Saratoga Horticultural Research Endowment (SHRE)
2016 Grant Progress Report

Project Title: Increasing the potential regional invasive predictability of the Plant Risk Evaluation tool for ornamentals in California by incorporating climatic matching data

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1. Introduction

We developed and published a Plant Risk Evaluation (PRE) tool for evaluating ornamental plants in California. The tool uses a systematic process relying on available scientific evidence to estimate the potential risk of an ornamental plant becoming invasive and causing environmental or economic harm in the state. This tool includes 20 questions statistically evaluated to provide separation power between known invasive and non-invasive species and a proven accuracy level of 100% for both predicting invasiveness and non-invasiveness in a validation study. Currently, the nursery industry in California is enthusiastic about employing the PRE tool and we are currently screening plants on the WUCOLS IV list to identify species having the highest potential for escape and invasiveness. Results of this project identified about 40 species that resulted in a reject outcome through the PRE model. Our objective in this proposal is to use the climate matching software (CLIMEX) to increase the geographic predictability of the PRE tool in California. The model can make predictive maps of potential invasive range and also of suitable climate for propagation in California. Adding this regional resolution will allow us to better predict where a plant may be the greatest threat to escape cultivation in California.

2. Goals/Objectives

Need #1: To develop a more accurate assessment of the geographic region for escape (from cultivation) and establishment of potentially invasive ornamental species categorized as reject (high risk) through the PRE model.

Outcome: This can be accomplished by modeling the potentially invasive range using climate-matching analyses (e.g., CLIMEX) under various assumptions (e.g., drought tolerance) and scenarios (e.g., irrigation, climate change). This analysis results in predictive maps of potential invasive range and also of suitable climate for propagation.

Need #2: Prediction is the most important factor in preventing new plant invasions. The PRE tool can determine the risk of ornamental plant species becoming invasive in a defined geographic region, and it is important to understand what regions are most vulnerable to escape and establish of a potential invasive species.

Outcome: Some species with invasive potential may only become invasive in specific locations, typically associated with a specific set of climatic parameters. For example, Carpobortus edulis (iceplant) is only invasive along coastal California and, though it is widely grown throughout the state, it has never been reported to escape cultivation in inland areas. Similar situations exist for many other invasive plants. Thus, to better understand the invasive potential of species in a geographic context, it is essential to assess the climatic suitability of different regions to each species with high risk of invasiveness, as determined by the PRE model.

Need #3: The CLIMEX climate matching simulation tool can quantify climatic suitability for plant species we evaluate with the PRE tool. The tool is not only useful for predicting potential areas of invasiveness for a particular plant species, but can also be used to define the optimal growing conditions for a species and therefore, the best areas for industry marketing suitability.

Outcome: By using information about the species native range (temperature, moisture, and photoperiod) it is possible to accurately develop potential suitability maps for growth of species in a new area (Steinmaus 2002). Within the CLIMEX tool, the potential habitat of the species can also be evaluated by adding an irrigation factor (Barney and DiTomaso 2011). This irrigation factor simulates were the plant might survive where water is not limiting. The value of this evaluation is that it can predict where the plant is unlikely to be invasive (except perhaps in a riparian system), but can be sold as a landscape ornamental.

Need #4: The ultimate need is to prevent the further escape and establishment of invasive plants originating from the nursery industry in California. Currently, 50% of the invasive plants in California (based on Cal-IPC inventory) originated from ornamental plants, while only 1% of introduced horticultural plants have escaped to become invasive.

Outcome: Our long-term goal is to not only provide growers with a science-based method to accurately screen their current stock and potential new introductions to California and to develop climate matching maps of the regions of greatest growth suitability, but also increase the probability of the tool being accepted for use by the industry as the basis for a nursery certification program. Ultimately, we hope that this project will remove new potentially invasive species from sale and distribution in California.

3. Discussion of Progress to Date

We previously evaluated the plants from the Water Use Classification of Landscape Species (WUCOLS IV) list using our PRE model with funding from the California Nurseries and Garden Centers (CANGC). Forty-five of these plant species came out as "high risk for invasiveness" in California, and were selected for this project to test the appropriateness of predicting the areas of invasion using a climate-matching model. We have completed collecting data on the worldwide distribution of each of the 45 plant species, including native and introduced (or invasive) ranges, from a wide variety of online plant occurance databases across the world. This information is used to parameter the CLIMEX climate model.

We have also completed collecting detailed meteorological data for all the continents across the planet we will create species distribution maps. With the distribution data for each species and the climate data for each region, we are now using the CLIMEX model to map each species. For each species, we start by creating a map that exactly replicates the native and introduced distributions of the species. We start with a CLIMEX template that closes matches the region we want to map (ie. Mediterranean, tropical, etc.). Each template has generalized climate parameters which can then be manipulated to obtain a more accurate map, such as temperate, moisture, and stress (cold, heat, dry). Using the climate data from that continent, we make small adjustments to the parameters (each adjustment representing a “model run”) until the CLIMEX map is an accurate (within 95%) representation of the actual species distribution data. Once this procedure has been completed, we can make a map predicting the distribution of the species in the region we are interested in, in this case, California.

A completed example is Scotch broom, Cytisus scoparius. We used the native and introduced distributions from Potter et al. 2008 (Fig. 1) to parameterize the CLIMEX model (Table 1 & Fig 2). The next step will be to create a map of the area we are interested in (California) with the same climate parameters to project the total potential range of this species. This can be done for any region of interest.

Figure 1. Native and introduced distribution for Scotch broom, *Cytisus scoparius*

Fig. 1 Worldwide distribution of *Cytisus scoparius*. Grey shading indicates the native distribution of the weed, cross hatch indicates administrative units where *C. scoparius* has been recorded and triangles indicate historical point locations where *C. scoparius* has been recorded (Information collated from records in the literature and a range of other sources: see *Appendix S1*).

Table 1 - CLIMEX parameter values used for modeling the worldwide distribution of *Cytisus scoparius* from Potter et al. 2008				
Index	**Parameter**	**Description**	**Value**	**Units**
Temperature	DV0	Limiting low temperature	8.5°	
	DV1	Lower optimal temperature	18.0°	C
	DV2	Upper optimal temperature	23.0°	C
	DV3	Limiting high temperature	28°	C
Moisture	SM0	Limiting low soil moisture	0.1	
	SM1	Lower optimal soil moisture	0.95	
	SM2	Upper optimal soil moisture	1.5	
	SM3	Limiting high soil moisture	2.5	
Cold stress	TTCS	Cold stress temperature threshol	-12.0°	
	THCS	Cold stress temperature rate	-0.01	$week^{-1}$
	DTCS	Degree-day threshold	8.0°	C days
	DHSC	Degree-day accumulation rate	-0.00025	$week^{-1}$
Heat stress	TTHS	Temperature threshold	28.0°	C
	THHS	Stress accumulation rate	0.001	$week^{-1}$
Dry stress	SMDS	Soil moisture dry-stress threshol	0.1	
	HDS	Stress accumulation rate	-0.05	$week^{-1}$
Wet stress	SMWS	Soil moisture wet-stress threshol	2.5	
	HWS	Stress accumulation rate	0.002	$week^{-1}$
Annual heat sum	PDD	Degree-day threshold	201.0°	C days

Figure 2. CLIMEX map parameterized for Scotch broom, *Cytisus scoparius*