

Utah Statewide Sagebrush Condition Assessment



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EXECUTIVE SUMMARY

Management of sagebrush habitats is an important natural-resource issue in Utah, and likely to remain so for the foreseeable future. Sagebrush shrublands support human uses or values such as livestock grazing and seasonal habitat for mule deer and other game species. Sagebrush in its many forms also provides habitat for a diverse array of non-game wildlife species and plants. Given the importance of sagebrush in Utah, managers need information to direct scarce funds toward effective, efficient conservation, management, and restoration of sagebrush habitats.

The purpose of this project was to assess the current condition of sagebrush habitats at relatively-large landscape scales. The results of this process are termed the **Utah Statewide Sagebrush Condition Assessment**. Ultimately, but beyond the scope of this project, this measure of sagebrush condition may be incorporated in a process that forecasts the outcomes of different types of management actions that are aimed at improving the condition of sagebrush habitats.

The geographic scope of the Assessment is very large, covering the entire state of Utah. Further, the Assessment is designed to be spatial in nature, such that its products would show the condition of sagebrush everywhere that it occurs in Utah. The Assessment obtained publicly-available spatial data from the National LANDFIRE program of biophysical settings (a.k.a. ecological systems) and their succession classes (a.k.a. vegetation classes). With these data, the Assessment used the landscape-scale concept of *Ecological Departure* as the measure of current condition of sagebrush ecological systems.

The LANDFIRE spatial data are grouped geographically by what are known as *Map Zones*. Seven map zones overlap Utah, three with major coverage and four with minor or minimal overlap. The spatial data contain five LANDFIRE ecological systems that: (a) have “sagebrush” in their name, and (b) have an extent of at least 100,000 acres in one or more of the seven map zones that cover Utah. Because two of these ecological systems are split into subtypes, a total of nine discrete LANDFIRE ecological systems were identified as representing “sagebrush” in Utah.

LANDFIRE state-and-transition models were obtained and reviewed to identify what are termed the *Vegetation Classes* of each sagebrush ecological system. These classes represent different expressions of vegetation that may occupy the unchanging abiotic and natural-disturbance “foundation” of each ecological system. There are two general categories of vegetation classes: (1) *reference* classes, that comprise expressions of pre-settlement vegetation that would have been expected under natural disturbance regimes and current climate; and (2) *uncharacteristic* classes, comprising non-reference vegetation resulting from unintentional events (e.g., invasion of cheatgrass), or from post-settlement land-use actions

For a sagebrush ecological system, the relative (percentage) amount of each reference vegetation class that would have been expected to occupy the landscape in the reference state is known as the *Natural Range of Variability* (NRV). The numerical class-% values that represent NRV for each ecological system are defined by the LANDFIRE state-and-transition models.

The current condition of sagebrush ecological systems is then measured using the landscape-scale metric of *Ecological Departure*. Ecological departure measures how greatly the current condition differs from (i.e., is *departed* from) the reference condition. More specifically, ecological departure is the magnitude of dissimilarity between:

- (1) the amounts (percentage) of vegetation classes that would be expected under reference conditions (NRV), as defined in the LANDFIRE models; and
- (2) the amounts (percentage) of vegetation classes that are currently present on the landscape, as derived from the LANDFIRE spatial data per interpretation of remote sensing imagery.

Ecological departure summarizes, in a single number, how out-of-balance each sagebrush ecological system is in terms of dissimilarity between the current amounts of vegetation classes present in an area, and the amounts of those classes that would be expected to occur in that area under a reference baseline conditions (NRV).

Ecological departure is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV itself (no departure), while 100% represents total departure. An aggregate metric known as *Ecological Departure Class* is used to group ecological departure scores into discrete categories. It has been traditional to use three ecological departure classes:

- Class 1 – low departure (<34%), green.
- Class 2 – moderate departure (34 - 66%), yellow.
- Class 3 – high departure (>66%), red.

The ecological departure value for an ecological system has meaning only when associated with a specific polygon (area) within which it is calculated. The LANDFIRE program refers to polygons within which departure is calculated as *Summary Units*. For this Assessment, summary unit polygons were defined as U.S. Geological Survey hydrologic units (watersheds) at the eight-digit level of their hierarchy, referred to hereafter as HUC-8 units or HUC-8 polygons. The state of Utah contains all or parts of 68 HUC-8 polygons; the largest is about 3.5 million acres, and the smallest is about 273,000 acres.

Finally, a simple framework was used to generate numerical results (outputs) from the LANDFIRE spatial data (inputs): For every instance where an individual sagebrush ecological system occurred within an individual HUC-8 summary unit, the LANDFIRE data were used to calculate an Ecological Departure score for that system in that summary unit.

These numerical results are presented as both a large table and as a set of maps. The table (Appendix C) contains the Ecological Departure score and Ecological Departure Class number for each system-HUC combination. The accompanying 112 maps (Appendix D) display the summary units (HUC-8 polygons) within which color-coded Ecological Departure Classes are shown. In an effort to promote the usefulness of mapped results to agency managers and staff, the 112 individual maps are “clipped” and zoomed in to administrative-unit boundaries of the Division of Wildlife Resources (DWR; 5 Regions) and of the Bureau of Land Management (BLM; 11 Field Offices).

INTRODUCTION

Management of sagebrush habitats is an important natural-resource issue in Utah, and likely to remain so for the foreseeable future. The amount of sagebrush has declined in Utah since the beginning of European human settlement. However, sagebrush shrublands are still quite extensive on appropriate sites in relatively undeveloped parts of the state.

Sagebrush shrublands support human uses or values such as livestock grazing and seasonal habitat for mule deer and other game species. Sagebrush in its many forms also provides habitat for a diverse array of non-game wildlife species and plants. The revised Utah Wildlife Action Plan (WAP) is likely to retain sagebrush steppe as one of the state's Key Habitats. More specifically, several wildlife species that rely on sagebrush will probably be designated as Species of Greatest Conservation Need (SGCN) in the revised WAP. Finally, management of sagebrush to meet various life-history needs of greater sage-grouse (*Centrocercus urophasianus*) is likely to remain a high-profile issue, regardless of whether or not the bird is listed as Endangered or Threatened.

PURPOSE

Given the importance of sagebrush in Utah, managers need information to direct scarce funds toward effective, efficient conservation, management, and restoration of sagebrush habitats.

The purpose of this project was to assess or measure the current condition of sagebrush habitats – i.e., sagebrush as a coarse-scale vegetation type *per se* – at relatively-large landscape scales. The results of this process are termed the **Utah Statewide Sagebrush Condition Assessment**. Ultimately, but beyond the scope of this project, this measure of sagebrush condition may be incorporated in a process that forecasts the outcomes of different types of management actions that are aimed at improving the condition of sagebrush habitats.

METHODS

Two fundamental points formed the basis of the Statewide Sagebrush Condition Assessment:

- The geographic scope of the Assessment is very large – the entire state of Utah, and large blocks of land within it.
- The Assessment is to be spatial in nature, such that the products show the condition of sagebrush everywhere that it occurs in Utah.

Out of these fundamental points arose four basic needs, listed as follows:

- The set of spatial data selected for the assessment must cover the whole state consistently, border to border;

- The spatial data need to be at a scale-of-resolution that is appropriate for (consistent with) this large geographic scope;
- The spatial data need to be available for minimal or no cost, because staff time of The Nature Conservancy is essentially being provided to do the Assessment; and
- It is necessary to use a *measure of condition* that the spatial data (as characterized above) are able to provide.

Therefore, two interrelated courses were followed that met the needs above:

- The Assessment used publicly-available raster data from the National LANDFIRE program – Biophysical Setting (BpS) and Succession Class (S-Class) – at face value. These data cover the entire state border-to-border in a consistent manner. Their grain of resolution is coarse (30-m pixel size), and their accuracy varies depending on BpS and location; the assumption was made that the sheer scope and size of the Assessment would damp out data inaccuracies.
- The Assessment used the landscape- (intermediate-) scale concept of *Ecological Departure* as the measure of condition of sagebrush Biophysical Settings. An Ecological Departure score is relevant only when associated with a specific geographic area (Summary Unit polygon) within which it is calculated.

These two courses were the general framework of the method to develop the Assessment. Specific steps or components of the Assessment process are listed below; terms and concepts that appear in these steps will be defined farther down in the report:

- A. Identify the LANDFIRE biophysical settings (hereafter termed “ecological systems”) in Utah that represent “sagebrush” and thus should be the subjects of this assessment.
- B. Obtain the Natural Range of Variability (NRV) values for the Reference Classes for all of the sagebrush ecological systems in all map zones that overlap the state. Reconcile differences, if possible, among NRV values for the same sagebrush ecological systems across map zones.
- C. Identify the Summary Unit polygons within which Ecological Departure scores will be calculated and reported/mapped for each sagebrush ecological system identified in Step A.
- D. Create the products that represent the Sagebrush Condition Assessment for Utah:
 - Table of Ecological Departure scores for each sagebrush ecological system in each Summary Unit polygon identified in Step C.
 - Corresponding maps that show classes of Ecological Departure scores for the Summary Unit polygons identified in Step C.
- E. Prepare the report that assembles all of the products that represent the Sagebrush Condition Assessment for Utah.

RESULTS

LANDFIRE Map Zones

The national LANDFIRE program divided the country into large GeoAreas, and each GeoArea into subsidiary *Map Zones*, as ecologically relevant divisions for their data acquisition and production planning. Figure 1 shows the seven numbered LANDFIRE map zones that overlap Utah. Three of these zones have major coverage in Utah: 16, 17, and 23. The other four have minor or minimal overlap: 13, 15, 22, and 24. Among adjacent map zones that do not overlap Utah, zone 18 comes the closest – parts of its southern margin basically coincide with the Utah-Idaho state line.

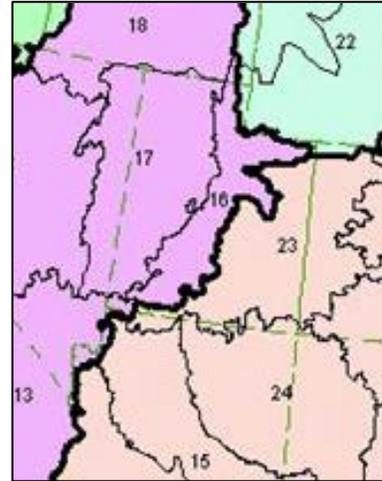


Figure 1. LANDFIRE map zones that overlap the state of Utah.

Ecological Systems That Represent Sagebrush

A list of all LANDFIRE ecological systems that occur within Utah, plus within a surrounding buffer zone, was evaluated to identify those systems that represent sagebrush habitats. The identification criteria were simple: sagebrush is represented by ecological systems that (1) have ‘sagebrush’ in their name, or (2) have sagebrush as a major constituent of their vegetation. Initial results of this evaluation are shown in Table 1: seven ecological systems that have ‘sagebrush’ in their name, plus one system that could have an appreciable sagebrush component to its vegetation, along with their acreages in Utah (plus the buffer), by map zone.

Table 1. LANDFIRE ecological systems that may represent “sagebrush” in Utah, by map zone.

Ecological System	Acres in Utah (plus surrounding buffer), by LANDFIRE map zone						
	13	15	16	17	22	23	24
Colorado Plateau Mixed Low Sagebrush Shrubland			176,605	18,606		262,461	1,835
Columbia Plateau Low Sagebrush Steppe				91,316			
Great Basin Xeric Mixed Sagebrush Shrubland	2,425		4,804	3,301,839			
Inter-Mountain Basins Big Sagebrush Shrubland	4,858	21,694	1,838,150	4,213,153	3,526,636	3,323,621	72,307
Inter-Mountain Basins Big Sagebrush Steppe	60		25,573	139,731		22,327	379
Inter-Mountain Basins Montane Sagebrush Steppe	1,886		1,499,667	498,384	1,153,771	165,855	
Inter-Mountain Basins Semi-Desert Shrub-Steppe	1,180	770	90,042	227,186	13,019	106,520	15,394
Wyoming Basins Dwarf Sagebrush Shrubland and Steppe					96,410		
	10,409	22,464	3,634,841	8,490,216	4,789,836	3,880,785	89,915

From this initial list of eight potential “sagebrush” ecological systems, three were dropped from further consideration. First, written model descriptions of the system without ‘sagebrush’ in its name (Inter-Mountain Basins Semi-Desert Shrub-Steppe) revealed that it does not consistently

contain enough sagebrush cover to justify its inclusion in this Assessment. Second, for an Assessment of this large scope (whole state), it was judged that a “sagebrush” ecological system should have appreciable areal extent in Utah to be included. In this case, “appreciable” was (arbitrarily) defined as having at least 100,000 acres in at least one of the seven map zones. Two of the ecological systems in Table 1 failed this standard (Columbia Plateau Low Sagebrush Steppe and Wyoming Basins Dwarf Sagebrush Shrubland and Steppe) and thus were dropped. In fact, it is probable that much of the 96,000+ acres of Wyoming Basins Dwarf Sagebrush Shrubland and Steppe in map zone 22 occur in the surrounding buffer – in the state of Wyoming – and that its extent in Utah proper is considerably less.

The remaining five ecological systems were thus deemed collectively to represent “sagebrush” in Utah for purposes of this Assessment:

- Colorado Plateau Mixed Low Sagebrush Shrubland
- Great Basin Xeric Mixed Sagebrush Shrubland
- Inter-Mountain Basins Big Sagebrush Shrubland
- Inter-Mountain Basins Big Sagebrush Steppe
- Inter-Mountain Basins Montane Sagebrush Steppe

The situation becomes more complex, however, because two of these ecological systems are treated more finely (i.e., split into sub-systems) in certain LANDFIRE map zones. The result is that the five ecological systems listed above grow to nine systems with unique names and associated model descriptions. These nine sagebrush ecological systems are shown in Table 2, along with their map zones of occurrence; the sub-systems that were split out in certain map zones are shown in red font color.

Table 2. The nine LANDFIRE ecological systems that represent “sagebrush” in Utah, by map zone.

Ecological System	Map Zone						
	13	15	16	17	22	23	24
Colorado Plateau Mixed Low Sagebrush Shrubland			X			X	X
Great Basin Xeric Mixed Sagebrush Shrubland	X		X	X			
Inter-Mountain Basins Big Sagebrush Shrubland	X	X	X	X		X	X
Inter-Mountain Basins Big Sagebrush Shrubland - Basin Big Sagebrush					X		
Inter-Mountain Basins Big Sagebrush Shrubland - Wyoming Big Sagebrush					X		
Inter-Mountain Basins Big Sagebrush Steppe			X	X		X	X
Inter-Mountain Basins Montane Sagebrush Steppe	X			X	X		
Inter-Mountain Basins Montane Sagebrush Steppe - Low Sagebrush			X			X	
Inter-Mountain Basins Montane Sagebrush Steppe - Mountain Big Sagebrush			X			X	

Figure 2 shows the distribution of these nine ecological systems that represent sagebrush in Utah.

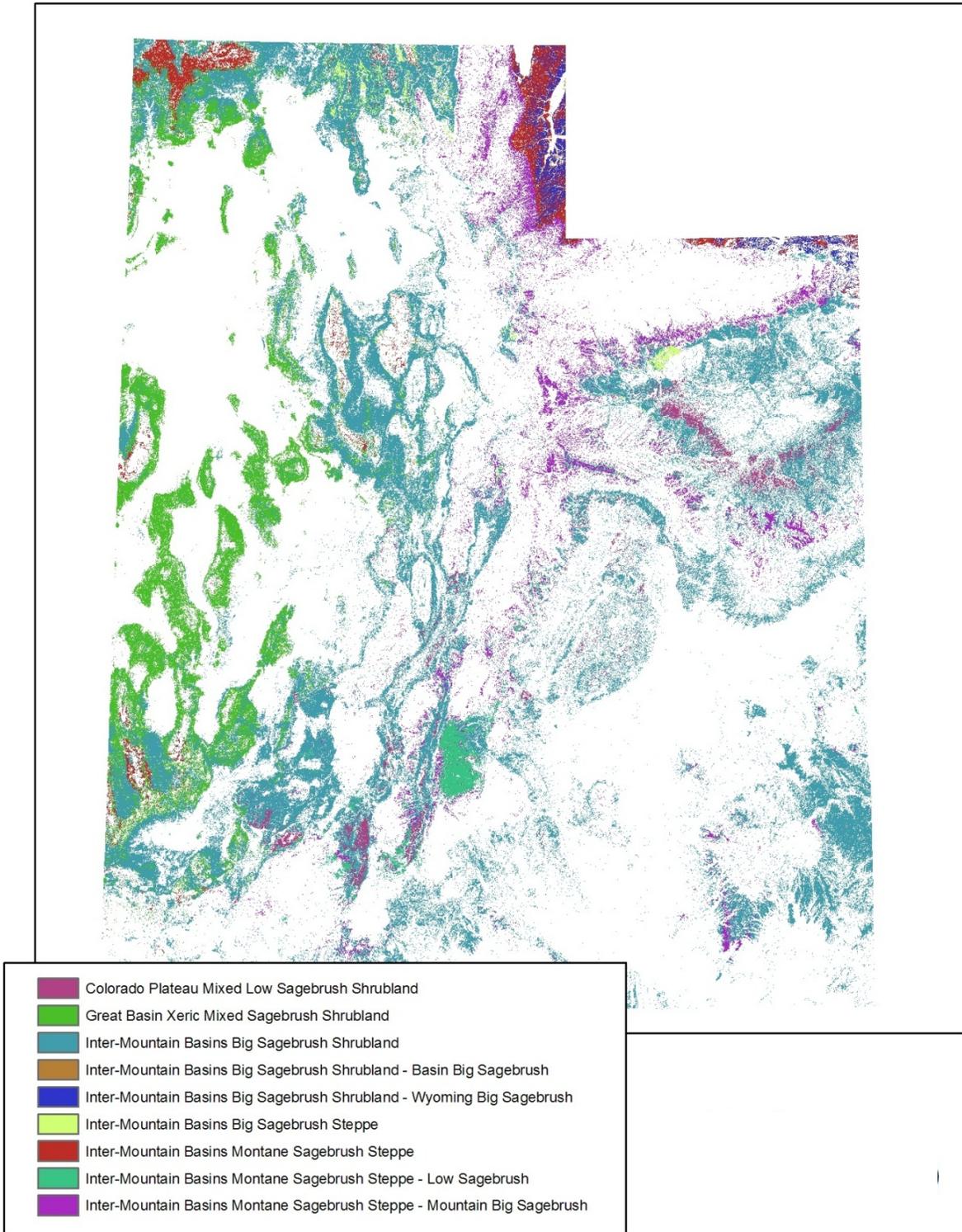


Figure 2. Distribution of the nine ecological systems that represent sagebrush in Utah.

LANDFIRE Models for Ecological Systems

The national LANDFIRE program developed state-and-transition models for ecological systems. Products for each system are the model itself (VDDT/PATH software platform) and an accompanying written description. Appendix A contains LANDFIRE model descriptions for most of the nine ecological systems that represent sagebrush in Utah (listed in Table 2).

Vegetation Classes.

Each written model description contains a discussion of another feature of ecological systems that is central to the measure of condition that is used in this Assessment. This feature is the partitioning of each system into discrete *Vegetation Classes*. Vegetation classes are known by the term Succession Class (S-Class) in the LANDFIRE products. Within this Assessment report the two terms are synonymous, and the latter term (vegetation class) is used exclusively hereafter.

Vegetation classes represent different expressions of the vegetation that may occupy the (virtually) unchanging abiotic and natural-disturbance “foundation” of each ecological system. Recall from page 4 of this report that “biophysical setting” is a synonym for ecological system; in fact, biophysical setting is the term used almost exclusively for this concept in the LANDFIRE products.

LANDFIRE products include two different types of vegetation classes for each ecological system: *reference* classes and *uncharacteristic* classes.

Reference classes comprise expressions of pre-settlement vegetation that would have been expected under natural disturbance regimes and the current climate. Reference classes typically represent succession, usually from herbaceous vegetation to increasing woody species dominance, either shrubs or trees. The LANDFIRE models define up to five reference classes for each ecological system. These five reference classes (or fewer, depending on the complexity of a system’s successional stages) are designated by the standard letters A-B-C-D-E in the models. The A-E reference classes are thus different successional/temporal phases within a single reference state. The LANDFIRE model descriptions (Appendix A) contain the specifications of each ecological system’s particular reference vegetation classes.

The reference condition for each ecological system does not encompass vegetation caused by unintentional events (e.g., invasion of cheatgrass), or by post-settlement land-use actions (such as fire suppression or domestic livestock grazing). Therefore, LANDFIRE vegetation-class spatial data also include vegetation (or site features) that are considered to be uncharacteristic of pre-settlement reference conditions. The uncharacteristic class is designated by the standard letter U in the spatial data. Many expressions of uncharacteristic conditions may now exist within any given ecological system, but the broad scope and coarse scale of the national LANDFIRE data reduce this complexity to just two uncharacteristic sub-classes: native (UN) and exotic (UE).

The spatial data for ecological systems and their vegetation classes used in this Assessment are from the LANDFIRE National Dataset, version 1.0.0. An optional update to both the ecological system and vegetation class datasets is the “refresh” version that adds fire, insect, and management events to provide a more updated picture of on-the-ground conditions. However, not all such events in Utah were added to this refresh version, so the original version 1.0.0 data were used. The LANDFIRE web page http://www.landfire.gov/data_overviews.php contains an overview of LANDFIRE data products, plus links to pages with more detailed descriptions of their data products such as version comparisons, vegetation, etc.

Natural Range of Variability.

As noted above, the constituent vegetation classes of ecological systems are central to the process used to measure the current condition of each system. As a final prerequisite to measuring condition, the concept known as *Natural Range of Variability* (NRV) must be defined for each ecological system. NRV is the relative amount (percentage) of each vegetation class that would be expected to occur in an ecological system under its reference condition, i.e., under natural disturbance regimes and current climate. In effect, NRV represents the presumed “baseline” mix of reference vegetation classes for each system, from which the current mix of vegetation classes is different (departed) by some quantitative amount.

NRV values were determined using the LANDFIRE model for each ecological system, and the NRV values are reported in the system’s written model description (see in Appendix A). NRV values for the ecological systems that collectively represent sagebrush in Utah (see Table 2) are shown on the next page in Table 3. Note that the value of the uncharacteristic class (both UN and UE sub-classes) *is always zero* in the NRV/reference state. Some ecological systems have more than one row (set of NRV values) in Table 3, because the NRV mix of reference classes differs within different LANDFIRE map zones. The rows in Table 3 are thus 13 unique combinations of (a) ecological systems, and (b) NRV class-% values. Current condition of these 13 unique combinations, reported via tables and maps, is the core product of this Assessment. Appendix B shows the distribution of these 13 system x NRV units in and surrounding Utah.

Ecological Departure

The current condition of ecological systems is measured using the landscape-scale metric of *Ecological Departure*. Ecological departure is a broad-scale measure of the “health” of an ecological system according to how greatly the current condition differs from (i.e., *is departed from*) the reference condition. Technically, an ecological departure value is generated by a formula that calculates the dissimilarity between:

- (1) the amounts (percentage) of vegetation classes that would be expected under reference conditions (NRV), as derived from the LANDFIRE models and stated in the written model descriptions (Appendix A); and
- (2) the amounts (percentage) of vegetation classes that are currently present on the landscape, as derived from the LANDFIRE raster data per interpretation of remote sensing imagery.

Table 3. Percentages of reference vegetation classes that represent the Natural Range of Variability (NRV) in sagebrush ecological systems in Utah.

Ecological System	NRV Class Percentages						Zones Where NRV %s Apply
	A	B	C	D	E	U	
Colorado Plateau Mixed Low Sagebrush Shrubland	10	70	20	0	0	0	16, 23, 24
Great Basin Xeric Mixed Sagebrush Shrubland	20	60	15	5	0	0	13
Great Basin Xeric Mixed Sagebrush Shrubland	15	60	15	10	0	0	16,17
Inter-Mountain Basins Big Sagebrush Shrubland	15	45	25	10	5	0	13
Inter-Mountain Basins Big Sagebrush Shrubland	15	30	25	30	0	0	15
Inter-Mountain Basins Big Sagebrush Shrubland	15	50	25	5	5	0	16, 17, 23, 24
Inter-Mountain Basins Big Sagebrush Shrubland - Basin Big Sagebrush	15	30	55	0	0	0	22
Inter-Mountain Basins Big Sagebrush Shrubland - Wyo. Big Sagebrush	20	20	30	30	0	0	22
Inter-Mountain Basins Big Sagebrush Steppe	20	50	30	0	0	0	16, 17, 23, 24
Inter-Mountain Basins Montane Sagebrush Steppe	20	50	15	10	5	0	13, 17
Inter-Mountain Basins Montane Sagebrush Steppe	5	15	30	50	0	0	22
Inter-Mountain Basins Montane Sagebrush Steppe - Low Sagebrush	10	35	55	0	0	0	16, 23
Inter-Mountain Basins Montane Sagebrush Steppe - Mtn. Big Sagebrush	20	50	15	10	5	0	16, 23

Ecological departure thus summarizes, in a single number, how out-of-balance each ecological system is in terms of dissimilarity between the current amounts of vegetation classes present in an area, and the amounts of those classes that would be expected to occur in that area under a reference baseline of natural disturbance regimes and current climate (NRV).

Ecological departure is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV itself (no departure), while 100% represents total departure. That is, the higher the number, the greater the departure. Further, an aggregate metric known as Ecological Departure Class is used to group ecological departure scores into discrete categories. It has been traditional to use three ecological departure classes*:

- Class 1 – low departure (<34%), green.
- Class 2 – moderate departure (34 - 66%), yellow.
- Class 3 – high departure (>66%), red.

Tables 4 and 5 show examples of the ecological departure calculation, and assignment to the corresponding ecological departure class, for two different sagebrush ecological systems. Table 6 shows the same information and calculation as in Table 5, but in a more-or-less transposed format. In the Table 6 example, the uncharacteristic class is split into sub-classes that are more descriptive and customized to the particular area, versus the two general uncharacteristic classes (UN and UE) of the coarse-scale national LANDFIRE raster data.

* There is nothing magical or mandatory about using three classes. The maps that accompany this report in Appendix D segregate the 0-100% range of ecological departure values into five equal color-coded departure classes, providing greater discrimination for visual display.

Table 4. Example of calculation of Ecological Departure and assignment to Ecological Departure Class.

Ecological System: Intermountain Basins Montane Sagebrush Steppe	Vegetation Class ¹						Sum
	A	B	C	D	E	U	
Natural range of variability (%)	20	50	15	10	5	0	100
Current acres of classes in area	182	7,950	58,718	6,659	264	46,123	119,896
Current % of classes in area	0.1	6.6	49.0	5.6	0.2	38.5	100
Minimum of NRV % or Current %	0.1	6.6	15.0	5.6	0.2	0	27.5
Ecological Departure (%) ²							72.5
Ecological Departure Class ³							3

1. Standard LANDFIRE coding: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed; and U = uncharacteristic.
2. Ecological Departure (ED) = $100\% - \sum_{i=1}^n \min\{Current_i, NRV_i\}$
3. Ecological Departure Class: 1 for $0\% \leq ED < 34\%$; 2 for $34\% \leq ED < 67\%$; 3 for $67\% \leq ED \leq 100\%$.

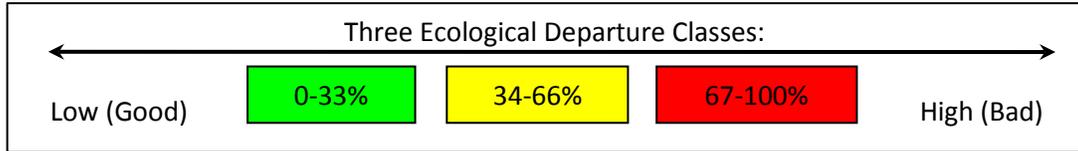


Table 5. Example of calculation of Ecological Departure and assignment to Ecological Departure Class.

Ecological System: Intermountain Basins Big Sagebrush Shrubland	Vegetation Class ¹						Sum
	A	B	C	D	E	U	
Natural range of variability (%)	16	28	41	6	9	0	100
Current acres of classes in area	9,600	1,200	18,000	27,600	50,400	13,200	120,000
Current % of classes in area	8	1	15	23	42	11	100
Minimum of NRV % or Current %	8	1	15	6	9	0	39
Ecological Departure (%) ²							61
Ecological Departure Class ³							2

1. Standard LANDFIRE coding: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed; and U = uncharacteristic.
2. Ecological Departure (ED) = $100\% - \sum_{i=1}^n \min\{Current_i, NRV_i\}$
3. Ecological Departure Class: 1 for $0\% \leq ED < 34\%$; 2 for $34\% \leq ED < 67\%$; 3 for $67\% \leq ED \leq 100\%$.

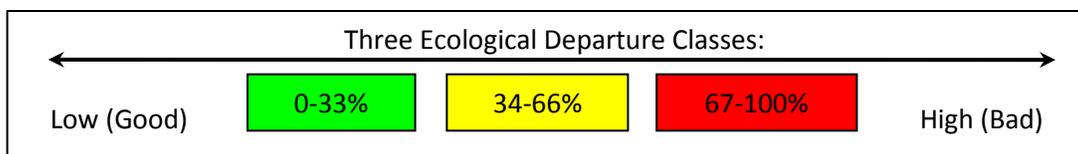


Table 6. Example of calculation of Ecological Departure and assignment to Ecological Departure Class.

Wyoming Big Sagebrush (= Intermountain Basins Big Sagebrush Shrubland)			
	Vegetation Class	NRV	Current Amount in Summary Unit
Reference	A (baby)	16%	8%
	B (adolescent)	28%	1%
	C (middle aged)	41%	15%
	D (mature)	6%	23%
	E (conifer-encroached)	9%	42%
Uncharacteristic	U-TA: Tree-Annual-Grass	0%	1%
	U-SAP: Shrub-Annual-Grass-Perennial-Grass	0%	4%
	U-DP: Depleted	0%	1%
	U-SA: Shrub-Annual-Grass	0%	5%
	U-AG: Annual-Grass	0%	0%
	U-ES: Early-Shrub	0%	0%
		100%	39%

$$\text{Ecological Departure} = 100\% - \sum_{i=1}^n \min\{Current_i, NRV_i\}$$

100% 39% **61**

Three Ecological Departure Classes:

←		→
Low (Good)	High (Bad)	
0-33%	34-66%	67-100%

Summary Units

It is crucial to understand that the ecological departure value for an ecological system has meaning only when associated with a specific polygon (area) within which it is calculated. In the results that appear farther down in this report, ecological departure values are always reported – within tables or on maps – as attributes of the polygon (area) to which they apply.

The LANDFIRE program refers to polygons within which departure is calculated as *Summary Units*. For a calculated departure value to be meaningful, summary unit polygons must be large enough to include the range of ecological/successional function (e.g., fire patch size, fire return interval) inherent to the ecological system in question. In other words, the most appropriate-sized summary unit is the smallest area in which the full expression of vegetation classes would be observed under the natural disturbance regime. Different sagebrush ecological systems thus could have different minimum-size thresholds for summary unit polygons. Applying this concept rigorously could introduce a measure of complexity that could be undesirable for, and inconsistent with, the coarse and relatively-simple structure of this Assessment.

As a very general rule-of-thumb, however, the ecological departure metric tends to become questionable or unreliable in summary units that are smaller than about 100,000 acres. Therefore this summary-unit minimum-size threshold was a factor in selecting the set of summary unit polygons used in this Assessment.

At the opposite end, there is not a clear-cut ecologically-meaningful maximum size for summary unit polygons, as long as the ecological system being assessed is homogeneous (the “same”)

throughout the polygon. Practically, however, summary unit polygons that are very large tend to “average to a muddy middle” the variations in a system’s ecological departure that may be “real” in different parts of a landscape, such as between individual mountain ranges or basins. Summary unit polygons larger than a few million acres probably lose this ability to discriminate among such imbedded physical landscape features.

Also considered was whether summary unit polygons should coincide with natural boundaries such as watersheds, or with artificial boundaries such as management-agency boundaries. There is no correct answer, though in general natural boundaries are more ecologically meaningful, while administrative-unit boundaries may be more relevant to agency managers – with the choice coming down to which alternative best meets the objectives and anticipated uses of the project.

For this Assessment, the summary unit polygons were defined naturally according to U.S. Geological Survey hydrologic units (basically, watersheds) at the eight-digit level of their hierarchy. These summary units are thus referred to hereafter as HUC-8 units or HUC-8 polygons. These are the summary units used for reporting of ecological departure calculations via tables and maps in this Assessment.

The state of Utah contains all or parts of 68 HUC-8 polygons. Their locations are shown in Figure 3, and their numbers, names, and acreages are listed in Table 7. The largest of these is about 3.5 million acres, pushing but not grossly exceeding the informal maximum desired size discussed above. The smallest HUC-8 polygon is about 273,000 acres, well above the rule-of-thumb 100,000-acre minimum-size threshold discussed above.

The national LANDFIRE raster data do allow for calculation of ecological departure in smaller summary unit HUC polygons, at the 10- and 12-digit levels. However, not only are there many more of these smaller-sized polygons within Utah (which would increase complexity of the Assessment), but many individual HUC-10 and especially HUC-12 polygons are far smaller than the rule-of-thumb 100,000-acre minimum-size threshold discussed above.

As a helpful reference for agency managers, maps of sagebrush ecological departure classes in HUC-8 polygons are overlain with outlines of administrative-unit boundaries of two major agencies in Utah: the five Regions of the Division of Wildlife Resources, and the eleven Field Offices of the Bureau of Land Management. This will be explained further in the section below that describes the map products of the Assessment.



Figure 3. Locations of the 68 HUC-8 polygons wholly or partly within Utah.

Table 7. Numbers, names, and acreages of the 68 HUC-8 polygons wholly or partly within Utah.

HUC-8 #	HUC-8 Name	Acres	HUC-8 #	HUC-8 Name	Acres
14010005	Colorado Headwaters-Plateau	272,955	15010013	Meadow Valley Wash	1,625,125
14030001	Westwater Canyon	931,162	16010101	Upper Bear	1,284,671
14030002	Upper Dolores	388,854	16010102	Central Bear	524,091
14030004	Lower Dolores	357,662	16010201	Bear Lake	277,135
14030005	Upper Colorado-Kane Springs	1,455,306	16010202	Middle Bear	395,599
14040106	Upper Green-Flaming Gorge Reservoir	1,599,676	16010203	Little Bear-Logan	565,402
14040107	Blacks Fork	1,754,756	16010204	Lower Bear-Malad	516,866
14040108	Muddy (WY)	617,327	16020101	Upper Weber	739,419
14050007	Lower White	1,135,667	16020102	Lower Weber	849,843
14060001	Lower Green-Diamond	627,346	16020201	Utah Lake	860,111
14060002	Ashley-Brush	412,848	16020202	Spanish Fork	615,961
14060003	Duchesne	1,713,446	16020203	Provo	438,745
14060004	Strawberry	744,712	16020204	Jordan	520,507
14060005	Lower Green-Desolation Canyon	1,244,616	16020301	Hamlin-Snake Valleys	1,995,567
14060006	Willow	610,238	16020302	Pine Valley	468,999
14060007	Price	1,206,455	16020303	Tule Valley	608,558
14060008	Lower Green	1,194,430	16020304	Rush-Tooele Valleys	772,726
14060009	San Rafael	1,555,982	16020305	Skull Valley	520,438
14070001	Upper Lake Powell	1,828,832	16020306	Southern Great Salt Lake Desert	3,504,550
14070002	Muddy (UT)	991,796	16020307	Pilot-Thousand Springs, Nevada, Utah	1,193,129
14070003	Fremont	1,250,140	16020308	Northern Great Salt Lake Desert	2,706,344
14070004	Dirty Devil	555,300	16020309	Curlew Valley	1,313,460
14070005	Escalante	1,295,710	16020310	Great Salt Lake	1,118,249
14070006	Lower Lake Powell	1,105,267	16030001	Upper Sevier	769,786
14070007	Paria	907,796	16030002	East Fork Sevier	794,442
14080201	Lower San Juan-Four Corners	1,275,526	16030003	Middle Sevier	1,184,621
14080202	McElmo	333,804	16030004	San Pitch	550,593
14080203	Montezuma	747,618	16030005	Lower Sevier	2,623,618
14080204	Chinle	298,621	16030006	Escalante Desert	2,106,719
14080205	Lower San Juan	1,560,126	16030007	Beaver Bottoms-Upper Beaver	1,105,046
15010003	Kanab	600,046	16030008	Lower Beaver	513,582
15010008	Upper Virgin	1,397,438	16030009	Sevier Lake	893,180
15010009	Fort Pearce Wash	899,102	17040210	Raft	473,356
15010010	Lower Virgin	856,088	17040211	Goose	455,457

Assessment Products: Maps and Tables

A simple framework was used to generate numerical results (outputs) from the LANDFIRE spatial data (inputs):

For every instance where an individual sagebrush ecological system (Table 2 / Appendix B) occurred within an individual HUC-8 summary unit (Figure 3 / Table 7), the LANDFIRE data were used to calculate an Ecological Departure score for that system in that summary unit.

The tabular product that displays these numerical results appears in Appendix C. Further explanation of this large table is provided on the cover page of Appendix C, though one important point is worth mentioning here.

The data in the table allow one to identify the particular vegetation classes that contribute most to high departure scores that are often found – information that would likely be of interest to managers. In other words, review of the current % values for vegetation classes can show which classes are most out-of-balance relative to their NRV reference condition. For example, high departure value may result from under-representation of early reference classes (A, B) relative to NRV %, overabundance of later reference classes (D, E) relative to NRV %, or preponderance of the uncharacteristic class (for which NRV % is always zero). Identifying particular reasons for high departure, even at this broad scope and coarse scale, may give managers some initial indication of problems and potential actions for improving conditions of sagebrush in locations under their authority.

Tables 8 and 9 show two examples drawn from the tables of Appendix C, illustrating vegetation classes that contribute in varying degrees to overall high values of ecological departure. The column labeled “**Amt of Current relative to NRV**” does not appear in the Appendix C tables, but is included below to show the magnitude and direction of discrepancy between current and NRV class percentages. Such information may be useful in designing projects that reduce the extent of classes that currently have too much (relative to NRV), or vice versa.

Table 8. Example of current vegetation class amounts contributing to ecological departure.

HUC-8	Ecological System	Acres	Veg Class	NRV %	Current %	Amt of <u>Current</u> relative to NRV	Ecological Departure
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	A	15	0.0	Far too little	66.3
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	B	50	6.9	Far too little	
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	C	25	16.8	Slightly too little	
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	D	5	21.0	Far too much	
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	E	5	13.5	Slightly too much	
Ashley-Brush	Inter-Mountain Basins Big Sagebrush Shrubland	65326	U	0	41.8	Far too much	

Table 9. Example of current vegetation class amounts contributing to ecological departure.

HUC-8	Ecological System	Acres	Veg Class	NRV %	Current %	Amt of <u>Current</u> relative to NRV	Ecological Departure
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	A	10	0.0	Too little	79.1
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	B	70	0.9	Far too little	
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	C	20	49.8	Far too much	
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	D	N/A	N/A	N/A	
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	E	N/A	N/A	N/A	
Duchesne	Colorado Plateau Mixed Low Sagebrush Shrubland	39675	U	0	49.3	Far too much	

The maps that accompany the tabular data appear in Appendix D. On these maps, HUC-8 polygons are the formal summary units within which color-coded classes of ecological departure are shown. In an effort to promote the usefulness of mapped results to agency managers and staff, the individual maps are “clipped” and zoomed in to administrative-unit boundaries of the Division of Wildlife Resources (DWR; 5 Regions) and of the Bureau of Land Management (BLM; 11 Field Offices). As a result, Appendix D contains a total of 112 maps that are represented by the cells with an “x” in Tables 10 and 11.

Table 10. Individual maps in Appendix D of sagebrush ecological systems in DWR Regions.

Ecological System	DWR Regions				
	No	Ce	So	NE	SE
Colorado Plateau Mixed Low Sagebrush Shrubland	X	X	X	X	X
Great Basin Xeric Mixed Sagebrush Shrubland	X	X	X		X
Inter-Mountain Basins Big Sagebrush Shrubland	X	X	X	X	X
Inter-Mountain Basins Big Sagebrush Shrubland - Basin Big Sagebrush	X	X		X	
Inter-Mountain Basins Big Sagebrush Shrubland - Wyoming Big Sagebrush	X	X		X	
Inter-Mountain Basins Big Sagebrush Steppe	X	X	X	X	X
Inter-Mountain Basins Montane Sagebrush Steppe	X	X	X	X	
Inter-Mountain Basins Montane Sagebrush Steppe - Low Sagebrush	X	X	X	X	X
Inter-Mountain Basins Montane Sagebrush Steppe - Mountain Big Sagebrush	X	X	X	X	X

Number of Maps in each DWR Region:	9	9	7	8	6
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Table 11. Individual maps in Appendix D of sagebrush ecological systems in BLM Field Offices.

Ecological System	BLM Field Offices										
	SL	Fill	CC	StG	Rich	Kan	Pri	GSE	Vern	Moab	Mont
Colorado Plateau Mixed Low Sagebrush Shrubland	X	X	X	X	X	X	X	X	X	X	X
Great Basin Xeric Mixed Sagebrush Shrubland	X	X	X	X	X	X	X				
Inter-Mountain Basins Big Sagebrush Shrubland	X	X	X	X	X	X	X	X	X	X	X
Inter-Mountain Basins Big Sagebrush Shrubland - Basin Big Sagebrush	X								X		
Inter-Mountain Basins Big Sagebrush Shrubland - Wyoming Big Sagebrush	X								X		
Inter-Mountain Basins Big Sagebrush Steppe	X	X	X	X	X	X	X	X	X	X	X
Inter-Mountain Basins Montane Sagebrush Steppe	X	X	X	X	X	X			X		
Inter-Mountain Basins Montane Sagebrush Steppe - Low Sagebrush	X	X	X	X	X	X	X	X	X	X	X
Inter-Mountain Basins Montane Sagebrush Steppe - Mountain Big Sagebrush	X	X	X	X	X	X	X	X	X	X	X

Number of Maps in each BLM Field Office:	9	7	7	7	7	7	6	5	8	5	5
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In a few cases, a map may contain a single HUC-8 polygon that displays within it two different classes (colors) of ecological departure for the same sagebrush ecological system*. This would

* A stark example of this appears on the BLM Kanab Field Office map for the Inter-Mountain Basins Big Sagebrush Shrubland ecological system (Appendix D Map #79): the Paria and Kanab HUC-8 polygons at lower-center each contain two different departure classes (colors).

seem contrary to the concept that an ecological system can have *only one* ecological departure value in a summary unit polygon. However, this apparent error is a legitimate anomaly caused where an “invisible” boundary between two LANDFIRE map zones cuts through a HUC-8 polygon, and those two map zones have different NRV values for the same sagebrush system. This is the case in the example mentioned in the footnote on the previous page: The Paria and Kanab HUC-8 polygons both contain the boundary between map zones 15 and 23 – and Table 3 above confirms that NRV class % values for Inter-Mountain Basins Big Sagebrush Shrubland are different in map zones 15 and 23. In effect, what is displayed are two separate sub-polygons (of the HUC-8 unit) that have different ecological departure values for the same sagebrush system, on account of different baseline NRV % values across the map zone boundary.

Potential Future Expansion

The same type of assessment reported above – ecological departure within HUC-8 summary units – can be done for additional ecological systems that were not included in this report. Two “sagebrush” ecological systems were dropped from this initial assessment because they were deemed (arbitrarily) not to have sufficient areal extent in Utah to be included: Columbia Plateau Low Sagebrush Steppe and Wyoming Basins Dwarf Sagebrush Shrubland and Steppe. However, small areal extent does not necessarily translate to low importance. The Columbia Plateau Low Sagebrush Steppe represents subalpine low sagebrush (typically above 9,000 feet elevation), and is distinct from the Great Basin Xeric Mixed Sagebrush Shrubland, which combines low and black sagebrush at elevations lower than subalpine. Although Columbia Plateau Low Sagebrush Steppe is not extensive in Utah, it can be locally very important for wildlife due to the high grass content and palatability of low sagebrush.

Other ecological systems that may be worthy of future statewide condition assessment are not named or dominated by species of sagebrush, but may be important for some life-cycle needs of sage-grouse or other sagebrush-obligate sensitive species. For example, the Rocky Mountain Lower Montane-Foothill Shrubland ecological system contains sites with mixed-shrub composition, including Utah serviceberry, antelope bitterbrush, Wyoming big sagebrush, low sagebrush, and mountain big sagebrush. This system is reported to represent good sage-grouse nesting habitat in Nevada if trees are absent (i.e. pinyon, juniper, Gambel oak), and is extensive in some parts of western Utah.

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