Climate Landscape Response (CLaRe) phenometrics in southern AZ using PRISM and MODIS data to identify nascent populations of buffelgrass

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Introduction
Buffelgrass (Pennisetum ciliare) is an invasive perennial that threatens the Sonoran desert ecosystems by out-competing native species and altering fire regimes. Current adaptive management actions have concluded that efforts to control buffelgrass must include the targeted application of herbicide, but the herbicide is only effective if applied when the buffelgrass is photosynthetically active, or “green”. Buffelgrass persists in the landscape in a highly-flammable senesced state and greens up periodically during the year when sufficient precipitation is received. The localized, heavy rains received during the monsoon season make it difficult to predict when and where it will be green and therefore susceptible to herbicide treatment. The need to enhance the effectiveness as well as optimize the timing of herbicide treatment for buffelgrass is a high priority for regional land managers.

Background
Previous research by Wallace et al. 2016 successfully mapped even low densities of buffelgrass (5%) by developing innovative metrics that coupled Moderate-resolution Imaging Spectroradiometer (MODIS) satellite imagery and PRISM precipitation data. These “Climate Landscape Response” (CLaRe) metrics leverage the degree of correlation between satellite-detected greenness and precipitation values in each 250m pixel. They expose buffelgrass due to its rapid green-up response to precipitation events, which is reflected in higher CLaRe correlation values. Regional managers found the approach and results compelling, however the proposed monitoring strategy was unfeasible due to the lack of personnel to validate these results and refine the model. Temporal CLaRe metrics, though much work remains, nascent buffelgrass (BG) populations using multi-temporal CLaRe metrics, though much work remains. Model differencing reveal native to BG transitions with similar patterns and geographies to the multi-temporal z-score class with expected signature of “above average” to “above average” CLaRe. Appropriate field data are required to validate these results and refine the methods.

Study Area
The study area is a rectangular shape in Arizona as shown above. It extends to Ajo Arizona in the west.

Data
Four types of data were used in this study: MODIS, PRISM, a vegetation map and buffelgrass field data.

Methods
CLaRe metrics were calculated from MODIS and PRISM ppt123 data for 2011 to 2016 using the PiCo algorithm developed by NASA for a related project. Field data were used to evaluate CLaRe performance within the two vegetation types that host the majority of buffelgrass (BG) in the region (above). To identify new infestations of BG, we used two approaches. First, we calculated BG presence models for the early years (~2012 = 2011,12,13) and the later years (~2015 = 2014,15,16), where a pixel is mapped as BG if it is one of the highest 20% of CLaRe values observed in at least 2 of 3 years within its vegetation type. Models for ~2012 and ~2015 were compared to look for transitions between native and BG. Second, CLaRe metrics were normalized for climate differences across years via a z-score transformation. These normalized images were input to an unsupervised classification to look for patterns that might reflect a new infestation. Chi-Sq tests were used to evaluate both the model differencing and the z-score classification approaches.

Results
Regional CLaRe Metrics 2011 to 2016: T-test results show significantly higher CLaRe values at BG locations relative to random points for all years (below, R). This confirms CLaRe metrics are able to regionally stratify landscapes with higher BG content, extending their use from the local application of Wallace et al. 2016.

Future Directions
Detection of new buffelgrass populations is a high priority for managers, and these research results will continue to be developed. In addition, we are actively seeking funding to design and develop the mobile app that will leverage the processing stream used in this study, including regional calculations of CLaRe metrics with NASA PiCo models. This research and the future web-based app will help managers detect, predict and monitor status of buffelgrass in their landscapes.

Z-Score Classification: An unsupervised classification of the stacked 6 years (2011-2016) of z-score transformed CLaRe metrics is shown below (L). The 10 classes requested correspond to the spectral signatures shown in the graph below (LR). Class 10 (white in map, with dashed signature) is the highest z-score across the years; chi-squared results with BG field data (LR) show BG presence points are strongly concentrated in this class. Class 4 (red) presents a profile confirming of a new BG invasion, with “average” (near 0) CLaRe dynamics 2011 through 2015 and a spike to above average CLaRe in 2016. The current field data do not allow validation of these results, however, and a field campaign is planned.

Conclusions
This study showed promising results toward detecting nascent buffelgrass (BG) populations using multi-temporal CLaRe metrics, though much work remains. Model differencing reveal native to BG transitions with similar patterns and geographies to the multi-temporal z-score class with expected signature of “average” to “above average” CLaRe. Appropriate field data are required to validate these results and refine the methods.

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References

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