

CIPM Research Grant Final Report – Grant 4W1045

Title: Predicting the occurrence of non-indigenous plant species in the Greater Yellowstone Ecosystem: A comparison of two models.
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Proposal Abstract

Invasive non-indigenous plant species (NIS) are a serious economic concern for land and park managers in the Greater Yellowstone Ecosystem (GYE). Considerable time and monetary resources are spent on NIS management in the region, and financial constraints often limit managers' ability to completely survey large land parcels for NIS. Being able to predict where within a park, national forest, or private land parcel NIS are most likely to be found will enable managers to more efficiently focus their limited resources. Previous research by our group has demonstrated the ability of a generalized logistic model (GLM) to predict the probability of occurrence of several NIS in the northern winter range of Yellowstone National Park and parts of the Gallatin National Forest. While the GLM model works well for many species, it does not predict the distributions of rare species as well as more common species, requires an intensive sampling scheme, and has only been parameterized for a few limited locations within the GYE. We proposed to compare the results of the GLM model with a more regional-scale ecological niche model (ENM), called Maxent, which utilizes presence-only data to determine which model would be the most appropriate tool for GYE land managers concerned about invasive NIS. We were specifically looking at how model accuracy for the two approaches was affected by data quality, spatial scale, and the inclusion of climate variables. We also examined whether the models differed in their generality, or ability to model species distributions in areas outside of the original region where they were built. By comparing probability of occurrence maps generated by the GLM and Maxent ENM, we determined the extent of agreement between models, identified when and where one model out-performs the other, and made recommendations on how each

tool could be used by land managers in the GYE. The NIS species we focused on for this analysis were Canada thistle, spotted knapweed, houndstongue and yellow toadflax.

Results

All results are based on our preliminary analysis of the modeling output. When the GLM and Maxent ENM models were built using data from Gallatin County and projected back into that region, the GLM modeling approach was generally more accurate than the Maxent model for all four species. To see whether the two modeling approaches differed in their generality, we applied models built for Gallatin County to the northern range of Yellowstone National Park (YNP-NR). Neither modeling approach was able to model Canada thistle distributions accurately in Yellowstone National Park, although both the GLM and Maxent were able to model houndstongue distributions in YNP-NR fairly well. We were unable to test model generality for spotted knapweed and yellow toadflax because no occurrences of those species have been observed in YNP-NR.

For Canada thistle only, we examined the importance of data quality on model performance by examining whether model accuracy was improved when we built models using randomly stratified data collected along transects versus opportunistically-collected data long roads and trails. In general, we found that data quality did not have a strong effect on model accuracy, although addition of stratified random data often improved the model accuracy. The resolution at which we modeled species distributions did have an effect on model accuracy, with the GLM and Maxent models having higher accuracy when modeling species distributions at 30m rather than 1km resolution.

Lastly, we explored the importance of including climate as predictor variables in the species occurrence models at 1 km resolution. We found that climate variables were important for predicting the occurrence of three of the NIS. Adding climate variables increased model accuracy for spotted knapweed and houndstongue for both the GLM and Maxent models, and climate was beneficial for modeling yellow toadflax distributions with the GLM. Climate had generally no effect on GLM and Maxent model accuracy for Canada thistle, and not effect on the yellow toadflax Maxent model.

Discussion

Although the analyses of the model output are still preliminary and we are not yet able to draw conclusions about our model comparison, it is clear that both the GLM and Maxent models are useful as predictive tools for modeling probability of occurrence for several NIS in the GYE. The preliminary data suggest that the GLM modeling approach may be preferred to Maxent for several of the NIS, even when built using opportunistically-collected data from alongside roads and trails (i.e., lower quality data). Climate variables did add some predictive power to the models at 1km resolution, but model accuracy was even higher when the species were modeled at 30m resolution without climate variables. This could indicate that climate is more important at higher resolutions and larger spatial extents, but that other factors (topography, land cover, etc.) are more important at finer resolutions. The observation that neither the GLM or Maxent models built for Canada thistle in Gallatin Country were transferable to the YNP-NR is possibly due to differences in the relationship between Canada thistle and wildfire in those two regions. A smaller proportion of the Gallatin sample had been exposed to wildfire and those areas which had were relatively recently burnt (< 10years), whereas large areas of the YNP-NR burnt during the 1988 fires, possibly providing a different

wildfire-NIS response. Both models were more transferable to YNP-NR for houndstongue, suggesting that relationships between houndstongue distributions and environmental variables are more consistent across the GYE. This does demonstrate that care should be taken to evaluate the potential overlap in disturbance and environmental variables when considering transferring models to other areas.

Publications

Cross, M.S., L.J.Rew, A.M. Schrag, B.D. Maxwell. (in preparation). Predicting the occurrence of non-indigenous plant species in the Greater Yellowstone Ecosystem: A comparison of two models. (We are planning to submit this manuscript to the Journal of Biogeography).

Products

In addition to the manuscript in preparation mentioned above, we have generated predicted occurrence maps for Canada thistle, spotted knapweed, yellow toadflax and houndstongue, at 1km and 30m resolution, using a general logistic model and the Maxent model, for Gallatin County and the northern range of Yellowstone National Park. These could be made available on a website.

Long-Term Goal/s and Continued Progress of Research

The development of an ENM for several NIS of concern in the GYE will contribute to two larger long-term projects. The project results will improve the optimization and prioritization of NIS management using predictive occurrence models so that managers can use resources more efficiently and reduce indirect effects on non-target species. The second long-term project examines the effects that climate and land-use activities have on the distribution of NIS, both now and in the future. While both climate and land-use are important to determining NIS distributions, certain species and geographic areas may be more strongly influenced by one or the other type of change. Using models like the ones developed for this project will increase our understanding of the synergistic impacts of land-use and climate change on the distribution of NIS, and can help improve our ability to predict which areas are most suitable for the establishment of invasive plants, both now and in the future.

Benefits of Seed Money

The CIPM seed grant provided support for building the Maxent model, running the Maxent and GLM models, and conducting statistical analyses associated with this research project. The CIPM seed grant was the primary funding source for this project; therefore, this research would not have been possible without CIPM's generous support. The preliminary results are being incorporated into a EPA proposal seeking to extend our knowledge of NIS, land use and climate change in the GYE.

Advancing This Research

One of the goals of this project was to examine whether one approach for modeling invasive plant species distributions would provide a more useful tool for land managers than another modeling approach that had already been tested for use in the Greater Yellowstone Ecosystem. Although it is unclear from our preliminary analyses

whether one model consistently outperforms the other, the models do hold promise for providing managers with a useful tool for prioritizing areas for invasive species management. One way to advance the reach of this work might be conduct workshops to educate local managers about how to understand and interpret the output from these models. Workshops like these would provide us with valuable feedback as to how to make these models more useful for management, as well as explore the possibility of training managers to use the models themselves.

Budget

The original budget was for \$4992.00, all in salary and wages. The models and maps generated by our project required more computer harddrive space than expected, and the allocated computer did not have sufficient resources. An external 160GB harddrive was purchased. Additional modeling software supplements were required to complete the task too. Therefore, \$322.22 was used to purchase the software and harddrive but this is within a 10% deviation from the proposed budget and we trust it is acceptable.