

# Montana Natural Heritage Program

## Landscape Integrity Model

The Montana Natural Heritage Program (MTNHP) Landscape Integrity Model (MTLIM) allows for rapid characterization of the landscape at any distance from a given wetland. The model assigns values to every pixel in the landscape based on its distance from various human stressors (e.g., roads, agriculture) in the surrounding landscape. Used in conjunction with aerial photographs, the MTLIM has a high degree of accuracy when used to identify areas where high-integrity wetlands may be found. It also predicts severely impacted wetlands well. However, it is not highly accurate in distinguishing between “good” and “fair” classes of wetlands, as these condition classes typically have both landscape level and site-level stressors. Because it uses GIS data that are readily available, the MTLIM is easily transferable to other Rocky Mountain states.

### OVERVIEW

**Lead developer(s):** Montana Natural Heritage Program (MTNHP).

**Year developed:** 2009.<sup>1</sup>

**Geographic area:** Statewide (Fig. 1).<sup>1</sup>

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

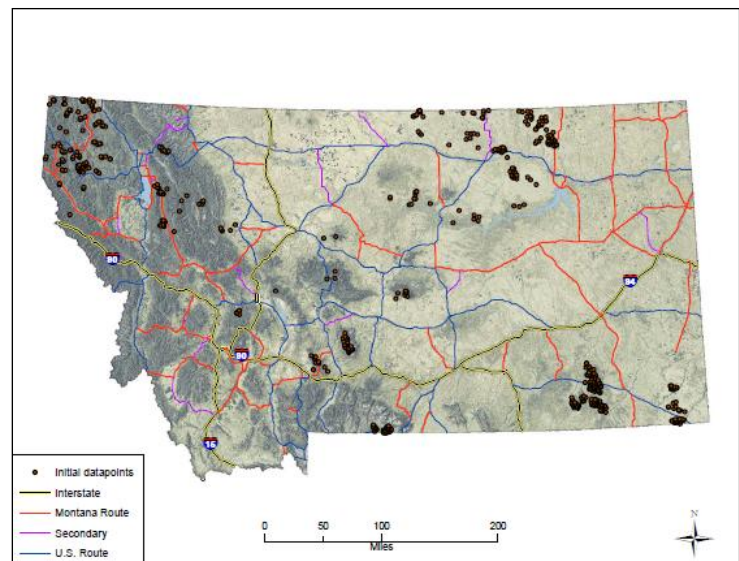
**Restoration/conservation:** Restoration (establishment and rehabilitation), enhancement, preservation/protection, and acquisition without preservation/protection.<sup>1</sup>

**Stakeholders:** The U.S. Environmental Protection Agency, Montana Department of Environmental Quality (MTDEQ), and other agencies/organizations seeking to identify high quality lands for wetland restoration/conservation.<sup>1</sup>

**Current status:** MTNHP is actively updating National Wetland Inventory (NWI) maps and collecting field data, as well as carrying out rotating basin assessments using rapid and intensive protocols. These maps and assessments are used to refine landscape prioritization analyses.<sup>2</sup>

### PRIORITIZATION ANALYSIS

**Determination of input factors/weightings:** MTNHP began development of the LIM with an attempt to find landscape-level predictors of wetland condition. The original data set came from thousands of Montana Department of Environmental Quality Rapid Assessment Method (MTDEQ-RAM) sites throughout the state. Many of these assessments were part of a statewide project to evaluate amphibian habitat. MTNHP then built a GIS layer of landscape-level



**Figure 1.** The MTNHP used existing rapid assessment wetland condition scores at the points shown above to calibrate the MTLIM. Used with permission from the Montana Department of Environmental Quality.

stressors based on the literature and expert judgment, and used a Classification and Regression Tree (CART) analysis to select those stressors with the greatest predictive value. In central eastern Montana, where there is a high density of seldom used roads, but heavy livestock use, no landscape predictors were particularly reliable. In western Montana, road density showed some predictive value for all wetland conditions.<sup>2,3</sup>

**Landscape prioritization tool(s):**

Landscape Integrity Model (LIM): MTNHP built the LIM model using input factors derived from the above analysis and metrics for landscape-level stressors shown by the scientific literature to have important impacts on wetland condition (Table 1). Final metrics comprised four categories (roads, land cover, hydrology, and resource extraction), each of which was made up of individual component layers representing human change to the landscape (e.g., “highways” in the “roads” category). To each component layer, the MTNHP researchers applied an inverse-weighted distance function that assigned a score to each 30m<sup>2</sup> pixel that reflected the decrease in magnitude of each impact with distance across the landscape. These individual component layers, scored for impacts, were weighted and summed into overall category rasters, which were in turn weighted and summed to obtain final MTLIM scores.<sup>2,3</sup>

*Prioritization objectives:*

- Wetland condition

**Table 1. Factors and associated data sources used to assess landscape integrity as part of the MTLIM.<sup>3</sup>**

<b>Factor (component) used in analysis</b>	<b>Data source(s)</b>
<b><i>Roads</i></b>	
4-wheel drive	2001 TIGER/US Census Bureau
Local roads, city streets	
Highways	
<b><i>Land cover</i></b>	
Urban	2001 NLCD
Crop agriculture	
Timber harvest	
<b><i>Hydrology</i></b>	
Artificial flow	2007 NHD
Water rights point-of-use	MTDNRC
Section 404 permits	MTNRIS
<b><i>Resource extraction</i></b>	
Abandoned mines	MTDEQ
Oil or gas extraction	MTNRIS

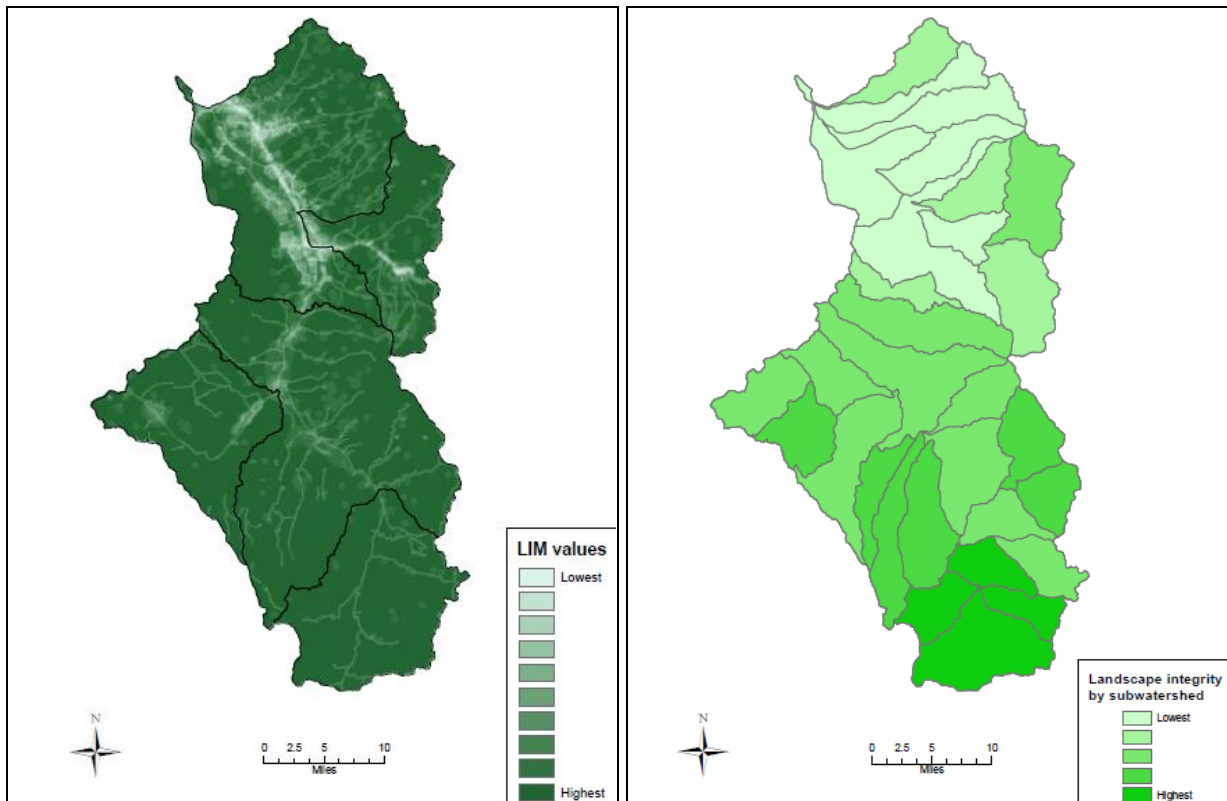
NLCD = National Land Cover Dataset; NHD = USGS National Hydrography dataset; MTDNRC= Montana Department of Natural Resources and Conservation; MTNRIS = Montana Natural Resource Information System; MTDEQ = Montana Department of Environmental Quality

**Validation of the landscape prioritization tool(s):** MTNHP has validated the Landscape Integrity Model approach in a recent project to identify wetlands in Minimally Disturbed Condition in the Rocky Mountain West. When followed by visual inspection of aerial photos to identify stressors that a GIS model might have missed (e.g., recent development, wildfire, timber

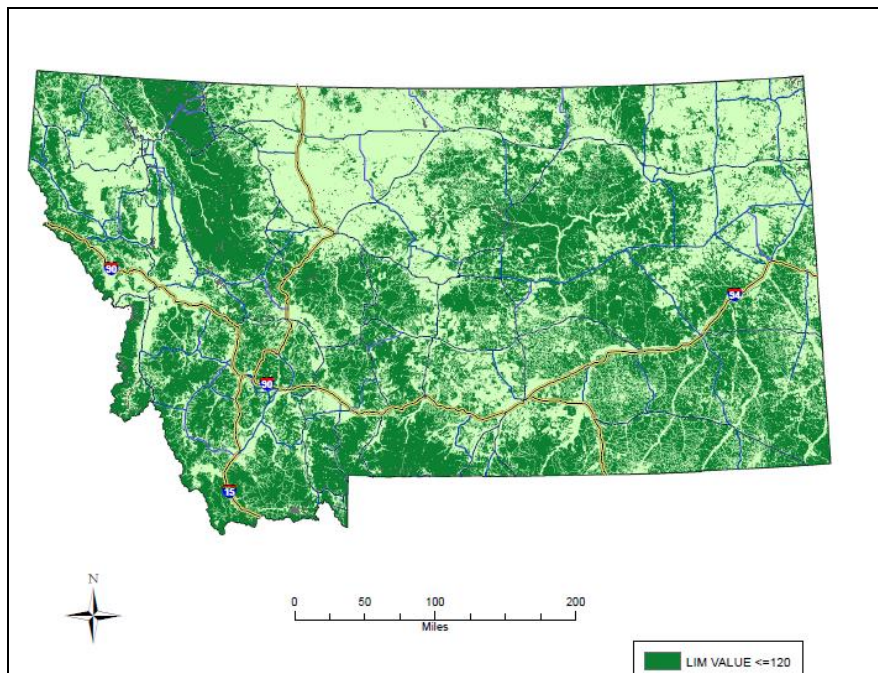
harvested, new roads), the model has proved to be very accurate for identifying minimally disturbed wetlands. When used across all condition classes, the model is less reliable. For example, in the original model development, MTNHP validated the MTLIM by comparing MTLIM-predicted categorical ratings with actual rapid assessment categorical ratings to three different datasets, with mediocre results.<sup>3</sup>

1. An independent sample of 180 wetlands drawn from a dataset of 1800 mapped palustrine and lacustrine wetlands throughout Montana, with 60 randomly selected and 120 selected specifically to incorporate a variety of environmental and disturbance gradients and unmapped areas found that 51% of ranks were correctly predicted.
2. A dataset consisting of 1800 randomly-selected wetlands drawn from all mapped palustrine and lacustrine wetlands in Montana.
1. 108 assessments completed using the Ecological Integrity Assessments (EIA), a rapid field-based assessment developed by MTNHP found that only 55.5% of ranks were correctly predicted.

**Prioritization products:** The Landscape Integrity Model has been described in MTNHP publications and the raster layer can be made available to interested parties on request. To support prioritization of wetland restoration or conservation, users may apply the model to visualize individual pixel ratings throughout the landscape or average MTLIM scores for subwatersheds (Figure 2) and identify large contiguous areas where high integrity wetlands are likely to be found (Figure 3). In some cases, users may also combine scores for individual wetlands with other metrics used in the MTNHP’s landscape prioritization, rapid assessment, and intensive assessment protocol (e.g., evidence of grazing within 1km) to increase the accuracy with which the MTLIM predicts wetland condition.<sup>2</sup>



**Figure 2.** Users seeking to prioritize wetland restoration or conservation can use the MTLIM output to visualize wetland condition at the pixel (*left*) and watershed (*right*) levels. Used with permission from the Montana Department of Environmental Quality.



**Figure 3.** GIS analysis can be applied to MTLIM results for the entire state to identify large, contiguous, high integrity wetland areas. Dark green areas in this map received low MTLIM scores, an indicator of low human disturbance. Used with permission from the Montana Department of Environmental Quality.

## **IMPLEMENTATION**

### **Regulatory/non-regulatory programs:**

- National Environmental Policy Act.<sup>1</sup>
- Habitat mitigation under the Endangered Species Act.<sup>1</sup>
- Water quality programs.<sup>1</sup>
- Section 404 wetland compensatory mitigation.<sup>1</sup>
  - Watershed approach to compensatory mitigation. MTLIM scores can be used to compare and contrast hydrologic units to guide the watershed approach to selecting mitigation sites across watersheds (Fig. 2B) or within watersheds (Fig. 2A).<sup>1</sup>
- Land trusts or other organizations seeking to protect high quality lands can use MTLIM scores to identify large contiguous areas in which high quality wetlands are likely to be found (Fig. 3).<sup>1</sup>

### **Transferability:**

- Montana NHP's MTLIM approach can be used with national datasets, or state-specific datasets. It is most transferable to Rocky Mountain states because of its emphasis on resource extraction stressors.<sup>3</sup>

### **Data gaps:**

Updated: 5/18/2012

- Roads-layer data do not include some unofficial but heavily used roads or any roads added in the state since the last census. However, in Montana, more recent transportation layers are available if an updated LIM is desired.<sup>2</sup>
- 2001 NLCD land cover data are incomplete as they are drawn from 1990s satellite imagery.<sup>3</sup> However, the Northwest Regional Gap Analysis Program map has been adapted and updated by the MTNHP, and these data could be used in an updated LIM.<sup>2</sup>
- Some of the water rights point-of-use data are imprecise, as they are based on points placed simply into the center of public land survey sections.<sup>3</sup>
- The energy layer used is current through the summer 2008, but now needs to be updated.<sup>3</sup>
- Abandoned mines data do not fully represent the extent of mining impacts.<sup>3</sup>
- A lack of statewide National Wetlands Inventory data prevented development of a distance layer for altered wetlands, which are likely important indicators of overall wetland condition.<sup>3</sup>
- A lack of large-scale GIS data for grazing.<sup>3</sup>

**Barriers:**

- Staff time.<sup>2</sup>
- Funding.<sup>2</sup>

**Future goals:**

- Use field-based assessments to calibrate the LIM separately for plains and mountain ecoregions. Because stressors operate at larger scales in the plains (e.g., weed seeds and dust travel farther than in forested regions), metrics linked with soil disturbance (e.g., distance from crop agriculture or roads) can be rescaled.<sup>3</sup>
- MTNHP has developed a separate landscape prioritization assessment approach as part of its rotating basin wetland ecological integrity assessments. As the landscape prioritization assessment is validated and calibrated against rapid assessment and intensive scoring, it can be used to refine the MTLIM. Rapid assessment and intensive data can also be used for this purpose.<sup>2</sup>

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<sup>1</sup> Interview on 11/14/2011 with Linda Vance, Senior Ecologist/Spatial Analysis Lab Director, Montana Natural Heritage Program.

<sup>2</sup> Feedback received on 5/15/2012 from Linda Vance, Senior Ecologist/Spatial Analysis Lab Director, Montana Natural Heritage Program.

<sup>3</sup> Vance LK. 2009. Assessing Wetland Condition with GIS: A Landscape Integrity Model for Montana. A Report to The Montana Department of Environmental Quality and The Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT. 23 pp. plus appendices.