



***From Fens to Floodplains:
Novel Applications of LLWW
Classification in Wetland
and Riparian Areas of the
Western US***

Riparian LLWW Automated Model

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Riparian LLWW Key Development

- Based on Lemly et al. (2018). *Keys to LLWW for Inland Wetlands of the Western United States* (v. Dec 10, 2018). CNHP, Colorado State University & GSS, Saint Mary's University.
 - LLWW adapted for the arid and semi-arid West
 - Classifies wetlands and waterbodies



Riparian LLWW Key Development

- **Similar but different systems**
 - Retained Landscape Positions, Landforms (except Flat), and Waterflow Paths
 - Riparian hydrology differs from wetlands
 - Restricted code combinations

Key A: Landscape Position

Following the USFWS definition, riparian areas are primarily associated with waterbodies (rivers, streams, lakes or drainageways). Landscape Position designates the water body that a riparian feature is associated with, either a river or stream (Lotic), lake (Lentic), or if the riparian area is associated with a small waterbody (pond) and/or is relatively isolated (Terrene). In this classification, all riparian areas within the geomorphic floodplain are considered Lotic, whether they are in or outside of the active floodplain. See Appendix A NOTE 1 for more information on distinguishing Landscape Position and NOTE 2 for information on classifying lakes and ponds.

1a. Riparian area is located within the geomorphic floodplain of a river, stream or intermittent/ephemeral drainageway and may be periodically flooded by overflow from the river/stream, from seasonal/temporary flow or influenced by the alluvial aquifer **Lotic (LO)**

Go to Key B-1 for Lotic Landforms

1b. Riparian area not located in a geomorphic floodplain or affected by a river, stream, intermittent or ephemeral drainageway **2**

2a. Riparian area located along the shore of a lake or reservoir, within the basin formed by a lake or reservoir, or along a stream flowing through a lake or reservoir basin. Associated waterbody a permanently flooded, deepwater lake or reservoir and riparian area experiences rising and falling water levels as a direct result of the lake or reservoir. **Lentic (LE)**

Go to Key C-1 for Lentic Landforms

2b. Riparian area associated with a small waterbody that is surrounded by upland OR riparian area contributes to a headwater tributary independently or as part of a wetland complex; hydrology maintained primarily by pond levels, surface runoff, but may also be influenced by groundwater **Terrene (TE)**

Go to Key D-1 for Terrene Landforms

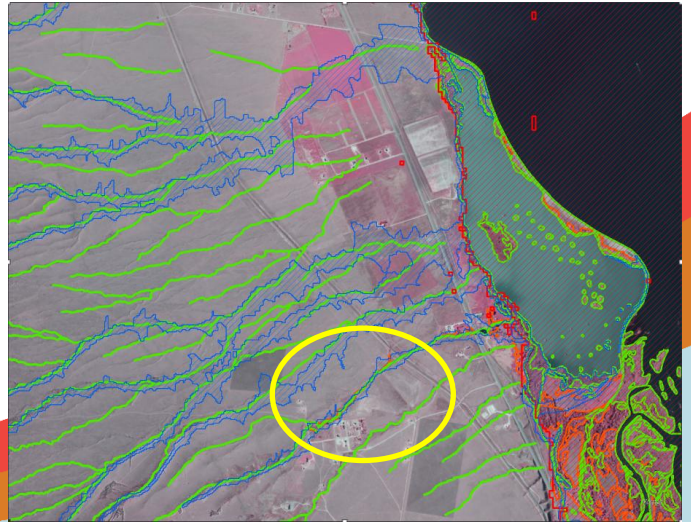
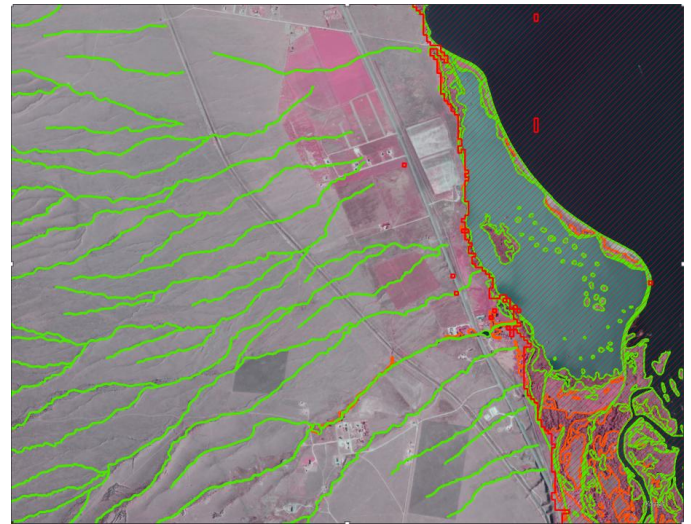
Why automate LLWW Classification?

- Reduces interpersonal and intrapersonal variance
- Saves time and money!
- Consistent rules lead to more consistent outputs
 - Dichotomous key structure
 - Repeatability



LLWW Model Development

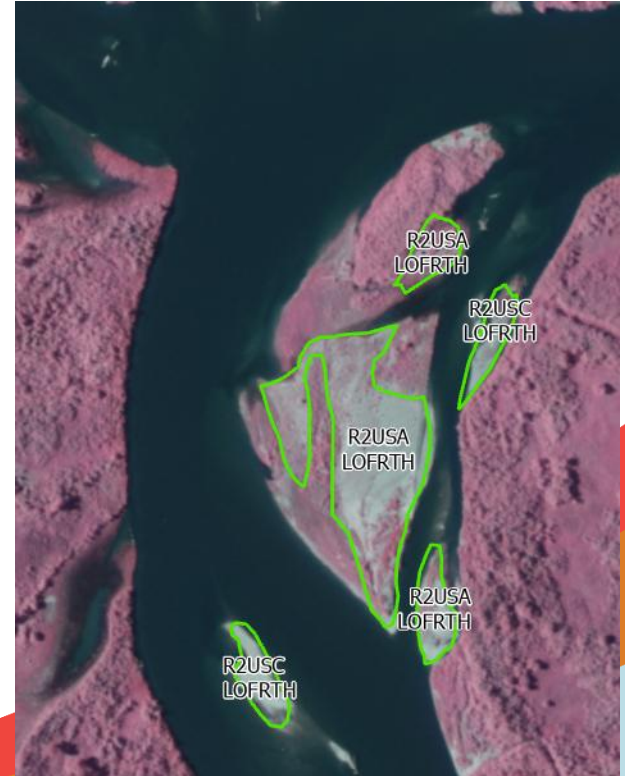
- **Variable input parameters allow flexibility across ecoregions while maintaining rulesets**
 - Ancillary datasets
 - Floodplain rasters, hydrography, soils data, etc.
 - Tailoring spatial relationships
 - Buffer distances, thresholding, DEM derivatives, etc.



LLWW Model Development

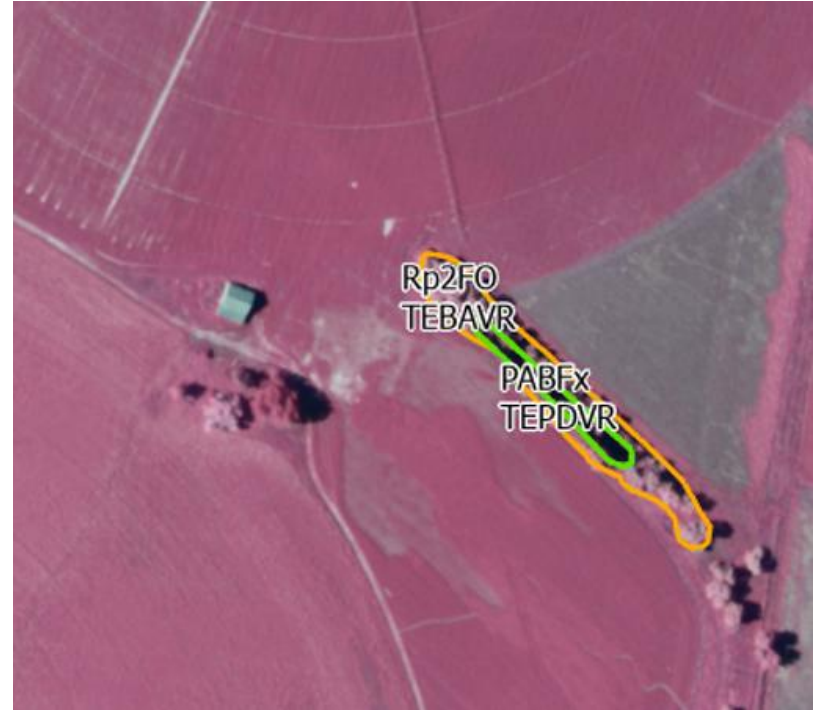
- **CHALLENGES**

- Riparian classification lacks key information
 - PUS(A or wetter) adjacent to a river/stream
 - Lotic Fringe
 - Water Regimes
 - Special Modifiers



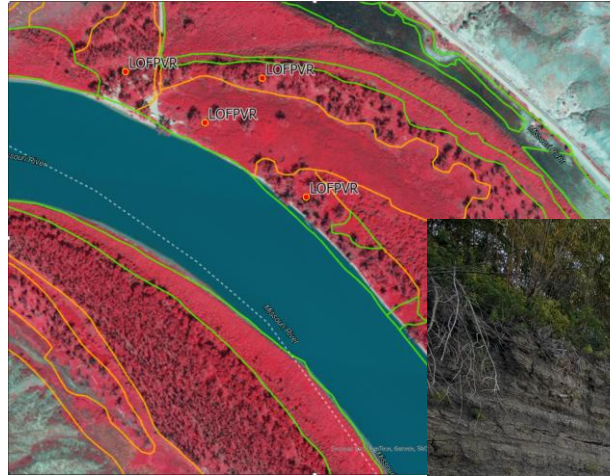
LLWW Model Development

- **Rp1 = Associated with Lotic Waterbody**
- **Rp2 = Associated with Lentic Waterbody**
 - <> Lentic Landscape Position
- **Attribution cannot be made in a vacuum**
 - Requires fully classified wetland LLWW data



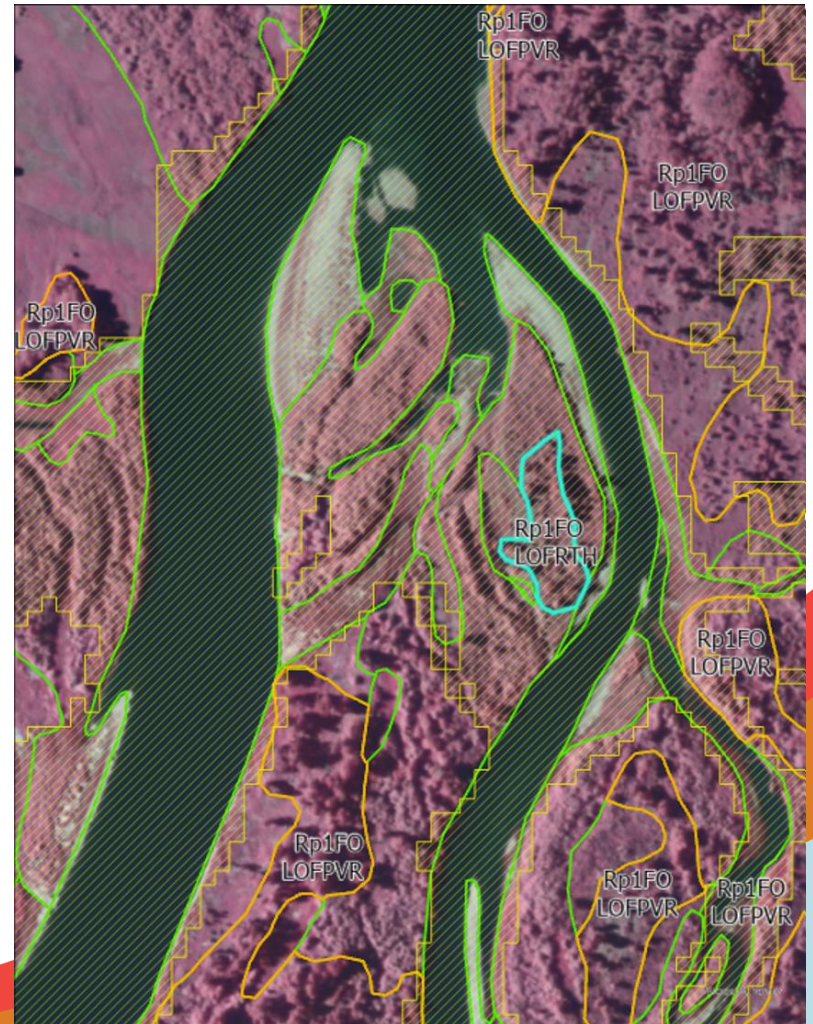
LLWW Model Development

- **Identifying Fringe Landforms**
- **Modified HAND Model**
 - Overcomes false adjacency when Riparian is situated above a large cutbank or terrace



LLWW Model Development

- **Identifying Fringe Landforms**
- **Modified HAND Model**
 - Incorporates existing waterbody mapping
 - User defined HAND output values and Riparian overlap percent threshold
 - Still requires horizontal spatial connection to waterbody and/or wetland Fringe

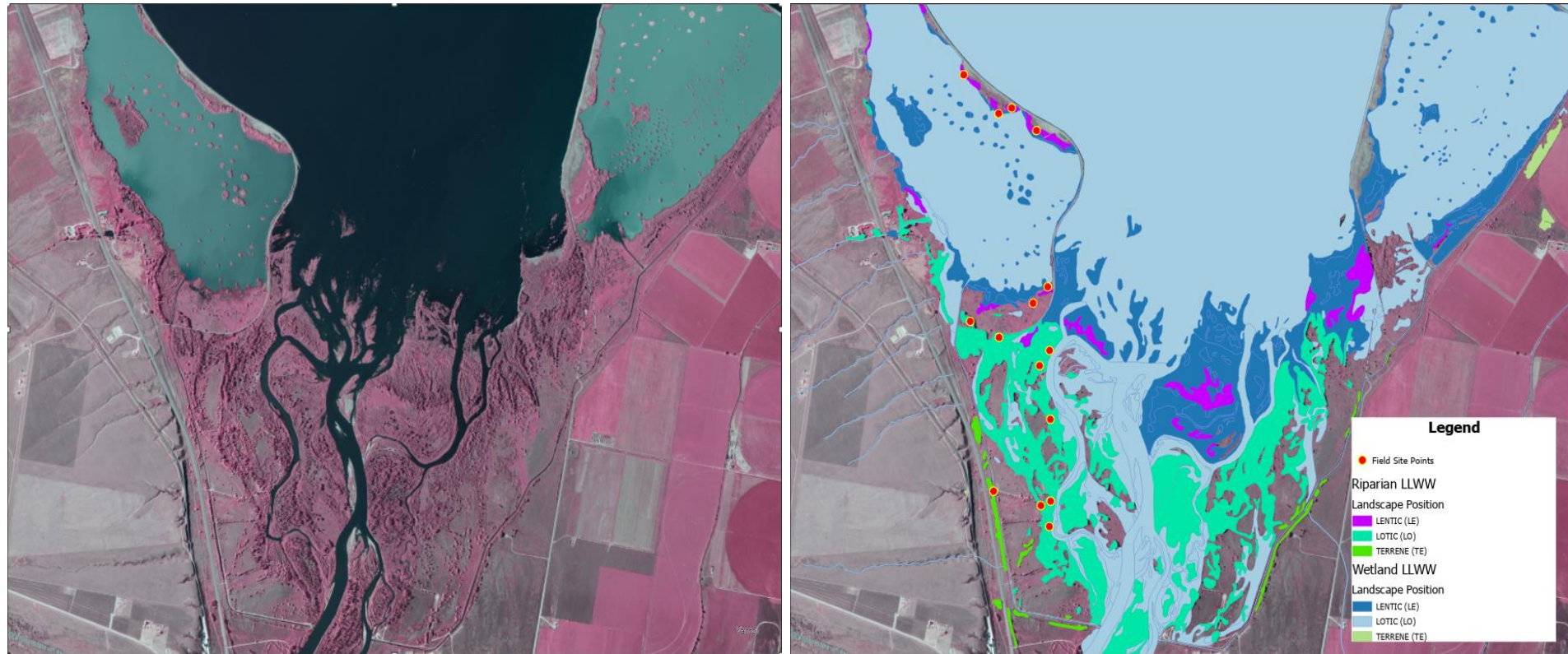


Field Assessment

- 3 HUC12s (Subwatersheds) in 3 ecoregion
- Summer 2026 Site Visits
 - UM
 - Whitehorse Creek - Canyon Ferry Lake near Townsend, MT
 - Knox-Ridge - Missouri River near Dry Junction, MT
 - SMU
 - Vermejo River Outlet, NE NM



- **Model Output – Canyon Ferry Reservoir, MT**



Model vs Manual Attribution

- Canyon Ferry Confusion Matrices Summary

Code Component	Classes	Total Features	Exact Matches	Overall Accuracy (All Features)	Accuracy Excl. 'TEXXXX'
1. Landscape Position	LE, LO, TE	328	303	92.4%	92.4%
2. Landform	BA, FP, FR, SL, XX (Unclassified)	328	278	84.8%	90.0%
3. Waterflow Path	BI, IN, OU, TB, TH, VR, XX (Unclassified)	328	281	85.7%	90.9%
4. Full Combined Code (LLWW)	16 Valid Schema Codes + 1 Unclassified Code	328	254	77.4%	82.2%

Model vs Manual Attribution

- **Inspecting Unclassified Riparian Polygons**
 - Irrigation-influenced features
 - Legacy riparian features
 - Riparian mapping errors



Applying Potential Functions

- **Potential Habitat Functions**

- Amphibian Turtle
- Aquatic Invertebrate
- Greater Sage Grouse
- Migratory Bird
- Other Wildlife
- Shorebird
- Waterfowl and Waterbird



- **Potential Geophysical Functions**

- Bank and Shoreline Stabilization
- Carbon Sequestration
- Groundwater Recharge
- Nutrient Transformation
- Sediment and Particulate Retention
- Stream Shading and Wood Structure
- Streamflow Maintenance
- Surface Water Detention





Thank you