Integrated Bioclimatic-Dynamic Modeling of Climate Change Impacts on Agricultural and Invasive Plant Distributions in the United States

Biological invasions of nonindigenous plants and pests are serious threats to the U.S. natural and managed ecosystems. It is well established that climate is the dominant determinant of the geographic distribution of plant species, native or alien. Given the dominant role of climate control, consequences of climate change on biodiversity have been studied mostly by statistical environmental matching or niche modeling (SEM). These models related observed species distributions to environmental envelopes and then, assuming the same stable relationships, project their spatial shifts (local enrichment or extinction) in response to envelope change under climate change scenarios.

There exist numerous challenges in the traditional SEM of present and future species distributions. These include: [1] little work on alternative crops and related weeds, motivating this study to focus on agricultural and invasive species affecting U.S. food production; [2] insufficient resolution, incomplete list and inappropriate use of predictors, requiring an interactive climate-ecosystem predictive component (CEP) to produce the best proxy of fundamental environmental limiters for the SEM development and subsequent projection; [3] ignorance of local-specific characteristics in the formulation of general niche-envelope regressions, seeking a spatially –explicit SEM to account for geographic differentiations in resource availability; [4] substantial model biases and inter-model differences, demanding an optimal ensemble of multiple CEP and SEM models driven by multiple climate change scenarios to represent the likely range and uncertainty of future projections.

The objective of this study is to solve these problems by develop and apply an integrated bioclimatic-dynamic ensemble modeling system to quantify and understand the impacts and uncertainties of regional climate changes from the present to 2050 on the U.S. agricultural and invasive plant species distributions emphasizing crop production. The system integrates a species environmental matching or niche modeling component (SEM) with a high-resolution dynamic regional climate-ecosystem predictive component (CEP) over North America (Fig. 1). Both components incorporate multiple alternative models representing the likely range of climate sensitivity and ecological response under the conceivable anthropogenic emissions scenarios to rigorously assess the result uncertainty for improving risk analysis.