Modeling aphid population dynamics

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Under ongoing climate change, it is becoming increasingly important to understand drivers of pest insect populations in cereal grain systems. The prediction of insect population trends is a complex task and often requires a dedicated approach to data collection. Using information collected over a multi-decadal time period and across a regional spatial extent, researchers at the University of Idaho and Washington State University have developed predictive models of cereal aphid populations for three common pest species (bird cherry-oat aphid, *Rhopalosiphum padi* (Figure 1); rose-grass aphid, *Metopolophium dirhodum*; and the Russian wheat aphid, *Diuraphis noxia*) that pose a significant management concern to agriculturalists. In addition to their direct negative effects on plant growth, these insects can also carry viruses such as barley yellow dwarf virus that substantially reduce cereal yields.

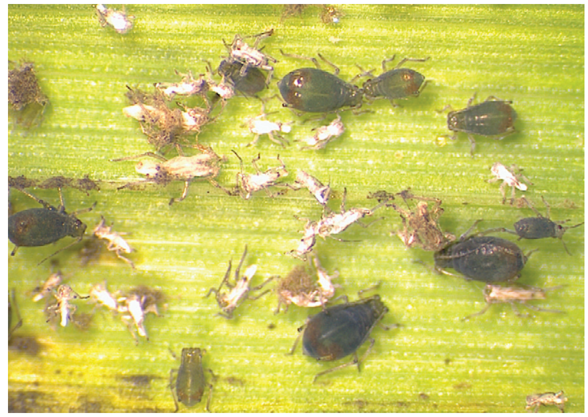

Figure 1. *The bird cherry-oat aphid,* Rhopalosiphum padi, *on wheat leaves. These aphids transmit damaging viruses and can severely reduce wheat yields when populations are high. Photo by Brad Stokes.*

IMPACT

Models can be used to predict years when cereal aphid population densities can be expected to reach high or low levels, thus indicating the need for applications of insecticides. Precision chemical application may be achieved by employing our models to estimate insect abundances as part of an overall integrated pest management strategy. Over the long term, this will contribute to reduced up-front costs for growers, as well as enhance the environmental sustainability of cereal grain production.

In the early 1980s, a network of 28 trapping locations was established throughout the Pacific and inland Northwest in cereal grain production regions (Figure 2). Each location was outfitted with a "suction trap"; a tower designed specifically to sample populations of migrating aerial insects (Figure 3). For 20 years, traps were operated by University scientists, and insect captures were identified and catalogued on a weekly basis. In addition, the application of surface-corrected climate models has allowed us to link these trap capture records with weather patterns during the operational dates of the trapping network. This information has allowed us to investigate how both intrinsic, population-driven factors and extrinsic climate effects influence year-to-year variation in aphid densities across the northwestern United States.

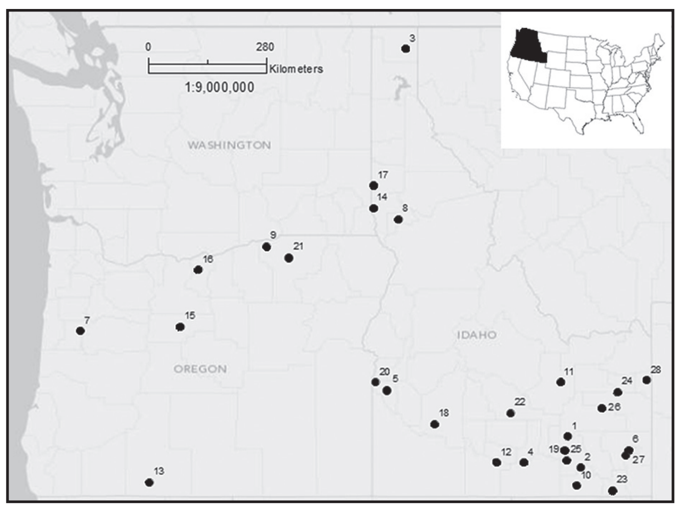

Figure 2. *Suction trap locations used in this study. The inset (upper right corner) highlights the geographic region encompassed by our study within the continental United States. Scale and distance bar is shown in the upper left corner. Locations correspond to (1) Aberdeen; (2) Arbon Valley; (3) Bonners Ferry; (4) Burley; (5) Caldwell; (6) Conda; (7) Corvallis; (8) Craigmont; (9) Hermiston; (10) Holbrook; (11) INEL; (12) Kimberly; (13) Klamath Falls; (14) Lewiston; (15) Madras; (16) Moro; (17) Moscow; (18) Mountain Home; (19) Neely; (20) Parma; (21) Pendleton; (22) Picabo; (23) Preston; (24) Ririe; (25) Rockland; (26) Shelley; (27) Soda Springs; (28) Tetonia.*

The important findings of our work were threefold: (1) Populations of each cereal aphid species are apparently strongly regulated by strong feedbacks: as aphid densities in a given year rise, aphid densities in the following year are likely to be considerably lower, and vice versa. (2) A combination of climate variables and population models were used to construct predictive models of inter-annual aphid density and population growth rate, with strong models developed for population growth rate in the case of all three species. (3) There was no clear biogeographic pattern of aphid density, suggesting that all locations surveyed are equivalent in terms of year-to-year aphid abundance.

These findings suggest that the processes regulating aphid population dynamics tend to occur over very large spatial scales. (The extent of our study region was more than 250,000 km, roughly the size of the United Kingdom.) However, aphid dynamics were not uniformly predicted by climatic variation at this scale; rather, certain species were highly responsive to climate, and others were not. Under projected warming, we predict that *D. noxia* will become less prevalent in the region, whereas *M. dirhodum* abundance is likely to increase if annual precipitation rises. Irrespective of climate variability, we expect that *R. padi* is likely to persist as a pest of cereal grains in the northwestern United States.

Figure 3. *A suction trap located near Moscow, Idaho. Photo by Brad Stokes.*