Analysis of Aspen Stand Structure and Composition in the Western U.S.: Implications for Management

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ABSTRACT: Aspen communities in the western U.S. are considered at risk because of low levels of disturbance and high levels of herbivory by wild and domestic ungulates. There appears to be a trend toward the loss of aspen-dominated stands West-wide. In some cases the loss is caused by succession, with shade-tolerant conifers becoming dominant. On dry sites where aspen is considered to be the climax, deterioration of aspen stands and loss of regeneration may lead to a conversion to sagebrush or grassland. Data from FIA plots, located in stands with an aspen component and covering the range of aspen west of the 103rd meridian, are being used to classify stands according to composition and structure. The results of this analysis should aid management decisions by providing a method for classifying stands according to their successional status, and may suggest alternative stand dynamics models by which aspen may be maintained on the landscape.

KEYWORDS: aspen, succession, multivariate analysis, stand structure, communities

INTRODUCTION

Effective management of the aspen resource requires an understanding of the diversity of composition and structure of stands in which aspen occurs. Management actions that are designed to promote aspen must take into account existing stand structure and composition. Desired future conditions for managed stands should fall within the range of stand conditions that would be expected to occur in the local geographic area, given the mix of potential associated species and the range of expected disturbances. Management actions should also consider the stand trajectories expected to occur following treatment, in order to assess the duration of the intended effect.

It is desirable, and perhaps necessary, to develop management scenarios that preserve elements of structural and compositional stand diversity, while achieving the objective of maintaining the place of aspen on the landscape. Given the wide range of aspen in North America, and the West in particular, it is likely that a wide range of management options exist and that some options may be exclusive to particular parts of aspen's range.

This study uses data collected by the U.S. Forest Service Forest Inventory and Analysis (FIA) program to analyze the range of composition and structure found in stands containing an aspen component in the western United States. A main goal of the study is to create a system by which stands that are candidates for management may be placed in the context of all western aspen stands, thereby giving managers a tool that may be used to determine the desired future status and trend for the stand. Management decisions can then be made in concert with goals and objectives defined during strategic landscape assessments.

DATA

The Forest Inventory and Analysis program is the nation's forest census. FIA plots are located on a grid that covers forested land of all ownerships in the U.S. The FIA plot design (fig. 1) is used in all locations. Nearly 120 variables are measured: 63 are collected only once per location and 40 to 56 are collected on each tree or subplot on every visit. In the past, a periodic inventory cycle was used and all plots in a state were measured every 10 years. FIA currently uses an annual inventory system and 1/10 of the plots in a state are visited each year. The annual inventory system was designed to capture change in a more timely manner than was possible using a periodic inventory.

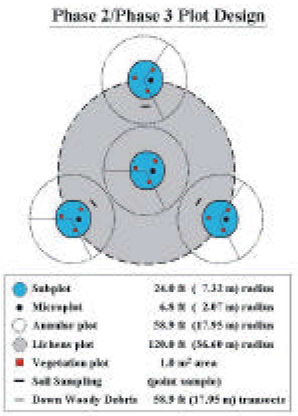

Figure 1. FIA mapped-plot design.

The extent of coverage in time and area make the FIA database well-suited for large-scale analyses. FIA data are available to the public, although the precise locations of sample plots are kept confidential by law to protect the privacy of private forest landowners and maintain the integrity of sample plots.

For this project, all plots in the FIA database that included at least one aspen tally tree were selected for analysis. The data cover 13 western states and include 3371 FIA plots (fig. 2). The analysis shown in this poster uses a subset of about 2900 plots and excludes dead trees and all trees less than 1 inch diameter. All live trees on a plot were divided into three classes: 1 to 5 inch, 5 to 10 inches, and 10+ inches. Stand density index (SDI) was calculated for each class by species. This provided a value for every species-diameter class combination present in the stand.

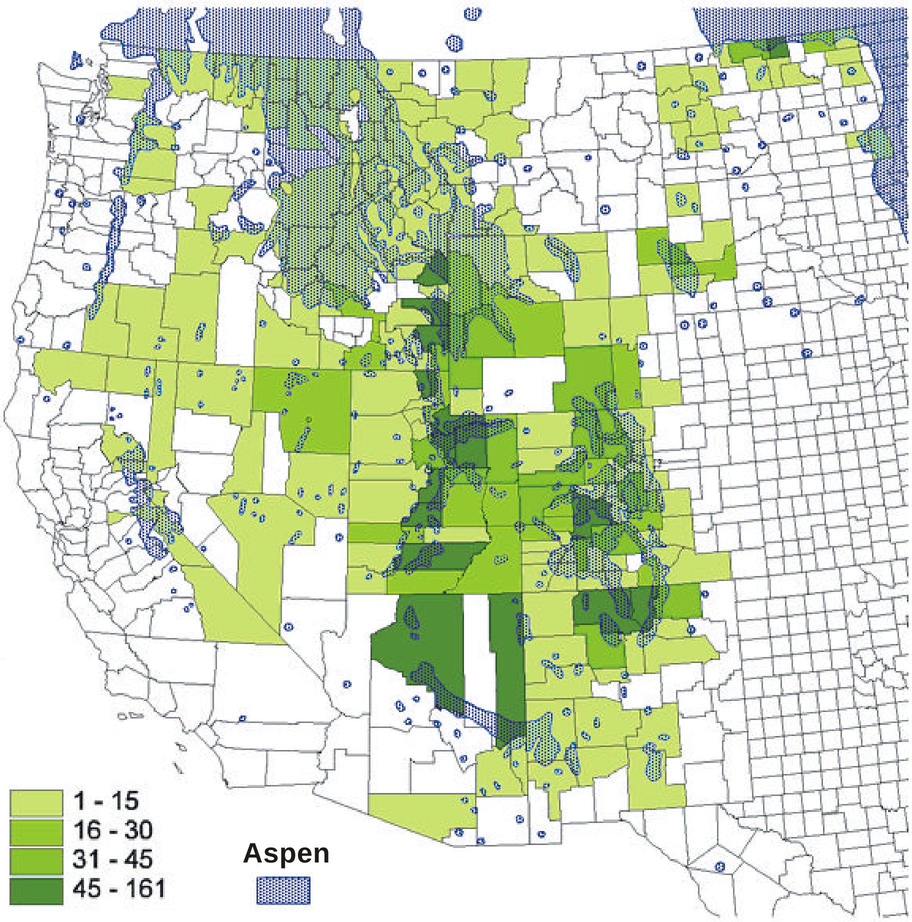

Figure 2. Locations of plots in the FIA database containing aspen. Legend indicates the number of aspen plots in each county.

Figure 3 gives an example of values calculated for two pure aspen stands. SDI is partitioned into many species-diameter class combinations in stands with multiple species. For the purpose of analysis, each combination is treated as a separate species, or “pseudospecies”. Therefore, the stand in figure 3A has two pseudospecies, while the stand in figure 3B has three. The mixed-species stand shown below (fig. 4) has six pseudospecies - three of which are aspen and three of which are conifers. Nearly 70 tree species occurred on plots with aspen, meaning that over 200 pseudospecies were potentially available for analysis (70 species x 3 diameter classes).

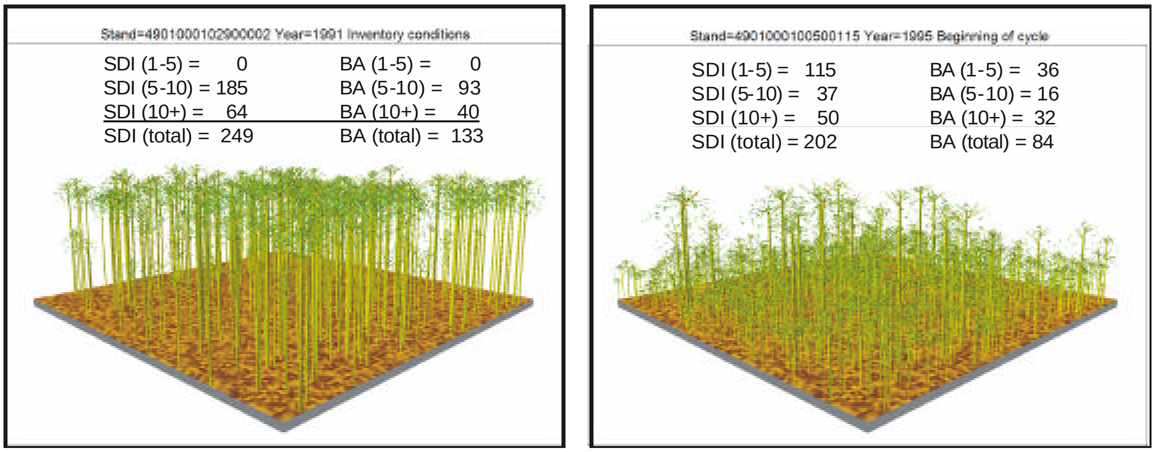

Figure 3. SDI and basal area calculated for aspen stands of different structure.

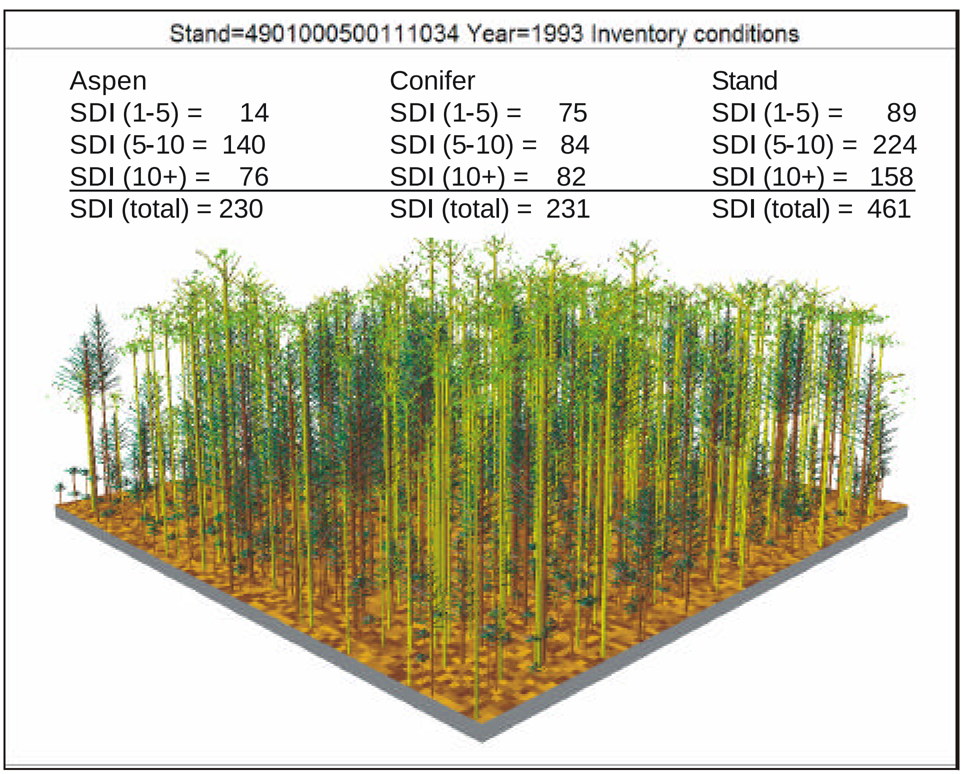

Figure 4. SDI partitioned among species-diameter class groups in a mixed species, uneven-aged stand.

However, many species were found on a small percentage of plots and were grouped as "other" species. As a result, 46 species (including "other") were retained for analysis, for a total of 131 pseudospecies. The number of pseudospecies was less than 3 times the number of species because some species achieve only limited size and had no tally trees in the largest size classes.

ANALYSIS

Each of the pseudospecies can be thought of as a "dimension" in which a stand might have a value. Two dimensions are easy to visualize and display (like grid coordinates on a map), but as the number of dimensions grows the data become increasingly difficult to analyze and visualize.

The case of pure aspen stands can be used as a simplified example. In this case, there are three dimensions – one for each diameter class. The three dimensions can be viewed easily in two-dimensional space (fig. 5). Every pure aspen stand is made up of varying proportions of trees in some or all of the three diameter classes (dimensions). Qualitatively, stands with different proportions are commonly labeled as even-aged, uneven-aged, or 2-storied. Consistently classifying a stand into one of these categories can be difficult without some quantitative measure, even when only one or two species are involved, so advanced quantitative methods are necessary in the case of many dimensions.

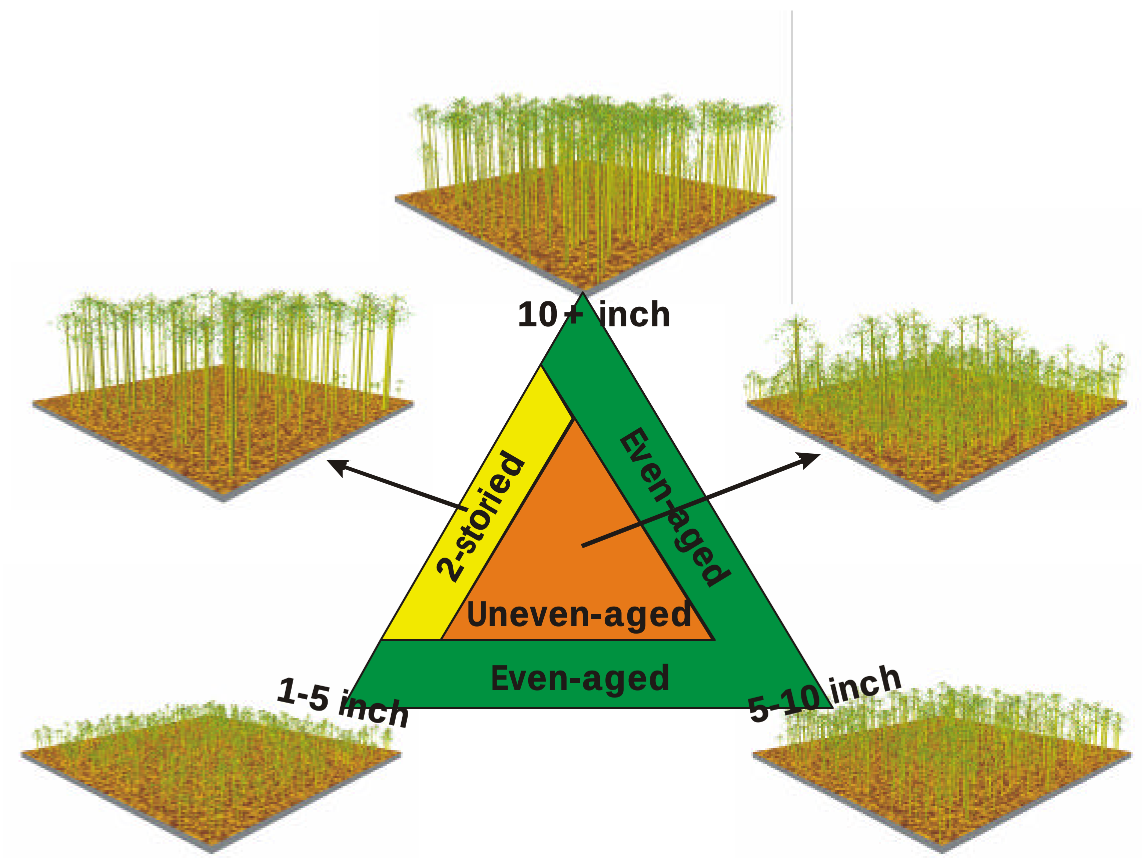

Figure 5. Qualitative grouping of pure aspen stands according to varying representation in each of the three diameter classes.

Several computational methods are available to help analyze multi-dimensional data such as was created from the FIA plot data. Most of these either cluster similar plots (or stands) into groups, or separate plots based on their dissimilarity. The examples shown here (figs. 6 and 7) were developed using detrended correspondence analysis (DCA), which separates plots on the basis of their dissimilarity.

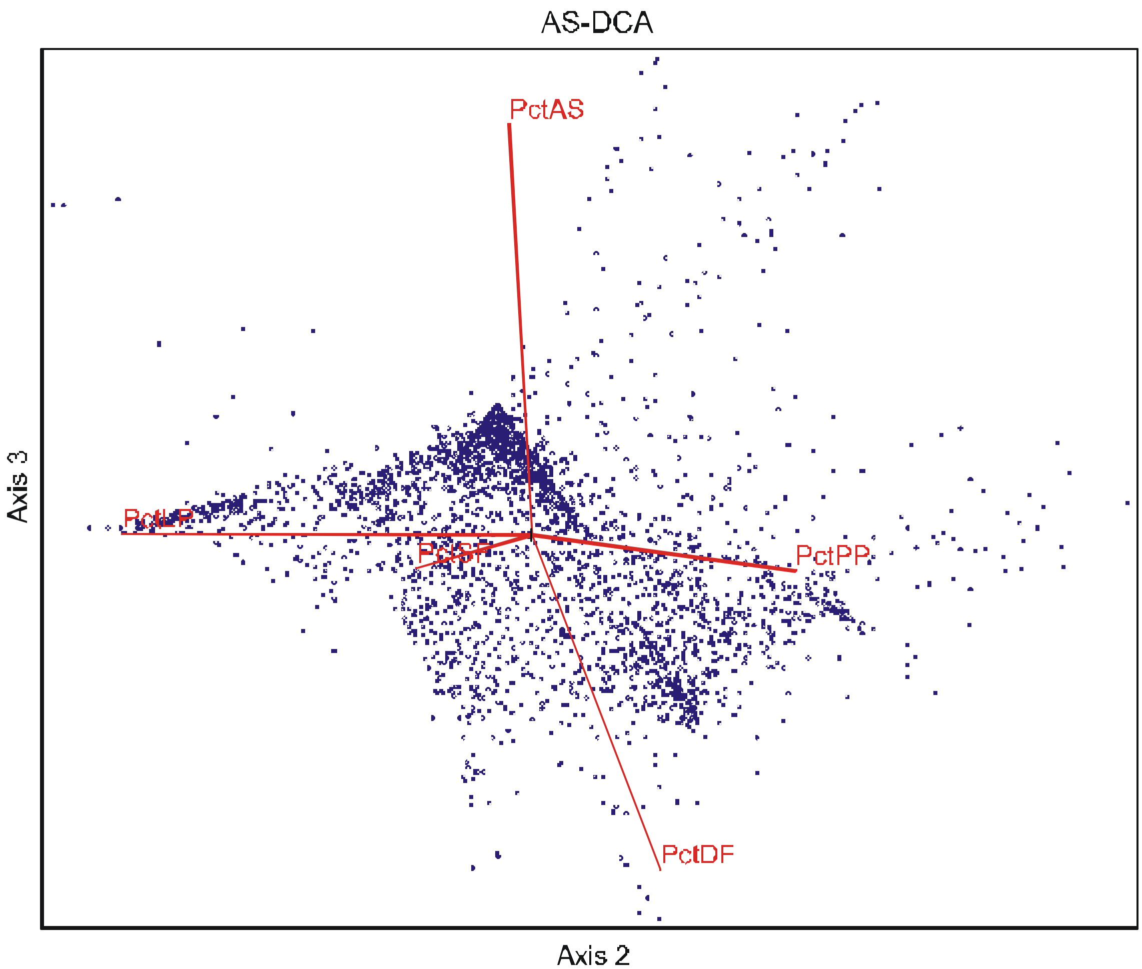

Figure 6. Biplot of DCA output showing the influence of pure aspen stands (PctAS) and four important groups of associated species: lodgepole pine (PctLP), ponderosa pine (PctPP), Douglas-fir (PctDF) and Engelmann spruce-subalpine fir (PctSF).

Figure 6 can be viewed as representing the diversity of aspen stand structure and composition in the western U.S., displayed in two dimensions. Fortunately, other variables can be included in the analysis and displayed as overlays. In the example, the red axes show the importance of several species that contribute to aspen stand structural and compositional diversity. Pure aspen stands are clustered in the peak located in the left-center of the scatter plot. Note that the axes representing the percentages of lodgepole pine (PctLP) and ponderosa pine (PctPP) are almost exactly opposite one another. The combination of these two axes is analogous to changing latitude along the Rocky Mountains, separating the northern states, where lodgepole pine is common, from Arizona and New Mexico, where lodgepole pine is absent. Figure 7 shows the data from a somewhat different perspective, with annotations showing other important species (or groups) and data points color coded according to the states in which the FIA plots were located. Most, if not all states represented in the sample have plots in the circled area, which indicates pure aspen stands.

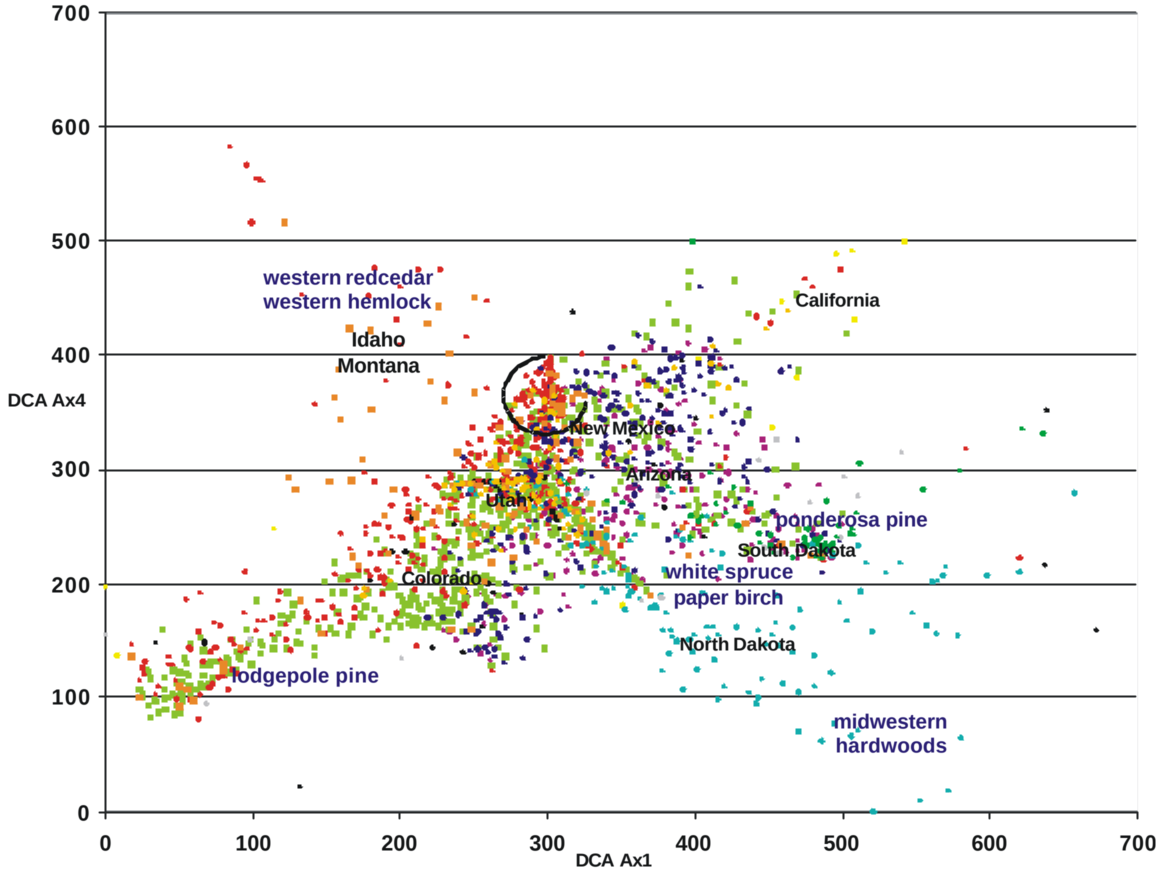

Figure 7. DCA plot label with locally important aspen associates. Plots are color coded according to state of origin, and state labels approximate regions of the data containing plots that are unique to or typical of the state. Pure aspen stands are near the circle.

MANAGEMENT IMPLICATIONS

In the classical view, aspen is considered an early successional species which, in the absence of disturbance, will eventually be replaced by shade tolerant conifers (fig. 8). So-called climax aspen stands are a variation of this view, in which the aspen stands may revert to grasslands or sagebrush in the absence of a regeneration event. However, the common occurrence of other fire-adapted species, such as lodgepole pine and ponderosa pine, as aspen associates suggests that other development paths are possible, if not likely, in the event of natural disturbances or management actions.

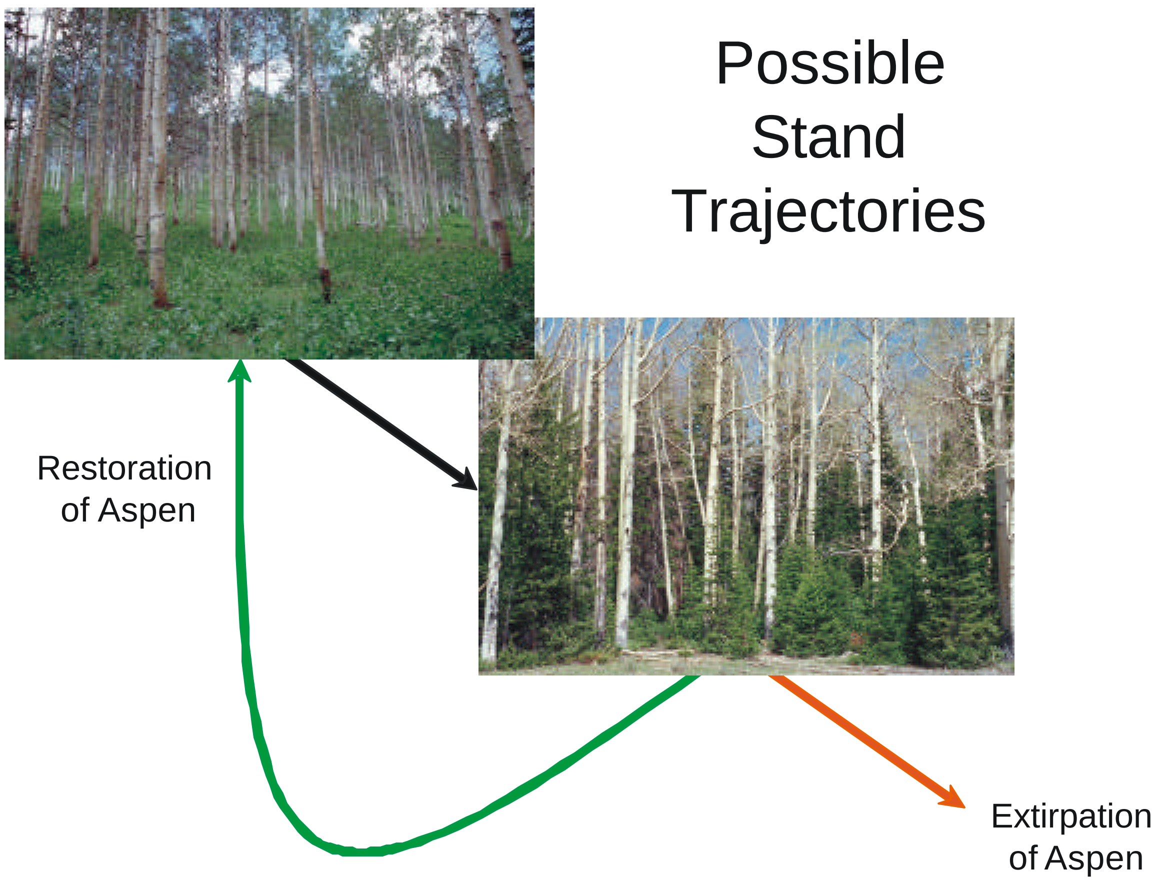

Figure 8. Classical view of aspen succession. In the absence of disturbance or management, aspen is gradually eliminated from the site. Management actions are commonly designed to "reset the clock" to a pure aspen state.

Two scenarios can be used to illustrate this point, using stands with structure and composition similar to the mixed-species stand illustrated in figure 4. In the first scenario, the conifer component is lodgepole pine. The position of the stand in figure 9 is indicated by point 1a. In the event of stand-replacing fire, the structure of the stand changes dramatically with a shift toward the 1-5 inch diameter class. However, composition may remain unchanged or shift toward either species, depending on the exact conditions of the disturbance (1b). If the disturbance is a mountain pine beetle infestation, stand trajectory shifts toward the pure aspen state (1c) along the lodgepole abundance pine axis.

If the conifer component is ponderosa pine (2a) and the disturbing agent is again fire, the direction and magnitude of change can be related to fire severity. In the absence of fire, composition may shift away from both aspen and ponderosa pine, and toward Douglas-fir (2b). Light fire may change composition only slightly (2c), while a severe stand-replacing event may eliminate conifers and approach a pure aspen state (2d).

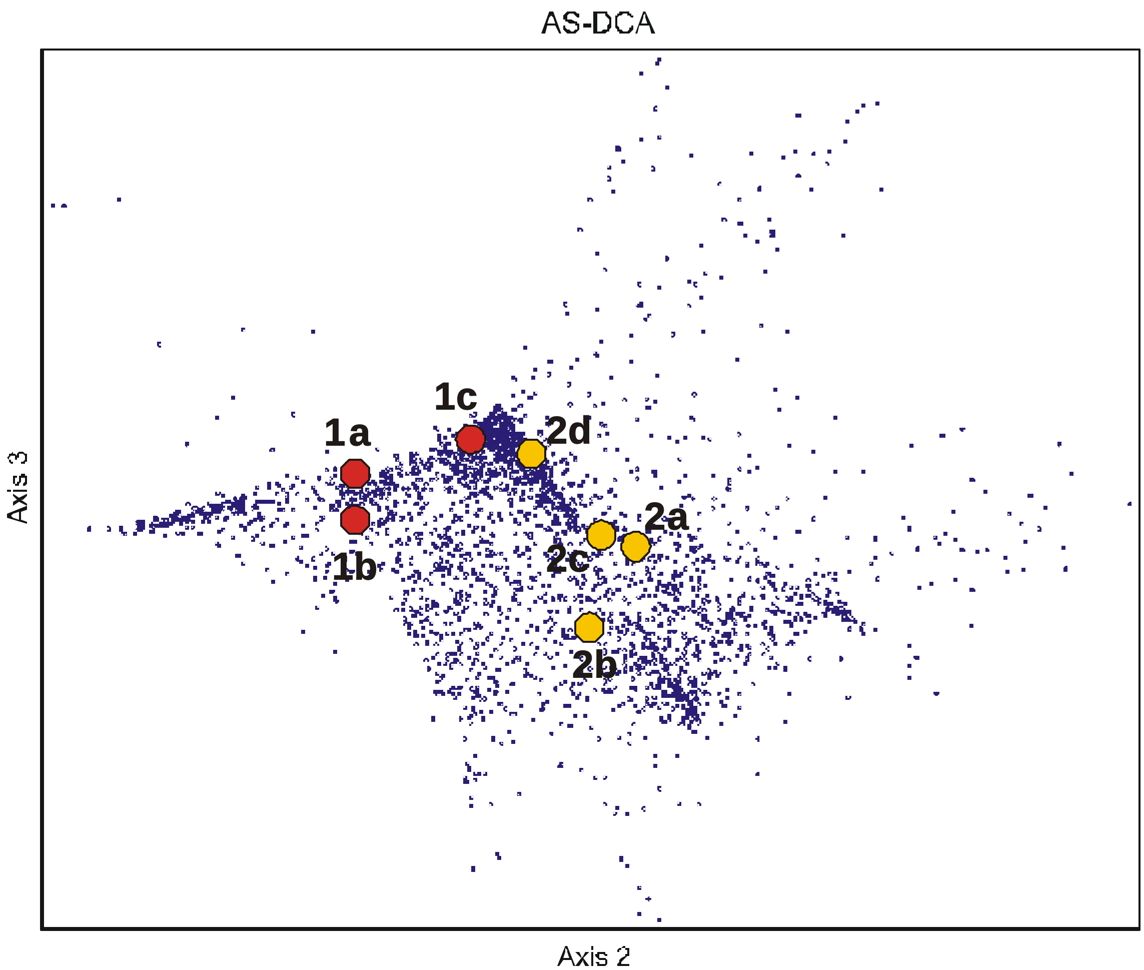

Figure 9. Alternative stand trajectories for hypothetical lodgepole and ponderosa pine stands illustrated as shifts in DCA model space.

CONCLUSION

The scenarios illustrated above are general examples of a wide range of possible stand trajectories. Actual stand dynamics will vary by location. However, the diversity of stand composition and structure revealed by this analysis suggests that some management actions may be used to maintain aspen on the landscape while maintaining a range of stand diversity that is greater than under the "reset clock" scenario.

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