Title:	**Development of a Weed Emergence Model for the Northeastern United States**		
Sponsoring Agency	NIFA	**Project Status**	ACTIVE
Funding Source	Hatch/Multi State	**Reporting Frequency**	Annual
Accession No.	1018540	**Project No.**	NYC-125838
		Multistate No.	NE1838
Project Start Date	12/12/2018	**Project End Date**	09/30/2022
Reporting Period Start Date	10/01/2019	**Reporting Period End Date**	09/30/2020
Submitted By	Crystal Clark	**Date Submitted to NIFA**	01/14/2021

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Non-Technical Summary

Unlike crops, which have been selected for uniform emergence, weed species have evolved variability in timing of their emergence; even seeds maturing on the same plant may germinate at different times. This "bet-hedging" strategy, with which a weed avoids putting all its "seed in one basket" of emergence timing, enables weeds to escape control measures that are applied at the "wrong" time. Post-emergence management carried out too early, i.e. before most problem weeds have emerged, will yield low returns for the effort, investment, and ecological cost of the management (herbicide off-target effects, soil compaction, etc.), as weed seeds that have yet to germinate are often unaffected. Providing seedling emergence information so that farmers can effectively time their weed management operations can increase efficacy of control, reduce labor costs, and minimize any negative environmental impacts (e.g. reduce the likelihood that repeat applications of an herbicide or cultivation may be required for late germinating/emerging weeds). There is, therefore, an urgent need for the development of time-specific weed management tools to help address the frequently asked, yet to be answered, question of when is the "right" time to control weeds?

Weed seedling emergence is a complex process regulated by a multitude of internal (e.g. species-specific parameters such as base temperature, base water potential) and environmental (e.g. soil temperature and moisture) factors. A range of modeling approaches, varying from simple empirical to advanced mechanistic models, have therefore been adopted to quantify the extent and time of emergence for a significant number of weeds. These can be used to produce weed management decision support tools, which enable farmers to determine the percent emergence of a specific weed species by a given date, taking into account the weather, management actions, and field conditions to that point. Populations of weeds respond differently in different regions to climate and habitat, requiring that emergence models be modified for a particular region. No weed management decision support tool exists for the Northeastern region of the United States, despite recent advances in our understanding of regional weed emergence patterns and developments in fine-scale weather prediction and soil moisture modeling. Data exist to create a weed forecasting product similar to those available for insect and disease threats to Northeastern agriculture, which would enable farmers to approach weed management with more precision and planning. In the past decade, decision support tools have been developed to help farmers manage weeds effectively in the Midwestern United States and Europe; these would serve as a road map for the Northeastern decision support tool. Recent advancements in climate and weather models and computational power have generated detailed weather data that are available to the general public free of charge. In the Northeast, daily weather data are now available on a 4 × 4 km grid across the region using the Applied Climate Information System (ACIS) Web Services (DeGaetano et al. 2014). These databases provide an unprecedented opportunity to estimate parameters directly relevant to seedling emergence such as growing degree day and hydrothermal time, from soil temperature and moisture data at very fine spatial resolution.
The **overarching goal of this project** is to work collaboratively across the northeast region to optimize farmers' ability to manage weeds in agricultural systems, in the face of challenges posed from a changing climate and increased prevalence of herbicide resistant weeds.

In this proposal, our goal is to develop and validate a user-friendly, online decision support tool for the real time prediction of weed emergence in the northeastern US. The decision support tool takes GPS location, soil type, tillage, crop data, and accesses weather history to provide percent emergence of the farmer's problem weeds at that location.

Accomplishments

Major goals of the project

(1)
Link Northeastern weed emergence timing data to existing weed emergence models and modern weather prediction models to create an online tool for farmers that will help them plan their weed management for optimal weed control. This tool will include three weeds that are problematic across the region: common lambsquarters (Chenopodium album), redroot pigweed (Amaranthus retroflexus) and large crabgrass (Digitaria sanguinalis). Common ragweed (Ambrosia artemisiifolia) will also be included in the northern portion of the Northeast and morningglory species (Ipomoea spp.) in the southern portion of the region. Individual participating states may also include one additional species of particular interest to their state.

(2)
Collect weed emergence data across the region to validate and refine the existing weed emergence models to fit Northeastern data, and refine the decision support tool through testing by select farmers and extension staff.

What was accomplished under these goals?

From October of 2019 through February of 2020, we planned and executed our first year of data collection, compiled the resulting data, and updated our emergence models with assistance from all of our partners. Mohsen Mesgaren of UC Davis and Carlos Santos of the University of Seville were key to this first years' work, especially in the model development area. Our progress were presented by Caroline Marschner at the 2020 NEPPSC conference in Philadelphia, PA, and we held two winter collaborator meetings to update our research plans and organize the upcoming field season.
As our first season of data were collected, it became clear that we needed more reliable in-field data collection for soil moisture and temperature. We submitted a revision to our budget to purchase field sensor equipment for this project, which was accepted, and received the sensors in March of 2020 for the 2020 field season.
In March 2020, the novel coronavirus pandemic and the resulting lockdowns at universities across the US precluded most of our partners, including our own lab, from initiating our 2020 field season in time to capture weed seedling emergence for our target species (March-April emergence initiation, depending on the state). In order to retain the ability to collect the three years of data necessary for this project, we stopped all spending and work on this project and received a one-year no cost extension, resulting in a grant end date of September 2022.

What opportunities for training and professional development has the project provided?

Our visiting scholar, Carlos Santos of the University of Seville, had the opportunity for substantial training in weed seedling emergence modeling with Mohsen Mesgaren of UC Davis, one of our mulitstate collaborators.

How have the results been disseminated to communities of interest?

Our progress was presented by Caroline Marschner at the 2020 NEPPSC conference in Philadelphia, PA, and to the Cornell University Integrated Pest Management course through the lens of weed emergence and climate change.

What do you plan to do during the next reporting period to accomplish the goals?

We plan to conduct our winter meetings, send the new sensor systems to our collaborators, and conduct our second field season this year (2021). We will continue to work on the review paper for the project. The next round of revisions for the model will fall in the 2022 fiscal year, as will development of the public-facing prediction model.

Participants

Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Scientist	0.2	0	0	0	0.2
Professional	0.1	0	0	0	0.1

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Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Technical	0	0	0	0	0
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	0.3	0	0	0	0.3

Student Count by Classification of Instructional Programs (CIP) Code

{NO DATA ENTERED}

Target Audience

We educated undergraduate students in the Cornell Integrated Pest Management course about the changes expected with climate change on weed seedling emergence and the complexities of modeling and predicting weed emergence.
We reached the weed science community with an update on our project and the changes to the models that our data suggested from the first year of data collection.

Products

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2020	YES

Citation

Marschner, C., Degaetano, A., Sousa-Ortega, C., VanGessel, M.J., & DiTommaso, A. (2020). Comparing models for weed seedling emergence in the Northeast. Proceedings of the Northeastern Plant, Pest and Soils Conference.

Other Products

Product Type

Data and Research Material

Description

Collated and analyzed the data produced in the first field season for this project, creating our first pool of data to support the model and prediction tool.

Product Type

Models

Description

Updated our preliminary models with the first year of data, experimenting with several different model types and testing them against our data.

Changes/Problems

We determined that sensor systems for soil moisture and temperature were needed to develop a more accurate model for the predictive tool. As a result, we submitted and were approved for a budget modification to reallocate funds to the purchase of the sensor systems.
The coronavirus pandemic halted this project, and all but one of our field sites collected no data in 2020. We paused both

work and spending on this project from March 2020, and will collect our second year of data in 2021 and the third in 2022. We received a no-cost extension to support this change.