We are responding to a number of concerns that were raised by James Johnston regarding restoration treatments and spatial pattern on the Malheur National Forest. James raises a host of methodological and theoretical issues with our reference dataset and approach. There are two overarching points we would like to first emphasize.

1. James implies that the within-stand spatial patterns created by restoration treatments are not that important ecologically and that ecological processes will largely take care of things over time. This view is not shared by the majority of scientists working in dry forest restoration. We offer five major synthesis publications from the Pacific Northwest, California, and the Southwest that clearly layout the rationale and supporting research for restoring spatial patterns that are consistent with reference conditions (Allen et al. 2002, North et al. 2009, Franklin et al. 2013, Reynolds et al. 2013, Stine et al. 2014).
2. James presents no alternative method of measuring spatial configuration or any datasets to support his claims. It is thus difficult to assess how he would quantify pattern in manner that permits an objective and straightforward comparison of treatments with reference conditions. There are undoubtedly improvements that can be made to the ICO approach; all approaches have advantages and disadvantages. We welcome any constructive suggestions. In the absence of any proposed alternative methods or datasets, we feel it is a solid approach and reference dataset to help managers and stakeholders quantify and manage for variability.

Below we respond to his major arguments:

* ***Reference conditions are guideposts, not rigid targets.***

Nowhere in the GTR or in other publications do we suggest that clumping ratios or other pattern metrics should be used to “strictly parameterize restoration treatments”, as suggested by James. We clearly indicate that targets for density, composition, and pattern should not be based on blind application of reference targets, but tailored to the specific conditions of a treatment unit.

We make this point very clearly in the GTR:

“The structure and composition of the historical forests found in this study offer information that can be used guide restoration efforts. While quantitative pattern metrics such as clump and opening size distributions from reference plots can be translated into prescriptions guidelines, it is critical that managers first understand the key components of historical patterns from a functional perspective. Ultimately, targets for variability should be based on the desired functions, current structure, biophysical conditions, and anticipated future disturbances. This requires knowing what components of historical patterns are important drivers of key functions and what aspects are just natural variation. Fixed recommendations for targets from research studies can quickly become cookie cutter guidelines.”

* ***Value of reference envelopes for spatial pattern.***

The goal of our reference conditions study on the Malheur NF was to quantify historical structure, composition, and pattern in a manner that could be practically applied to restoration prescriptions and monitoring of treatments. We sought to provide managers and stakeholders with an objective way to know if treatments are creating variability that is consistent with historical forests conditions, and thus likely to provide the desired ecological functions such as habitat, understory diversity, low- and mixed-severity fire behavior, and resilience in the face of disturbance.

This information is meant to guide the adaptive management process, not give treatments a passing or failing grade. The fact that 2 of the Tin units had high proportions of individual trees and low proportions of medium to large clumps is an opportunity for discussion about the variability of these treatments relative to the management objectives. The exact percentages of certain clump sizes are not the point of the monitoring, but instead whether the post-treatment pattern will achieve the desired functions. For example, do the Tin units have enough contrast in light environment from larger openings and larger clumps to promote a variable understory response?

* ***The reference conditions study provides guidance for creating variability from stand to stand.***

Our reference study suggests a high level of variability across the landscape. Some plots had higher density (trees per acre) and were very clumpy while others had low density, higher numbers of individuals, and no large clumps. Hagmann (2013, 2014) found a high level of fine scale variation in historical density across large swaths of the Klamath and Warm Springs Indian reservations. Given the strong relationship between density (trees per acre) and clumping (Abella and Denton 2009, Larson et al. 2012, Churchill 2013, Clyatt et al. 2016), this indicates that historical landscapes did not have large areas with low clumping, but instead a wide range of conditions and high fine scale variation. There was not the same kind of variability from stand to stand in historical forests.

**Monitoring helps ensure that treatments are not creating the same kind of variability across large areas of the landscape.** While we agree with James that the Tin units will likely develop conditions within historical envelopes over time, other treatment units should end up at the more variable end of the envelope. If the majority of restoration treatments on the Malheur NF result in conditions that are at or beyond the more uniform end of the reference envelope, the functions associated with more variable units, such as habitat, are not likely to be achieved. For example, recent research on the whiteheaded woodpecker indicates that variation from stand to stand, and the interspersion of these variable stand structures, promotes optimal habitat (Latif et al. 2015). In short, this kind of monitoring helps us ensure we are not doing the same thing everywhere.

* ***Applicability of reference dataset***

The density, composition, and pattern found in this reference study correspond with the ranges found in other published reference studies in frequent fire forests across the interior west (Harrod et al. 1999, Youngblood et al. 2004, Abella and Denton 2009, Sánchez Meador et al. 2009, Larson and Churchill 2012, Larson et al. 2012, Churchill 2013, Lydersen et al. 2013, Reynolds et al. 2013, Fry et al. 2014, Clyatt et al. 2016), as well as two other similar reference datasets from the Colville and Fremont-Winema National Forests that are not yet published (see attached table). In general, the least variable plots have a maximum of around 50% of trees as individuals and have no large clumps. The most clumped plots have around 10% as individuals and 10-30% in large clumps. These studies range from dry to more mesic plant associations and include plots greater than 5 acres.

This reference study reconstructed structure, composition, and pattern on 14 x 2.7 – 12.3 acre plots for a total of 143 acres. This study is the most spatially extensive reconstruction done in the Blue Mountains or anywhere in Oregon. As we note above, we do not claim that we fully captured the historical range of pattern. However, the fact that these plots are similar to other sites across the west indicates they are not outliers. In the absence of any other data, we think it is reasonable to conclude that this study offers a good approximation of the actual range of historical pattern.

Contrary to what James claims, our plot locations were not subjectively located. In order to do credible reconstruction, we selected areas that not been previously harvested. Within these areas, however, plot location was randomly selected based on a stratification by potential vegetation series.

An additional issue is plot size. We have found that plots smaller than around 5 acres are not sufficient to characterize openings and the range of clump sizes (Churchill 2013). Smaller plots result in a wider range of clump proportions and other spatial pattern metrics. The Youngblood et al. (2004) and Harrod et al. (1999) studies that James cites use 2.5 ac and 1.3 ac plots, respectively. Thus it makes sense that a wider range of pattern was found. Abella and Denton (2009) also found a wider range of pattern with 2.5 acre plots. If we re-analyzed our data using a 2.5 acre plot size, we would also find a wider range. Conversely, if Youngblood or Harrod had used larger plots, it is likely that they would have found a similar range as discussed above.

* ***ICO method for quantifying pattern/spatial configuration.***

We have found through extensive analysis and experience that quantifying pattern in terms of individual trees, clumps, and openings (ICO) characterizes spatial configuration in terms of ecologically important elements that can be easily identified on the ground (Larson and Churchill 2012, Churchill 2013, Churchill et al. 2014, Clyatt et al. 2016). The proportions of trees in different clump sizes, the size distribution of open space, and tree density (trees per acre) are closely related and offer a robust way to quantify pattern that is ecologically meaningful (Churchill 2013). Other methods tend to be very abstract and hard to use in a management context.

We do use several additional methods of quantifying pattern in the GTR and in other studies to buttress the ICO approach, including basal area distributions and point pattern statistics. These additional methods can be used with the ICO monitoring data that is collected. These studies show that clump size proportions, along with tree density and ideally open space distributions, are a robust way to compare treated stands with reference conditions (Churchill 2013).

James also claims that using a crown interlock distance of 20’ to define clumps somehow invalidates the approach. We note in the GTR that this distance does not work for all clumps or all situations. However, it offers a practical definition for clumps that allows for objective comparison with reference conditions. Other studies have done extensively analysis of this distance and independently came up with a very similar distance (Abella and Denton 2009, Sánchez Meador et al. 2009). Also, a different distance or a diameter based radius can be used with the ICO approach (Lydersen et al. 2013).

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