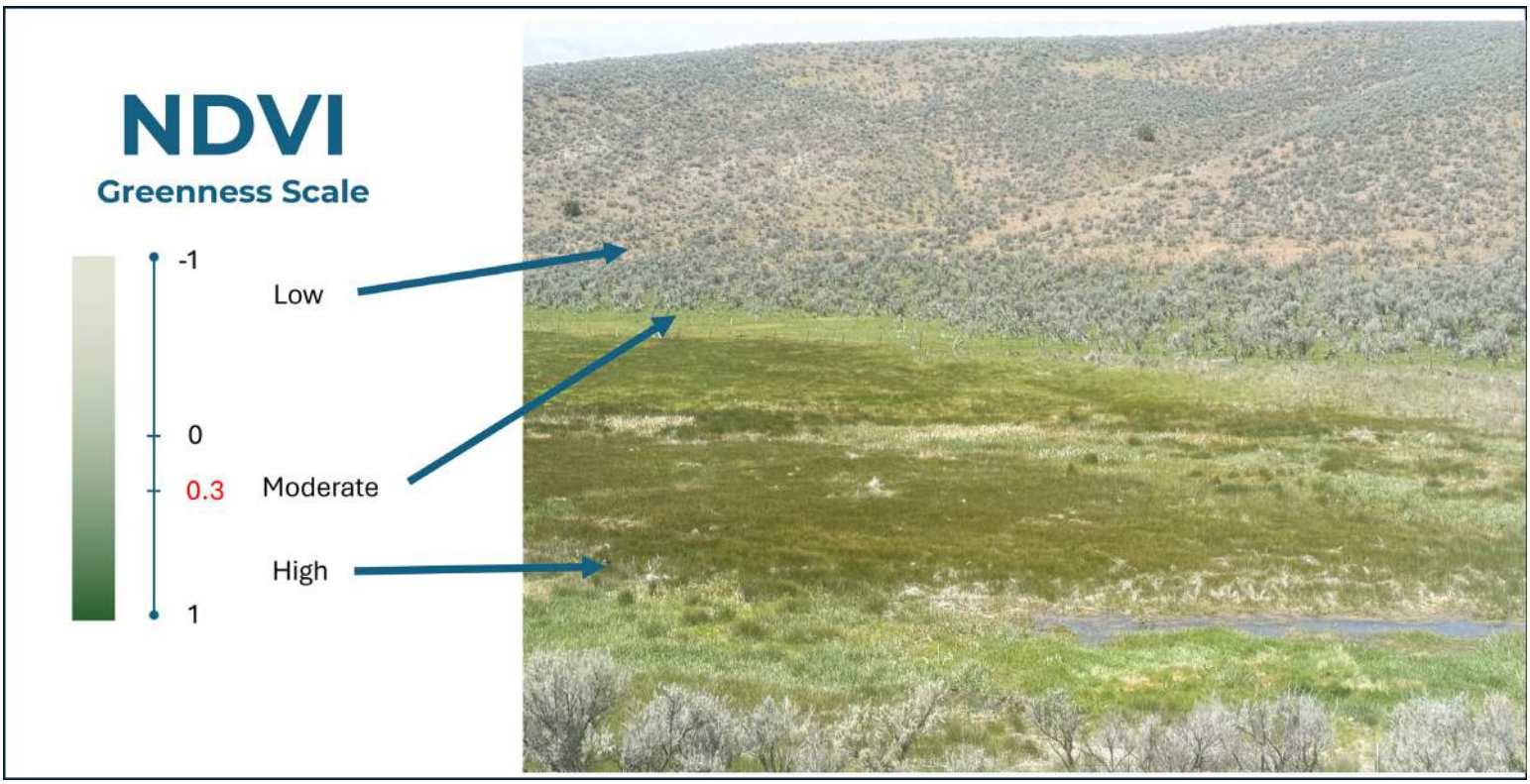


Figure 3. Normalized Difference Vegetation Index (NDVI) is a measure of vegetation greenness that ranges from –1 to 1, with higher values generally indicating greater vegetation productivity and moisture availability. In this example, the surrounding upland vegetation has relatively low NDVI values, while the greener valley-bottom vegetation has higher NDVI values. The NDVI value of 0.3 (shown in red) represents the threshold used by the Mesic Analysis Platform to identify productive mesic vegetation during the late growing season.

For each year, the platform analyzes Landsat imagery collected during the late growing season to calculate average vegetation productivity using the Normalized Difference Vegetation Index (NDVI)—a measure of vegetation "greenness." Productive mesic resources are defined by vegetation with NDVI of ≥ 0.3, on a scale from -1 (low productivity) to 1 (high productivity) (Figure 3). This is a standard threshold for productive mesic resources in western North America (Donnelly et al. 2016, 2018; Lundblad et al., 2022; Weier & Herring, 2000).

Mesic resource persistence is defined as how consistently a pixel, or valley bottom, supported productive late-season vegetation over 40+ years of satellite imagery. Higher values indicate more reliable water availability and a stable mesic habitat.

Pixels that exceed the defined greenness threshold are classified as productive for that year, and the platform then calculates how consistently productivity occurs over time (Figure 4). By measuring the frequency with which individual pixels remain green late into the season, the platform identifies stable, long-term mesic areas that provide reliable sources of moisture and productive forage. The result is a science-based map that helps land managers locate, prioritize, and conserve the mesic resources that are most important for wildlife, livestock, and watershed resilience (Mueller, 2025).

MAP represents the next generation of the original Sage Grouse Initiative Mesic Resource Layer (Donnelly et al. 2016), integrating new science and data, such as, the Sagebrush Conservation Design (hereafter: SCD) and Valley-Bottom Extraction Tool (VBET, accessed from the Riverscapes Data Exchange) to reveal where mesic resources persist, where they have degraded, and where targeted restoration will yield the greatest return.

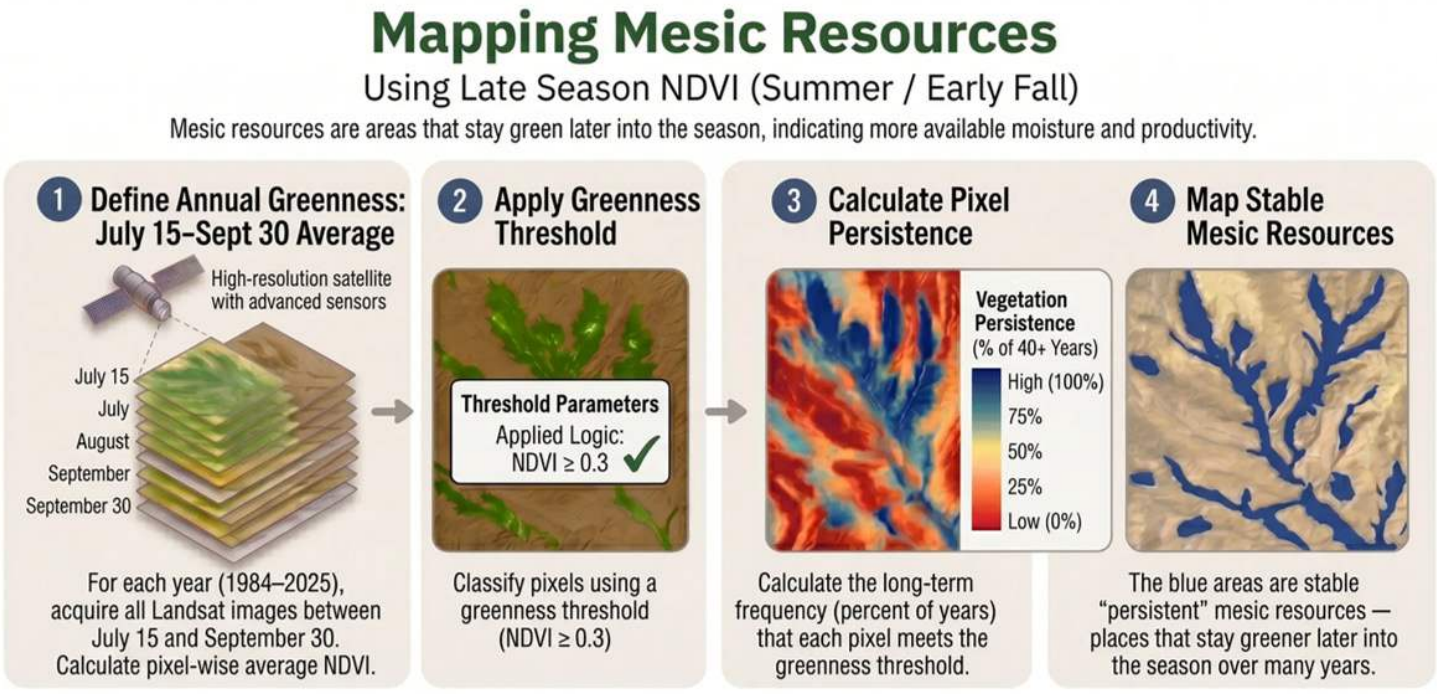


Figure 4. Mapping mesic resources using late-season vegetation productivity derived from Normalized Difference Vegetation Index (NDVI). For each year from 1984–2025, average NDVI is calculated from satellite imagery . Pixels meeting the productivity threshold (NDVI ≥ 0.3) are classified as mesic, and the frequency with which each pixel meets this threshold is calculated across the 40-year period. Areas with high vegetation persistence represent stable mesic resources that consistently retain green vegetation later into the growing season and are potential priorities for conservation and restoration planning. Kris Mueller with Google Gemini (https://gemini.google.com/app)

Prioritizing Where to Work

Implementing mesic conservation and restoration is valuable anywhere it occurs in the sagebrush biome given the critical importance of water and green forage in the summer. However, money and human capacity are inherently limited, making it essential to strategically prioritize where efforts will yield the greatest ecological benefit if the goal is to achieve large-scale outcomes. Working Lands for Wildlife's "Defend the Core" strategy for threat reduction emphasizes proactive management to maintain and bolster intact, high-quality habitats over reactive restoration of heavily degraded areas (Figure 5). This strategy is at the heart of the SCD for conserving sagebrush uplands.

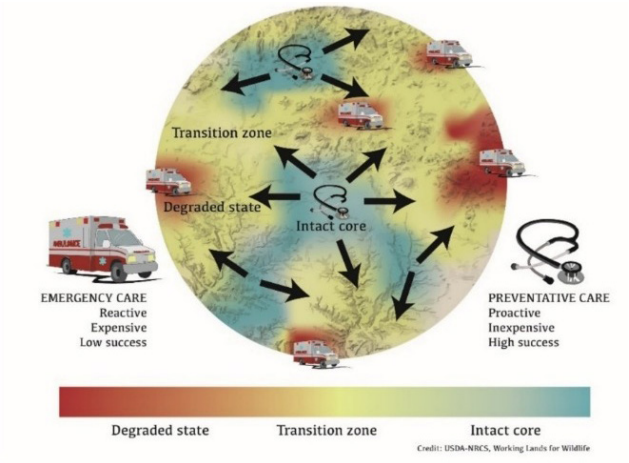


Figure 5. MAP now allows users to apply the "Defend the Core" strategic approach to mesic resource conservation from watershed to reach scales.



Prioritize Watersheds



Map Mesic Landscapes



Analyze Stream Reaches

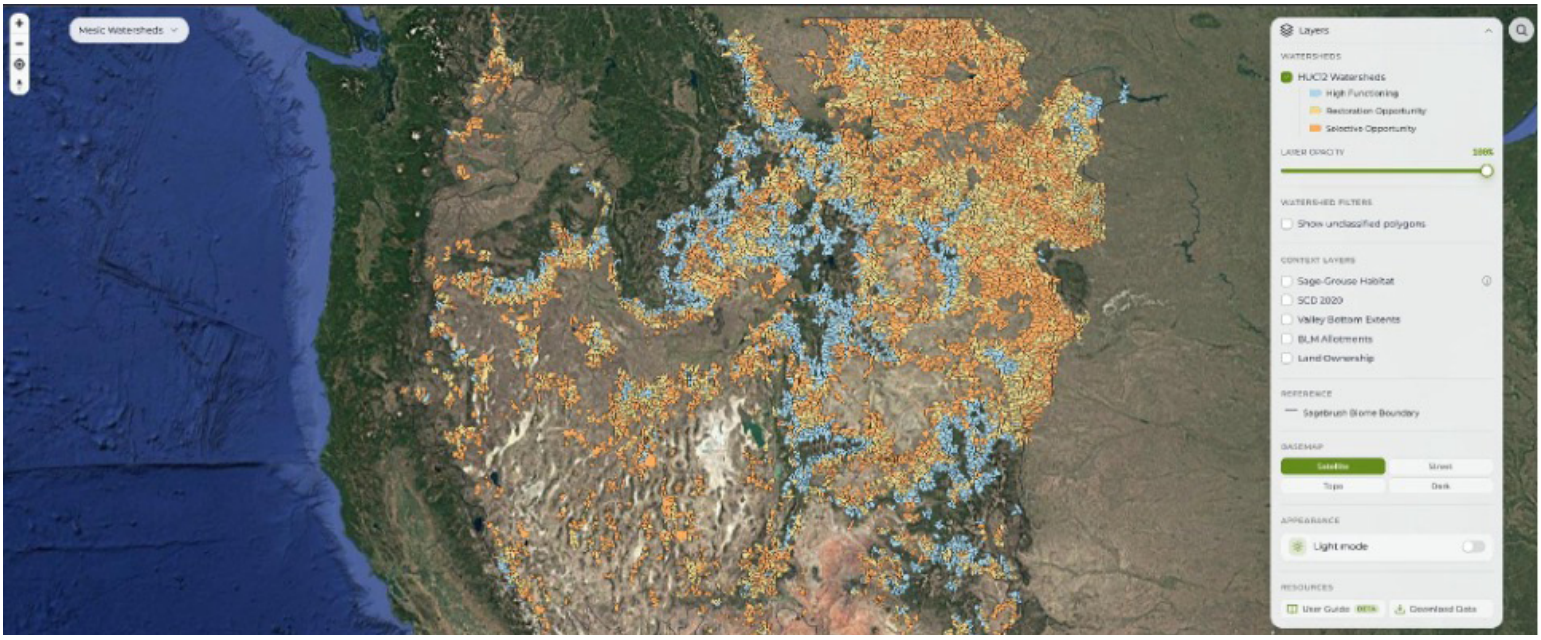
Figure 6. The Mesic Analysis Platform includes three modules for different levels of planning and implementation.

Mesic Analysis Platform (MAP) Overview: From Watershed to Stream Reach

Effective conservation planning occurs at multiple scales from large regions to watersheds to individual stream reaches. MAP includes three integrated modules tailored to different levels of planning and implementation (Figure 6). These can be used together or separately depending on the needs of the user.

- **Mesic Watersheds:** This module helps users rank HUC12 subwatersheds for mesic conservation potential based on long-term productivity persistence trends in valley bottoms and their linkage to the SCD's intact sagebrush ecosystems, making it ideal for landscape-scale prioritization and strategic investment where the goal is conserving mesic resources within important sagebrush landscapes.
- **Mesic Landscapes:** This module shows a complete picture of all the mesic resources in an area, including valley bottoms and upland mesic assets. This module is meant more for field staff, grazing planners, and land managers, who need to identify and prioritize mesic resources including upland rangelands. This map also includes riparian trees within the valley bottoms, but masks out upland forest trees.
- **Mesic Valley Bottoms:** This module allows users to examine individual stream reaches and prioritize restoration or management treatments in riparian floodplains based on local conditions.

Together, these modules create a flexible planning system that helps managers move seamlessly from regional prioritization to on-the-ground implementation.



Module 1. Mesic Watersheds

Watersheds (HUC12) are classified by vegetation persistence — how consistently mesic vegetation stays productive in late summer — and proximity to intact sagebrush uplands from the SCD. A decision tree filters for watersheds where ≥15% of valley bottoms lie within 5 km of SCD Core Sagebrush Areas (CSAs) or Growth Opportunity Areas (GOAs), then assigns three management tiers based on the balance of persistence classes.

Tier	Strategy	Description
Tier 1	Protect & Maintain	Abundant high-persistence valley bottoms near intact uplands. Priority for easements and protection.
Tier 2	Restore & Enhance	High persistence interspersed with moderate persistence; water is present but is unevenly distributed creating restoration opportunities.
Tier 3	Strategically Manage	Limited but present mesic areas in water-limited landscapes. Selective interventions and extensive field assessment recommended.

Watershed Statistics Panel

Click any watershed polygon to open the statistics panel, which shows Proportion of Watershed Valley Bottoms for Vegetation Persistence, Forested, Irrigated, Ownership, and Proximity to CSAs.

The statistics panel includes three interactive time series charts showing 41 years of data (1984–2025) calculated within valley bottoms for the selected watershed.

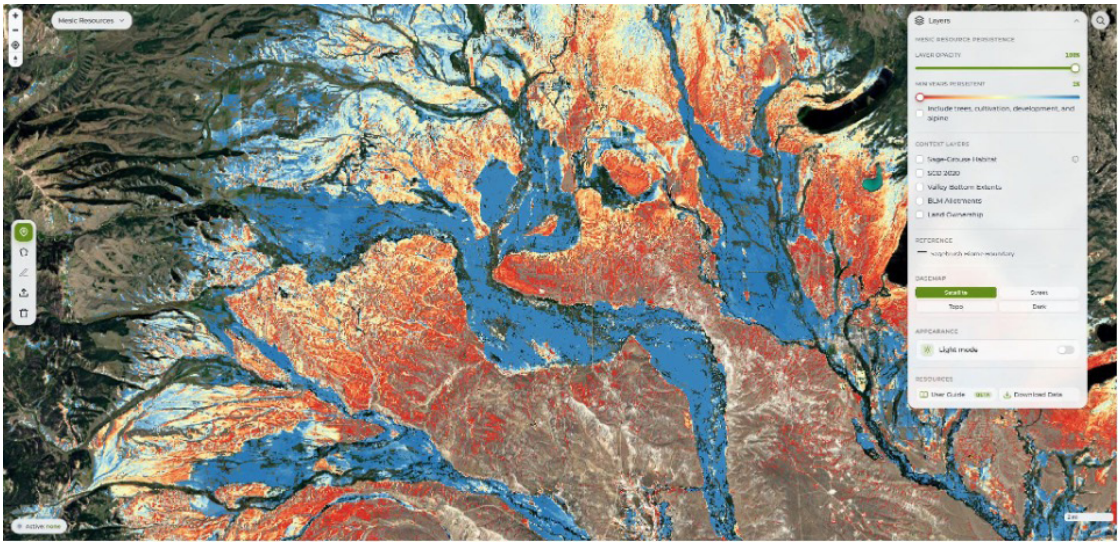


Time Series Charts	
Mean Late-Season NDVI in Valley Bottoms	Annual mean NDVI for July 15–Sept 30. Green line = above 0.3 (productive mesic); orange line = below 0.3. Dashed line marks the 0.3 threshold. Stable green across decades indicates reliable groundwater connectivity.
Vegetation Cover in Valley Bottoms	Annual fractional cover from the Rangeland Analysis Platform (RAP): Annual Forb/Grass, Perennial Forb/Grass, Shrub, Tree. Reveals long-term shifts in plant community composition within valley bottoms.
Drought Severity in Valley Bottoms	The Palmer Drought Severity Index (PDSI) allows comparison with NDVI trends to distinguish climate-driven productivity dips from structural hydrologic decline.

FILTER TIP
Toggle “Show unclassified polygons” under Watershed Filters to display the 60% of watersheds outside the tiered thresholds — useful for understanding the full landscape context.

Module 2. Mesic Landscapes

Each 30m pixel is colored by how reliably it supported productive vegetation during the late growing season (July 15–September 30) from 1984 to 2025. A pixel is classified as productive each year if its NDVI meets or exceeds 0.3. This module captures a complete picture of all mesic resources, including valley bottom herbaceous plants, riparian woody species, plus upland herbaceous seeps, springs, and meadows.



Note: Upland tree cover has been masked; however, this tool does not differentiate between deciduous trees (willows/cottonwoods) and conifers within riparian corridors. On-site verification is recommended.

Dark Blue — ≥75% of years	Stable, groundwater-connected mesic vegetation. These are the core refugia to prioritize for protection and “defend the core” strategies.
Medium blue — 25–74%	Moderate persistence — reliable in most years but subject to periodic drought-driven loss.
Orange — 1–24%	Rarely productive.
Red — <1%	Very rarely productive. Often indicate water-limited landscapes.

Layer Controls

Min Years Productive — sets the minimum persistence threshold for displayed pixels. Setting to 25% shows locations productive in ≥ 1 of 4 years; increasing to 75% reveals only the most stable, groundwater-reliant sites.

Include trees, cultivation, development, and alpine — by default, pixels with >10% tree cover, cultivation, urban development, or alpine landscapes are excluded to focus on herbaceous mesic systems. Toggle to show all pixels.

Point, Polygon & Upload Analysis

The left toolbar provides four interaction modes for generating a time series analysis on any area of interest:

Click a Point

41-year NDVI persistence, RAP vegetation cover, and Palmer Drought Severity Index for that specific location. Results appear instantly in the analysis panel.

Draw a Polygon

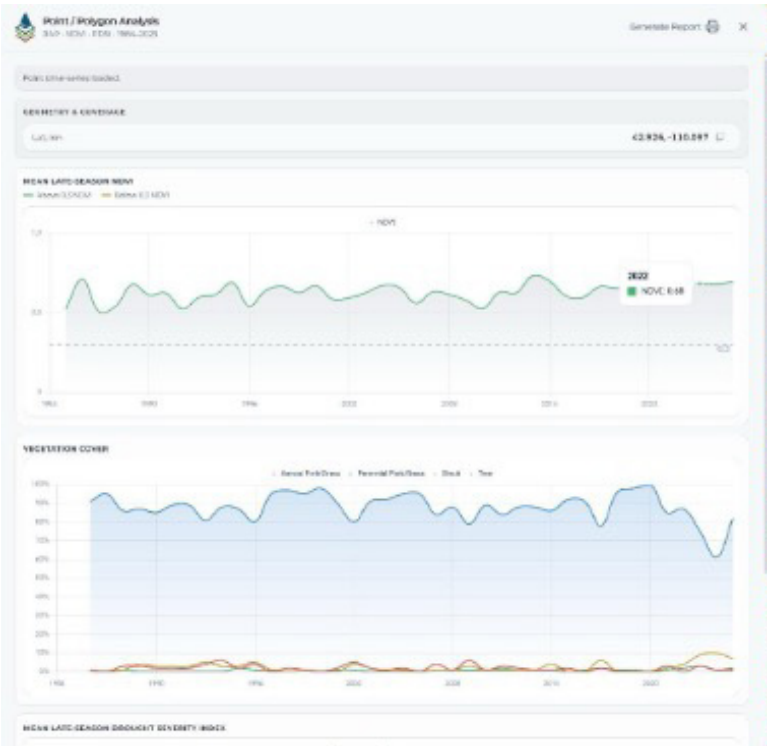
Outline any area — allotment, pasture, or project boundary — to get mean statistics for the entire polygon.

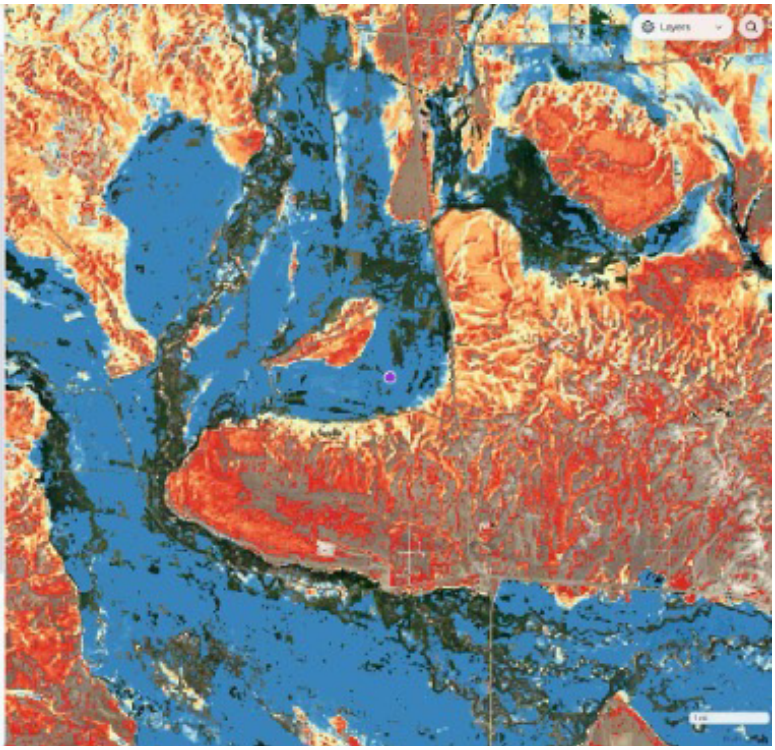
Upload a Boundary

Drag-and-drop a GeoJSON, Shapefile, or KML file (max 500,000 acres) for a custom-area-of-interest analysis.

Generate a Report

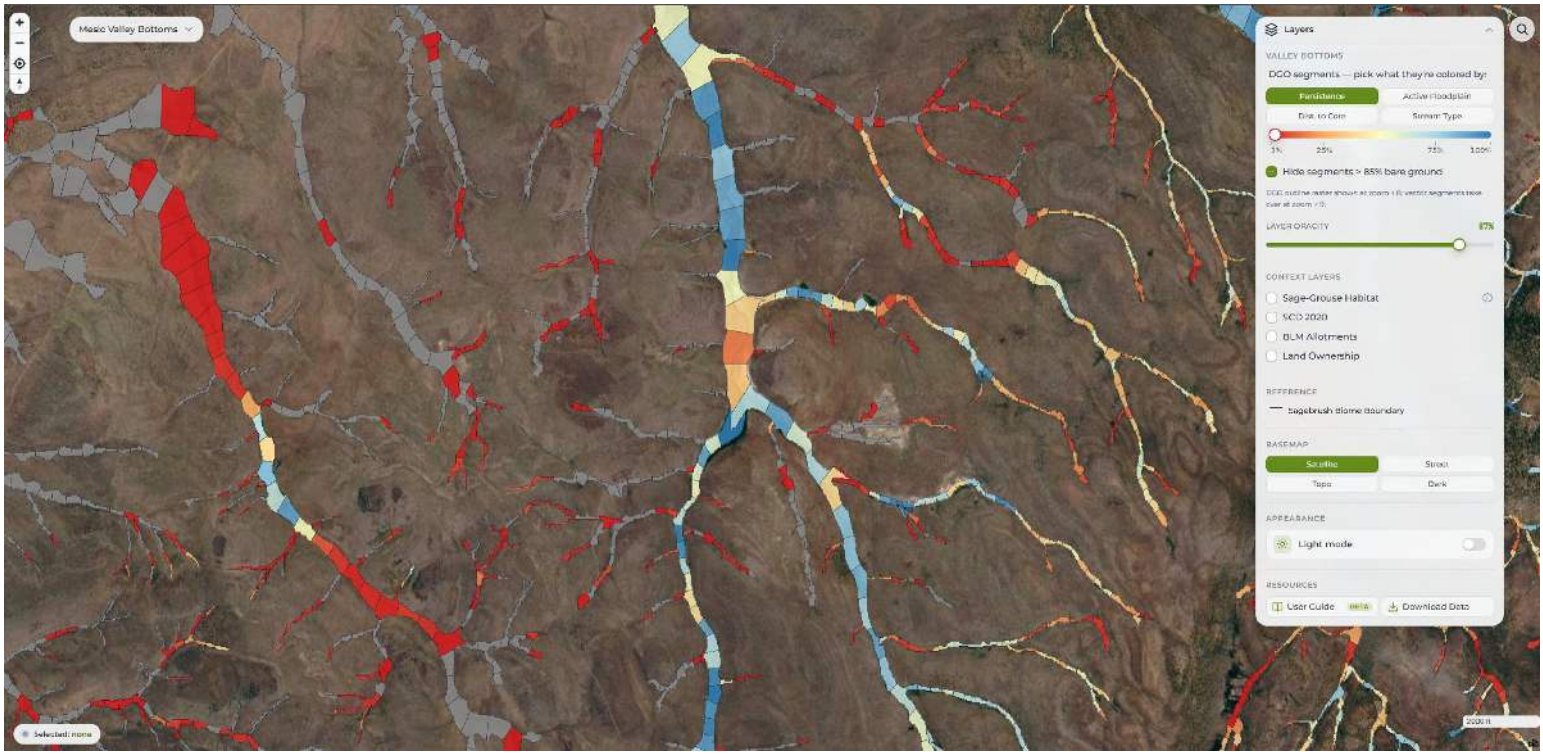
Produces a printable PDF of all statistics and time series charts for the selected area.





Time Series Charts

Same as Module 1. Mesic Watersheds. Clicking a point or generating a polygon report produces three interactive charts covering 1984–2025 for the selected area.



Module 3. Mesic Valley Bottoms

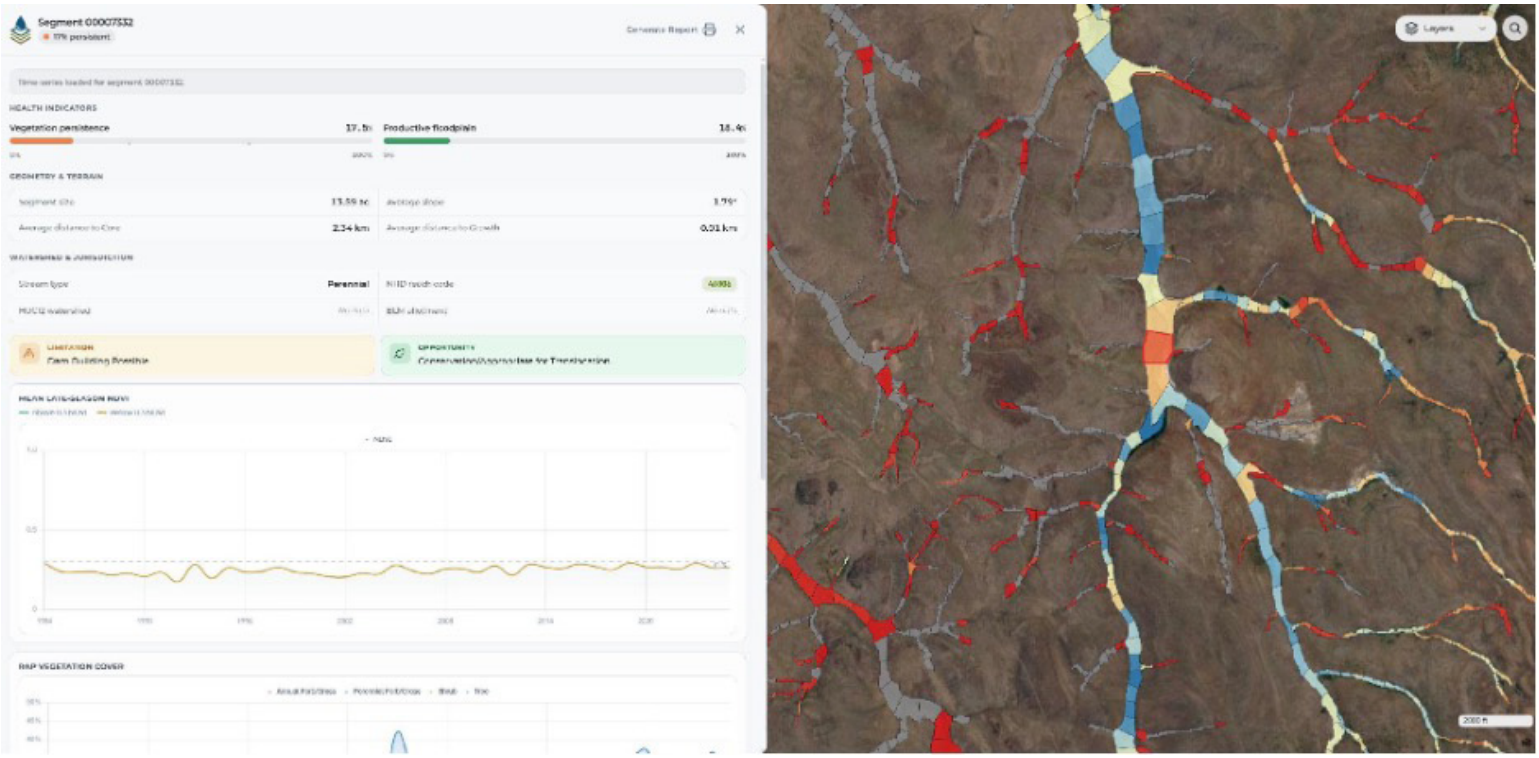
The Mesic Valley Bottom module utilizes Riverscape Consortium's VBET to serve up data by standardized valley bottom segments. Four valley bottom outputs can be visualized to help with planning and decision making by selecting one of the options found at the top of the layers menu.

1	**Persistence**	How consistently the segment supported productive late-season vegetation over 40+ years. Red segments between blue reaches = disconnected, priority restoration site(s). Persistence values shown are the average of pixels within the segment.
2	**Active Floodplain**	Proportion of valley bottom with persistent vegetation (>50%) — measures hydrologic connectivity. Low values relative to neighbors may indicate channel incision.
3	**Dist. to Core**	Distance to nearest SCD CSA. Darker = closer; higher priority for wildlife dependent on both mesic and upland habitats.
4	**Stream Type**	Flow regime: Perennial (water year-round), Intermittent (water part-time of the year), Ephemeral (rarely surface water present), Canal/ Other (often have persistent water, but highly managed). Influences restoration feasibility and most effective management actions.

Segment Statistics Panel

Clicking any valley-bottom segment highlights it and opens a full statistics panel.

Healthy Indicators	Vegetation persistence (%) and active floodplain (%) — the two primary metrics for assessing mesic function and determining restoration need.
Geometry & Terrain	Segment size (acres), average slope, average distance to CSAs, and average distance to GOAs.
Watershed & Jurisdiction	Stream type (perennial/intermittent/ephemeral), HUC12 subwatershed name, and BLM allotment name — links the reach to land management context.
BRAT Outputs	Beaver Restoration Assessment Tool outputs: Limitation flags (e.g., “Dam Building Possible”) and Opportunity flags (e.g., “Conservation/Appropriate for Translocation”).
41-Year Time Series	Mean late-season NDVI and RAP vegetation cover charts at the reach level — for historical trend analysis, restoration monitoring, and treatment evaluation.



An Example of How to Use MAP

MAP is intended to be applied as a decision-support tool to assess current mesic area conditions, determine areas for improvement, and monitor post-treatment effects. In this section, we present a hypothetical scenario to demonstrate a step-by-step process. Local, real-world priorities may differ.

Hypothetical conservation scenario:

- Goal: Find opportunities for Low-Tech Process-Based Restoration (LTPBR) within the foothills around Ruby Valley, MT.
- Values: Support high-quality mesic resources in CSAs.



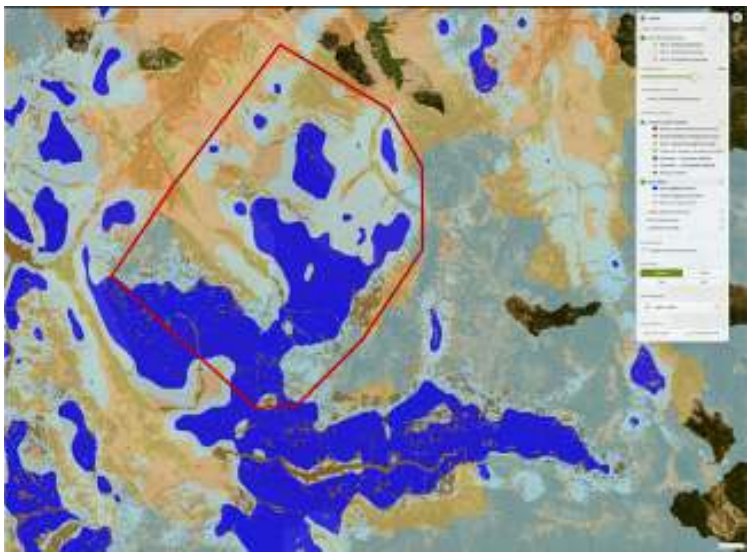
Step 1. Rank Watersheds for Mesic Conservation Opportunities Using the Mesic Watersheds Module

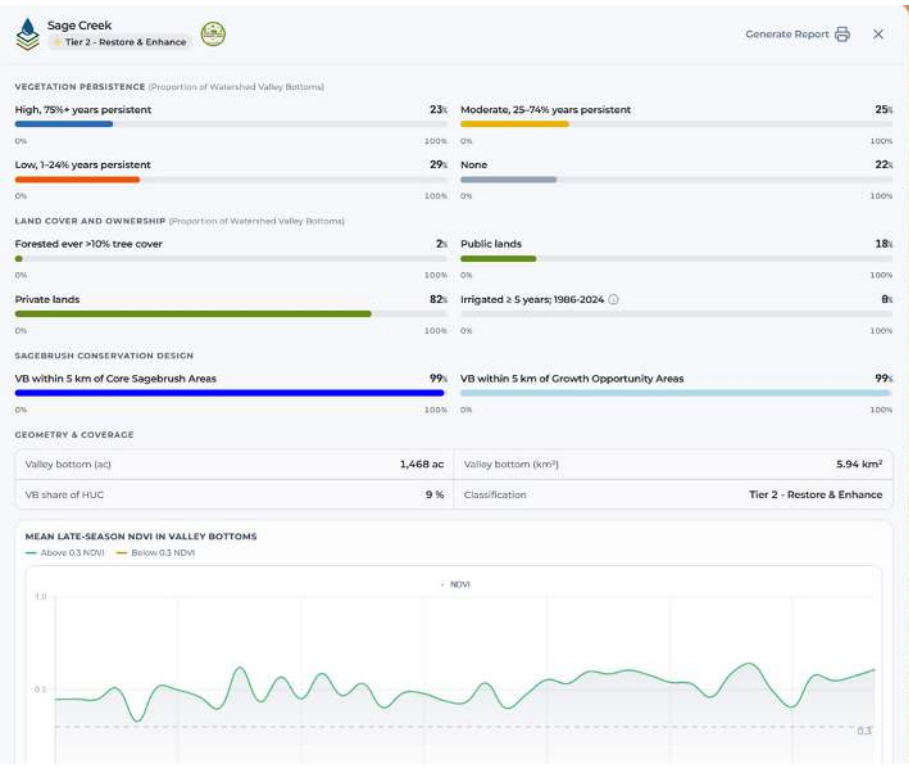
Zoom into the estimated extent of the region under consideration. Tier 1 watersheds are often in good condition, while Tier 3 watersheds may require extensive inputs to achieve meaningful gains. Look for Tier 2 watersheds where restoration and enhancement is 1) needed, and 2) has connection to SCD and sage-grouse habitat and thus valuable landscape context. In this region there are several Tier 1 watersheds, some scattered Tier 3 watersheds, and a number of Tier 2 watersheds.

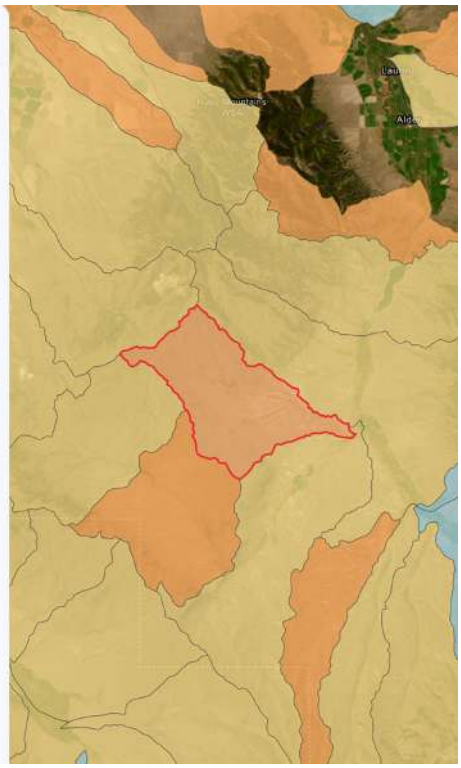


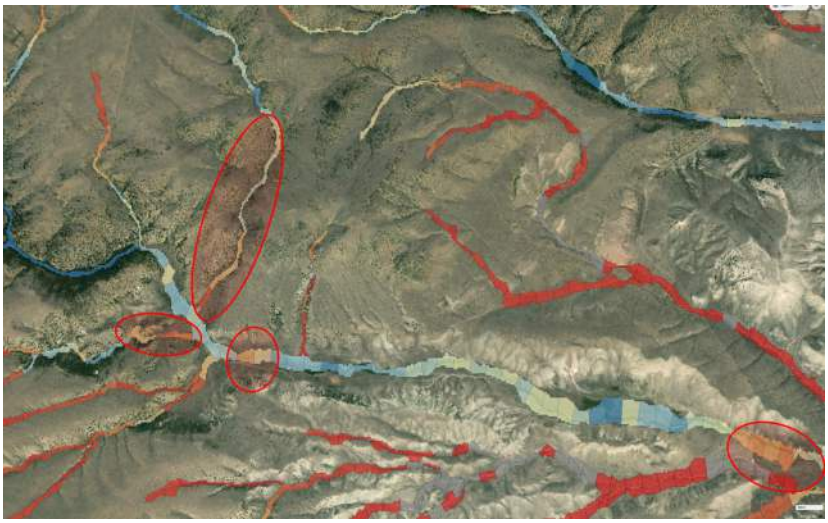
Sage Creek Watershed appears to be a prime area to look for LTPBR opportunities at a smaller scale. Much of the watershed is located in a sage-grouse Priority Habitat Management Area in CSAs according to the SCD. The remainder of the watershed is considered to be a GOA within sage-grouse general habitat management area.

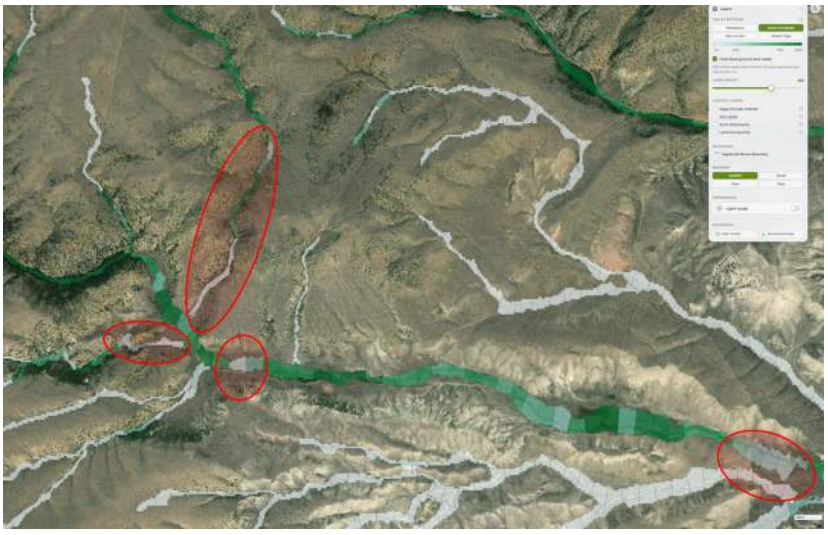
Clicking on the Sage Creek Watershed polygon, we see it is indeed classified as Tier 2-Restore & Enhance and contains 1,468 acres of valley bottom. It consists of 82% private land and 18% public land. We also note that 99% of the valley bottoms are within 5 km of CSAs or GOAs.











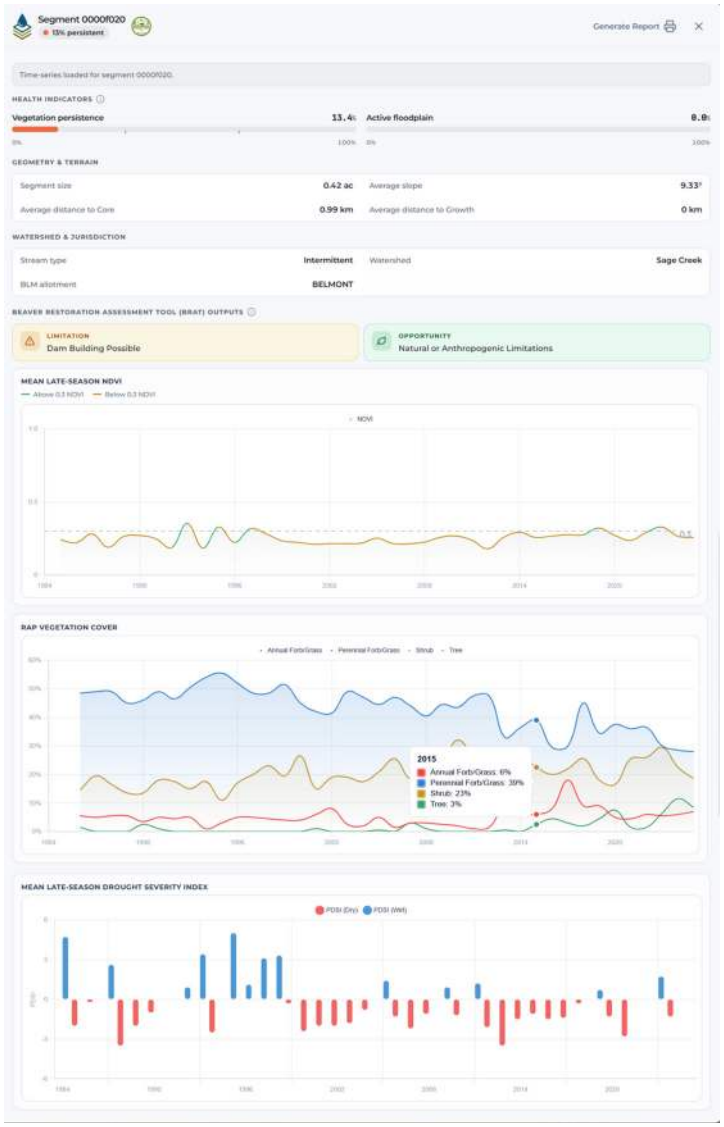
Step 2. Use the Mesic Valley Bottom Module to Look for Improvement Opportunities

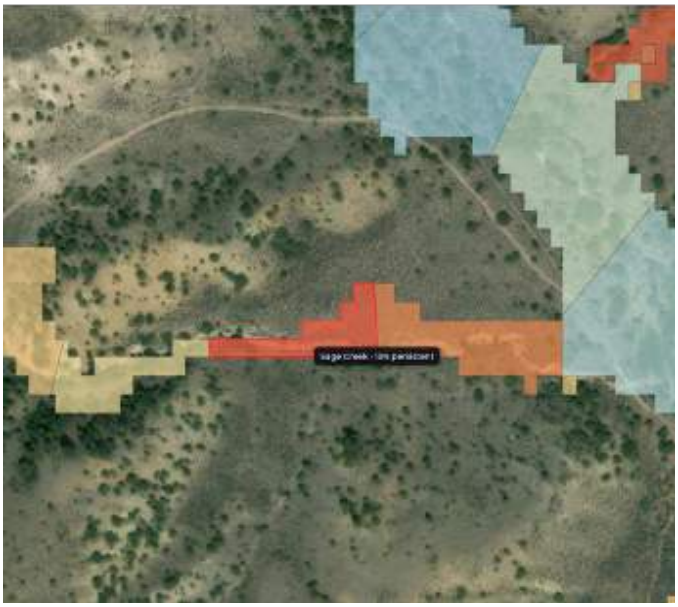
In Persistence mode, look for red/orange segments sandwiched between blue reaches. Switch to Active Floodplain mode to confirm whether the proportion of hydrologically connected floodplain is low relative to neighboring reaches — these dual-flag sites are your highest-confidence LTPBR candidates. Using Persistence mode and Active Floodplain mode we note several areas where the channel appears restricted and the floodplain is a low percentage of its potential width.

FILTER TIP
Hide bare ground and water — removes segments where mean bare ground exceeds 85% of segment area, OR persistent water exceeds 25% of segment area, filtering denuded and open-water segments to reduce visual clutter in low vegetation or open-water areas.

Step 3. Examine Individual Stream Reaches

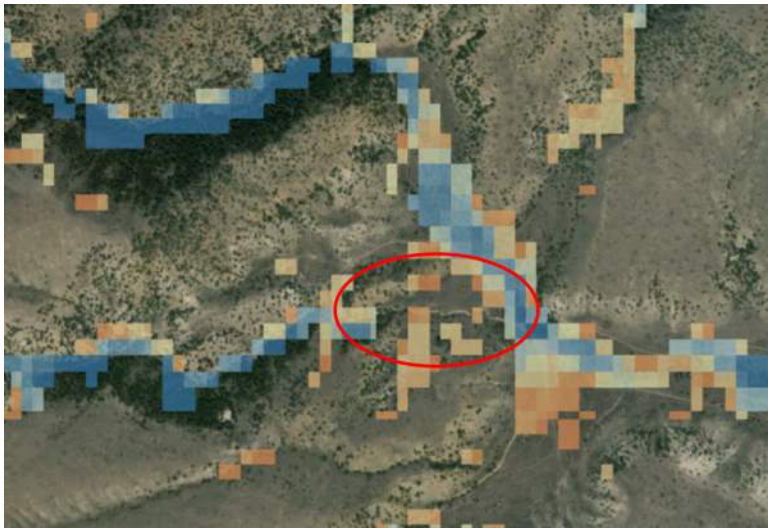
Sage Creek segment 0000f020 is an intermittent reach with an average vegetative persistence of 13%, filling 0.0% of the active floodplain. Because this is an intermittent stream system, water is likely only flowing during portions of the year. This should be a consideration when determining how effective practice implementation will be and what time of the year to do it. It is located on public land within the Belmont BLM grazing allotment. The Beaver Restoration Assessment Tool labels this stream reach as capable of maintaining beaver dams, while also having natural or anthropogenic limitations. This means the stream reach could be a potential location for low-tech restoration through Beaver Dam Analogs (BDAs), though it is important to investigate whether predetermined management plans, or other landscape context that cannot be captured by remote sensing, may limit what restoration practices can be implemented.

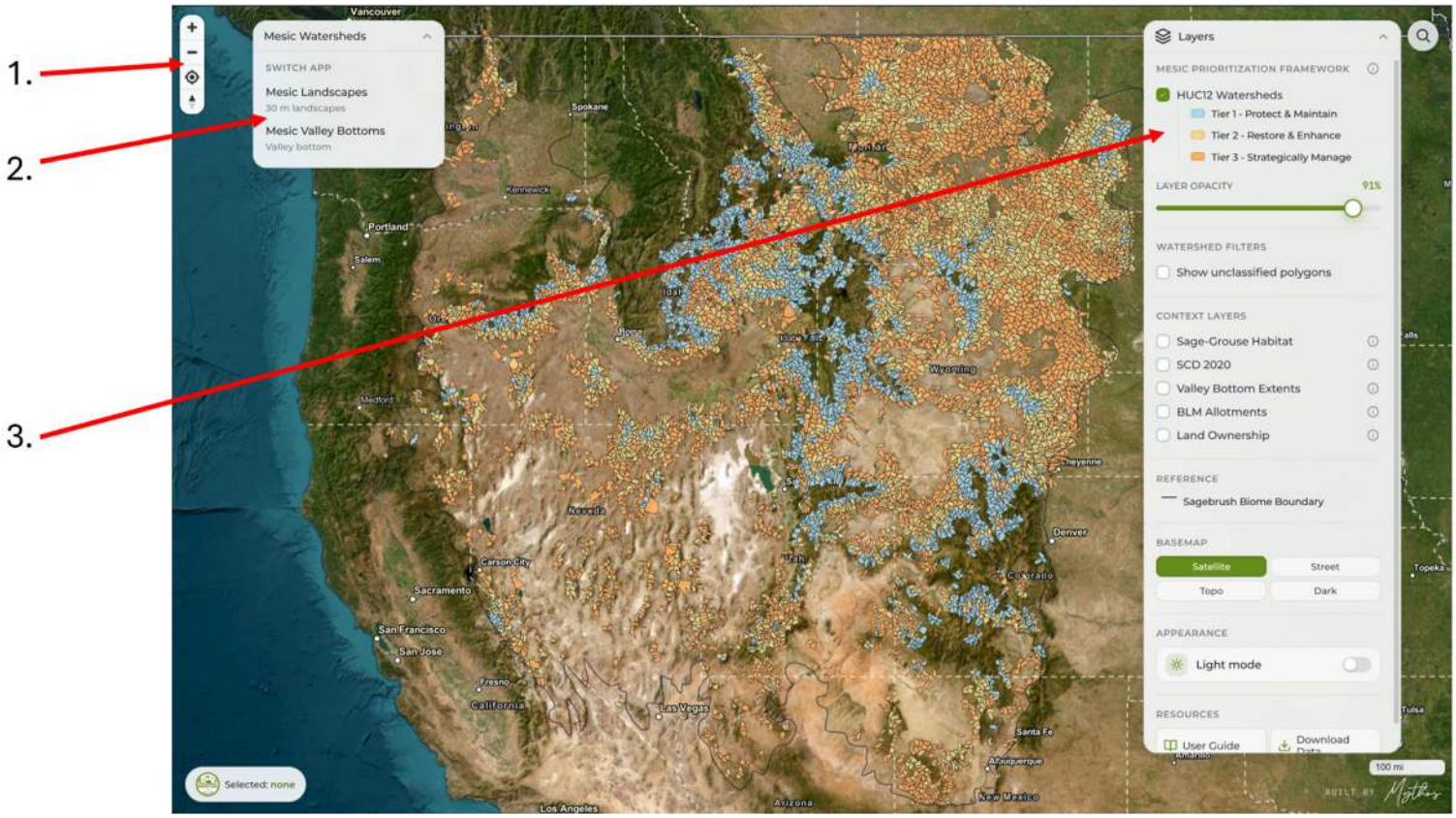




Step 4. Assess Upland Resources

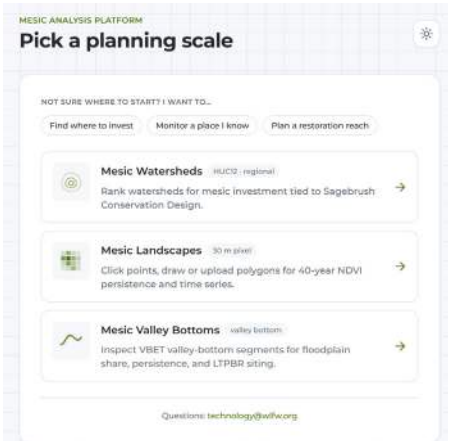
The Valley Bottom Tool was used to identify this possible disconnection and potential restoration, but it only shows persistence of the vegetation within those valley bottoms. If the user wants to take a more detailed look at the mesic landscape both within and outside that valley bottom, they can switch to the Mesic Landscapes Module and see the persistence at a pixel level. Now, looking at that same reach, we can see a little more clearly the break in persistent vegetation and area that could be improved.





Appendix 1. Navigating the Web App

Pick a Planning Scale



Choose between the three application modules (Mesic Watersheds, Mesic Landscapes, and Mesic Valley Bottoms) based on the planning scale at which you work. Clicking takes you directly into the selected module.

Zoom and Center (1)

At the top left of the screen, you will find buttons to zoom in or out (+ and -). The "Center" button will allow your computer to access and center the map to your current location. The up/down triangle button will recenter your screen with north facing up.

Module Selection (2)

A drop-down panel in the upper left of the screen allows users to switch directly between apps while maintaining the same map location and a similar viewing scale.

Layers (3)

At the top right of each module, you will find a layers button. At the top of the layers menu, you will find the key to the featured module and a **Layer Opacity Slider** that allows you to adjust the transparency of the featured resource. All three apps offer several **Context Layers** including priority sage-grouse habitat, SCD 2020, BLM allotments, and land ownership. A floating i button linking to detailed information is located to the right of each layer. You can also choose from four **Basemaps** (satellite, street, topo, and dark). In the layers menu you will also find options to change the **Appearance** of the screen from light mode to dark mode as well as a **Resources** section with links to visit this user guide and download data.

Appendix 2. Mesic Analysis Platform Glossary of Terms and Outputs

Active Floodplain — The portion of the valley bottom that remains hydrologically connected to the stream channel via persistently productive vegetation (>50% persistence, 1984-2025). Reaches with low active floodplain relative to the total valley bottom may indicate channel incision or floodplain disconnection—key targets for Low-Tech Process-Based Restoration.

Average Distance to Core Sagebrush Area — The average distance from a stream reach or valley-bottom segment to the nearest CSA, as defined by the Sagebrush Conservation Design 2020. Lower values indicate closer proximity to intact sagebrush habitats and may represent greater opportunities to integrate mesic and upland conservation objectives.

Average Distance to Growth Opportunity Area — The average distance from a stream reach or valley-bottom segment to the nearest GOA, as defined by the Sagebrush Conservation Design 2020. Lower values indicate greater proximity to areas where strategic conservation and restoration may help expand or connect intact sagebrush habitat.

BRAT Limitations — Identifies areas where beaver are unlikely to build dams under current conditions and differentiates stream segments that are limited by anthropogenic factors from those that are naturally limited. The output combines existing and historic dam-building capacity with slope and drainage-area thresholds to identify potential limitations to beaver dam establishment. Outputs include:

- Anthropogenically Limited
- Stream Power Limited
- Slope Limited
- Potential Reservoir or Land Use Change
- Naturally Vegetation Limited
- Stream Size Limited
- Dam Building Possible

BRAT Opportunities — Identifies the level of opportunity and effort required to establish beaver dams across the landscape. The output is based on comparisons between historic and existing dam-building capacity, the potential risk of undesirable dam impacts, and surrounding land use within the riverscape. Outputs include:

- Beaver Mimicry
- Conflict Management
- Conservation/Appropriate for Translocation
- Encourage Beaver Expansion/Colonization
- Land Management Change
- Natural or Anthropogenic Limitations
- Potential Floodplain/Side Channel Opportunities

Core Sagebrush Area (CSA) — An area identified by the Sagebrush Conservation Design as having relatively high ecological integrity and intact sagebrush habitat. CSAs generally support abundant sagebrush and perennial herbaceous vegetation, with low levels of invasive annual grasses, conifer expansion, and human modification. These areas are important priorities for protecting intact habitat and maintaining connectivity.

Dist. to Core — Distance to the nearest CSA, as defined by the Sagebrush Conservation Design. Reaches closer to intact sagebrush uplands may represent higher-priority conservation and restoration opportunities for wildlife that depend on both mesic and upland habitats.

Forested Ever — Identifies valley-bottom areas that have supported forest or tree cover >10% at some point during the period of available remote-sensing observations (1986 – 2025; RAP). This layer can help identify areas where woody vegetation has historically occurred and provide context for evaluating current vegetation conditions, potential encroachment, and changes in valley-bottom structure.

Growth Opportunity Area (GOA) — An area identified by the Sagebrush Conservation Design as having potential to expand or improve the conservation value and connectivity of intact sagebrush habitat. Growth Opportunity Areas may provide strategic locations for restoration or management actions that increase the size, connectivity, or resilience of associated Core Sagebrush Areas.

Health Indicators, Valley Bottoms — A suite of indicators used to characterize the ecological condition and function of valley bottoms. These indicators provide information about vegetation productivity, persistence, hydrologic function, and other characteristics that can help identify areas of high ecological value, degradation, or restoration opportunity.

Hydrologic Unit Code (HUC) — A standardized system developed by the U.S. Geological Survey to identify and organize watersheds and drainage areas at multiple spatial scales. HUCs provide a consistent framework for evaluating mesic resources and restoration opportunities within broader watershed contexts.

Irrigated ≥5 Years; 1986–2024 — Identifies areas that were classified as irrigated for at least five years during the 1986–2024 period. This layer provides context for distinguishing naturally functioning mesic systems from areas where vegetation productivity and water availability may be influenced by long-term agricultural irrigation.

Land Cover and Ownership — Displays land-cover characteristics and landownership patterns within and surrounding valley bottoms. These layers provide important context for evaluating management feasibility, restoration constraints, conservation priorities, and opportunities for coordination among landowners and management jurisdictions.

Normalized Difference Vegetation Index (NDVI) — A satellite-derived measure of vegetation greenness and productivity calculated from the difference between near-infrared and red reflectance. NDVI is commonly used to characterize vegetation vigor, seasonal productivity, and changes in plant cover through time.

Palmer Drought Severity Index (PDSI) — A climate-based index used to characterize the relative severity and duration of drought or unusually wet conditions. PDSI provides climatic context for interpreting vegetation productivity and persistence and helps distinguish changes associated with long-term site conditions from those driven by short-term climatic variability.

Persistence — How consistently a pixel or valley bottom supported productive late-season vegetation over 40+ years of satellite imagery. Higher values indicate more reliable water availability and a stable mesic habitat. See the MAP's Mesic Resource Persistence layer for additional information.

Rangeland Analysis Platform (RAP) — A remote-sensing data platform that provides spatially explicit estimates of vegetation cover and other rangeland characteristics across the western United States. RAP products can be used to evaluate vegetation composition, productivity, and trends at relatively fine spatial and temporal scales.

Stream Type — The flow regime of a stream reach, describing the typical duration and frequency of surface water flow. Stream permanence influences water availability, ecological function, restoration feasibility, and the types of management actions most likely to succeed.

Perennial Stream — A stream that typically has continuous surface flow throughout the year under normal climatic conditions. Perennial streams generally have the most consistent water availability and may offer greater opportunities for mesic habitat conservation and process-based restoration.

Intermittent Stream — A stream that flows during certain times of the year, typically in response to seasonal precipitation, snowmelt, groundwater contributions, or other predictable hydrologic conditions. Intermittent streams may provide important seasonal mesic habitat and can be highly responsive to restoration that improves water retention and floodplain connectivity.

Ephemeral Stream — A stream that flows only briefly in direct response to precipitation events or rapid snowmelt and typically lacks sustained surface flow between events. Although ephemeral streams may have limited surface-water availability, they can still influence watershed hydrology, sediment transport, and downstream mesic systems.

Tier 1—Protect & Maintain — The highest conservation-priority category for areas with relatively intact and persistent mesic resources near intact sagebrush systems. Management should emphasize protecting existing ecological function, preventing degradation, maintaining hydrologic connectivity, and avoiding actions that could reduce long-term resilience.

Tier 2—Restore & Enhance — Areas where mesic resources near intact sagebrush systems retain sufficient ecological function or restoration potential to benefit from targeted improvements. Management should focus on restoring hydrologic processes, improving vegetation productivity and persistence, enhancing habitat quality, and addressing limiting factors before further degradation occurs.

Tier 3—Strategically Manage — Areas where mesic resources are more water limited or constrained by environmental or management factors. Actions should be targeted strategically toward locations where restoration is feasible and likely to produce meaningful ecological benefits, while recognizing that some sites may be better suited to long-term management, monitoring, or protection of remaining functional resources.

Valley Bottom — Valley bottoms represent the area that could plausibly flood under contemporary flow regimes if floodplains were intact. The low-lying portion of a watershed associated with a stream channel and its adjacent floodplain (active and inactive). Valley bottoms often concentrate water and support disproportionately productive vegetation and important wildlife habitats relative to surrounding uplands.

Vegetation Persistence — The degree to which productive vegetation is consistently maintained within a valley bottom over time, based on long-term satellite observations. High vegetation persistence indicates relatively stable and reliable growing conditions and may serve as an indicator of sustained water availability and mesic habitat function.

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Data Sources	
NDVI	Landsat 5, 7, 8 & 9 (30 m spatial resolution) via Google Earth Engine
Vegetation Cover	Rangeland Analysis Platform (RAP 30-meter) — rangeland.ntsg.umt.edu
Valley Bottoms	Valley Bottom Extraction Tool (VBET) — Riverscapes Data Exchange (data.riverscapes.net)
SCD Uplands	Sagebrush Conservation Design — Doherty et al. 2022 · USGS OFR 2022-1081
Land Ownership	Protected Areas Database of the US (PAD-US 4.1) — USGS 2024
Irrigation	IrrMapper Random Forest v1.2 via Google Earth Engine
Climate	GRIDMET · Palmer Drought Severity Index (PDSI)

References & Data Links

PLATFORM & DATA ACCESS
Mesic Analysis Platform: mesic.app
Raw Mesic Data Download: rangeland.ntsg.umt.edu/data/mesic/
Source Code: github.com/krisMueller/Beyond_Uplands_Mesic_Frameworks
Valley Bottom Extraction Tool (VBET): tools.riverscapes.net/vbet
Rangeland Analysis Platform (RAP): rangeland.app



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