Montana Land Cover Plan

A Plan for Statewide Land Cover Mapping, Maintenance, and Distribution

2020-2022

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PREPARED BY:

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**Prepared for consideration
by the Montana Land Information Advisory Council, with input from the Montana Land Cover
Working Group**

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Acknowledgement

Table of Contents

Land cover mapping of the Yellowstone floodplain near Billings, Montana based on segmentation and classification of NAIP imagery.

Executive Summary

The Montana Land Information Act (MLIA) requires an annual land information plan be prepared that describes Montana's priority needs in regard to the collection, maintenance, and dissemination of land information (MCA 90-1-404(c)). The Montana Land Information Plan 2019/2020 identifies as a priority the development of a partnership-driven plan for creating and routinely updating a new Land Cover layer.

The purpose of the Montana Land Cover Plan is to provide recommendations for the collection, maintenance, and dissemination of land cover data in Montana. The primary goal of this plan is to outline a comprehensive revision of statewide land cover mapping products and a process for consistent maintenance and regular updates through September 2022. Ongoing longer-term goals include land cover time-series applications, the development of additional land cover products as identified by the Montana Land Cover Working Group, and pathways for citizen science participation.

The historic MSDI Montana Land Cover data layer was last updated in 2017 to reflect modified or disturbed landscapes such as insect-killed forests, fire perimeters, changes in urban and agricultural land use, and changes to the transportation infrastructure. Despite continued widespread use and limited regular updates, the historic MSDI Montana Land Cover layer is outdated - in part due to the mapping and classification that is embedded from the original satellite imagery and classification methods from over 20 years ago.

The Montana 2020-2022 Land Cover Plan makes four recommendations:

Recommendation 1: Develop a dynamic new MSDI Land Cover framework (MTLandCover_2021) derived from Interagency Landfire ReMap products (https://landfire.gov/) published in 2017. The framework will consists of both an adaptive set of raster and vector geodatabase features and derived stand-alone products, including high resolution single theme products, and an independent time-series platform for interacting with temporal datasets derived from the Landsat archive (1984-present).

Recommendation 2: Evaluate the accuracy of the MTLandCover _2021 *Existing Vegetation Type* (*EVT*) raster product. This evaluation should include expert ecological review, comparisons to the historic MSDI Land Cover mapping, and where possible, assessments that leverage ground reference data (e.g., BLM AIM, and LMF; NRCS NRI) to refine the MTLandcover_2021 ecological systems attributes and to characterize classification uncertainty.

Recommendation 3: Evaluate the utility of a time-series platform for accurately visualizing trends in ecological conditions and re-evaluating state rankings for ecological systems. This effort would support the Environmental Quality Council mandate to track changes in the status of Montana's environment by incorporating Landsat NDVI time-series and annual land cover change products (1985-2016) that are in production under the Land Change Monitoring, Assessment, and Projection program (USGS).

Recommendation 4: Assess interest in the development of additional derived land cover products

and their maintenance requirements through feedback from the Land Cover Working Group. Objectives may include one or more of the following:

- Utilizing the dense network of MT ground reference samples, high resolution datasets, and lidar acquisitions to generate continuous cover products that address information needs such as wooded draw detection, fuel loading, intermittent streamflow, and habitat suitability modeling for agencies and programs that manage wildlife, habitat and other vegetation resources.

- Incorporation of georeferenced photographs that document historic and current land cover and land use.

Timeline for Implementing Land Cover Plan Recommendations

| Recommendation	Completion Timeline	Status (Dec. 2020)
1. Draft version MTLandCover_2021 dataset	Fall 2022	In progress (preliminary Land Cover dataset available)
2. Evaluate MTLandCover_2021 accuracy	Fall 2022	In progress (comparison to current product complete)
3. Develop land cover time-series applications; pursue follow-on funding	Ongoing	Started (ramp up needed)
4. Actively engage and pursue partners (develop additional products)	Ongoing	Started (ramp up needed)

Boundaries of the 2017 Liberty wildfire northeast of Missoula, Montana are visible on this 09/28/2017 Landsat 8 image (false color composite displays of bands 7, 5, and 2 are often used to visualize wildfire burn scars).

Introduction

The Montana Land Information Act (MLIA) requires an annual land information plan be prepared that describes Montana's priority needs regarding the collection, maintenance, and dissemination of land information (MCA 90-1-404(c)). The Montana Land Information Plan 2019/2020 identifies as a priority the development of a partnership-driven plan for creating and routinely updating a new Land Cover mapping dataset.

A Land Cover Working Group (LCWG) was formed in early 2020 and participants from state, federal, and non-profit organizations convened on March 27th 2020 to identify land cover mapping needs for Montana, inform a plan for creating and routinely updating a new Land Cover dataset, and establish a timeline for both developing a Land Cover Plan as well as mapping product updates and life cycles.
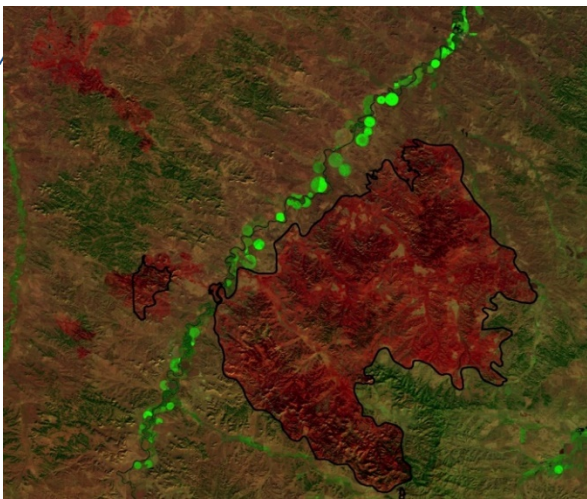
A significant outcome of the first LCWG meeting was the identification of land cover user needs and applications. Participants agreed on the critical need for improved rangeland mapping, including the ability to determine levels of invasion by alien plant species. Additional user need input included time-series information for tracking altered ecological systems, utilizing the wealth of field data that are available across the state, and product turnaround time that is temporally current within 12-18 months. A range of user needs that include higher resolution products, with fewer classes but greater accuracy was also identified. There were also concerns raised about addressing changes to land cover mapping that could potentially impact Montana Natural Heritage Program (MTNHP) uses and web applications if land cover mapping that combined datasets with different spatial and thematic resolutions were to be adopted.

Follow-up meetings of the LCWG included presentations from national and regional experts demonstrating on-going land cover mapping and analysis efforts and further discussion of how Montana might build upon these activities. The LCWG also formed a rangelands subgroup which has met and identified as a primary focus rangeland health and invasive species issues.

Purpose and Background

The purpose of the Montana Land Cover Plan is to provide recommendations for the collection, maintenance, and dissemination of land cover data in Montana. The primary goal of this plan is to outline a comprehensive revision of statewide land cover mapping products and a process for consistent maintenance and regular updates. Ongoing longer-term goals include land cover time-series applications, the development of additional land cover products as identified by the Montana Land Cover Working Group, and pathways for citizen science participation.

The historic MSDI Montana Land Cover data layer was last updated in 2017 to reflect modified or disturbed landscapes such as insect-killed forests, fire perimeters, changes in urban and agricultural land use, and changes to the transportation infrastructure. As part of its core mission, SAL has performed similar regularly scheduled updates to the original 2009 Montana Land Cover mapping since becoming stewards of this layer (**Table 1**).

The first statewide land cover map was released in 1998 by SAL as a product of Montana Gap Analysis, part of the national USGS-sponsored Gap Analysis Project. Although mapped at 30-m pixel resolution, it was released at 90-m pixel resolution to correspond with national GAP standards at that time.

In 2004, the USGS initiated the Northwest Regional Gap Analysis Project (NWGAP) with the objective of creating seamless regional maps. Working on an ecoregional basis, NWGAP generated a 30-meter pixel resolution image classification product using pixel-based modeling and 1999-2001 Landsat ETM+ scenes. The initial NWGAP work for Montana was then provided to SAL where edge-matching of the mapping zones, quality control checks, and mapping updates were completed prior to release in 2009. Since that time, the lack of sufficient dedicated funding has limited land cover mapping activities to minimal updates.
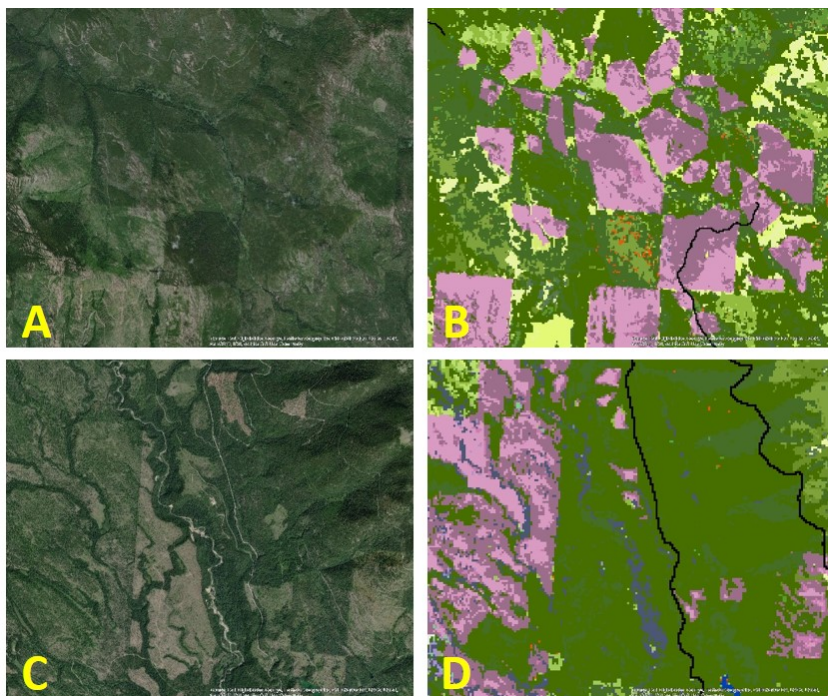
A comparison of recent imagery (WorldView 2016, A & C) and harvested forest pixels (pink/purple) in the MT Landcover 2017 dataset (B & D) that are outdated, either because of new growth (A) or because of recent timber harvest projects (panel C).

Despite continued widespread use and limited regular updates, the historic MSDI Montana Land Cover layer is outdated - in part due to the mapping and classification that is embedded from the original satellite imagery and classification methods from over 20 years ago (Table 1).

Table 1. Initial release of the Montana Land Cover dataset in 2009, and updates performed by Spatial Analysis Lab (SAL) since then.

Description	Imagery/Dataset	Year
Northwest GAP Classification (Sanborn and University of Idaho); edge-matching and quality control by SAL	Landsat 1999-2000	2009
Cliffs and Canyons Agriculture	30m NED DEM Dept. of Revenue Final Land Unit (FLU) 2009	2010
Wildland fire boundaries	GeoMAC 2010	2011
Wildland fire boundaries Large river valley bottom classification (local update)	GeoMAC 2011 NAIP 2011	2012
Developed classes Oil and gas Wind turbines Transportation Ice & Snow and Rocky Mountain Cliff & Canyon	Montana Cadastral 2012, Structures Framework 2012 Montana Board of Oil and Gas 01/13 FAA Obstruction Evaluation 04/12 MSDI Transportation Framework 08/12 NAIP 2011	2013
Insect-infected forests	NAIP 2011	2014
Wildland fire boundaries Agriculture Ice & Snow Russian olive (local update) CMR Wildlife Refuge classification (local update)	GeoMAC 2014 Dept. of Revenue FLU 2014 NAIP 2013 NAIP 2013 SPOT 2011	2015
Agriculture Transportation	Dept. of Revenue FLU 2015 MSDI Transportation Framework 08/15	2016
Wildland fire boundaries Agriculture Transportation Structures	GeoMAC 2015-2017; Landsat 2017 Dept. of Revenue FLU 2017 MSDI Transportation Framework 10/17 Structures Framework 10/17	2017

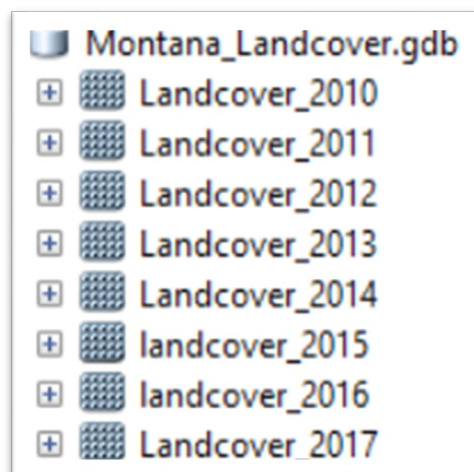## *Historic and Recommended MSDI Land Cover Framework*

The Montana Spatial Data Infrastructure (MSDI) Land Cover mapping records natural biological communities, disturbances (e.g., pests and invasive species, fire), and human activities. Map units are based on an Ecological Systems mid-scale classification adapted for Montana and used in the MTNHP Field Guide for Ecological Systems. The Montana Ecological Systems Classification can be cross-referenced to the US National Vegetation Classification. Both systems are standardized approaches to classifying existing vegetation.

The historic MSDI Land Cover mapping consists of annual 30-meter land cover rasters, where each year reflects regular updates (e.g., fire boundaries, transportation, agricultural land inventories) and the integration of higher resolution mapping products when they are made available and adopted (e.g., insect-killed forests).

The MTLandCover_2021 dataset has emerged in response to user needs identified by the LCWG and from questionnaire responses provided by MTNHP partners.

The MTLandCover_2021 dataset is derived from the published Interagency Landfire ReMap products, which are based on 2016 Landsat imagery, and will consist of both an adaptive set of raster and vector geodatabase features and derived stand-alone products, including high resolution single theme products, and an independent time-series platform for interacting with temporal datasets derived from the Landsat archive (1984-present).

An example of the file structure under the current MSDI Framework.

The primary geodatabase includes a Landfire ReMap 30-meter raster of *Existing Vegetation Types* (*EVT*) cross-referenced to MT Ecological Systems. The Landfire ReMap program is a continuation of the GAP program and provides continuity between the historic Montana Land Cover mapping and the *EVT* mapping recommended in this plan. This continuity addresses the concern about impacts of new land cover mapping on MTNHP applications such as the Montana Ecological Systems Field Guide. Additional 30-meter rasters in the MTLandCover_2021 geodatabase include *Existing Vegetation Height* (*EVH*) and *Existing Vegetation Cover* (*EVC*), both of which leverage lidar data

acquired for Montana. The Landfire Remap *Biophysical Settings (BPS)* raster will also be included in the geodatabase and represents the vegetation system that may have been dominant on the landscape prior to Euro-American settlement. The MT LandCover_2021 geodatabase will also have the flexibility to accommodate independent single theme products, such as high resolution conifer encroachment, impervious surface, or irrigated lands for the state, or invasion of a weed species across a region.

In response to the recognized need for time-series land cover with the ability to track land cover change, an evaluation of time-series products using Google Earth Engine is being conducted. The prototype application includes a Normalized Difference Vegetation Index (NDVI) time-series; brightness, greenness and wetness spectral components derived from Tasseled Cap transformations; and annual change products such as *Time of Spectral Change* and *Change Magnitude* that have recently been released under the USGS Land Change Monitoring, Assessment, and Projection (LCMAP) program.

A Montana Land Cover Explorer is currently under development using a Google Earth Engine platform to visualize time-series information and calculations that could be summarized at various levels, including land cover classes, watersheds, and managed areas. Here, we show feature summarization of a) tasseled-cap information using b) county boundaries, with Deer Lodge County selected. The c) time series charts that are generated can be downloaded as images or as tables.
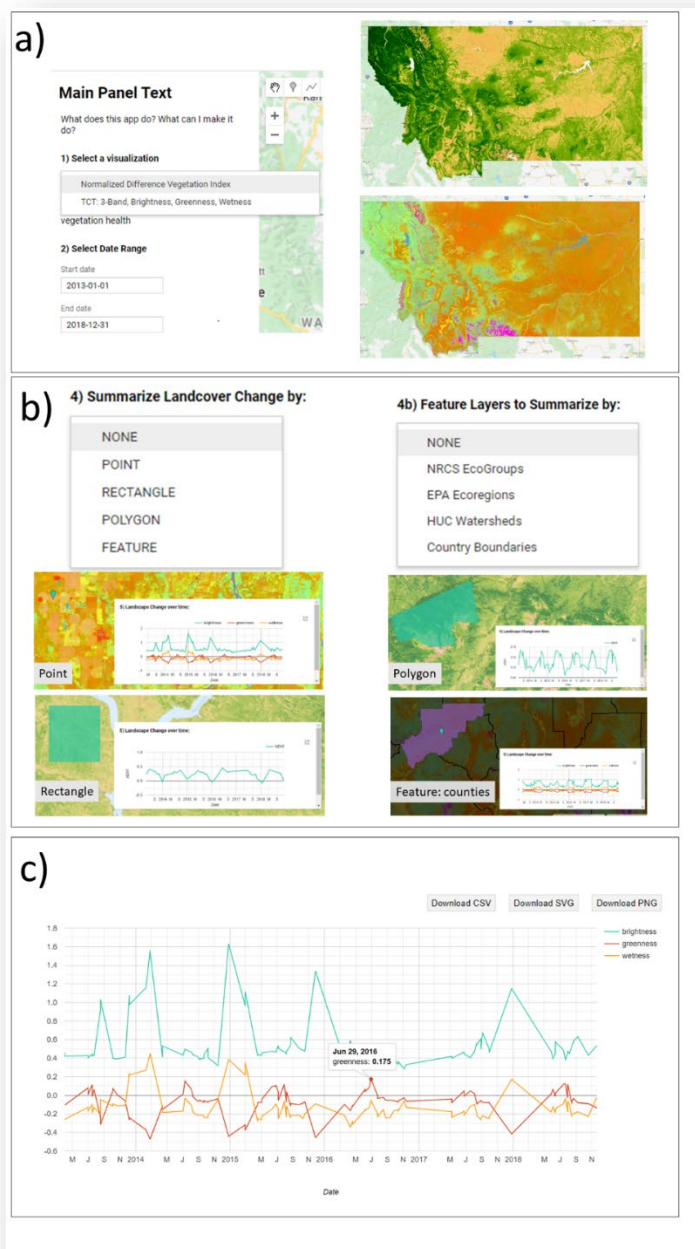
Land Cover Product Evaluation

The LCWG will assist the theme lead in identifying ecological reviewers and developing a review protocol and schedule to evaluate the MTLandCover_2021 dataset using an approach organized by geographical boundaries with ecological/biophysical parameters (e.g., 8-digit HUCS; ecoregions). When conducting land cover mapping assessments, reviewers will be provided support material and training in the use of field mapping and survey tools along with supporting online environmental data such as the Ecological Site Reviewer (ESR) online map application for downloading field support maps and uploading proposed revisions. Additional supporting information for Land Cover reviewers and data users is available as georeferenced photos of ground reference data in the Natural Heritage

Map Viewer under the Georeferenced Photos task, and in historical georeferenced photos made available through the University of Montana's Mansfield Library. Also provided are custom geodatabases at the watershed scale that include recommended Land Cover products and other relevant HUC Environmental Data Products. Both resources are accessible from: https://geoinfo.msl.mt.gov/nrcs_partnership.

All proposed updates and revisions will be assessed by the LCWG prior to incorporation into the MTLandCover_2021 dataset and will be made on a schedule determined in coordination with the LCWG. Throughout this process, compatibility with the NHP Montana Ecological Systems Field Guide will be maintained. All SAL Land Cover support activities are dependent on available funding.

Land Cover Mapping Applications

The Land Cover mapping dataset provides land information. It describes physical characteristics of the surface of the earth and is intricately tied to human land use and business activities (e.g., silviculture, mining, agriculture, communications, energy exploration, construction, reclamation, conservation) and disturbance responses (e.g., pest and weed invasion, fire). Mapping the extent and distribution of ecological systems in the Land Cover theme helps meet a statutory requirement that the "Montana Natural Heritage Program shall be designed to be compatible with similar programs in other states" (MCA 90-15-302(2)). The theme is unique in that it synthesizes information from several other MSDI layers. For example, information from the Cadastral (county-by-county) and Structures layers can be used to improve human development classes and Transportation updates are routinely incorporated into Land Cover revisions.
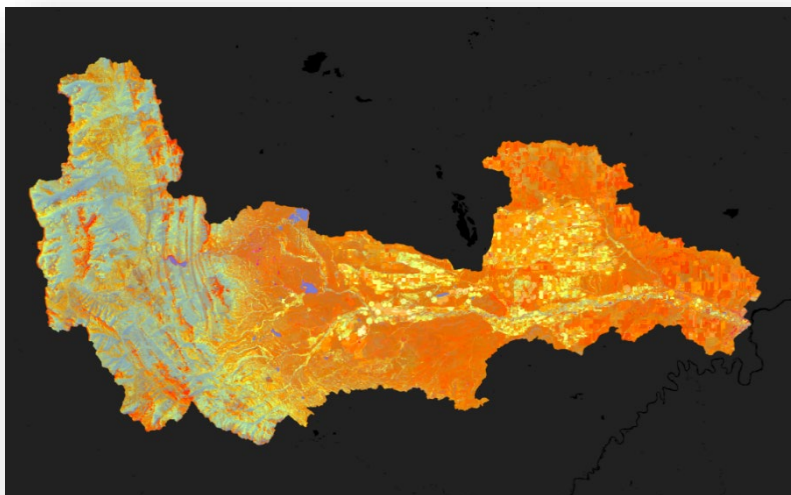
A Tasseled Cap transformation of Landsat bands display combinations of brightness, greenness, and wetness across the Sun watershed, Rocky Mountain Front, Montana

Agencies and end users that consume Montana Land Cover information include county planning and engineering departments; state, federal, and tribal resource management agencies; private sector businesses such as engineering and environmental consulting; and non-profit land and watershed conservation groups. The widespread use is attributed, in part, to the land cover summary that is included in Environmental Summary Reports generated for National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) project reviews.

Land Cover mapping supports numerous additional key business applications. It informs conservation status ranking for habitats and individual plant and animal species and disaster mitigation and planning. Land cover is an input for county and watershed level floodplain modeling, drought monitoring, and water use in managed systems. Land cover information can also be used in large scale economic and environmental impact assessments, conservation planning, and Resource Management Plan revisions.

Maintenance and Dissemination

The historic MSDI Land Cover theme and the MTLandCover_2021 are disseminated through resources hosted by the Montana State Library, including direct data downloads through the MSDI Land Cover homepage, interactive web mapping through the Ecological Site Reviewer, and the Land Cover StoryMap for tracking LCWG activities and the progress of updates and revisions (https://umontana.maps.arcgis.com/apps/MapSeries/index.html?appid=bf21aac01c68442a840bda384a8a0279). A Land Cover Times-Series Explorer is also under development and can be made accessible through platforms such as Google Earth Engine and ArcGIS Online.

The LCWG recognizes that valuable land cover information can also be found in studies and projects from all or portions of Montana that have been conducted over the past years or are ongoing. The LCWG has identified the need to assess these land cover related data that have been generated for a variety of information needs and to coordinate the evaluation of these products and potential integration into the MT_LandCover_2021 dataset.

The Land Cover theme lead will continue to work with the Land Cover Working Group to identify data gaps, examine information needs for high resolution mapping products (spatial, spectral, temporal), and to build collaborations with partners to pursue funding support. The LCWG and theme lead will also continue to assess and recommend best practices for modifications, updates, and statewide improvements to the MT LandCover_2021 dataset and support the development of consistent and repeatable processes for updating land cover in the future.

Partnerships, Collaborations, and Funding Sources

Maintenance of the MSDI Land Cover dataset has been supported by contributions from the core MTNHP annual budget and MLIA allocations from MSL for more than 10 years. Limited annual updates have been conducted due to the lack of adequate funding. Due to its status as an MSDI theme under the stewardship of the MTNHP, Land Cover has not been eligible for MSDI grant funding and has not received direct contributions from partner agencies for the past two decades. Recognizing the importance of Montana Land Cover mapping and urgent need for modernization, in 2019, the Montana NRCS partnered with MSL to provide seed money to develop modernized data and methods for mapping land cover and land use in Montana, with the goal of a revised MSDI Land Cover dataset and the development of a process for consistent and repeatable future updates. This funding source will be exhausted in September 2022 and to successfully move forward, it is imperative that investment from additional partner agencies and alternative funding sources be identified and secured to complete the work that has been outlined in this plan.