

# Colorado Natural Heritage Program Landscape Integrity Model

The Colorado Natural Heritage Program (CNHP) Landscape Integrity Model (LIM) assesses potential wetland condition by describing the spatial effects of multiple landscape features that act as stressors to the aquatic environment. GIS data on stressors are combined to produce a landscape integrity map that informs users of wetland condition based on the level of predicted stress. To ensure the quality of the output, CNHP is applying a rigorous calibration and validation method based on the correlation with field-based wetland condition metrics. CNHP will use the LIM to provide an initial “coarse filter” for identifying high and low quality wetland sites across the state. Areas of high landscape integrity may be targeted for conservation, while areas of low landscape integrity may require restoration or other management action. The LIM tool is highly transferable to other states, particularly those neighboring Colorado and that share similar wetland characteristics.

## OVERVIEW

**Lead developer(s):** Colorado Natural Heritage Program (CNHP) and Colorado Parks and Wildlife (CPW).<sup>1</sup>

**Year developed:** 2011.<sup>1</sup>

**Geographic area:** The state of Colorado. Through a series of river basin-scale wetland condition assessment projects, the LIM will be calibrated with field data collected in each of the state’s ten major river basins (Fig. 1).<sup>2</sup>

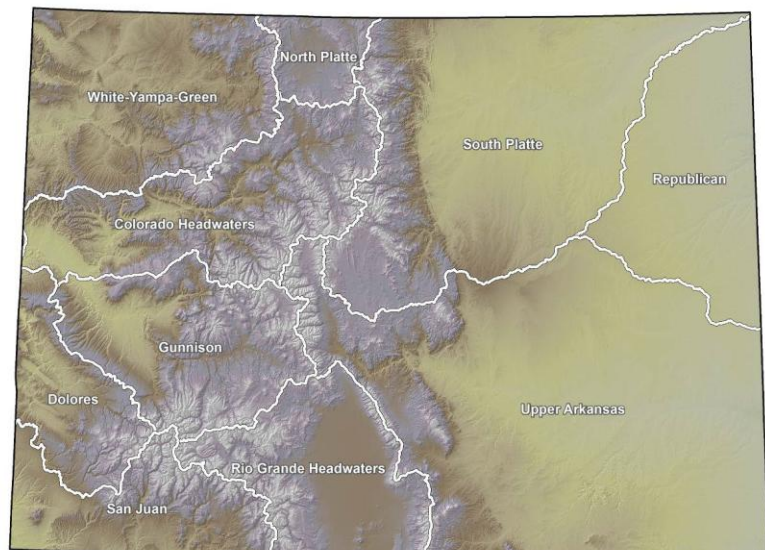
**Resource types:** Wetlands.<sup>1</sup>

**Restoration/conservation:**

Restoration (reestablishment and rehabilitation), creation, enhancement, preservation/protection, and acquisition without preservation/protection.<sup>3</sup>

**Stakeholders:** As part of CNHP’s broader conservation planning process, the LIM may be used to inform wetland restoration and conservation decisionmaking by the Colorado Parks and Wildlife (CPW), the USDA Natural Resources Conservation Service (NRCS), the U.S. Army Corps of Engineers (Corps), the Colorado Department of Transportation (CDOT), The Nature Conservancy (TNC), Ducks Unlimited (DU), and various land trusts.<sup>3</sup>

**Current status:** CNHP is currently in the process of evaluating outputs of the LIM tool using rapid wetland conditions assessments, which it expects to complete over the course of a few



**Figure 1. The CNHP LIM will be used to assess wetland stressors for each of Colorado’s ten major river basins. Used with permission from Colorado Natural Heritage Wetland Assessment.**

years. To date, it has evaluated the results for two basins. After validation is complete, CNHP plans to begin using the LIM to support prioritization efforts by applying it to help guide its targeted assessment program.<sup>4</sup>

## **PRIORITIZATION ANALYSIS**

### **Landscape prioritization tool(s):**

Landscape integrity model: CNHP’s LIM ranks wetlands in terms of their “overall landscape integrity,” an indicator of the overall stress on each wetland derived by combining four stressor categories comprising 13 total stressors (Table 1). Each stressor was modeled based on a single landscape feature that served as an indicator of stress on surrounding wetlands and was derived from readily-available GIS data. CNHP assigned a weight to each stressor based on the best professional judgment of the LIM team and modeled the decline in the effect of each stressor, or lack thereof, across space using the distance-decay function described by the equation in Figure 2, below.

$y = \frac{1}{1 + \exp(b(\frac{x}{c} - a))} \times w$	<p>where</p> <p><i>a</i> - shifts curve to right or left</p> <p><i>b</i> - determines spread of curve, or slope of the rapidly decreasing part of curve.</p> <p><i>c</i> - scalar to adjust total distance of interest (= distance in meters divided by 20)</p> <p><i>x</i> - distance in meters from threat</p> <p><i>w</i> - weight of threat (maximum value)</p>
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**Figure 2. CNHP’s LIM quantifies the effects of surrounding stressors on wetlands using a distance-decay function that describes the decline in 13 stressors (represented by GIS data on stressor-associated landscape features) across the landscape. Used with permission from Colorado Natural Heritage Wetland Assessment.**

Using the distance-decay curve, the team had the ability to describe the effect of stressors in a variety of ways, ranging from having a high impact (i.e., high weight) but declining rapidly with distance to having a low impact (i.e., low weight) but decaying gradually. Within buffer regions surrounding each wetland, CNHP used these stressor maps to calculate landscape integrity scores.

A distance-decay function was not used, however, to describe the effects of Tamarisk populations and hydrologic modification. Tamarisk effects were described simply in terms of the footprint of Tamarisk distributions. Effects of hydrologic modifications, which accumulate with the water flow downstream rather than propagating equally in all directions, were described using TNC’s method for calculating hydrologic disturbance downstream.

CNHP and partners will use the final output map resulting from this process to prioritize wetland protection, restoration, and enhancement efforts (see Figure 4). For example, a wetland may be determined to be a good candidate for protection if it is determined to have high landscape integrity (low stress). On the other hand, if a wetland has low landscape integrity (high stress), but is restorable within its natural range of variation, it may represent a good candidate for restoration. A wetland may be a good candidate for enhancement if it has low landscape integrity

(high stress) and cannot be restored to within its natural range of variation, but can be enhanced for specific ecological functions.

*Prioritization objectives assessed:*

- Wetland condition

**Table 1. The CNHP LIM used the following factors and associated data sources to assess stressors to landscape integrity.**

<b>Factor used in analysis</b>	<b>Data source</b>
<b><i>Land use and development</i></b>	
Industrial/urban development	LandFire current vegetation: high and medium intensity development
Suburban/rural development	LandFire current vegetation: low intensity development
Highly modified open space	LandFire current vegetation: developed open space
Primary roads (interstate highways)	US Census TIGER/Line: primary roads
Secondary roads (state highways)	US Census TIGER/Line: secondary roads
Local and primitive roads	US Census TIGER/Line: local/primitive roads
Agriculture	LandFire current vegetation: pasture/hay and cultivated/irrigated
<b><i>Energy development and resource extraction</i></b>	
Active oil and gas wells	Colorado Oil and Gas Conservation Commission: active wells
Inactive oil and gas wells	Colorado Oil and Gas Conservation Commission: plugged/abandoned wells
Wind turbines	CNHP
Active sand and gravel mines	Colorado Division of Mine Safety: active sand and gravel mines
Other active and abandoned mines	Colorado Division of Mine Safety: all other active mines
<b><i>Hydrologic modification</i></b>	
Reservoir storage as proportion of mean annual flow	TNC Freshwater Measures Database
Water use as a proportion of mean annual flow	TNC Freshwater Measures Database
Dams and diversions by stream length	TNC Freshwater Measures Database
Groundwater wells	Colorado Division of Water Resources: active groundwater wells
<b><i>Weed infestations</i></b>	
Tamarisk populations	The Tamarisk Coalition and TNC

Wetland profiling: CNHP completes wetland profiles for each of Colorado’s ten major river basins by summarizing information about the extent and distribution of wetlands within each. Using various classification systems to group wetland types into “bundles” of wetlands sharing similar ecological functions, CNHP is able to obtain information about the abundance and location of wetland functions throughout river basins. For example, profiles obtained for

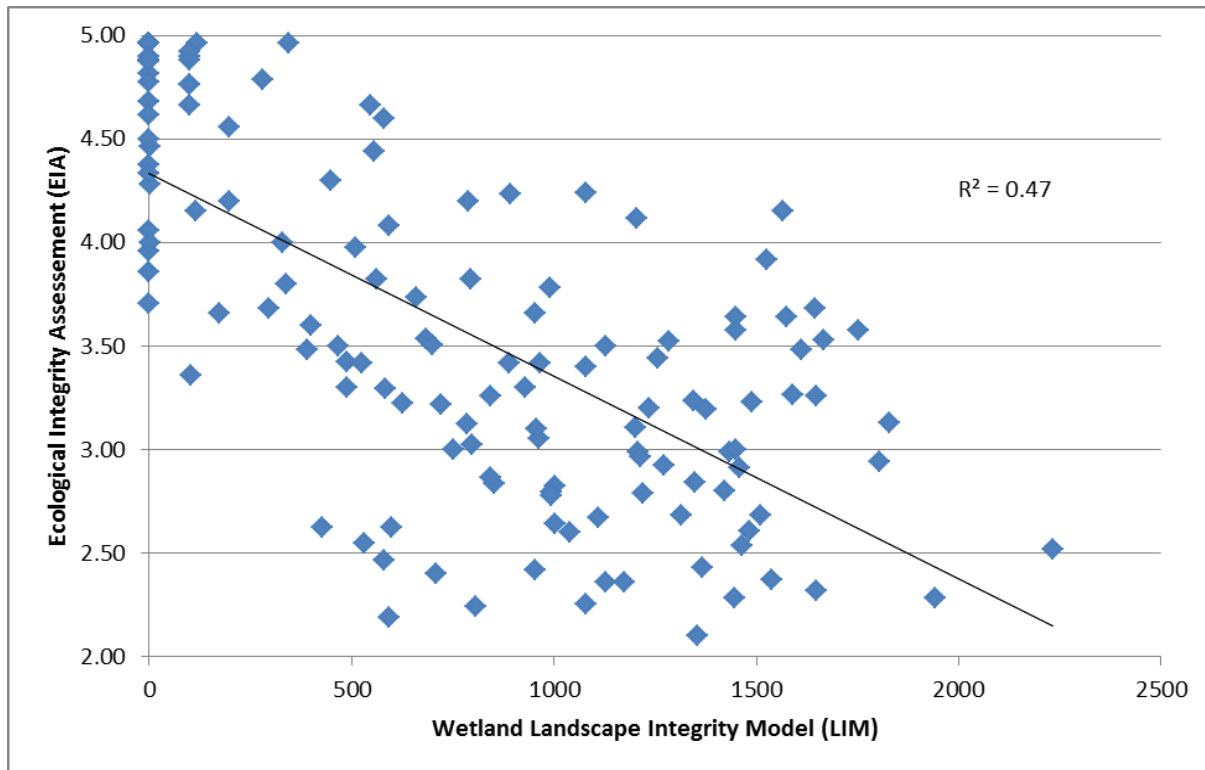
depressional wetlands enable CNHP to make inferences about the status and trends of wetland-dependent wildlife species, such as waterbirds and amphibians, which often depend on habitat provided by depressional wetlands.<sup>1</sup>

*Prioritization objectives assessed:*

- Wetland condition

Factor used in analysis	Data source(s)
Existing wetlands	NWI
Wetland condition	Landscape integrity model outputs

**Validation of the landscape prioritization tool(s):** Landscape prioritization LIM results have been correlated with the results of field-based rapid assessment methods from two river basins. Rapid assessment methods included the Human Disturbance Index (HDI), Ecological Integrity Assessment (EIA), and Mean C assessment. Because each correlation was strong, CNHP concluded that the LIM model was an effective tool for the assessment of landscape integrity, though weights on input stressors may need adjustments. CNHP did not find a strong correlation between LIM results and intensive results obtained using the Vegetation Index of Biotic Integrity (VIBI), but the VIBI method is also under development and was only applied to a handful of sites. An example of the correlations used by CNHP to validate its LIM model is shown in Figure 3, which relates LIM scores with rapid assessment EIA results. Overall, CNHP found that rapid assessment/intensive methods demonstrated a similar pattern of stressors as obtained using the LIM, with wetlands at lower elevations (e.g., marshes and saline wetlands) having lower landscape integrity scores and wetlands at higher elevations (e.g., fens and riparian shrublands) having higher scores.<sup>4</sup>

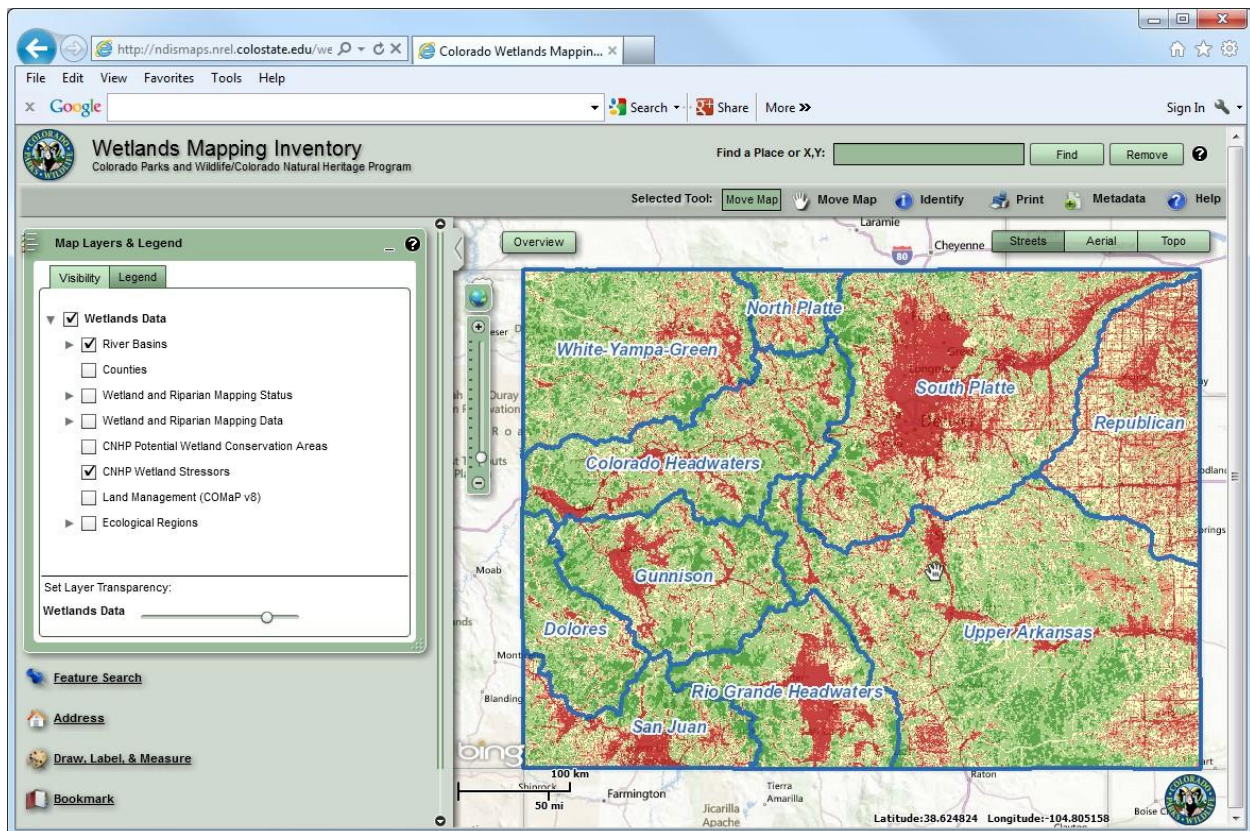


**Figure 3. Rapid assessment results for EIA assessments correlate strongly with landscape prioritization LIM results. Strong correlations were also demonstrated between LIM and rapid assessment results for HDI and Mean C assessments. Used with permission from Colorado Natural Heritage Wetland Assessment.**

**Refinement of landscape priorities:** CNHP will use LIM results as a coarse filter for identifying high and low quality wetlands, and plans to seek funding to apply more detailed targeted assessment methods. In this way, the LIM will support CNHP’s broader conservation planning program, which primarily involves field-based assessments that are used to rank wetlands in terms of a “biodiversity significance rank” (B-rank) by conducting surveys at the county level. The method can also be used to rank wetlands at the watershed, planning area, and ecoregional scale. CNHP stores survey data in its Biotics database and uses the data to rank wetlands and uplands in terms of their biodiversity significance.<sup>5</sup>

The biodiversity significance rank (B-rank) ranks wetlands on a scale of 1-5, with wetlands receiving a rank of ‘B1’ considered to have “outstanding significance” and those receiving a rank of ‘B5’ having only “general significance.” The B-rank is obtained by combining a “global rarity rank,” ranging from G1 (“critically imperiled”) to G5 (“very common”), with an “element occurrence rank,” ranging from A (“relatively large, pristine, defensible, and viable”) to D (“too degraded or not viable”).

**Prioritization products:** CNHP’s map of wetland landscape integrity can be visualized using an online interactive map developed by CNHP in collaboration with CPW (Figure 4). The map can be accessed at: <http://www.cnhp.colostate.edu/wetlandinventory/index.asp>.



**Figure 4. CNHP and CPW support an interactive map that the public can use to visualize LIM results overlaid with other spatial data of interest. Used with permission from Colorado Natural Heritage Wetland Assessment.**

In addition to visualizing the LIM stressor map, users of the interactive tool can overlay boundary data for river basins, counties, and ecoregions as well as other features of interest (e.g., a variety of wetland and riparian GIS datasets). Users can also view CNHP's map of Priority Conservation Areas (Figure 5), which in the future will be selected using a targeted assessment process guided by the LIM tool. A variety of static maps and GIS data are available for download from CNHP's website at: <http://www.cnhp.colostate.edu/download/gis.asp>.

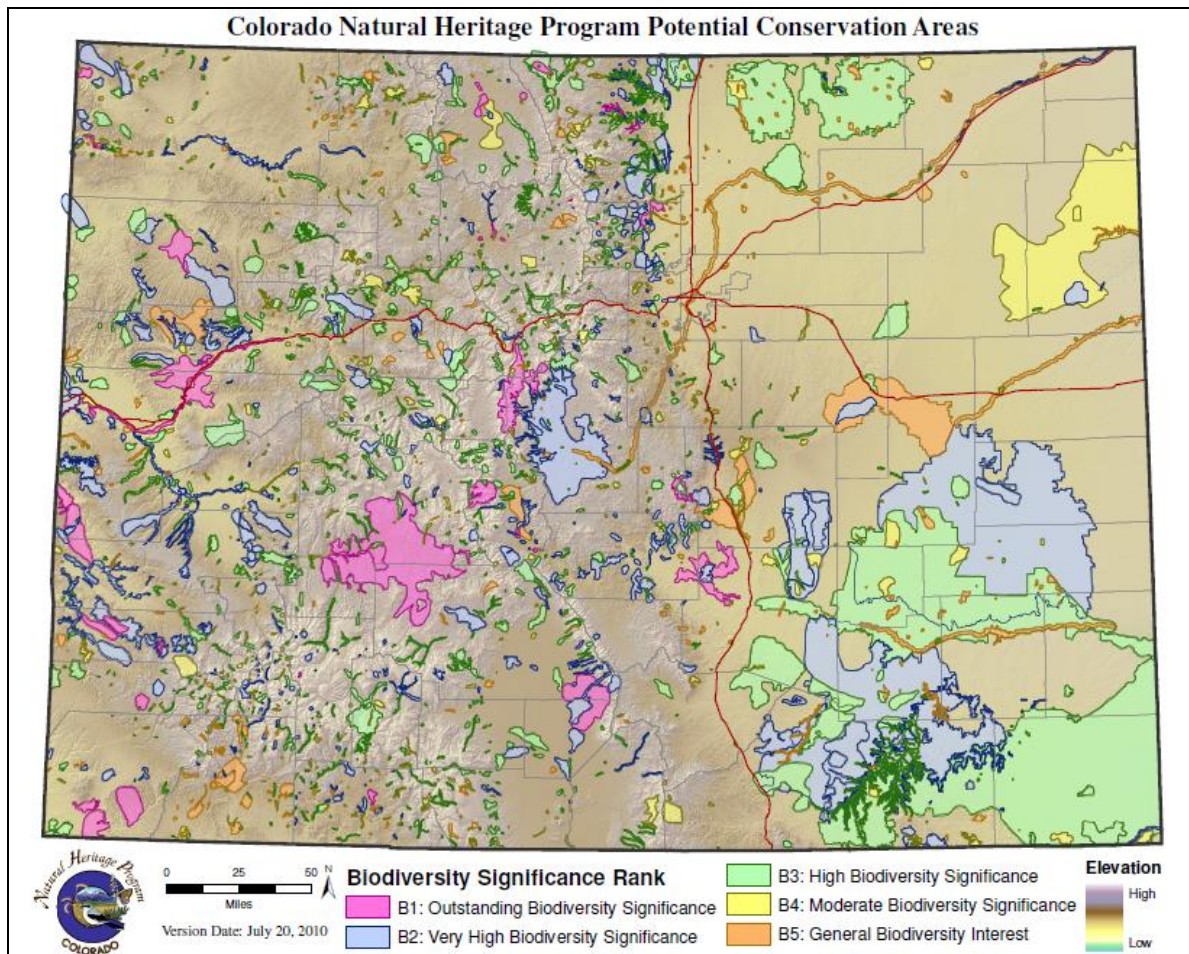


Figure 5. Priority Conservation Areas are currently identified using CNHP's field-based targeted assessment method. Once completed, CNHP's LIM tool will be used to guide the targeted assessments. Used with permission from Colorado Natural Heritage Wetland Assessment.

## IMPLEMENTATION

**Regulatory/non-regulatory programs:** As discussed above, the LIM will be used to inform CNHP's broader conservation planning efforts. In doing so, it could support the following regulatory and non-regulatory programs:

- Wetland habitat restoration: Colorado Parks and Wildlife (CPW) administers the Wetland Wildlife Conservation Program, which funds over \$1 million annually in wetland habitat restoration. The LIM and associated targeted field assessments will help CPW prioritize wetland types and geographic areas most in need of restoration.<sup>2</sup>
- Section 404 compensatory mitigation for wetlands: Conservation planning informed by LIM may support the selection of wetland mitigation sites. Because CNHP's targeted assessment data can be used to rank wetlands at the watershed level, they may be used in support of a watershed approach to mitigation.<sup>3</sup>

- Endangered species compensatory mitigation: Guided by the LIM, targeted assessments could identify high biodiversity sites that may be prioritized for endangered species mitigation.<sup>3</sup>

**Transferability:**

- Because the LIM was designed with regional application in mind, once completed, it could readily serve as a model tool for states neighboring Colorado seeking to prioritize wetland restoration and conservation. In fact, EPA has already expressed interest in applying it to Wyoming, New Mexico, and Utah. The tool is readily transferable to these states because wetlands in this region tend to have very similar characteristics, such as plant diversity and hydrology.<sup>3</sup>

**Data gaps:**

- A lack of comprehensively digitized National Wetlands Inventory (NWI) maps. Converting remaining NWI maps to a digital spatial format is important for ensuring that high quality wetland data are used in the LIM model. CNHP has the scans of the hard copy maps and is currently writing grants to obtain the funding they need to digitize them.<sup>3</sup>

**Barriers:**

- Funding for targeted assessments and for further validation of the LIM.<sup>3</sup>
- Property rights concerns associated with using the LIM to identify specific areas on a map as priorities.<sup>3</sup>

**Future goals:**

- Obtain comprehensive digital wetland maps for Colorado. CNHP staff members have the skills to complete the maps but lack the necessary funding.<sup>3</sup>
- Complete validation of the LIM.<sup>2</sup>

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<sup>1</sup> Colorado Natural Heritage Program. 2011. Statewide Strategies to Improve Effectiveness in Protecting and Restoring Colorado's Wetland Resource.

<sup>2</sup> Feedback provided on 3/7/12 by Joanna Lemly, Wetland Ecologist, Colorado Natural Heritage Program.

<sup>3</sup> Interview on 8/15/11 with Denise Culver, Colorado Natural Heritage Program.

<sup>4</sup> Feedback provided on 5/16/2012 by Joanna Lemly, Wetland Ecologist, Colorado Natural Heritage Program.

<sup>5</sup> Colorado Natural Heritage Program. 2010. Colorado Natural Heritage Program Wetland Program Plan: A Vision for Building Comprehensive Wetland Information for the State of Colorado. Planning Years 2011-2015.