Section 1: Invasive and Emerging Pests

PEST EVENT MAPPING: A NEW TOOL TO AID IN PREDICTION OF INSECT PHENOLOGY

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Introduction

The ability to predict when and where new pests might arrive can greatly aid invasive monitoring, IPM, and biological control programs at local, state and national levels. Until now, high resolution maps that predict the date of a forecasted insect event such as first adult flight or egg hatch have not been available. Such maps potentially allow end-users with little or no technical training to access and use such maps. We demonstrate the building blocks and provide examples of such maps that have the potential to make such decision support tools commonplace for varying phenological decision support needs.

Historical Context

Degree-day (DD) models and maps have become relatively common decision support tools in IPM and invasive species management. Numerous states use degree-day maps to predict current, and sometimes, future pest status for major pests. OSU IPPC has posted online standard temperature threshold (32, 41, 50 F) degree-day maps for more than 15 years (first daily updated Oregon DD maps were online by 1998). At the state and greater extents, such maps provide synoptic (but not local or field-level IPM) decision support, by helping users to visualize: 1) the tracking of DD build-up over the current growing season, 2) to compare the current year with 30-year normals, and 3) to assess the differences in DDs between current and normal years. After further development, tools have been added to allow 1) end-user online DD mapmaking, 2) interfaces that allow focus on local regions and conditions, and 3) the opportunity to support field-level IPM decision making. Degree-day maps, to be useful, require careful scrutiny and interpretation. Pest events mapped as calendar dates, on the other hand, can offer a less technically inclined user the ability to visualize when selected phenological events are predicted to occur.

Methods

Pest Event Maps (PEMs) are based upon new programming initially developed for standard degree-day maps, and make use of PRISM monthly climate data (800 meter resolution) (=gridded data), National Climate Data Center (NCDC) 30-year (1981-2010) normals for >5,000 locations (=climate station data), and the full database of near-real time public and agricultural weather networks available at OSU IPPC (>15,000 observing weather stations). The program first computes monthly degree-day totals from the gridded data, then subtracts each month from the target event DD total (e.g. spotted wing Drosophila 1st spring time oviposition, 261 DDs after Jan 1). The resulting temporally coarse PEM is then corrected using day-of-year predictions of the selected event for all available observing weather stations in the region of interest (48 State US available). The correction layer is the result of a 1/distance squared interpolation of differences between the PRISM-based and station-based day-of-year estimates. The correction layer is added to the PRISM-based map and then other GIS layers added to produce the final PEMs. The maps currently consume over 90 minutes of computer time on a relatively fast server, making them slow and inefficient to produce compared to regular DD maps. The example SWD 1st oviposition event maps in Fig. 1 illustrate the need for close-up detail for even monthly resolution of an event in Western states, while the mapping is relatively straight-forward for Midwestern and Eastern states. Further close-ups to the county level would allow delineation to even the daily temporal resolution. These maps can be automated and posted weekly to provide region-wide decision support.

Discussion

The pest event mapping system offers many opportunities for pre-configured, automated mapping for needs such as invasive species mapping for USDA APHIS PPQ, similar to a series of weekly DD maps currently issued by PPQ for 12+ species, e.g. gypsy moth flight and egg hatch, for the U.S., and in particular, Western States (PPQ primarily for internal and cooperator use only). For IPM, high resolution PEM maps could include critical IPM models and needs, such as codling moth first egg hatch, W. cherry fruit fly first emergence, and SWD first spring oviposition. While these opportunities are diverse, certain assumptions and limitations must be considered, including:

1) Maps of pest events could imply precision that is lacking; these remain products of DD models which suffer numerous sources of error and lack of precision; we recommend the use of a warning advisory with all maps stating the main sources of error in the mapping and caution in their use.
2) These maps are to be used initially for invasive pests, for which primarily only presumptive, rather than well-validated models exist. They should therefore be used conservatively in this context, such as for earliest trap placement dates (considered a major potential use for these maps).
3) Currently the maps are limited to a single calendar date to use as the starting or biofix date. Across a wide area, this becomes a severe limitation depending on the model.
4) The maps rely, to a much greater extent than for degree-day maps, on forecasted weather data. We are addressing this need with further research in the use of virtual weather data, and longer term (30-90 day) temperature forecasting.

Because of these assumptions and limitations, prototype maps will be tested for some length of time, perhaps several years, using primarily 1) APHIS PPQ invasive pests, such as gypsy moth, 2) well-researched IPM pest species such as those previously mentioned, and for 3) research uses including for weed biological control agents such as for Galerucella spp. beetles on purple loosestrife, an invasive weed. This research is funded by a USDA Forest Service Biological

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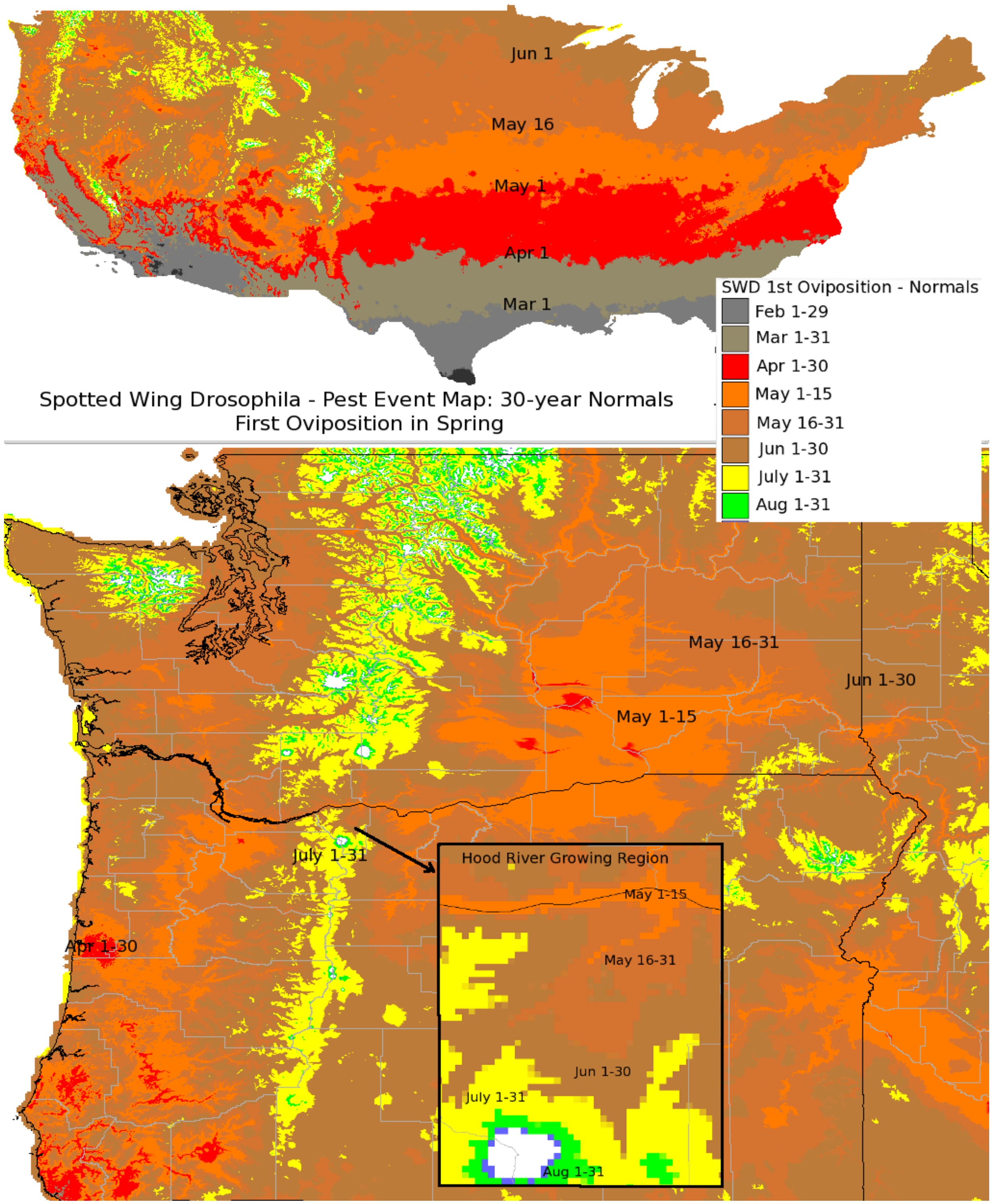

Figure 1. An example pest event map produced using OSU IPPC Pest Event Mapping (PEM) system. Example pest event using spotted wing Drosophila 1st springtime oviposition (261 DD after Jan 1, Tlow=50F), calculated using recent 30-year Normal data.