CRITERION 1—

# Chapter 2. Landscape Pattern and Context of Forest and Grassland in Alaska, Hawaii, and Puerto Rico

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## Introduction

As development introduces competing land uses into forest and grassland landscapes, the public concerns for landscape patterns are expressed through headline issues such as urban sprawl and forest fragmentation. The task for resource managers is to maintain an appropriate balance of biodiversity, water quality, recreation experience, and other amenities in forest and grassland ecosystems. A prerequisite for informed actions at local, regional, and national scales is reliable information about landscape patterns at those scales. National assessments document the status and trends of landscape patterns in a consistent fashion nationwide, making it possible to identify national strategies to achieve particular objectives. To the extent that nationally available input data are able to also capture important local details, the same information can be used for local planning as well.

Previous reports by the national Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture, (Ambrose and others 2008, Conkling 2011, Coulston and others 2005, Potter and Conkling 2012) have addressed different aspects of forest and grassland spatial patterns, but have been limited by data available for the conterminous United States plus the District of Columbia. Following the recent release (Homer and others 2007) of the 2001 National Land Cover Database (NLCD) for the States of Alaska and Hawaii and the Commonwealth of Puerto Rico (hereafter, all referred to as "States"), the objective of this chapter is to extend landscape pattern assessments to these additional States. The spatial patterns of forest and grassland ("sectors") are evaluated with several measures of landcover composition and configuration. The analyses are conducted at several spatial scales, and the results are summarized in two ways to highlight landscape-level and sector-level interpretations.

## Methods

Three fundamental metrics of landscape patterns are measured on landcover maps of Alaska, Hawaii, and Puerto Rico. The three metrics are "area density" (a measure of landcover dominance), "landscape mosaic" (landcover juxtaposition), and "morphological spatial pattern" (landcover spatial structure). Several analysis scales are defined by neighborhood size (for area density and landscape mosaic) or by effective edge width (morphological spatial pattern). The results are summarized separately at the landscape level, and separately for the forest and grassland sectors, by scale and by State. This section describes with examples the input landcover maps and the procedures for measuring the metrics and summarizing the results.

**Landcover maps**—The input database is a set of landcover maps for Alaska, Hawaii, and Puerto Rico that were extracted from the 2001

NLCD (Homer and others 2004, 2007). The NLCD maps have a spatial resolution of 0.09 ha pixel$^{-1}$ (i.e., each pixel is 30 m x 30 m, about the size of a baseball diamond infield) and a thematic resolution of 19 landcover types (table 2.1). The landcover maps of Alaska, Hawaii, and Puerto Rico contain approximately 1.7 billion, 19 million, and 10 million pixels, respectively.

For analyses, the thematic resolution was condensed from 19 to 8 generalized landcover types (table 2.1), including generalized "forest" and "grassland" types. Since landcover patterns are typically correlated with the amounts of different landcover types in a landscape, the proportions of each State that are covered by each of the eight generalized NLCD classes (table 2.1) provide information for interpreting the pattern measurements. The analyses considered adjacent ocean water area; for reporting, the map extents were limited to the boundaries of detailed State maps (fig. 2.1) (ESRI 2005).

**Area density**—As a measure of landcover dominance, area density describes a given pixel on a landcover map by the proportion of the neighboring pixels that are either forest ("forest area density") or grassland ("grassland area density"). The measurements were conducted with a "moving window" algorithm (e.g., Riitters and others 2002) that measured both forest and grassland area density in the unique neighborhoods (hereafter, "landscapes") surrounding each individual pixel on the landcover maps. The measurements were

**Table 2.1 —The percentages of Alaska, Hawaii and Puerto Rico that are covered by each of the eight generalized NLCD landcover classes. The original 19 NLCD landcover types are shown for comparisons**

| Generalized landcover type | Alaska | Hawaii | Puerto Rico | Included original NLCD landcover types |
|---|---|---|---|---|
| | Percent of total State area | | | |
| Water, Ice | 8.9 (2)[a] | 0.3 (50) | 0.9 (45) | Open water; Perennial ice/snow |
| Developed | 0.1 (52) | 8.6 (19) | 14.6 (6) | Developed, open space; Developed, low intensity; Developed, medium intensity; Developed, high intensity |
| Barren | 8.4 (3) | 14.1 (1) | 0.5 (22) | Barren land |
| Forest | 29.0 (34) | 28.4 (35) | 46.5 (22) | Deciduous forest; Evergreen forest; Mixed forest; Woody wetlands |
| Shrubland | 43.0 (7) | 29.0 (11) | 2.7 (23) | Dwarf scrub; Scrub/shrub |
| Grassland | 7.3 (17) | 13.4 (12) | 28.3 (10) | Grassland/herbaceous; Sedge herbaceous; Moss |
| Agriculture | <0.1 (52) | 6.2 (42) | 4.9 (43) | Pasture/hay; Cultivated crops |
| Wetland | 3.3 (7) | 0.1 (49) | 1.5 (16) | Emergent herbaceous wetland |

Due to rounding, columns may not sum to 100.
[a] The numbers in parentheses indicate the descending rank among the 50 States plus the District of Columbia and Puerto Rico for that proportion.

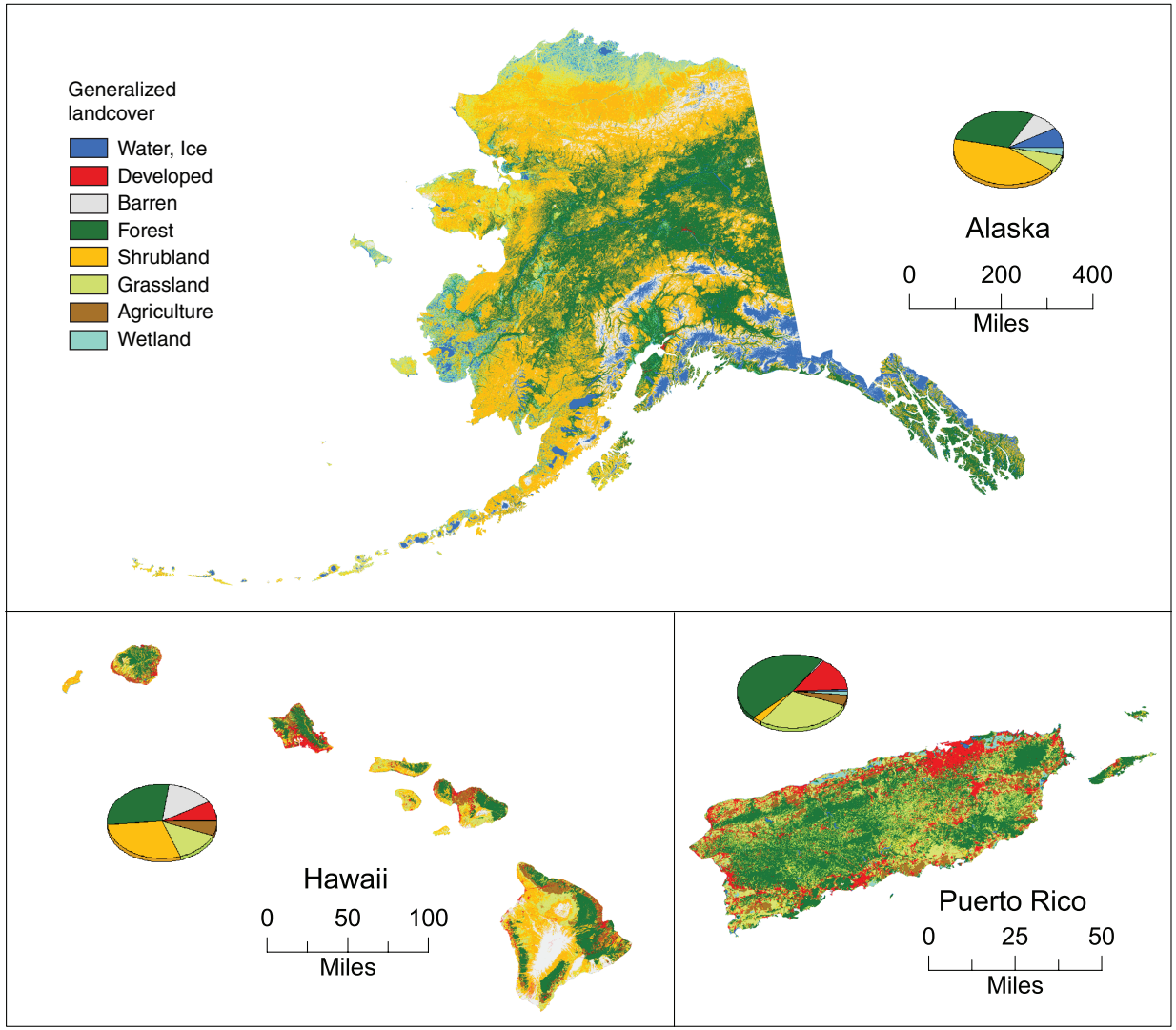


*Figure 2.1—Generalized landcover types for Alaska, Hawaii, and Puerto Rico. Source: NLCD 2001 (Homer and others 2007).*

repeated using square landscapes of size 15.21 ha (13 pixels x 13 pixels) and 590.49 ha (81 x 81). The four measured area density values for a given landcover pixel were then stored as new pixel values on four new maps at the location of that landcover pixel. For example, a pixel value on a map of grassland area density, 15.21-ha scale, represents the proportion of the surrounding 15.21-ha landscape that was grassland on the input landcover map. Generally, a pixel value on a map of forest (or grassland) area density represents the proportion of the surrounding 15.21-ha (or 590.49-ha) landscape that was forest (or grassland) on the original landcover map. By using that procedure, area density is defined as a contextual (landscape) attribute. The procedure preserves options for post-stratification because the spatial resolution of the four area density maps is the same as that of the input landcover maps (0.09 ha pixel$^{-1}$). The measured values were continuous in the range [0, 1] and were converted to seven area density classes for reporting (table 2.2). Figure 2.2 illustrates the input and output maps for an arbitrary landcover type called "foreground."

**Landscape mosaic**—As a measure of landcover juxtaposition and anthropogenic interface zones, the landscape mosaic metric describes a given pixel on a landcover map by the relative proportions of the neighboring pixels that are "agriculture," "developed," or "natural" (i.e., neither agriculture nor developed) on the landcover map. The measurements were conducted by using an algorithm (Riitters and others 2009b) that is similar to the algorithm used for the area density measurements, and employed the same two landscape sizes (15.21 ha and 590.49 ha). For a given pixel on the landcover map, the measured proportions of the three generalized landcover types (i.e., agriculture, developed, and natural) were converted to a landscape mosaic categorical value by using a tri-polar classification model (fig. 2.3). Thus, a pixel value on a map of landscape mosaics represents the landscape mosaic category of the 15.21-ha (or 590.49-ha) landscape surrounding that pixel location on the original landcover map. Like the area density maps, the landscape mosaic maps describe the landscape context surrounding a given landcover pixel, and options are preserved for post-stratification because the spatial resolution of the landscape mosaic maps is the same as that of the input landcover maps (0.09 ha pixel$^{-1}$).

**Table 2.2—Conversion of continuous area-density measurements to categorical values for reporting**

| Area density class | Continuous area density (p) range |
|---|---|
| Intact | $p = 1.0$ |
| Interior | $0.9 \leq p < 1.0$ |
| Dominant | $0.6 \leq p < 0.9$ |
| Transitional | $0.4 \leq p < 0.6$ |
| Patchy | $0.1 \leq p < 0.4$ |
| Rare | $0.0 \leq p < 0.1$ |
| None | $p = 0.0$ |

Note: area density (p) was measured separately for forest and grassland.

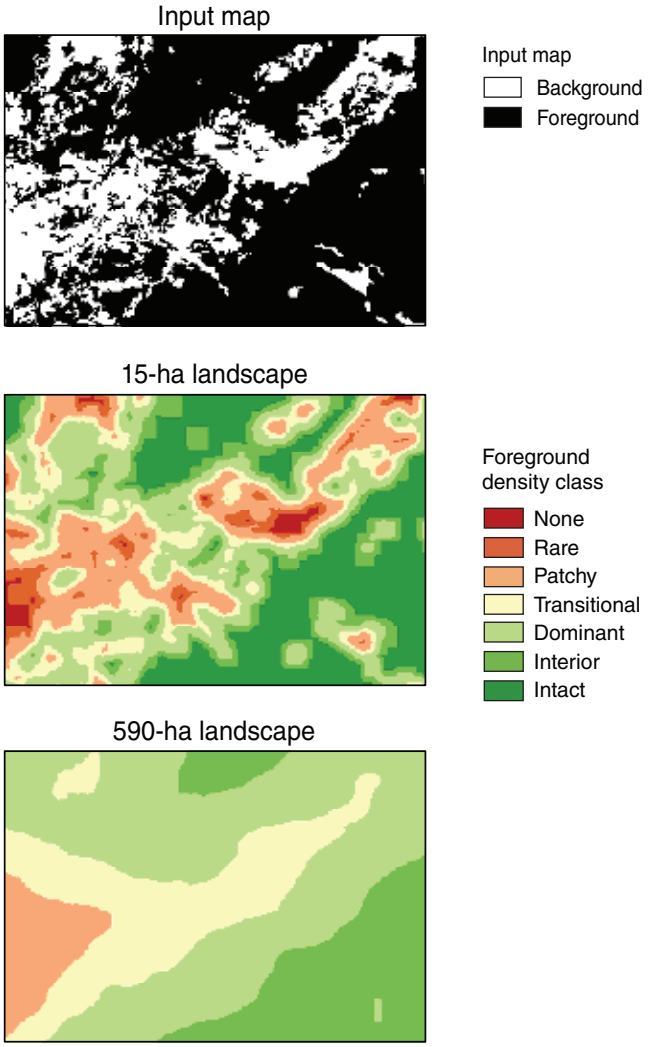


*Figure 2.2—Illustration of the area density metric for an arbitrary landcover type called foreground using landscape sizes of 15 ha and 590 ha. The original landcover map was converted to a binary map of "foreground" (forest or grassland) and "background" (top). Maps of the foreground area density in a surrounding landscape are shown for 15-ha (middle) and 590-ha (bottom) neighborhoods. See table 2.2 for definitions of the area density classes.*

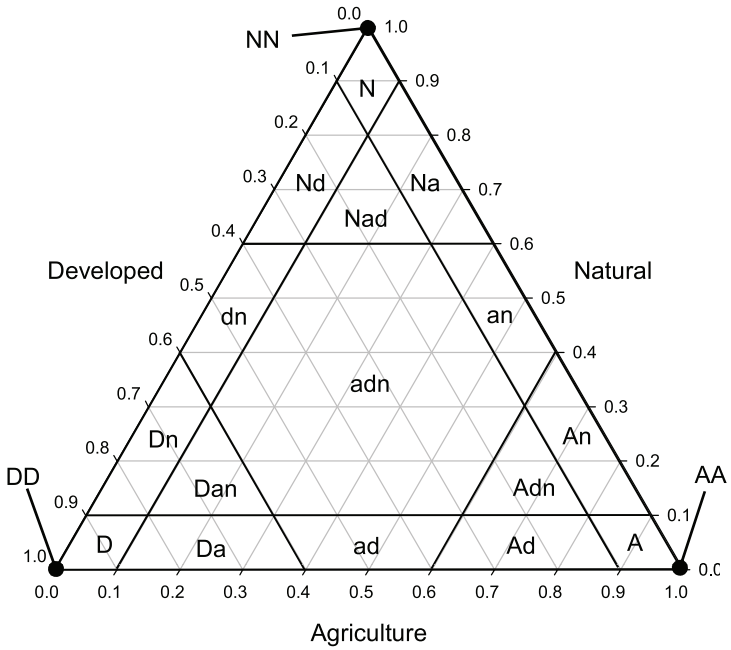


*Figure 2.3—The landscape mosaic tri-polar classification model identifies 19 landscape mosaic categories according to the proportions of developed, agriculture, and natural (i.e., neither developed nor agriculture) landcover types in a surrounding landscape. See text for explanation of the landscape mosaic coding system.*

The partitioning of the tri-polar classification model (fig. 2.3) indicates the critical values of 10 percent, 60 percent, and 100 percent along each axis. The landscape mosaic category labels are coded as follows. A lower-case letter (n, d, a) appears in a label if the corresponding landcover type (natural, developed, agriculture, respectively) comprises at least 10 percent but < 60 percent of the landscape. An upper-case letter (N, D, A) appears if that landcover type comprises at least 60 percent but < 100 percent of the landscape. A letter does not appear if that landcover type comprises < 10 percent of the landscape. The labels NN, DD, and AA indicate landscapes that contain exactly 100 percent of the corresponding landcover type. Figure 2.4 illustrates the generalized landcover input map and the corresponding landscape mosaic output maps for two landscape sizes.

**Morphological spatial pattern**—Landcover spatial structure is described by metrics from morphological spatial pattern analysis (MSPA). Each pixel on a landcover map is labeled according to the structural role that is played by that pixel, relative to other pixels of the same landcover type. For example, a pixel may be part of a "connector" cluster between two "core" clusters. The labels were determined by using an algorithm (Soille and Vogt 2009) that classifies individual forest or grassland pixels on a landcover map into one of 19 mutually exclusive MSPA categories. As illustrated in figure 2.5, those 19 categories were condensed to six categories which are the essential features of spatial structure from MSPA (Riitters and others

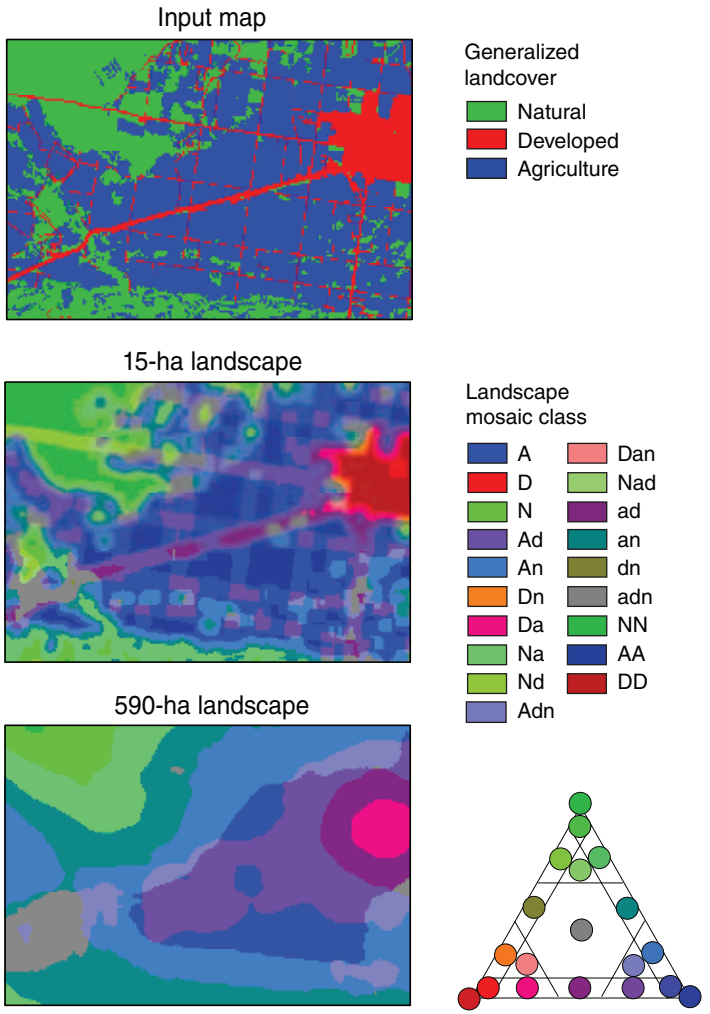


*Figure 2.4—Illustration of the landscape mosaic metric for landscape sizes of 15 ha and 590 ha. The generalized landcover map (top) portrays developed, agriculture, and natural pixels. Maps of the landscape mosaic class in a surrounding landscape are shown for 15-ha (middle) and 590-ha (bottom) landscapes. See text for definitions of landscape mosaic classes. Note that by comparisons to figure 2.3, the inset figure at bottom right can be used to interpret the colors in the landscape mosaic class legend.*

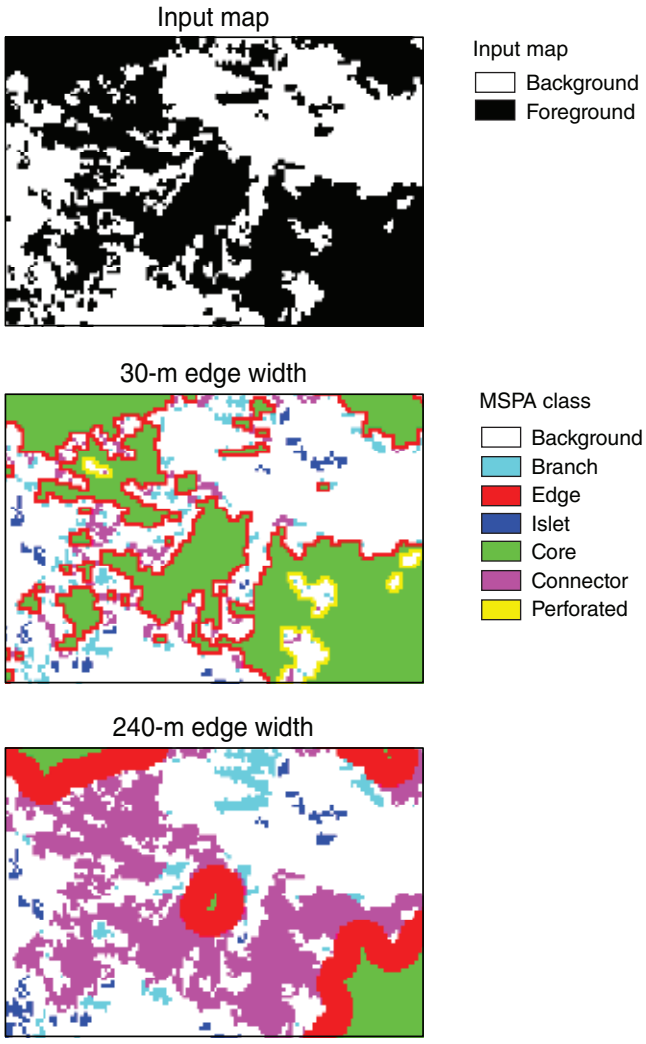


*Figure 2.5—Illustration of the morphological spatial pattern classification for effective edge widths of 30 m and 240 m. The legend of the original landcover map has been converted to "foreground" (e.g., forest, or grassland) and "background" (top). Maps of the morphological spatial pattern classes are shown for effective edge widths of 30 m (middle) and 240 m (bottom). See text for definitions of the pattern classes.*

2007, 2009a). The forest results are referred to as "forest MSPA" and the grassland results are called "grassland MSPA." The measurements were repeated using four "effective edge widths" (Soille and Vogt 2009) of 30 m, 60 m, 120 m, and 240 m, which define the scales of the MSPA (Ostapowicz and others 2008). Figure 2.5 illustrates the differences between results obtained for effective edge widths of 30 m and 240 m.

Using the forest landcover type as an example, the MSPA algorithm starts by defining "core" forest pixels as those which were more than the effective edge width away from any nonforest pixel. The remaining forest pixels are then subdivided into five categories representing their structural roles in relation to clusters of core forest pixels as follows. "Edge" forest pixels form the exterior perimeters of clusters of core forest, and "perforated" forest pixels form the interior perimeters (i.e., forest pixels adjacent to holes in core forest clusters). "Connector" forest pixels are clusters that are connected to edge forest pixels at both ends, or to perforated forest pixels at both ends. "Branch" forest pixels are clusters that are connected to edge, perforated, or connector forest pixels at one end only. "Islet" forest pixels are isolated clusters that were too small to contain core pixels.

Google Earth examples of forest area density, landscape mosaic, and morphological spatial pattern (http://www.forestthreats.org/tools/landcover-maps/landcover-maps) may be valuable for visualizing how the spatial pattern

metrics relate to the underlying landcover at local to national scales. A complete description of the Google Earth examples is contained in the FHM 2008 national technical report (Potter and Conkling 2012).

**Data summaries**—The area density maps and the landscape mosaic maps were first summarized at the "landscape level," which means that every pixel location on the original landcover maps was included in a summary, regardless of its particular landcover type. The same maps were then summarized at the "sector level" by summarizing only the values for the pixels that were either forest or grassland on the original landcover maps. The sector-level pixels to be included in a given summary were identified by simple geographic overlays of the maps of pattern metrics and the original landcover maps. As the names imply, landscape-level summaries describe landscape patterns without regard to actual landscape composition, whereas sector-level summaries describe the specific patterns in locations that have forest or grassland. The MSPA metrics are by definition sector-level only. For each scale of analysis, summary tables were prepared at the State level by examining the proportions of total area that were in the landscape pattern classes. For landscape-level summaries, the proportions were based on the total area of a State. For sector-level summaries, the proportions were based on the total area of forest or grassland in a State.

## Results

The landscape-level summaries of the landscape mosaic metric, by landscape size and by State, are shown in table 2.3. The percentages are based on the total area in each State. The four subtotals in the table refer to landscape mosaic "dominance" classes (Conkling 2011), which refer to landscapes that are dominated by (i.e., contain at least 60 percent of) the three generalized landcover types (natural, agriculture, developed) and landscapes that are not dominated by any one of those three types (mixed).

The landscape-level summaries of the forest area density and grassland area density metrics, by landscape size and by State, are shown in table 2.4. Table 2.4a refers to forest area density and table 2.4b refers to grassland area density, and the percentages are based on the total area of each State in both cases.

The forest sector-level summaries of the landscape mosaic metric, by landscape size and by State, are shown in table 2.5. The values shown in these summaries are calculated using a subset of the pixels used in the landscape-level summaries (table 2.3); the subset consists of all the pixel values corresponding to forest landcover on the original landcover map. The percentages are based on the total forest area in each State. The landscape mosaic dominance classes are as defined above for table 2.3.

**Table 2.3—Landscape-level summary of the landscape mosaic metric. The percent of total State area in each of 19 landscape mosaic classes is shown for two landscape sizes. The subtotals show the percentages in subgroups of landscape mosaic dominance classes (natural, agriculture, developed, mixed)**

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Landscape mosaic class | Percent of total area in State | | | | | |
| NN | 99.3 | 61.6 | 45.9 | 97.4 | 28.6 | 4.7 |
| N | 0.3 | 9.1 | 16.7 | 2.4 | 42.4 | 47.0 |
| Na | 0.0 | 0.9 | 1.6 | 0.0 | 2.8 | 4.4 |
| Nd | 0.2 | 13.5 | 15.8 | 0.1 | 10.8 | 24.9 |
| Nad | 0.0 | 0.5 | 0.2 | 0.0 | 1.9 | 3.0 |
| Natural subtotal | 99.9 | 85.7 | 80.2 | 100.0 | 86.5 | 83.9 |
| AA | 0.0 | 0.8 | 1.0 | 0.0 | 0.0 | 0.0 |
| A | 0.0 | 1.1 | 1.1 | 0.0 | 0.7 | 0.1 |
| Ad | 0.0 | 1.8 | 0.3 | 0.0 | 0.6 | 0.0 |
| An | 0.0 | 0.9 | 1.5 | 0.0 | 1.0 | 0.6 |
| Adn | 0.0 | 0.6 | 0.2 | 0.0 | 0.6 | 0.2 |
| Agriculture subtotal | 0.0 | 5.2 | 4.0 | 0.0 | 2.9 | 0.9 |
| DD | 0.0 | 0.9 | 1.9 | 0.0 | 0.0 | 0.0 |
| D | 0.0 | 0.8 | 2.0 | 0.0 | 0.3 | 0.9 |
| Da | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Dn | 0.0 | 1.8 | 5.0 | 0.0 | 1.3 | 3.2 |
| Dan | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 |
| Developed subtotal | 0.0 | 3.7 | 9.0 | 0.0 | 1.7 | 4.1 |
| ad | 0.0 | 0.3 | 0.1 | 0.0 | 0.1 | 0.0 |
| an | 0.0 | 0.6 | 1.0 | 0.0 | 1.3 | 1.5 |
| dn | 0.0 | 1.9 | 4.7 | 0.0 | 2.1 | 4.9 |
| adn | 0.0 | 2.6 | 1.1 | 0.0 | 5.5 | 4.8 |
| Mixed subtotal | 0.0 | 5.4 | 6.8 | 0.0 | 8.9 | 11.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 2.4—Landscape-level summary of (A) forest area density class and (B) grassland area density class for two landscape sizes, by State**

(A) Forest area density

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Forest area density class | Percent of total area in State | | | | | |
| No forest | 48.7 | 51.4 | 14.2 | 33.4 | 35.5 | 0.8 |
| Rare forest | 8.6 | 7.3 | 10.1 | 18.5 | 16.6 | 11.7 |
| Patchy forest | 11.0 | 10.4 | 22.3 | 15.0 | 16.1 | 32.1 |
| Transitional forest | 5.7 | 5.2 | 14.2 | 8.6 | 8.4 | 21.0 |
| Dominant forest | 10.3 | 9.6 | 21.4 | 15.6 | 14.1 | 28.3 |
| Interior forest | 6.8 | 5.9 | 9.2 | 8.7 | 8.6 | 5.7 |
| Intact forest | 8.9 | 10.1 | 8.6 | 0.3 | 0.8 | 0.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

(B) Grassland area density

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Grassland area density class | Percent of total area in State | | | | | |
| No grassland | 76.7 | 59.6 | 17.6 | 62.2 | 29.0 | 1.2 |
| Rare grassland | 8.2 | 13.7 | 16.6 | 20.5 | 36.4 | 14.7 |
| Patchy grassland | 7.8 | 13.4 | 35.8 | 10.6 | 24.6 | 59.2 |
| Transitional grassland | 2.6 | 4.2 | 15.1 | 3.2 | 4.7 | 20.5 |
| Dominant grassland | 2.9 | 5.2 | 11.9 | 3.0 | 4.0 | 4.3 |
| Interior grassland | 1.0 | 2.1 | 2.1 | 0.5 | 1.4 | 0.2 |
| Intact grassland | 0.7 | 1.8 | 0.9 | 0.0 | 0.0 | 0.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

**Table 2.5—Forest sector-level summary of the landscape mosaic metric. The percent of total forest area in each State in each of 19 landscape mosaic classes is shown for two landscape sizes. The subtotals show the percentages in subgroups of landscape mosaic dominance classes (natural, agriculture, developed, mixed)**

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Landscape mosaic class | Percent of total forest area in State | | | | | |
| NN | 98.8 | 71.2 | 67.8 | 94.9 | 32.6 | 8.9 |
| N | 0.7 | 10.7 | 17.2 | 4.7 | 45.2 | 64.3 |
| Na | 0.0 | 1.4 | 1.2 | 0.1 | 3.9 | 3.3 |
| Nd | 0.4 | 12.5 | 10.9 | 0.3 | 11.3 | 18.7 |
| Nad | 0.0 | 0.6 | 0.1 | 0.0 | 2.0 | 1.4 |
| Natural subtotal | 100.0 | 96.5 | 97.2 | 100.0 | 95.0 | 96.5 |
| AA[a] | – | – | – | – | – | – |
| A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ad | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| An | 0.0 | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 |
| Adn | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 |
| Agriculture subtotal | 0.0 | 0.2 | 0.2 | 0.0 | 0.3 | 0.1 |
| DD[a] | – | – | – | – | – | – |
| D | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Da | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dn | 0.0 | 0.4 | 0.5 | 0.0 | 0.3 | 0.6 |
| Dan | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Developed subtotal | 0.0 | 0.5 | 0.5 | 0.0 | 0.3 | 0.6 |
| ad | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| an | 0.0 | 0.4 | 0.4 | 0.0 | 0.7 | 0.3 |
| dn | 0.0 | 1.2 | 1.5 | 0.0 | 1.2 | 1.5 |
| adn | 0.0 | 1.2 | 0.2 | 0.0 | 2.6 | 1.0 |
| Mixed subtotal | 0.0 | 2.8 | 2.1 | 0.0 | 4.4 | 2.9 |
| Total forest area | 100 | 100 | 100 | 100 | 100 | 100 |

[a] This class is not possible in a forest-level summary.

The grassland sector-level summaries of the landscape mosaic metric, by landscape size and by State, are shown in table 2.6. The values shown in these summaries are calculated using a subset of the pixels used in the landscape-level summaries (table 2.3); the subset consists of all the pixel values corresponding to grassland landcover on the original landcover map. The percentages are based on the total grassland area in each State. The landscape mosaic dominance classes are as defined above for table 2.3.

The forest and grassland sector-level summaries of the forest area density and grassland area density metrics, by landscape size and by State, are shown in table 2.7. Table 2.7a refers to forest area density and table 2.7b refers to grassland area density. The values included in these summaries are subsets of the values included in the landscape-level summaries (table 2.4a and table 2.4b, respectively); the subsets consist of all the pixel values corresponding to forest (table 2.7a) or grassland (table 2.7b) on the original landcover map. The percentages are based on the total forest area (table 2.7a) or total grassland area (table 2.7b) in each State.

The summaries of the forest MSPA classes, by effective edge width and by State, are shown in table 2.8. The percentages are based on the total forest area in each State. Similarly, table 2.9 shows the summaries of the grassland MSPA classes, with the percentages based on the total grassland area in each State.

**Table 2.6—Grassland sector-level summary of the landscape mosaic metric. The percent of total grassland area in each State in each of 19 landscape mosaic classes is shown for two landscape sizes. The subtotals show the percentages in subgroups of landscape mosaic dominance classes (natural, agriculture, developed, mixed)**

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Landscape mosaic class | Percent of total grassland area in State | | | | | |
| NN | 99.7 | 60.1 | 40.5 | 98.3 | 17.0 | 1.5 |
| N | 0.2 | 14.7 | 25.1 | 1.6 | 55.6 | 46.4 |
| Na | 0.0 | 1.4 | 2.6 | 0.0 | 5.0 | 5.2 |
| Nd | 0.1 | 19.3 | 23.7 | 0.1 | 13.0 | 32.1 |
| Nad | 0.0 | 0.8 | 0.5 | 0.0 | 2.7 | 4.5 |
| Natural subtotal | 100.0 | 96.2 | 92.4 | 100.0 | 93.3 | 89.6 |
| AA[a] | – | – | – | – | – | – |
| A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ad | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| An | 0.0 | 0.2 | 0.1 | 0.0 | 0.2 | 0.2 |
| Adn | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 |
| Agriculture subtotal | 0.0 | 0.3 | 0.1 | 0.0 | 0.4 | 0.3 |
| DD[a] | – | – | – | – | – | – |
| D | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Da | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dn | 0.0 | 0.3 | 1.5 | 0.0 | 0.2 | 0.9 |
| Dan | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Developed subtotal | 0.0 | 0.3 | 1.6 | 0.0 | 0.2 | 1.0 |
| ad | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| an | 0.0 | 0.5 | 0.7 | 0.0 | 1.2 | 1.1 |
| dn | 0.0 | 1.3 | 4.2 | 0.0 | 1.3 | 3.9 |
| adn | 0.0 | 1.4 | 0.9 | 0.0 | 3.6 | 4.2 |
| Mixed subtotal | 0.0 | 3.2 | 5.9 | 0.0 | 6.1 | 9.2 |
| Total grassland area | 100 | 100 | 100 | 100 | 100 | 100 |

[a] This class is not possible in a grassland-level summary.

**Table 2.7—Sector-level summary of (A) forest area density class and (B) grassland area density class for two landscape sizes, by State**

(A) Forest area density

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Forest area density class | Percent of total forest area in State | | | | | |
| Rare forest | 0.7 | 0.6 | 0.5 | 1.7 | 1.6 | 0.9 |
| Patchy forest | 7.3 | 6.9 | 9.5 | 10.7 | 11.4 | 16.2 |
| Transitional forest | 9.8 | 9.4 | 15.3 | 15.1 | 15.3 | 23.3 |
| Dominant forest | 28.7 | 27.4 | 36.9 | 42.5 | 39.6 | 46.7 |
| Interior forest | 22.9 | 20.3 | 19.3 | 29.0 | 29.3 | 11.9 |
| Intact forest | 30.7 | 35.4 | 18.6 | 1.0 | 2.8 | 0.9 |
| Total forest | 100 | 100 | 100 | 100 | 100 | 100 |

(B) Grassland area density

| Landscape size | 15.21 ha | | | 590.49 ha | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| Grassland area density class | Percent of total grassland area in State | | | | | |
| Rare grassland | 3.0 | 2.5 | 1.3 | 8.1 | 7.9 | 2.1 |
| Patchy grassland | 21.9 | 19.5 | 26.3 | 31.1 | 37.9 | 49.2 |
| Transitional grassland | 18.9 | 17.2 | 28.2 | 22.9 | 19.9 | 37.0 |
| Dominant grassland | 32.4 | 31.9 | 33.6 | 30.9 | 24.7 | 11.1 |
| Interior grassland | 13.7 | 15.3 | 7.3 | 6.8 | 9.8 | 0.6 |
| Intact grassland | 10.1 | 13.5 | 3.2 | 0.2 | 0.0 | 0.0 |
| Total grassland | 100 | 100 | 100 | 100 | 100 | 100 |

Note: the “no forest” and “no grassland” classes are not possible in sector-level summaries.

**Table 2.8—Summary of forest morphological spatial pattern analysis (MSPA) classes for four effective edge widths, by State**

| Edge width | 30 m | | | 60 m | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| MSPA class | Percent of total forest area in State | | | | | |
| Core | 70.9 | 74.5 | 64.2 | 57.6 | 61.1 | 46.2 |
| Edge | 10.9 | 13.9 | 18.6 | 15.4 | 18.6 | 25.0 |
| Perforated | 4.9 | 2.4 | 4.0 | 5.8 | 2.9 | 2.7 |
| Connector | 6.1 | 3.1 | 4.9 | 11.6 | 6.9 | 12.1 |
| Branch | 3.8 | 3.8 | 6.0 | 4.1 | 5.3 | 8.6 |
| Islet | 3.2 | 2.3 | 2.3 | 5.5 | 5.3 | 5.5 |
| Total forest area | 100 | 100 | 100 | 100 | 100 | 100 |

| Edge width | 120 m | | | 240 m | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| MSPA class | Percent of total forest area in State | | | | | |
| Core | 45.4 | 49.4 | 32.1 | 27.3 | 32.3 | 16.0 |
| Edge | 19.9 | 21.9 | 27.3 | 23.8 | 24.0 | 21.5 |
| Perforated | 5.4 | 3.0 | 1.3 | 3.4 | 2.2 | 0.6 |
| Connector | 18.6 | 11.8 | 22.7 | 33.8 | 23.6 | 43.6 |
| Branch | 3.4 | 5.3 | 8.2 | 1.7 | 3.6 | 4.0 |
| Islet | 7.2 | 8.7 | 8.5 | 10.0 | 14.3 | 14.3 |
| Total forest area | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 2.9—Summary of grassland morphological spatial pattern analysis (MSPA) classes for four effective edge widths, by State**

| Edge width | 30 m | | | 60 m | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| MSPA class | Percent of total grassland area in State | | | | | |
| Core | 46.3 | 53.7 | 39.7 | 30.7 | 36.7 | 19.8 |
| Edge | 18.0 | 22.3 | 30.0 | 20.0 | 24.2 | 26.2 |
| Perforated | 3.5 | 1.4 | 0.9 | 2.7 | 1.3 | 0.5 |
| Connector | 12.0 | 6.0 | 9.0 | 19.2 | 11.0 | 18.5 |
| Branch | 8.0 | 8.0 | 12.5 | 7.0 | 9.0 | 14.7 |
| Islet | 12.2 | 8.6 | 8.1 | 20.5 | 17.9 | 20.4 |
| Total grassland area | 100 | 100 | 100 | 100 | 100 | 100 |

| Edge width | 120 m | | | 240 m | | |
|---|---|---|---|---|---|---|
| State | Alaska | Hawaii | Puerto Rico | Alaska | Hawaii | Puerto Rico |
| MSPA class | Percent of total grassland area in State | | | | | |
| Core | 19.8 | 24.8 | 9.4 | 8.4 | 11.5 | 2.4 |
| Edge | 20.1 | 23.7 | 18.8 | 14.5 | 18.1 | 7.8 |
| Perforated | 1.6 | 1.1 | 0.3 | 0.7 | 0.7 | 0.1 |
| Connector | 26.3 | 15.9 | 28.0 | 36.9 | 21.3 | 32.2 |
| Branch | 4.9 | 7.3 | 11.5 | 1.9 | 3.3 | 4.1 |
| Islet | 27.3 | 27.2 | 32.0 | 37.6 | 45.1 | 53.5 |
| Total grassland area | 100 | 100 | 100 | 100 | 100 | 100 |

## Discussion

The objective of this chapter is to take advantage of the newly released landcover maps for Alaska, Hawaii, and Puerto Rico to extend previous landscape pattern assessments to those areas. Three landscape pattern metrics—area density, landscape mosaic, and morphological spatial pattern—were measured at multiple spatial scales for the three States, and the results were mapped at the same spatial resolution as the original landcover maps. A set of summary tables demonstrates data aggregation strategies to estimate the proportions of area that are characterized by different types of landscape patterns, considering both total State area (landscape-level) and total forest or grassland area within States (sector-level).

The three types of pattern metrics that appear in this chapter are the same as reported in several other Forest Service assessment reports. The forest area density metric is the basis for reporting "fragmentation of forests" in national reports on sustainable forests (2003 and 2010), and all three types of metrics appear as descriptors of landscape, forest, and grassland patterns in the 2010 Resources Planning Act Assessment. Those reports also include the conterminous United States, providing comparisons with the three States considered in this chapter.

Full data interpretations usually must proceed with finer-scale aggregations such as counties or watersheds, and ideally are conducted by specialists with reference to individual pixel values instead of aggregations of any kind. Such detailed interpretations necessarily are outside the practical scope of the present chapter. In the future, specialists might access the detailed maps of landscape patterns for a variety of interpretations, probably using geographic overlays with other local and/or issue-specific maps for that purpose. At the levels of aggregation reported here, the results can be interpreted in roughly the same ways as previous reports that considered the same metrics in the conterminous United States.

In broad terms, the results of this chapter indicate that the landscape pattern metrics, when aggregated to State level, paint the same sort of pictures that are painted for other States with comparable intensities of human land uses. Alaska will be important in national assessments because of the relatively minor human footprint compared to all other States. The sheer size of Alaska relative to all other States means that national-level summaries will be weighted heavily by the results for Alaska alone. Thus, an important question for future assessments is whether to consider Alaska as a separate population for aggregating and reporting results.

In contrast, both Hawaii and Puerto Rico are unusual because both comprise sets of islands, and as a result, some of the landscape patterns reflect the influence of adjacent water, especially when the metrics are calculated within large landscapes that include substantial amounts of water. It may be useful to restrict the range of scales reported for Hawaii and Puerto Rico to minimize any "island effect" in the data. In summary, the analyses and databases presented in this chapter open the door to future work aimed at addressing the causes and consequences of landscape patterns in a consistent fashion nationwide.

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