

Evaluating Remotely Sensed Rangeland Vegetation Maps

In recent years, technology in remote sensing has advanced dramatically, and a variety of new map products have been created to depict vegetation composition and condition across the rangelands of the western United States. As the number of map products has increased, there is greater need for guidelines on how to understand remotely sensed products and evaluate multiple options to choose the map best suited to a particular purpose. This document provides some recommendations, guidelines and best practices for how to compare, evaluate and use remotely sensed map products in rangeland assessment and management applications. Click [here](#) for an overview of map products available for rangeland applications in Oregon (many are also available elsewhere), as well as other resources for understanding and using rangeland maps.



Understanding remotely sensed products

Remotely sensed products use satellite or aerial imagery (often combined with field data) to generate continuous information across large areas. This is extremely useful in large, remote landscapes. Potential uses of remote sensing in rangelands include:

- **Assessment** of vegetation condition across multiple scales in space and time. Vegetation can be characterized in different ways for mapping (e.g., land cover types, functional groups, individual species distribution or cover). Vegetation maps can be used qualitatively (e.g., illustrate spatial patterns) and quantitatively (e.g., estimate the proportion of an area meeting certain criteria).
- **Monitoring** change over time. Remotely sensed maps can monitor changes in vegetation condition, disturbances such as fires, and restoration activities. However, few maps are currently designed specifically for robust change detection.
- **Management** needs, including identifying areas for potential management actions based on current vegetation (e.g., invasive annual grass), site type (e.g., resistance and resilience), spatial patterns (e.g. proximity to favorable habitat or other restoration treatments), or other characteristics.

There are many approaches to building remotely sensed maps, each with different strengths and limitations. All maps are based on models that carry assumptions and errors, and many factors influence the quality of the imagery and ability to accurately predict vegetation attributes. Although remotely sensed products can be used to capture dynamic vegetation conditions (e.g., seasonal and inter-annual variability), the primary focus of this document is on static vegetation maps of upland rangeland conditions over multiple years, in the absence of major disturbance. However, some of the guidelines here may also be applicable to other types of maps or datasets.

The quality of rangeland map products are particularly limited by:

- *Scarce plot data* compared to the large extent of rangelands. Although the availability of plot data is improving, most western rangelands have limited field plot data, needed to build and validate many maps.
- *High seasonal and inter-annual variability* adds to the challenge in mapping many important components of rangeland vegetation, particularly invasive annual grasses and forbs.
- *Low cover* vegetation components are often less visible in imagery and can be difficult to distinguish from other species or background imagery such as soil and rocks.

Recommendations for evaluating and using maps

① **Start by defining your management application.** Once the purpose is defined, use this document to evaluate map products that may aid in answering your question. Maps that are useful for one application for a particular geography or scale may be poorly suited to others.

② **Understand the basics about individual map products, or consult an expert or trusted guidance.** Documentation should be provided, including: intended purpose(s) of the map, spatial extent and resolution, time frame(s) represented, accuracy and precision (e.g., confidence intervals), etc. Click [here](#) for basic information about current map products available in Oregon.

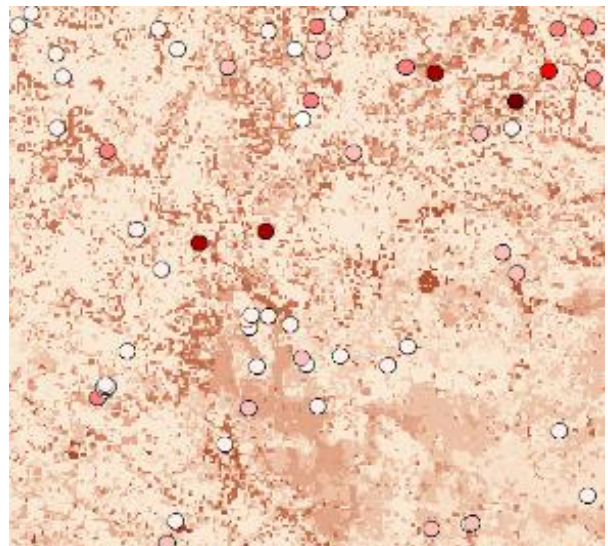
③ **Use maps as a first cut, not a final answer.** The best use of remotely sensed products is usually early in an assessment or planning exercise. Remotely sensed products can help managers visualize and communicate broad patterns, illustrate threats present in an area, summarize conditions at mid to broad scales, and highlight areas with higher uncertainty where field work may need to be prioritized. Remotely sensed maps should complement and support – but not replace – field data, expert knowledge, and other information.

④ **Do not evaluate maps at the pixel level.** Although it is tempting to zoom closely into areas you know well to evaluate a map, precision at very fine scales is often low. In addition, errors at very fine scales often do not reflect the broader quality of the map. Evaluate the map in multiple places and at broader scales for a well-rounded view of the map strengths and limitations.

⑤ **Use expert opinion to evaluate products.** Evaluate the map against expert knowledge of the area. Start at the broadest spatial scale across your area of interest and consider the general patterns and proportions across the landscape. If maps depict continuous percent cover estimates, it may be helpful to classify the map into categories with thresholds meaningful to your application (see table below), and calculate the proportions of those classes across your area. Then start to evaluate smaller areas, without checking pixel level precision.

⑥ **Use available plot data to evaluate maps.** You may be able to use plot data to evaluate how a map is performing. However, avoid comparing plot data values directly to mapped values for an individual pixel, as pixel-level precision does not reflect broader map quality. However, using independent plots (plots that were not used to build the map) as an aggregated group can be a valuable source of information to evaluate a map. To assess spatial precision, visually evaluate whether spatial patterns in the map broadly match those in the plot data. To evaluate the overall accuracy of the map, calculate basic statistics (minimum, maximum, or average) across the area, or the proportion of plots that are in condition classes of

IAG cover classes	Mapped pixels	Percent of plots
absent	50%	52%
1-4%	19%	22%
5-24%	24%	24%
25-49%	6%	2%
>50%	<1%	<1%

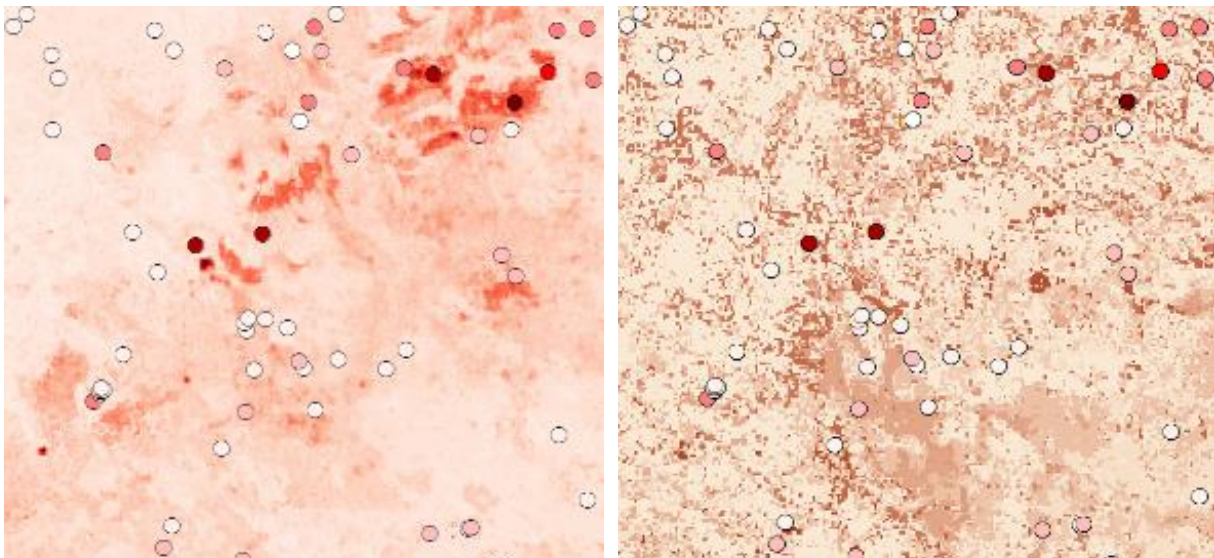


Invasive annual grass (IAG) cover from a remotely sensed map is overlaid with independent plot data (circles), above. Higher cover is shown with greater color saturation, but colors do not match exactly. Percentages of mapped pixels and independent plot data in IAG cover classes are shown in the table. Values show a relatively close match, indicating a fairly accurate prediction of map values.

interest in both the map and the plot dataset (see table above). Note areas where plots are more abundant or absent, and therefore proportions may be over- or under-represented. For instance, if large areas contain an absence of a vegetation condition of interest but there are few samples there, maps may overestimate their distribution.

⑦ **Use imagery to evaluate maps.** Some map attributes such as juniper trees and burn scars, can be visible and evaluated from aerial imagery. However, remember not to evaluate maps on a pixel-by-pixel scale. Be aware of the time frame of the map relative to the imagery (e.g., was mapping conducted pre- or post-fire?).

⑧ **Compare maps where multiple products are available.** There often are multiple maps available for a particular vegetation attribute of interest. All maps may show similar patterns, or one may be clearly best for your purposes. If maps conflict or it is unclear which to use, consider the suggestions above for evaluating each map. One map may contain more error because of the quality or distribution of input data, or time frame relative to a disturbance or land treatment. Consider whether accuracy or precision is more important for your application. If identifying spatial patterns (precision) is important, visual inspection of map patterns relative to the spatial distribution of plot data or knowledge of conditions on the ground may be most helpful. If summarizing vegetation conditions across an area is important, you may want to clip maps to area(s) of interest and calculate basic statistics in the map values, and compare those to plot data or expert knowledge. When comparing categorical maps (maps that are binned into classes), keep in mind that thresholds used to define categories may be different. Categorical maps built for similar purposes but with different rule sets may appear to conflict at first glance, but actually show similar patterns when accounting for differences in the categorization. If multiple maps agree in some areas of your landscape and differ in others, you may consider targeting additional field visits or sampling in areas where maps disagree.



The two maps above show predicted invasive annual grass (IAG) cover from different sources for a ~12,000 acre area, with independent plot data overlaid in circles. Very light colors indicate absence or trace cover and darker colors indicate high cover values, but colors do not match exactly. The map to the left has higher precision in depicting spatial patterns with lower accuracy of predicted values, whereas the map to the right has higher accuracy in predicting the proportion of plots in IAG cover classes (see table above) but lower precision in depicting spatial patterns.

Technology in remotely sensing is improving rapidly. Keep up to date with new products to take full advantage of mapping in natural resource management applications.