BIOAg Project Report

Report Type:
Final

Title:
Building a spatially explicit phenology model for Colorado potato beetle

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Abstract
Potatoes are one of the highest-value crops grown in Washington, but growers face threats from pests such as the Colorado potato beetle (CPB). Because potatoes are an annual crop that grow for only 4-5 months, these pests live outside crop fields from September to May, and adults migrate into fields in late spring when non-irrigated hosts wilt in the late spring and early summer. Potato growers would benefit from models that predict CPB arrival into potato fields and when damage is likely to commence. Our project addresses this by assessing the population dynamics of CPB to generate map-based forecasts that predict where and when CBP would emerge in the potato growing field after overwintering.

Project Description
Potatoes are an annual crop that **is** typically planted in late April or early May and harvested in September or October. Potatoes are often rotated with other crops over a 3-4 year cycle, such that potato**es are** not planted in the same location from year to year. For both of these reasons, insect pests of potato do not overwinter within fields. Rather, insect pests live outside crop fields from September to May, and migrate into potatoes as non-irrigated hosts wilt in the late spring and early summer. After dispersal, pests like CPB begin feeding and reproduction, and subsequent generations live in the potato crop through harvest. Growers would benefit from models that predict when dispersal events occur and when key life stages that are susceptible to management are present. Similarly, growers would benefit from models that predict when CPB are pupating in the soil (when insecticides are not effective). Our project addresses these needs through two objectives: the first links monitoring data with satellite imagery and weather data to predict when CPB emerges after overwinter and when dispersal into potatoes occurs. The second objective is to build phenology models to predict when key stages are present after dispersal occurs.

(Objective 1) Build species distribution models that link monitoring data and satellite imagery with models to predict variation in CPB abundance across Columbia Basin production regions

(Objective 2) Create models that estimate key phenological stages involved in CPB management

Outputs
(1) We built habitat suitability models for CPB in Washington using long-term climate variables (Fig. 1). This model has been validated based on movement of CPB into potato fields, which allows us to predict when insects arrive in field edges

(2) We built a phenological distribution model for CPB in Washington to estimate the emergence time of CPB, which was estimated using temperatures from the WSU AgWeatherNet (Fig. 1). The model was validated at 32 potato crop fields with help from our cooperators in WSU Extension (Tim Waters and Carrie Wohleb)

(3) We built a phenological model of CPB adults and larvae that predicts major life events in the Pacific Northwest (Figs. 2A, 2B). We built recommendations based on this model, with growers advised to spray pesticides when 50% egg hatch in the second generation had occurred (Figs. 3, 4). Early results from this model were promising and show growers can reduce their sprays by 1-2 per acre per year by using the model.

Methods, Results, and Discussion
Habitat suitability models were calibrated using machine learning methods, and by correlating observations with climate variables, the phenology model predictions across geography were estimated using a process-based approach by relating CPB physiology with daily temperature from AgWeatherNet (AWN). Our habitat suitability prediction shows that vast areas in central and southern Washington and low-elevation areas of Cascade Mountains are suitable for CPB (Fig. 1). The emergence time of CPB after overwintering was also well predicted using AWN data (Fig. 1). We assembled field monitor data to validate these predictions, allowing us to fine tune the model settings and parameters to develop a phenology for the entire life cycle across the Pacific Northwest (Fig. 2). These model predictions were turned into recommendations on the WSU Decision Aid System, which have been distributed widely to growers (Fig. 3).

Publications, Handouts, Other Text & Web Products
Gengping Zhu, Luis Osorio-Olvera, Vera Pfeiffer, Javier Gutierrez Illan, Lisa G. Neven, David W. Crowder (2024) Enhancing monitoring to promote early detection and eradication of invasive species. Ecography, doi: 10.1111/ecog.07105.

Gengping Zhu, Abigail Cohen, Ben Bradford, Tim Waters, David Crowder (2025) Building a phenology model for Colorado potato beetle. Journal of Economic Entomology, in preparation.

Outreach & Education Activities
The results have been presented in Washington and Oregon farm fairs and IPM meetings. Specifically, we presented at the WA/OR Potato Conference in 2023 and 2024, the Entomological Society of America Annual Meeting in 2023 and 2024, and the Othello Potato Conference in 2023 and 2024. We also held four digital workshops each year on the Colorado Potato beetle model through the WSU DAS System. Finally, weekly updates on potato insect populations were sent to our list serve of over 1,000 individuals.

Impacts
(a) Short-term - knowledge gained and shared
We developed habitat and phenological models for Colorado potato beetles. Spatially explicit predictions of CBP abundance and critical development stages will be provided. These spatially explicit predictions contribute to our understanding of suitable habitat and emergence time of CBP in Washington State and would help growers to better timing their first spray of pesticides. Model recommendations have been developed and widely deployed on the WSU DAS.

(b) *Intermediate-term - current & expected change in behaviors and when they may be expected*
Our project will provide a catalyst for the further development of the potato and vegetable DAS. All major insect pests of potato have a life cycle similar to that of CPB, where they live outside crop fields and migrate into fields in May. This project will provide a foundation for building similar tools for beet leafhopper, potato psyllid, and lygus, among other species.

(c) Long-term - potential change in economic/environmental/social situations
Our project is a component of a larger-term effort by WSU DAS and WSU CAHNRS, more generally, to build digital decision support tools for potato and fruit growers in Washington.

Additional funding applied for/secured:
(1) WSDA Specialty Crop Block Grant Program

(2) USDA NIFA Agricultural Biosecurity Program

(3) USDA NIFA Data Science for Food and Agricultural Systems Program

Graduate students funded
Emily Rampone and Camille Wagstaff

Recommendations for future research:
The spatially explicit predictions of CBP abundance and critical development stages will be provided. We will also continue to assemble field data to validate our spatially explicit habitat and phenology model predictions for Colorado potato beetle in the Pacific Northwest.

Habitat suitability

The *i*th day of the year
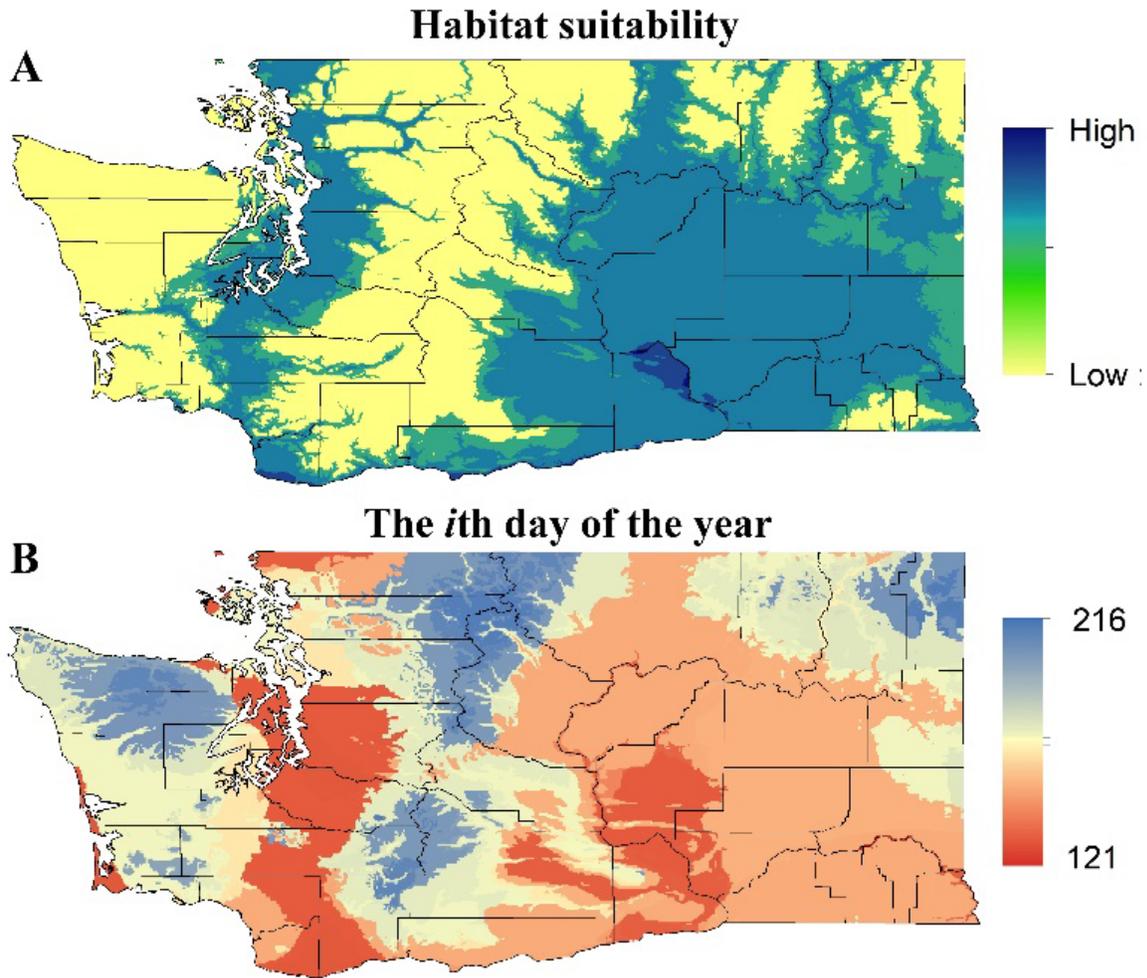
Figure 1. Habitat suitability and early emergence time predictions were estimated (A) using occurrence and climate data, while (B) emergence time (i.e., day of the year) was estimated by relating the CBP low-temperature development threshold and growing degree days requirement with daily temperature data.
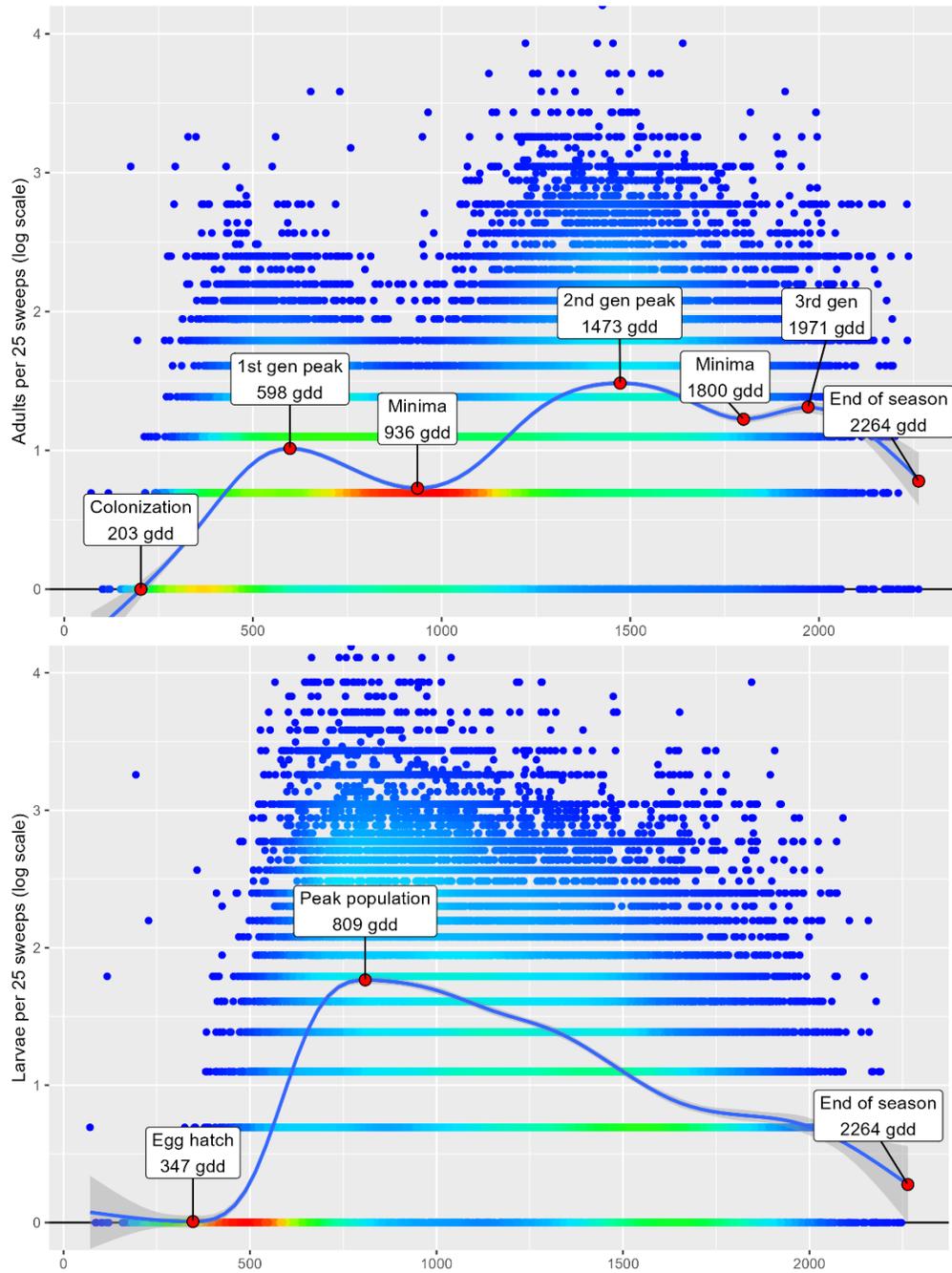
Figure 2. Phenological predictions for (A) CPB adults and (B) CPB larvae. The phenological models were validated using field modeling data and have been used within the WSU DAS in 2024 to guide grower decisions (see Fig. 3)
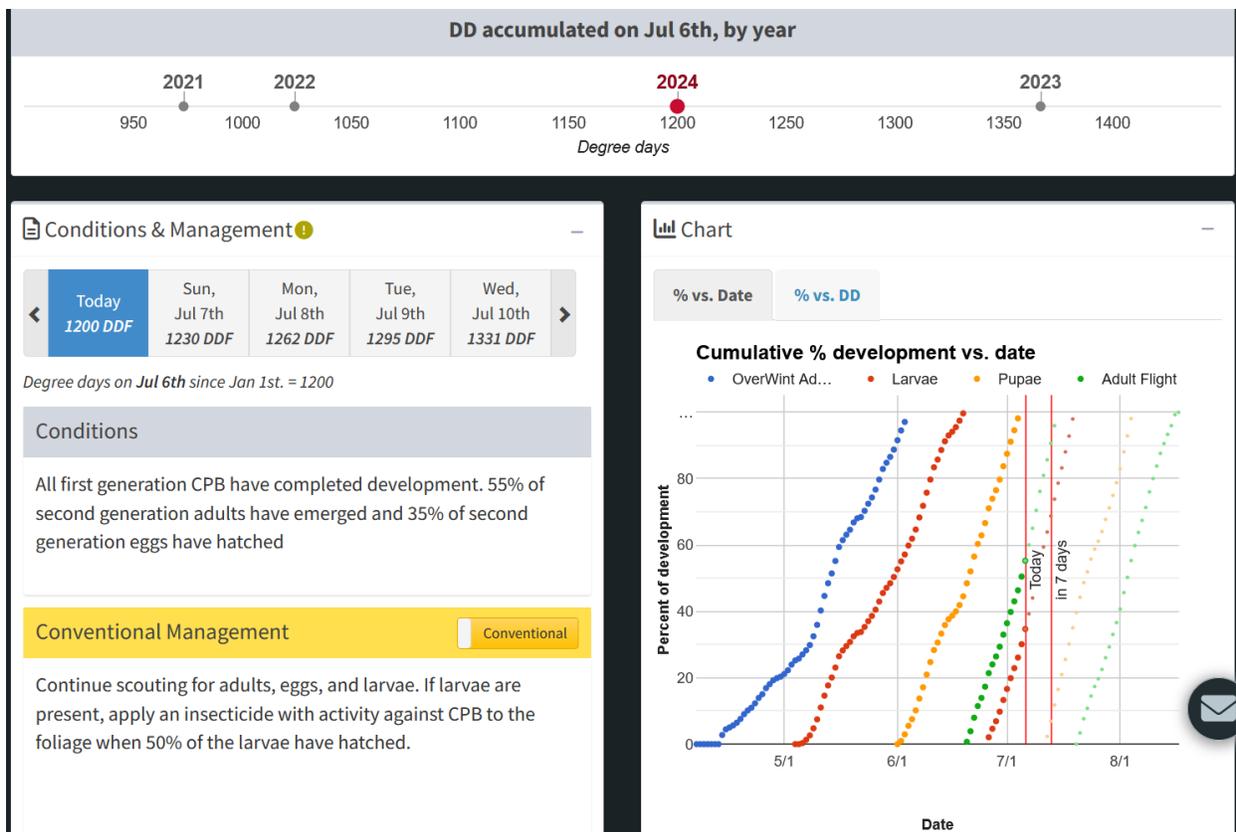
Figure 3. Example output from the WSU Decision Aid System in Pasco, WA, on July 6, 2025. The model provides charts, degree days accumulation, and recommendations for management.