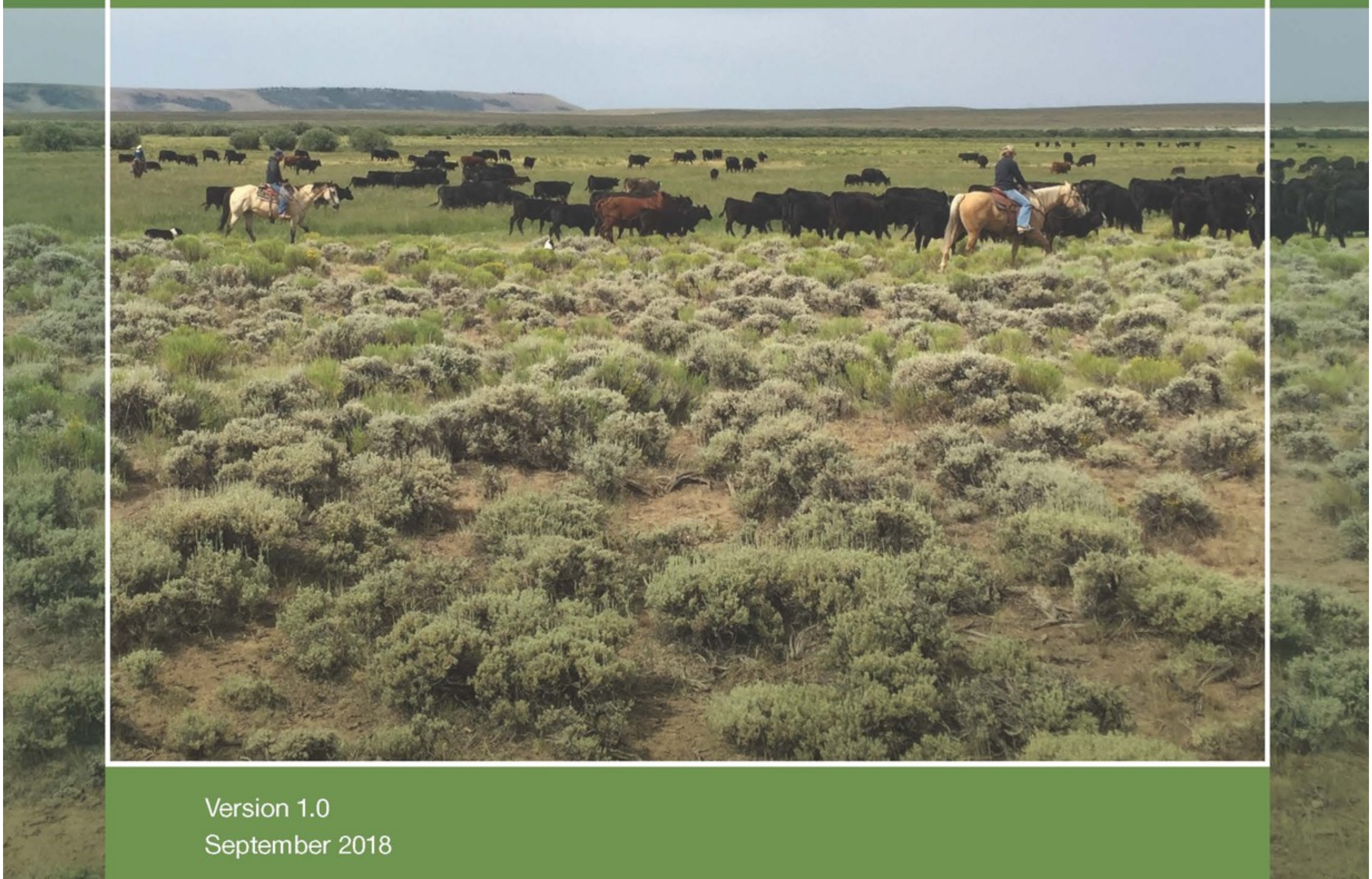
Rangeland Analysis Platform

User Guide



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http://rangelands.app

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

USDA
United States Department of Agriculture
Natural Resources Conservation Service

UNIVERSITY OF MONTANA

Contents

The Rangeland Analysis Platform

The Rangeland Analysis Platform (https://rangelands.app) is a free online application that provides simple and fast access to geospatial data of western U.S. rangeland resources. The tool was developed to provide landowners, resource managers, conservationists, and scientists access to data that can inform land management planning, decision making, and the evaluation of outcomes. The Rangeland Analysis Platform (RAP) uses innovative cloud computing technology to provide maps and analysis opportunities straight to your desktop, delivered securely and instantaneously.

⚠ **The maps and data provided by RAP are intended to be used alongside local knowledge and site-specific data** to inform management actions that improve rangelands and wildlife habitat. RAP should not be used in isolation to quantify rangeland resources, to determine or define thresholds, or to evaluate the efficacy of management practices or treatments. Such analysis or evaluation should be conducted in concert with information specific to the area under investigation, including past management practices, treatments, conservation efforts, and anthropogenic or natural disturbances. **Please read the Key Considerations section in this manual prior to conducting any analysis.**

Vegetation Cover Maps and Data

The RAP provides annual, historical (1984 to present) vegetation cover maps for western U.S. rangelands. The maps are percent cover estimates of annual forbs and grasses (AFG), perennial forbs and grasses (PFG), shrubs (SHR), trees (TREE), and bare ground (BG) at 30x30 meter resolution. These datasets allow for examination of vegetation dynamics that are particularly important for the long-term monitoring, conservation, and management of U.S. rangelands. The maps will be updated annually.

These estimates of vegetation cover make it possible to assess changes in functional group composition, transitions to new vegetation states, efficacy of vegetation treatments, and vegetation dynamics pre- and post-disturbance across both space *and* time.

Evaluations can be summarized at broad scales (e.g., landscapes, watersheds, allotments, or pastures) as well as examined for variation across space. The ability to examine spatial variation of vegetation cover helps focus management activities and financial resources on the locations that need the most attention.

Annual maps from 1984 to present enable users to track vegetation dynamics through time, which can be especially useful in areas where historical data or knowledge is lacking. For instance, understanding historical vegetation dynamics can be particularly helpful in restoring landscapes after a disturbance (such as wildfire) when the area lacks information on pre-disturbance land cover.

How Are the Maps Produced?

RAP relies on extensive field data gathered through both the Natural Resources Conservation Service (NRCS) National Resources Inventory (NRI) program and the Bureau of Land Management (BLM) Assessment, Inventory, and Monitoring (AIM) program, as well as the dedicated personnel who have collected and processed these data. The field plots from these large-scale systematic monitoring programs capture the vegetation heterogeneity of the land surface. Over 30,000 NRI and AIM field plots from 2004-2016 (to be updated as more data becomes available) are used in conjunction with the historical Landsat satellite record, gridded meteorology, and abiotic land surface data (e.g. soils, topography) in a Random Forests machine learning algorithm and a geospatial cloud computing environment to produce annual maps of vegetation cover across the western U.S. at 30m resolution from 1984 to present.

Field plots were converted to percent cover per plot for five vegetation cover classes: AFG, PFG, SHR, TREE, and BG. In Google Earth Engine (GEE) we compiled sets of 215 geo-spatial layers (Landsat images, gridded meteorology, and abiotic land surface data); one set for each year (2004-2016) of the field plot data. The 215 geospatial layers are then sampled over each field plot corresponding to the year the plot was measured, providing training data for use in the Random Forests machine learning algorithm. Random Forests regression models (one for each vegetation cover class) are then trained to minimize the error between modeled percent cover values and field plot percent cover values. The trained models are then run for each year (1984-present) over every 30m pixel in the western U.S., providing predictions of percent cover for AFG, PFG, SHR, TREE, and BG. Detailed methods can be found in Jones et al. (2018).

The use of machine learning coupled with a cloud computing platform for planetary-scale analysis (GEE) represents an innovation in vegetation and land cover mapping that is on the forefront of emerging technology. Combining these technologies with the NRI and AIM plot level monitoring programs permits the creation of vegetation cover datasets at an unprecedented blend of temporal fidelity, spatial resolution, and geographic scale. The future of such maps can only improve as new remote sensing data, the continuation of field monitoring programs, cloud computing platforms, and advanced machine learning algorithms become more available and accessible.

How Accurate are the Models and Vegetation Cover Maps?

⚠ It is important to remember that these vegetation cover data are modeled estimates.

While the vegetation cover maps are based on over 30,000 ground measurements and satellite observations of the land surface (including over 231,000 Landsat scenes), they nonetheless have associated error metrics that must be considered (Table 1).

Table 1. *Mean Absolute Error and Root Mean Square Error per vegetation cover class using out-of-bag samples within the Random Forests model.*

Vegetation Cover Class	Annual Forbs and Grasses	Perennial Forbs and Grasses	Shrubs	Trees	Bare Ground
Mean Absolute Error (%)	7.8%	11.2%	6.9%	4.7%	7.3%
Root Mean Square Error (%)	11.8%	14.9%	9.9%	8.5%	10.6%

The errors in Table 1 provide an assessment of accuracy. In basic terms, if the vegetation cover value of a mapped area is 35% AFG, then there is confidence that the annual forb and grass cover of that pixel is between 27.2% and 42.8% (35% +/- the mean absolute error of 7.8%).

Errors were calculated by withholding a randomly selected fraction of the field plots (37%) from each regression tree to use for validation (in Random Forests these are called out-of-bag, or OOB, samples). This is similar to the classic hold-out method for validating models, but has the advantage of being implemented across an ensemble of regression trees where each sample is held out of multiple trees. This allows for a calculation of error for every plot. The vegetation cover maps were also validated against three independent field plot datasets across the western U.S., all of which used different field collection protocols and varying plot sizes. Errors from those plots were similar to the errors found using the OOB method.

For a complete description of the data, methods, and errors associated with the vegetation cover maps and data, please read the peer-reviewed manuscript, Jones et al. (2018).

Using the Rangeland Analysis Platform

Navigating the Platform

The user-friendly, online interface (www.rangelands.app) allows for quick and easy access to visualize maps, calculate vegetation data over time for a region of interest, and export the time series data. The webpage is divided into two panels: a selection and analysis panel, and a map panel. Figures 1 and 2 provide detailed descriptions on how to interact with the webpage.

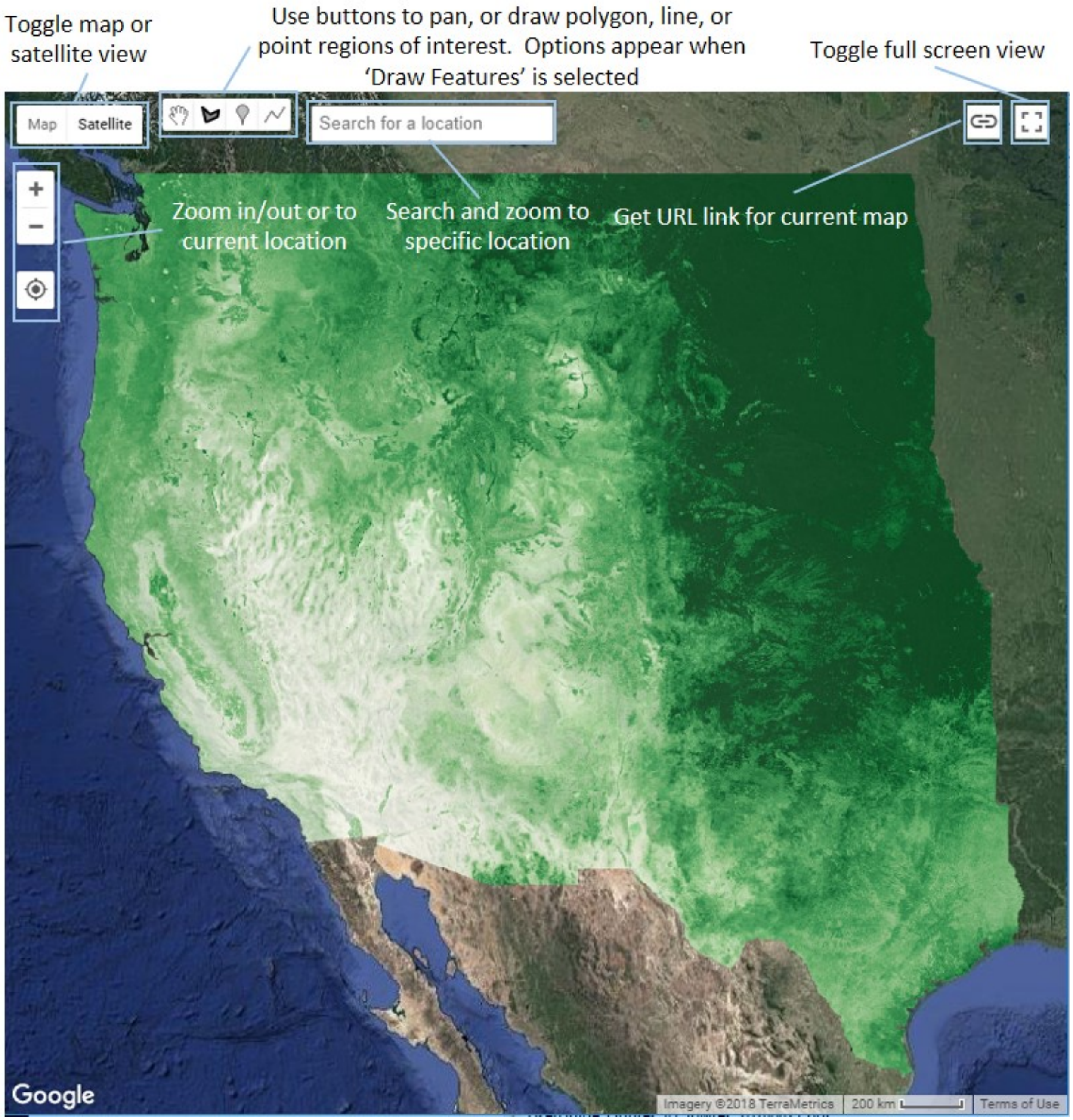


Figure 1. *The selection and analysis panel of the Rangeland Analysis Platform*

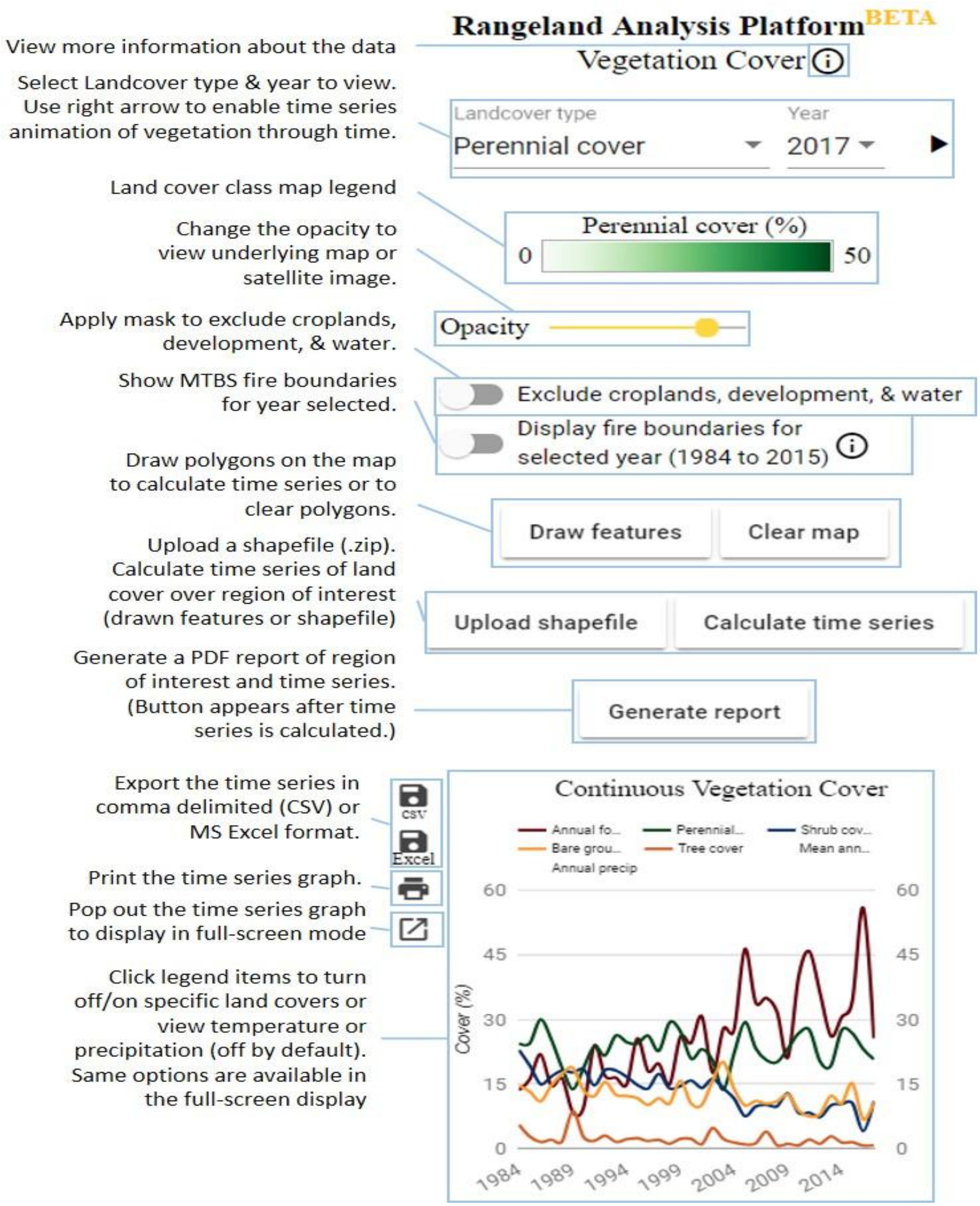


Figure 2. *The map panel of the Rangeland Analysis Platform*

Visualize Vegetation Cover Maps

1. Select the vegetation cover class from the drop-down menu.*
2. Select the year to view from the drop-down menu.
3. To view a time series animation (1984 to present) of the selected vegetation cover class click the play button (right arrow).

* *The map legend maximum value will change based on the vegetation cover type selected.*

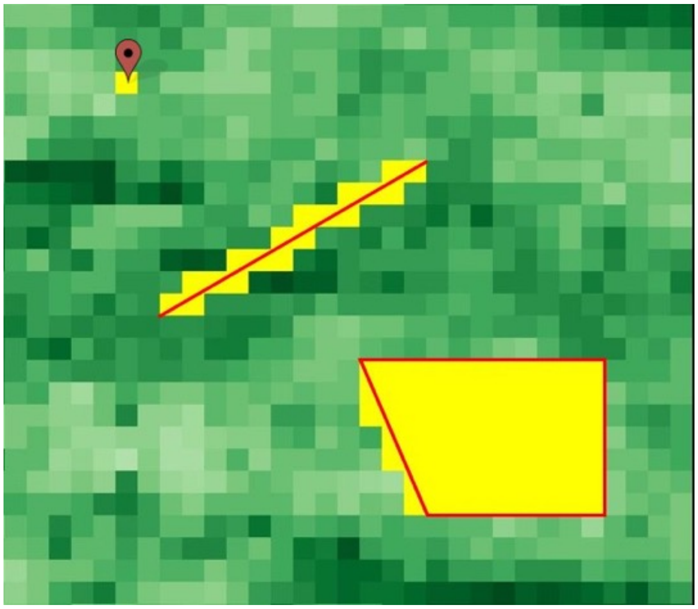
Additional visualization options:

- **Use the opacity slider to view the underlying map or satellite image**. This is particularly useful for locating a specific area and when drawing your own features.
- **Exclude crops, development, and water** by selecting the toggle. This excludes or "masks" these particular land covers as defined in the National Land Cover Database (NLCD) 2011 Land Cover product (Homer et al. 2011). See Appendix: Table A1 for a list of the NLCD land cover values/classes that are masked in this application.
- **Display fire boundaries from the Monitoring Trends in Burn Severity geodatabase** (MTBS 2017). Fire boundaries for the year selected are displayed on the map (currently available from 1984-2016). Clicking on a boundary will display the Fire Name, Fire Start Date, and Fire Size in acres, and provide an option to calculate the vegetation cover time series within the boundary.

Calculating Time Series

RAP provides time series of average annual vegetation cover values, average annual temperature (degrees F), and total annual precipitation (inches) for any region of interest.

There are three options to define a region of interest: draw features directly on the map (points, lines, or polygons; Figure 3); upload a zipped shapefile (.zip file); or use the pre-loaded fire boundaries. In all cases it is important to consider the number and size of the regions of interest – more features and larger polygons may take longer to calculate.



ⓘ *It is important to remember that vegetation cover, temperature, and precipitation values generated are calculated as either an average of the 30x30m pixels within the polygon, an average of the pixels that intersect the line, or the single pixel value at a point.*

Figure 3. *Sample image (at a zoom level to highlight pixel boundaries) displaying point, line, and polygon regions of interest and the pixels (yellow) that would be used in the time series calculation.*

Including developed and open water areas, perennial snow/ice, crops, or wetlands in a region of interest can affect the time series calculations. The vegetation values within such regions should be given minimal confidence unless the user has specific information regarding that area. A mask is provided to exclude such areas from analysis (Homer et al. 2011; see Visualize Vegetation Cover Maps section). Table A1 in the Appendix displays which categories are masked in RAP implementation.

⚠ When RAP calculates a time series, it uses only unmasked pixels within the region of interest. This masking can be controlled by the 'Exclude croplands, development, & water' toggle.

Option 1: Draw features directly on the map.

1. Click the 'Draw Features' button. The default option is to draw polygons. If a point or line feature is desired, click the point or line buttons in the top left corner of the map panel.
2. Draw features on the map over region(s) of interest. Multiple features can be drawn.
3. Click the 'Calculate Time Series' button.
4. A graph will appear when calculations are finished.
5. If multiple features were drawn, click a feature to view its time series.

Option 2: Upload shapefile.

1. The shapefile may contain point, line, or polygon geometries.
2. Compress the shapefile to .zip format containing the .shp, .shx, .dbf, and .prj files. The other files within a shapefile are optional. *NOTE: If the .prj (projection) file is not provided, GCS WGS84 is assumed*.
3. Click the 'Upload shapefile' button.
4. Navigate to the compressed (.zip) shapefile. Select the file and click open. The map panel will zoom to the spatial extent of the shapefile.
5. Click the 'Calculate time series' button.
6. A graph will appear when calculations are finished.
7. If multiple features were in the shapefile, click on a feature to view its time series.

Option 3: Pre-loaded fire boundaries.

1. Toggle the 'Display fire boundaries for selected year' option. Fire boundaries are from the Monitoring Trends in Burn Severity (MTBS) geodatabase, currently available from 1984-2016. If other years are selected in the Year drop down box, fire boundaries will not appear.
2. Click on a fire boundary. The Fire Name, Fire Start Date, and Fire Size (acres) will appear in a small pop-up dialog.
3. Click Calculate time series within the pop-up dialog. (Clicking 'Calculate time series' in the left-hand panel will not produce a time series chart for fire boundaries.)

ⓘ *Only 50 features can be processed at a time. If more than 50 features are drawn or present in a shapefile, only the first 50 features will be used for analysis.*

ⓘ *RAP can accommodate polygons of various sizes. It may take longer to calculate the times series for larger-sized polygons. If no calculation response is received initially, please try again.*

The Time Series Graph

The interactive time series graph displays the average annual values for each vegetation cover class and total annual precipitation (inches) for the region of interest. Mean annual temperature (degrees F) is not shown in the graph, but is provided in the exported CSV or Excel file. Temperature and precipitation are calculated using GRIDMET (Abatzoglou 2013).

A small version of the plot appears in the left-hand selection and analysis panel, and a pop-out button allows users to view a full-screen display of the graph. In both the small and large versions, the user can:

- Mouse over a line to view the value for that vegetation cover and year.
- Remove or add vegetation cover lines by clicking on the name of the vegetation cover in the legend.
- Add of remove the mean annual temperature or annual precipitation area plots (both are off by default) by clicking on the names in the legend.

The data can be:

- Saved to a report.
- Exported in comma-delimited format (.csv).
- Exported in MS Excel format (.xls).
- Printed.

Application Examples

Managing land for livestock and wildlife requires understanding how vegetation responds to human- or natural-caused changes through time, such as drought, irrigation, grazing, or wildfire. Information available through RAP can help landowners, managers, or conservationists sustain valuable water and soil resources, improve forage for livestock and wildlife, or manage weeds and wildfires. *This online app is designed to be used in conjunction with on-the-ground data and site-specific knowledge*.

RAP allows users to instantaneously visualize and estimate the percent vegetation cover across the western U.S. from 1984 to present. Maps can display individual vegetation types or a composite of vegetation cover types (Figure 4). RAP provides this data at an unprecedented level of geographic coverage and temporal fidelity allowing examination of vegetation cover through time from statewide to ranch/pasture scales (Figure 5).

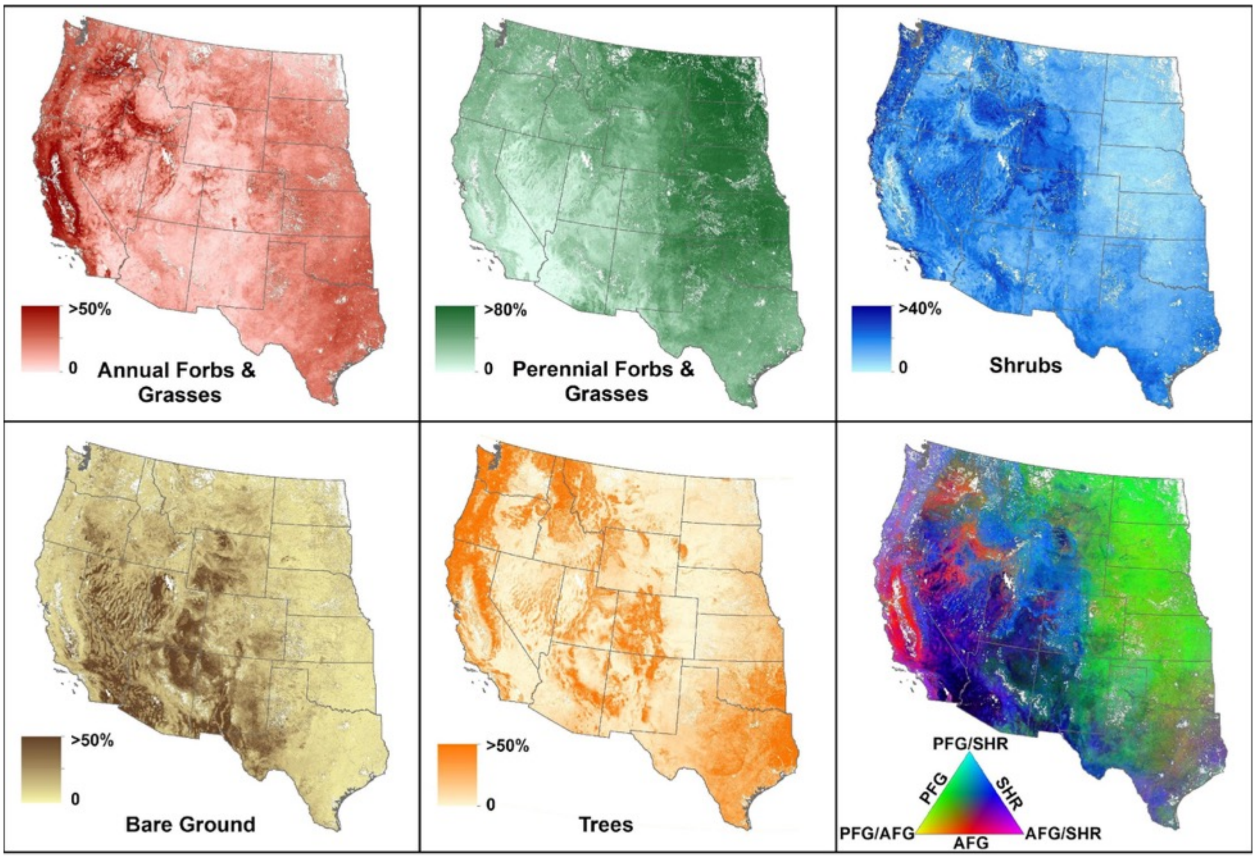


Figure 4. *Maps from the year 2016 show the percent vegetation cover estimates of five different classes, as well as a composite map for three vegetation classes: red=annual forbs and grasses, green=perennial forbs and grasses, blue=shrub. Gray areas are non-rangeland (e.g. croplands, development, or water).*

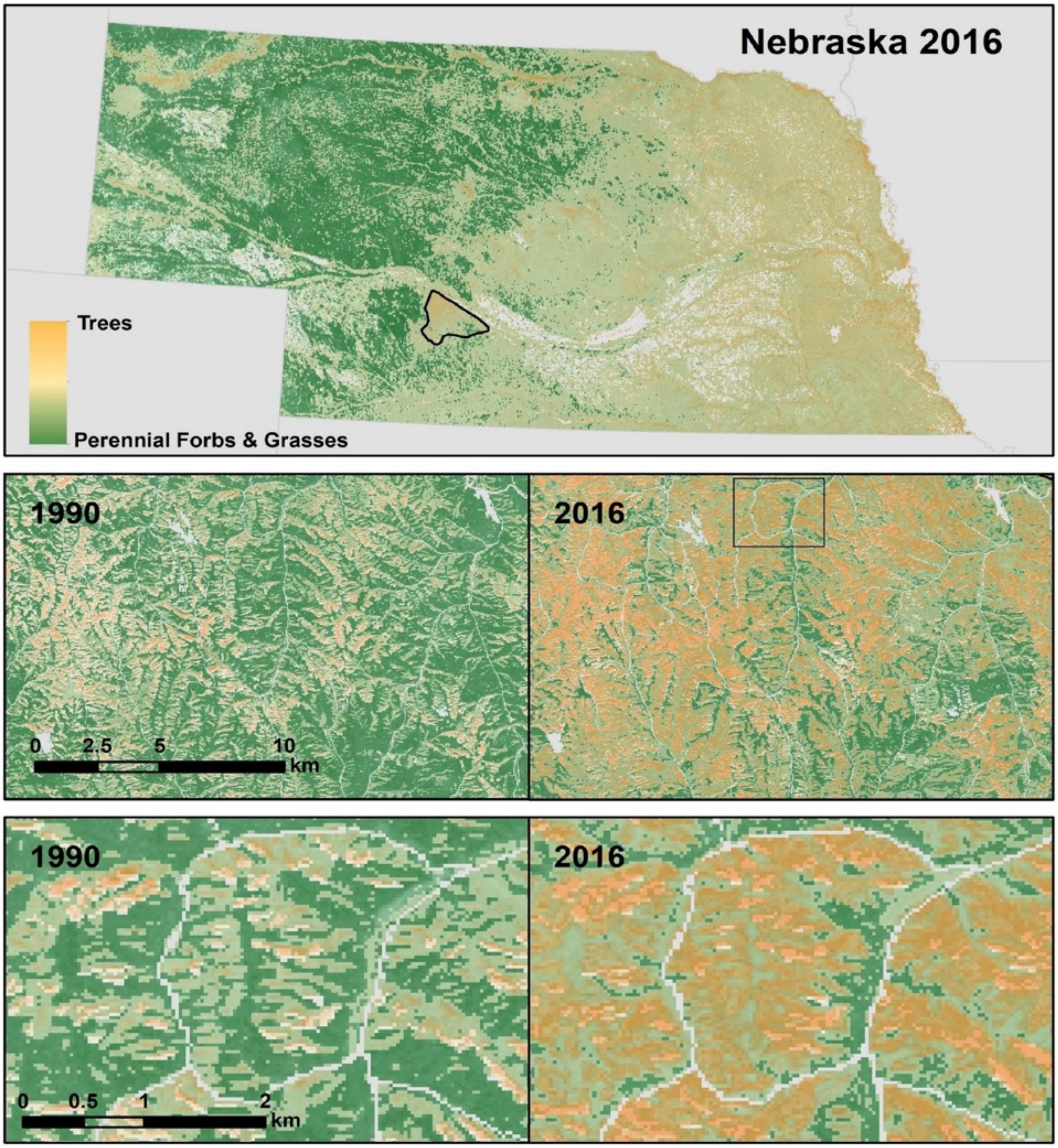


Figure 5. *Tree and perennial forb and grass cover in Nebraska for year 2016 at statewide (top), regional (middle), and ranch/pasture (lower) geographic scales show increasing tree cover and decreasing perennial forb and grass cover from 1990 to 2016. Regional map is within the Loess Canyons outlined in the black polygon of the top panel, and the ranch/pasture map is within the area outlined by the black square in the middle panel.*

Example 1: Grazing and Rangeland Health

Evaluating the vegetation response to livestock grazing management strategies is one common goal of rangeland monitoring and adaptive management. RAP can provide the much-needed historical records of vegetation cover across large swaths of grazing lands. For instance, Figure 6 provides estimates over a 15,000-acre grazing allotment administered by the BLM in Montana. Annual means of PFG, AFG, SHR, BG and total precipitation within the allotment are shown alongside photos detailing the same point-of-view from both 2002 and 2010 (provided by the BLM Billings, Montana Field Office).

Managers can use this information to help consider how site-level conditions relate to overall conditions in the surrounding area, assess whether changes in functional groups are within the normal range of variability, or evaluate potential response to management, weather, climate, or other factors.

This data must be coupled with detailed knowledge of the site's management history, grazing strategies, and climate or weather patterns to make informed management decisions.

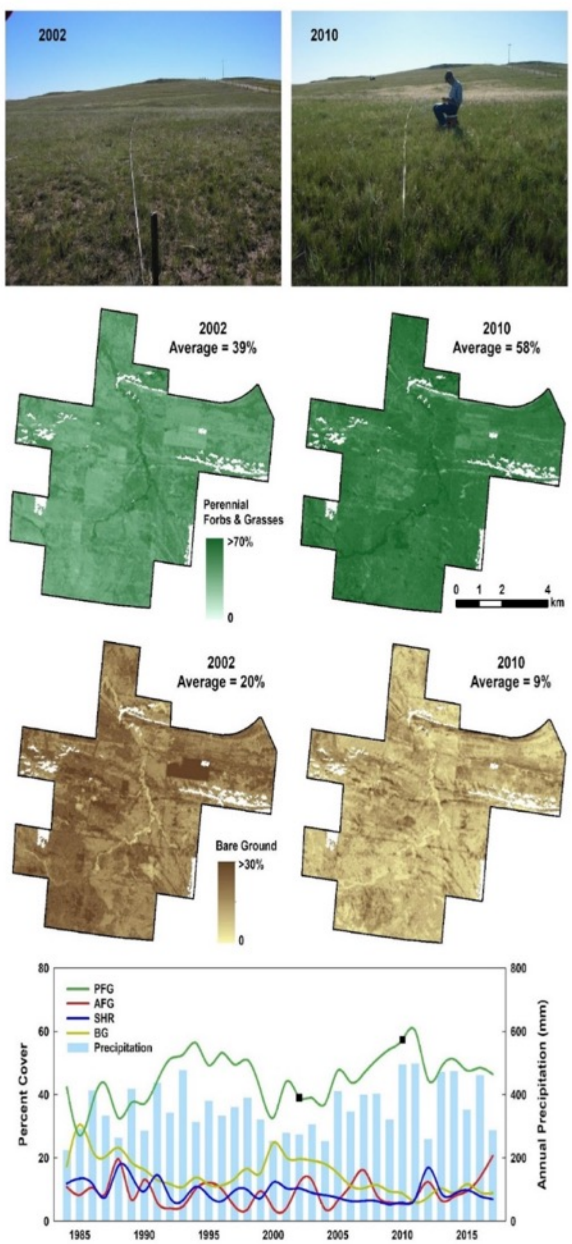


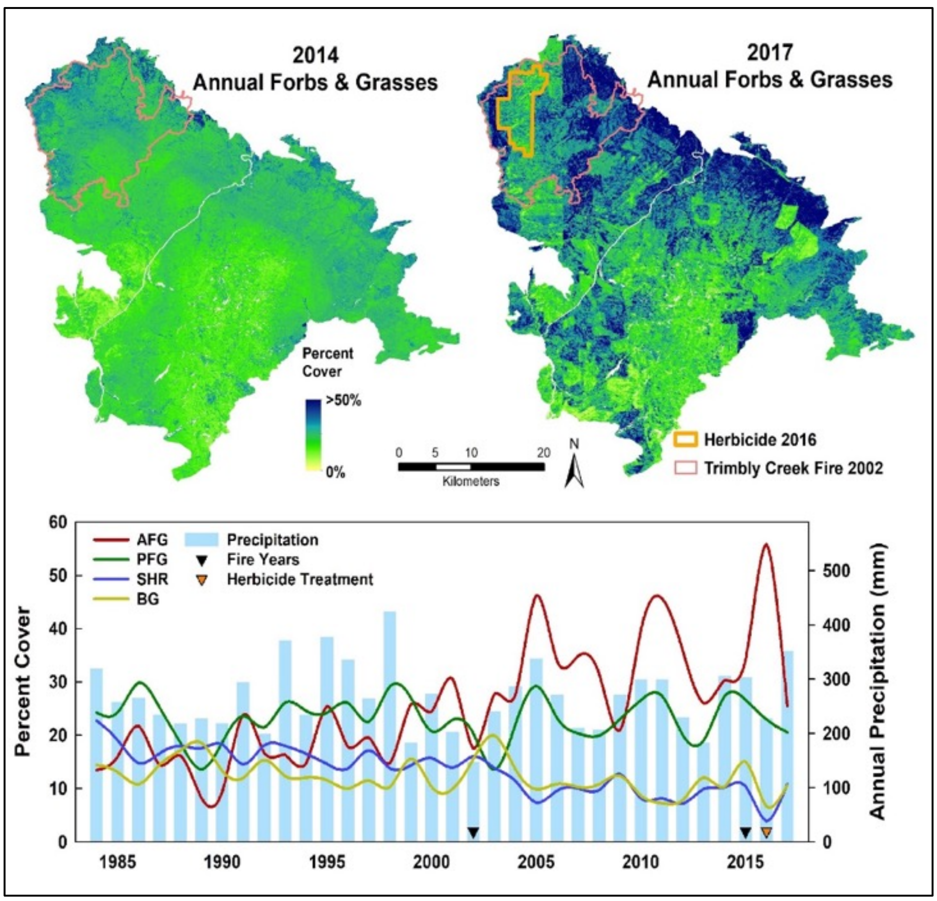
Figure 6. *Top: Photos of a BLM grazing allotment in Montana taken from the same point-of-view in 2002 (left photo) and 2010 (right photo). Middle: Allotment maps of perennial forbs and grasses as well as bare ground cover from the same years. Lower: Plot displays annual precipitation and percent cover means within the allotment for four vegetation cover classes from 1984 to 2017. Black squares within the graph represent the years displayed in the photos and maps. Averages do not display model errors.*

Example 2: Wildfire and Treatments

Larger, hotter, and more frequent wildfires are a threat to western rangelands, particularly in the sagebrush steppe, one of North America's largest terrestrial ecosystems. Pre-fire vegetation composition influences fire severity as well as post-fire plant succession. Understanding the pre-fire vegetation composition—alongside weather, soils, and other abiotic factors—helps in developing post-fire rehabilitation plans and in strategically targeting financial resources to improve range health and resilience.

Annually updated maps of post-fire conditions can also help land managers monitor the outcomes of rehabilitation efforts. For instance, Figure 7 shows pre- and post-fire maps of AFG cover over the 2015 Soda Fire, and a time series of mean cover values within the boundaries of an herbicide treatment applied in 2016. These RAP-produced data can be used alongside detailed local information to assess the herbicide treatment efficacy at reducing annual grasses (like invasive cheatgrass, which leads to more wildfires) to improve ecosystem resiliency. RAP provides a rapid way to identify potential areas of concern for future field investigation to determine the need for follow-up treatments.

Figure 7. *Maps of annual forb and grass cover for years 2014 and 2017 within the 2015 Soda Fire perimeter. A previous fire (pink polygon; Trimbly Creek Fire; 2002) and herbicide treatment applied in 2016 (orange polygon) are also displayed. Plot displays percent cover means and annual precipitation within the herbicide boundary for four vegetation cover classes from 1984 to 2017, with triangles noting years of fire (black) and herbicide application (orange). Note: only a single herbicide treatment is shown and does not represent a complete record of treatments. Multiple post-fire treatments (herbicides, seeding, planting, etc.) are not included in this particular analysis. This is just provided for example purposes.*



Example 3: Evaluating Conservation Practices

Expansion of woody species into grasslands is a major concern throughout the western U.S. Forage for livestock and habitat for grassland-dependent birds is reduced when trees like eastern red cedar or pinyon-juniper take over rangeland.

Conservation partners and landowners are removing woody species to restore rangeland resources like perennial forbs and grasses. RAP provides a means to evaluate these large-scale landscape treatments and also help prioritize resources for future conifer removal projects.

Figure 8 illustrates how RAP was used to assess outcomes from a 2015 prescribed burn within the Loess Canyons of Nebraska, which was designed to reduce the spread of encroaching cedars. The maps and time series plot show that the burn succeeded in decreasing the average percent tree cover, and increasing the perennial forbs and grasses within the treated area.

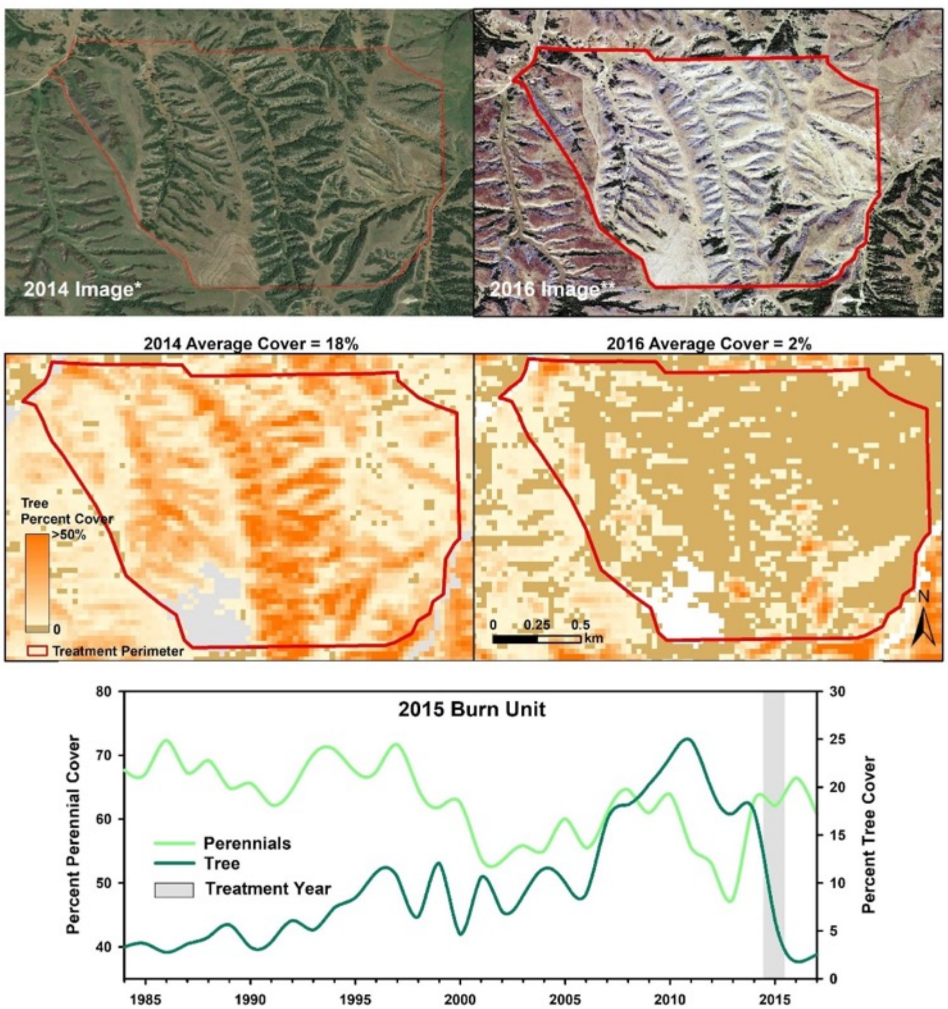


Figure 8. *<u>Top:</u> Aerial photography shows tree cover in the Loess Canyons of Nebraska in 2014 (Image: Google Earth) and 2016 (Image: USDA NAIP). <u>Middle:</u> RAP-produced maps calculating the percent cover of trees pre- and post-burn within the treatment boundary (red polygon). <u>Lower:</u> Time series of mean perennial forb and grass as well as tree cover from 1984 to 2017 within the burn boundary (gray bar in 2015 denotes treatment year).*

Key Considerations for Interpreting Vegetation Cover Data

The vegetation cover data and maps provided by RAP are intended to be used alongside local knowledge and data to inform management actions. They should not be used in isolation to quantify rangeland resources, determine or define cover thresholds, or evaluate the efficacy of management practices or treatments. Such analysis or evaluation should be conducted alongside information and data specific to the area under investigation including past management practices, land surface treatments, conservation efforts, and any anthropogenic or natural disturbances. When using these data to monitor vegetation cover, it is important to consider the factors highlighted below.
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Vegetation Cover Estimates Are Modeled and Have Associated Error Metrics

When interpreting the modeled vegetation cover, it is vital to consider the model error specific to each vegetation cover class, as shown in Table 2.

Table 2. *Mean Absolute Error and Root Mean Square Error per vegetation cover class using out-of-bag samples within the Random Forests model.*

Vegetation Cover Class	Annual Forbs and Grasses	Perennial Forbs and Grasses	Shrubs	Trees		Bare Ground
Mean Absolute Error (%)	7.8%	11.2%	6.9%	4.7%		7.3%
Root Mean Square Error (%)	11.8%	14.9%	9.9%	8.5%		10.6%

These errors provide an accuracy assessment. In basic terms, the vegetation cover value of a given pixel (e.g. 35% Annual Forb and Grass cover) should be thought of as 35% +/- 7.8%. Hence, the confidence that the Annual Forb and Grass cover of that pixel is between 27.2% and 42.8% (if using mean absolute error).

Measuring Vegetation Cover: Visual, Plot, And Aerial Estimates

RAP provides aerial (top-down) vegetation cover estimates. These aerial estimates may vary from on-the-ground visual estimation or plot measurements. The user must consider how different methods may provide different estimates of vegetation cover.

As an example, consider Figure 9 which shows an area experiencing juniper encroachment in 2011. The figure provides an on-the-ground photograph (Figure 9A), an aerial image (Figure 9B), and a modeled tree cover estimate using 1m resolution aerial photos (Figure 9C) (Falkowski et al. 2017). Overlaid on Figure 9B & C are the location (red marker), orientation, and approximate visual extent (dashed line) of the on-the-ground photograph. White and yellow Xs (Figure 9B) illustrate potential randomly distributed line-point-intercept plots (each consisting of two 150 feet transects).

The modeled tree cover using the high-resolution aerial data (Figure 9C) provides a mean tree cover value of 4.5% for this area. The mean RAP-calculated tree cover value is 4%. However, the percentage of tree cover from the on-the-ground photograph (Figure 9A) appears much higher than 4% based on the field of view. In terms of plot level estimates, note that depending on which plots were randomly selected – yellow versus white – tree cover estimates would vary significantly. It is important that the user considers and understands how different estimation methods can provide different cover estimates. Horizontal or on-the-ground perspectives commonly provided by photographs can be especially misleading, since the space between grasses, shrubs, and trees cannot be seen.

Figure 9. *An on-the-ground photograph (A), an aerial image (B), and a modeled tree cover estimate using 1m resolution aerial photos (8C). Included in B and C are the location (red marker), orientation, and approximate visual extent (dashed line) of the on-the-ground photograph. White and yellow Xs (B) illustrate potential randomly distributed line-point-intercept plots.*

Combine Error Metrics with Local Knowledge to Assess Time Series

⚠ When examining a time series, a user must account for the error metrics for each vegetation cover class. If a specific vegetation cover is fluctuating within the error bounds, it should be interpreted as model error or noise.

⚠ A user must also incorporate local knowledge of the system when interpreting the time series. For example, the model will predict changes in vegetation cover values when there are spatial and temporal changes in Landsat reflectance values, vegetation indices, and meteorology. However, in some cases multi-year oscillation in vegetation cover values may not align with expectations or with knowledge of the region under examination.

As a specific case, reconsider the tree cover example from the Evaluating Conservation Practices section (plot shown again in Figure 10 below). Variables such as temperature, precipitation, and potential evapotranspiration affect the predicted tree cover values. However, under natural undisturbed conditions, it’s generally unrealistic to expect the significant increases and decreases in tree cover as shown on the plot below between 1996-2006, which appear to be on the order of ~10-12%. Although some fluctuations may occur (e.g. die-off, thinning, recruitment), this modeled response is most likely due to fluctuations in temperature and precipitation over that region across subsequent years, resulting in the model predicting corresponding lower or higher tree cover values. It would be more appropriate to interpret that specific decade as having a somewhat consistent tree cover within the region.

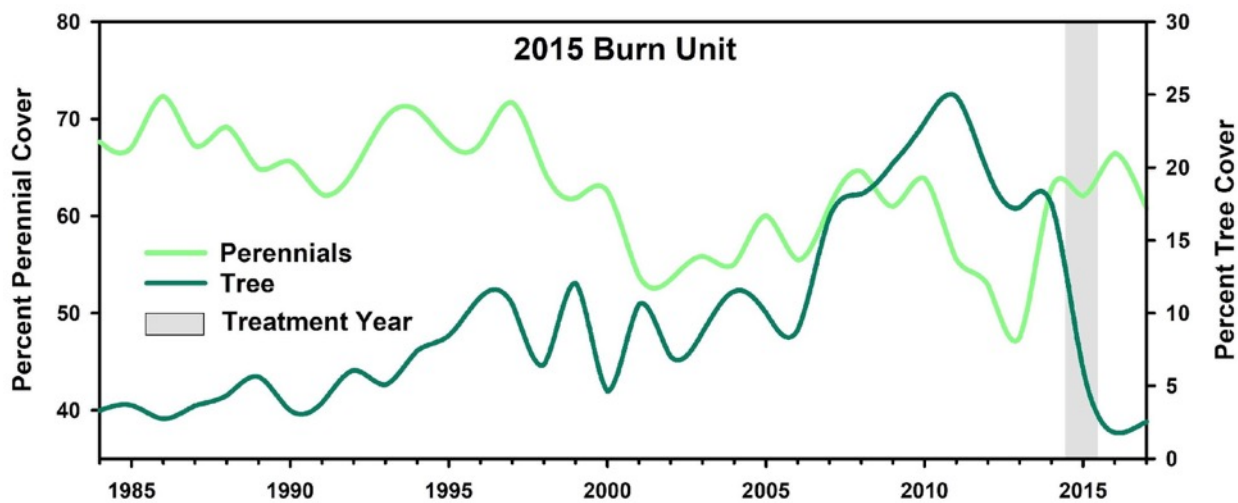

Figure 10. *Annual mean percent cover of trees and perennial forbs and grasses within a 600-acre treatment boundary. The fluctuations from 1996 to 2006 are unexpected under natural, undisturbed conditions and are likely modeled responses due to temperature and precipitation fluctuations. A more appropriate interpretation of the data during this time period would be a consistent amount of tree cover.*

Gaps in Landsat Data Can Affect Vegetation Cover Estimates

⚠ The model uses seasonal summaries (e.g. spring maximums, summer means, fall minimums, etc.) of Landsat satellite data in vegetation cover predictions. In some years, limited satellite data are available over regions due to reduced satellite coverage, clouds, missing data, etc. This is particularly true for years 1984-1998 when only Landsat 5 was in orbit (Figure 11), but can occur in other years as well. These limited retrievals result in visual artifacts within the vegetation cover data, which can be seen as differences in predicted values along the Landsat orbital paths (Figure 12).

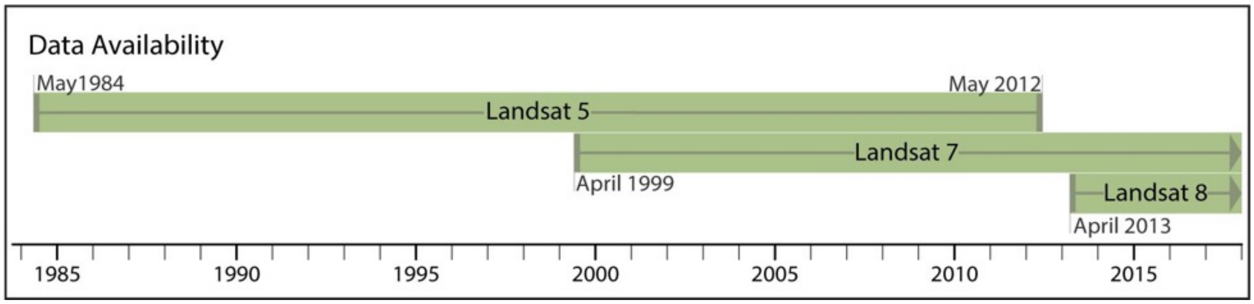

Figure 11. *Temporal coverage and periods of overlap of the three Landsat sensors used in the creation of the vegetation cover products.*

Limited data in Landsat 7 retrievals also occur from year 2003 onward when the Scan Line Corrector (SLC) failed, resulting in data gaps throughout Landsat 7 scenes. These SLC gaps are often supplemented by subsequent passes of Landsat 7, data provided by Landsat 5 (in orbit until May 2012), and Landsat 8 (launched April 2013), but in some cases the effect of SLC gaps can be seen in the resulting vegetation cover predictions.

In the cases of limited data, summary statistics used in the model are derived from minimal samples and may not be representative of the actual land surface conditions. This results in inconsistent vegetation cover values along specific orbital paths or SLC data gaps. See Figure 12 for how these limitations can appear on RAP.

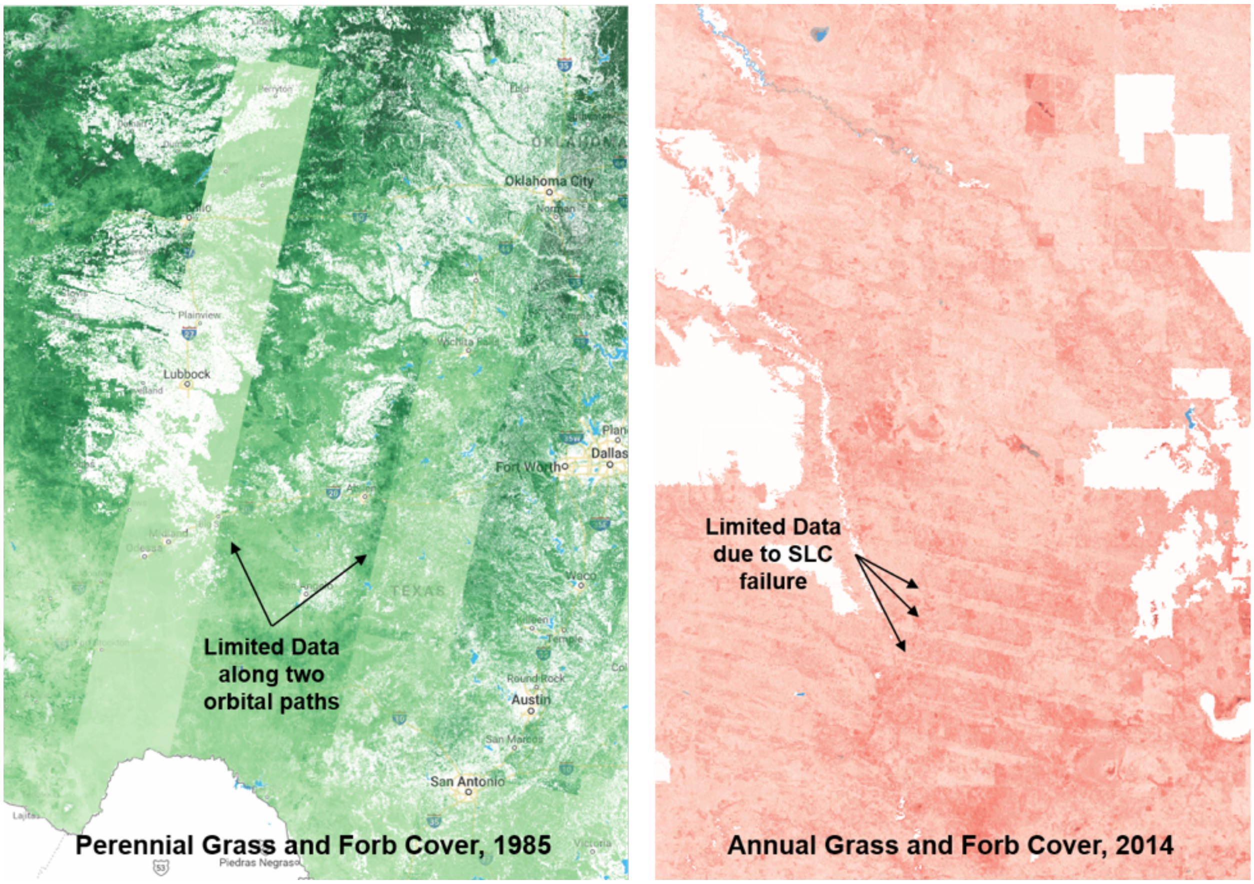

Figure 12. *Examples of visual artifacts resulting from limited satellite data. Left map shows effects of limited data along two orbital paths, and right map shows effects of limited data due to Landsat 7 SLC failure. White sections in each image represent non-rangeland areas.*

The degree to which these data gaps affect vegetation cover values varies both spatially and temporally. Although primarily visual, the user must account for these artifacts while conducting any analysis.

⚠ When analyzing a time series, the user should examine the vegetation cover maps to determine if data limitations are present and the degree to which those values may be affected. This can be done by viewing the vegetation cover animations and also by comparing neighboring pixels within and outside the affected areas. In years when visual artifacts are present over the region of interest, the data should be assessed carefully.

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Falkowski et al. 2017. Mapping tree canopy cover in support of proactive prairie grouse conservation in western North America. *Rangeland Ecology & Management* **70**:15-24.

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Appendix

Table A1. *Categories of the NLCD 2011 Land Cover product (Homer et al. 2015) that are masked and unmasked in RAP. When the mask is applied, only unmasked pixels will be used to calculate time series values.*

<table>
<tr><th>NLCD 2011 Value</th><th>Land Cover Class</th><th>RAP Mask</th></tr>
<tr><td>11</td><td>Open Water</td><td rowspan="9">Masked</td></tr>
<tr><td>12</td><td>Perennial Ice/Snow</td></tr>
<tr><td>21</td><td>Developed, Open Space</td></tr>
<tr><td>22</td><td>Developed, Low Intensity</td></tr>
<tr><td>23</td><td>Developed, Medium Intensity</td></tr>
<tr><td>24</td><td>Developed High Intensity</td></tr>
<tr><td>82</td><td>Cultivated Crops</td></tr>
<tr><td>90</td><td>Woody Wetlands</td></tr>
<tr><td>95</td><td>Emergent Herbaceous Wetlands</td></tr>
<tr><td>31</td><td>Barren Land (Rock/Sand/Clay)</td><td rowspan="7">Unmasked</td></tr>
<tr><td>41</td><td>Deciduous Forest</td></tr>
<tr><td>42</td><td>Evergreen Forest</td></tr>
<tr><td>43</td><td>Mixed Forest</td></tr>
<tr><td>52</td><td>Shrub/Scrub</td></tr>
<tr><td>71</td><td>Grassland/Herbaceous</td></tr>
<tr><td>81</td><td>Pasture/Hay</td></tr>
<tr><td>51</td><td>Dwarf Scrub</td><td rowspan="4">Not applicable. Alaska only.</td></tr>
<tr><td>72</td><td>Sedge/Herbaceous</td></tr>
<tr><td>73</td><td>Lichens</td></tr>
<tr><td>74</td><td>Moss</td></tr>
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