

Ecosystem Departure Planning Product: the ECO Score

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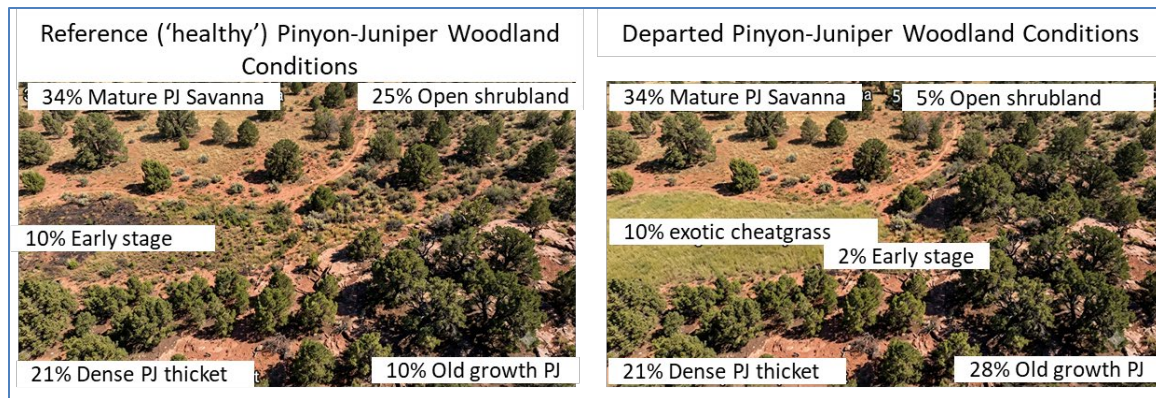
This report accompanies the Utah ECO Score raster product: Stuber, E.F. (2026), 2024 geospatial Ecosystem Condition (ECO) Score layer for Utah, USA: U.S. Geological Survey data release, <https://doi.org/10.5066/P13EXQGF>, ArcGIS online ECO Score Viewer, <https://arcg.is/105TqG1>

Background

Ecological restoration is widely used to address ecosystem degradation resulting from altered disturbance regimes, invasive species, woody encroachment, agriculture, development, and other influences. Restoration planning benefits from objective measures that quantify the health, or condition of ecosystems considered for restoration. We developed the Ecosystem Condition (ECO) Score raster product to help biologists incorporate ecosystem condition into restoration project planning and prioritization across Utah.

What is Ecosystem Departure?

Ecosystem departure, the backbone of the Ecosystem Condition (ECO) Score, measures the degree to which current vegetation composition differs from the composition expected under natural variation & disturbance regimes for a given ecosystem – it measures how different the ecosystem currently looks from what it 'should' look like (see example figure below). Reference conditions are specific to the vegetation systems expected in each different ecosystem type accounting for characteristic succession patterns and typical disturbance processes (e.g., ecosystem types in Utah include: Inter-Mountain Basins Montane Sagebrush Steppe, Rocky Mountain Aspen Forest and Woodland, Colorado Plateau Pinyon-Juniper Woodland). A landscape's ECO score, reflecting how departed the area is currently, compared with its expected reference state, provides a consistent, objective way to identify areas that are closer to or farther from reference conditions, or measure any area of interest's ECO Score.



For example, a 'healthy' Colorado Plateau Pinyon-Juniper Woodland (left, ECO Score = 0 (perfect)) is expected to be comprised of: 10% of early-stage vegetation (e.g., grasses, forbs, and seedlings revegetating post-fire or other replacing disturbance); 25% mid-development open canopy vegetation (e.g., open PJ-woodland with mixed shrub and herbaceous understory); 21% mid-development closed canopy (e.g., dense PJ-woodland with understory vegetation being lost through increasing canopy shading); a majority of late-development open canopy vegetation (34%, e.g., mature open PJ-woodland with well-developed mixed grass, shrub, and herbaceous understory); and only 10% of late-development closed canopy vegetation (e.g., large, old PJ with dense, closed canopy). Right: if the landscape is invaded by cheatgrass (10% instead of 0%), or has increasing amounts of dense old growth PJ (28% instead of 10%) and is depleted in its mid-development open canopy stage (5% instead of 25%) then the landscape is considered departed, or of low health and is assigned a higher ECO Score.

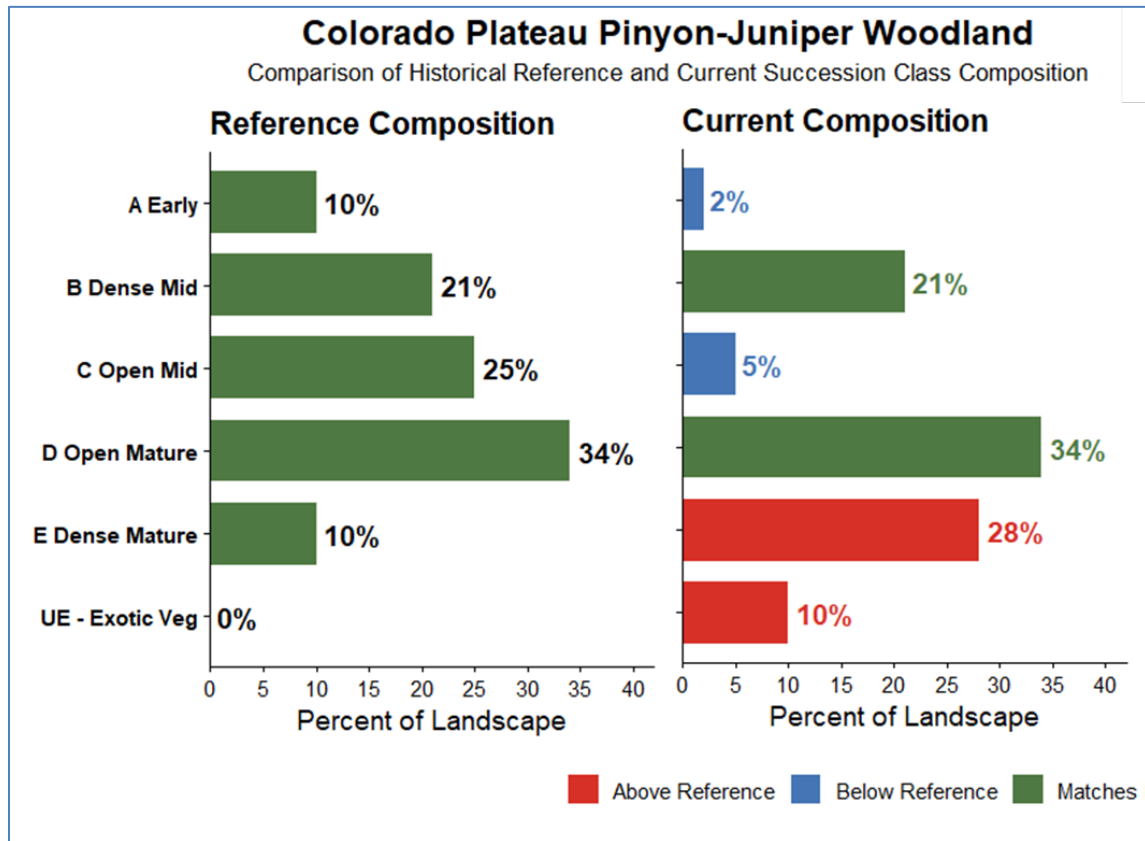
Relationship to LANDFIRE Vegetation Departure

The ECO Score raster product available here follows the well-established scientific foundation of the LANDFIRE Vegetation Departure and Fire Regime Condition Class methodologies, and is analogous to the US Forest Service LANDFIRE Vegetation Departure metric. But, unlike the standard LANDFIRE Vegetation Departure raster, which summarizes departure at the ecosystem scale (ecosystems in Utah are on average 385,000 acres and are assigned a single condition score by LANDFIRE), this product was developed at 300 m resolution (~23 acres) to better represent within-ecosystem variability and provide finer-scale information useful for restoration project evaluation and planning.

ECO Score Development

LANDFIRE Succession Class (S-Class) maps at 30 m resolution were summarized within 300 m analysis cells. Each 300 m cell contains the proportional cover of seven vegetation classes: A (early development), B (mid-development closed), C (mid-development open), D (late-development open), E (late-development closed), UN (uncharacteristic native), and UE (uncharacteristic exotic). S-classes for each ecosystem type consider the type, cover, and

height of vegetation, and whether the vegetation is characteristic of ecosystem type. The dominant LANDFIRE Biophysical Setting in each 300 m cell was used to identify the ecosystem type and reference-condition expectations. Pixels designated as 'barren', 'water', or 'developed' are masked to NA as they have no associated reference conditions.

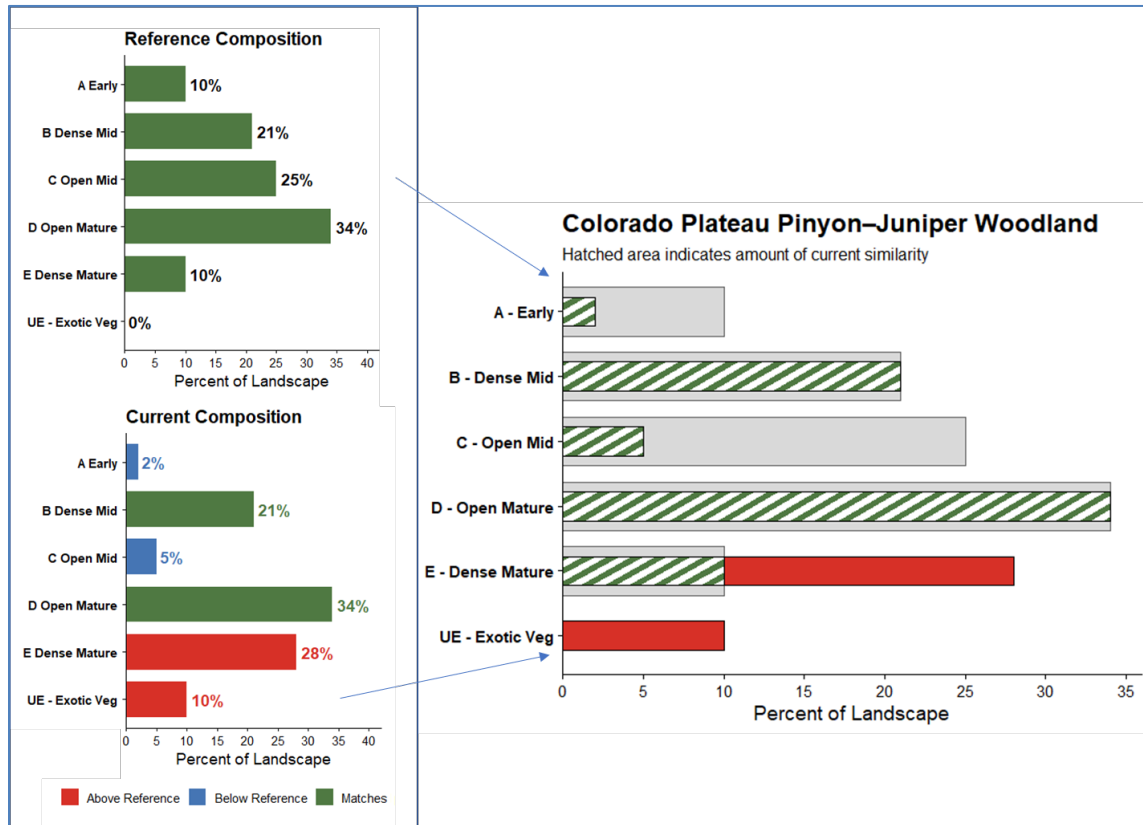


Based on a current map of vegetation succession stages across Utah, we can calculate the %cover in each stage (current composition: right) and compare that to the %cover expected if the ecosystem was healthy (matching reference conditions: left). Here, for example, a landscape proposed for restoration (right) may be depleted in early stage vegetation (A early) and mid-development open canopy vegetation (C Open Mid), and be over-represented in the dense mature vegetation (E Dense Mature) and Exotic vegetation (UE Exotic Veg) classes, while still exactly matching the %cover expected in the reference state for the B (Dense Mid) and D (Open Mature) succession stages.

ECO Score Calculation

The ECO Score raster provides a single, integrated departure score ranging from 0 to 100, where larger values indicate greater departure from reference conditions. The score is based on the same ecological departure framework used by the LANDFIRE Vegetation Departure product and the Fire Regime Condition Class (FRCC) methodology.

To calculate the score, vegetation conditions within each 300 m grid cell are first summarized across seven LANDFIRE Succession Classes (S-Classes): A, B, C, D, E, UN, and UE. Current proportions of each S-Class are compared with the proportions expected under reference conditions for the corresponding ecosystem type. Individual S-Class departures are then combined into a single aggregate Ecosystem Condition score that represents the overall degree of departure from the ecosystem's expected reference condition.



The ECO Score is calculated by comparing the amount of similarity in the %cover of 7 vegetation succession classes currently in the landscape (bottom left) with the %cover expected for a healthy version of the same ecosystem (top left). If we overlap the current composition with the expected reference composition (right) we can determine amounts of similarity (right, hatched areas) and differences in composition (right, un hatched) which determine the ECO Score.

Interpreting Values

The ECO Score provides a straightforward measure of overall ecosystem condition relative to reference expectations. An ECO Score of 0 indicates that current vegetation composition exactly matches reference conditions, while a score of 100 indicates complete departure from the expected vegetation composition. Higher scores generally reflect greater alteration of ecosystem structure, succession patterns, disturbance processes, or the presence of uncharacteristic vegetation (like cheatgrass).

For restoration planning and project ranking, higher ECO Scores generally indicate landscapes with a greater potential need for restoration. However, departure scores should be considered alongside biological objectives, focal species requirements, feasibility, cost, land ownership, and local field knowledge. The score is best interpreted as an indicator of ecosystem condition and restoration opportunity rather than a direct measure of habitat quality for any individual species.

Limitations

The ECO Score is derived from existing vetted geospatial and model-based data developed by the LANDFIRE Team (S-class and Biophysical Settings rasters (30m resolution), and average expected reference conditions), thus limits associated with these products are carried over to the ECO Score product. The ECO Score was also calculated for 300m resolution 'landscapes' across Utah, with a final published resolution of ~390m after re-projection to WGS 84 / Pseudo-Mercator. While 390m resolution is a vast improvement over the default available product, 390m may still be coarse for some landscapes and objectives. Further, because the ECO Score relies on LANDFIRE raster layers which are updated every 1-4 years, the most current version of the ECO Score may be behind current actual field conditions and not reflect more recent disturbances or changes (e.g., 2024 is the most current available product as of September 2026).

Selected References

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