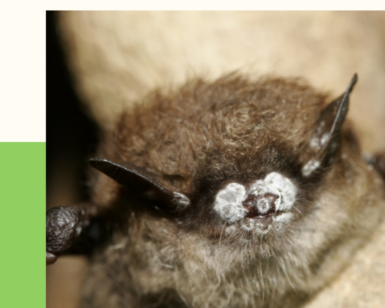
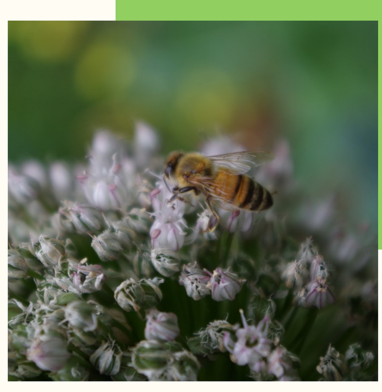


The Buzz About White Nose Syndrome:



Risks to Native Bee Populations Following a PNW WNS Outbreak

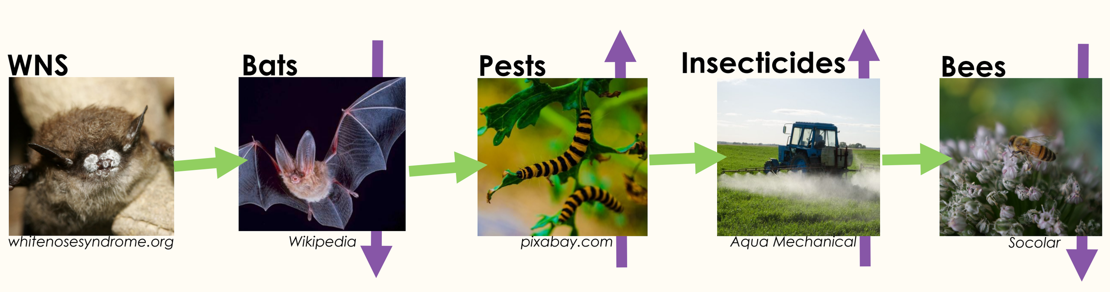
Background

In 2006, white-nose syndrome (WNS) emerged in the Northeastern United States as a bat pathogen of unprecedented mortality (Blehert et al., 2009). In affected areas, bat populations have declined by up to 90% (Langwig et al., 2012). Of bats' many important ecological roles, their insect predation is paramount in agricultural systems, as it prevents pest damage to crops (Boyles et al., 2011). In the absence of bats, many farmers resort to pesticides; insecticide use has already increased dramatically in the Northeast in the years since the WNS outbreak (Maine & Boyles, 2015). Native bee populations have been shown to be particularly sensitive to insecticide use, specifically neonicotinoids, and it is thought to be a major risk factor in colony collapse disorder, also known as CCD (Cresswell, 2010). We can therefore expect that in areas that experience high bat die-offs, native bee populations will be put in risk if they are within range of agricultural cropland.

Figure 1. Study Area

In 2016, the first case of WNS was reported on the West Coast. This case in Washington state suggests a strong possibility that WNS will now spread through the Western United States, killing bats in a similar pattern to the East Coast. That area can be rudimentarily approximated by temperature: recent pathology has shown that the WNS fungus can only grow optimally between temperatures of 5-18° C, and that temperature is one of the top predictors of WNS mortality (Flory et al., 2012). Cropland in these areas is therefore particularly likely to pose a new threat to bee populations, especially if it is close to bee habitat.

This chain of events is summarized below:



We can further approximate risk level to bees by using data on current insecticide use to inform conclusions about which areas have the highest probability of elevating insecticide use in response to a bat die-off. Assuming that insecticide use will continue to follow current trends, areas that currently show higher usage will be of particular concern to native bee populations.

Project Goal and Spatial Questions:

Where might we want to put additional efforts into preserving native bee populations in the Pacific Northwest through limiting neonicotinoid pesticide usage?

- Where is WNS likely to spread, namely, where will temperatures remain between 7 and 14 degrees Celsius?
- Where in these areas is insecticide use likely to increase, namely, where is the cropland in this area, and how prevalent is current insecticide use on this cropland?
- Where are bee populations most likely to intersect with this cropland, namely, which of this cropland is within 3km of bee habitat?

Tufts University
Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy

Cartographer: Yvonne Socolar,
AFE Candidate 2018

Projection:
NW: NAD_1983_UTM_Zone_11N
NE: NAD_1983_UTM_Zone_17N

Methodology

Because WNS exclusively affects hibernating bats, the relevant temperatures will be the coldest and warmest ones during their months of hibernation (November-March). As January is the coldest of those months, mean 30-year normal temperature was used to approximate the cold extremes that might occur in bat caves. March high 30-year normal were then assumed to approximate the highest temperatures that the fungus might be exposed to in the bat caves. Using the 5-18° C optimum temperature from the literature as a starting point, temperature overlays on the East Coast were adjusted until they visually resembled East Coast WNS distribution maps (Figures 2 & 3). The 7-14° C range was therefore chosen to model West Coast WNS range (Figure 4).

As the threat of increased insecticide use is exclusively on cropland, land use with the classification of "Pasture/Hay" and "Cultivated Crops" was selected from the NLCD 2011 Land Cover dataset. Deciduous, evergreen and mixed forest was selected from the same dataset as an approximation of bee habitat, as per EPA methodology (Figure 6; EPA, 2016). As bees have an average flight range of 3km, this was the critical distance used to determine if cropland was "within range" of bee habitat (Beekman and Ratnieks, 2000; Kremen et al., 2004).

Data on percent of cropland treated with insecticides from the USDA was used to classify counties as, low (0-10%), medium (10-30%) or high (30-100%) areas of pesticide use (Figure 7).

These datasets were then combined in the following manner:

- Only cropland in the projected WNS area was examined.
- Cropland was given a weight of 1, 2 or 3, depending on whether it was in an area of low, medium or high pesticide risk, respectively.
- Cropland was given a weight of 0 or 3, depending on whether or not it was within 3km (Euclidean distance) of bee habitat.
- Cropland weights were added to make a risk raster, values 1-6.

Results

Values 1-3 show increasing insecticide risk in areas not within range of bee habitat; values 4-6 show increasing insecticide risk in areas with bee habitat within 3km. All areas are on cropland within the projected presence of WNS. The most concentrated region of high risk is the Willamette Valley in northwestern Oregon.

Risk Level		Area (acres)	Proportion
Outside range of bee habitat	1	1856	9%
	2	4512	21%
	3	1848	8%
Within range of bee habitat	4	3360	15%
	5	7988	37%
	6	2210	10%

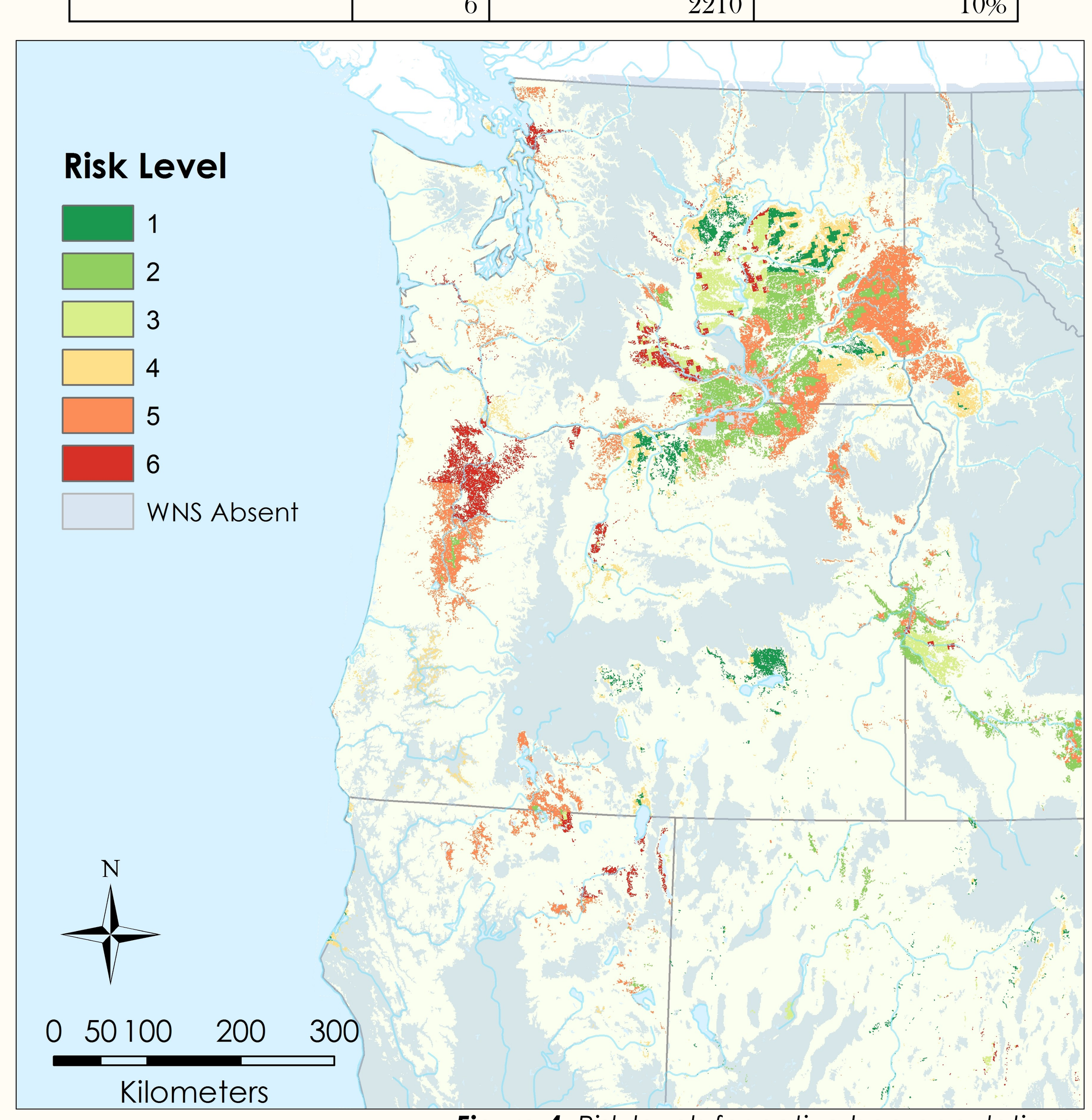


Figure 4. Risk levels for native bee populations.

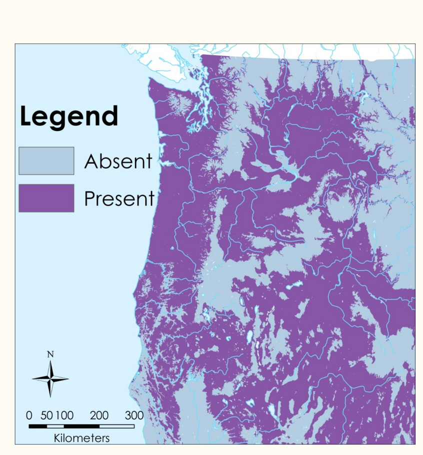


Figure 5. Projected temperature -based WNS distribution

This dataset was obtained by using the PRISM model to distribute point measurements of average January, and high March, air temperatures from 1981-2010 on an 800m grid cell resolution. Temperatures between 7 and 14° Celsius are classified as "presence".

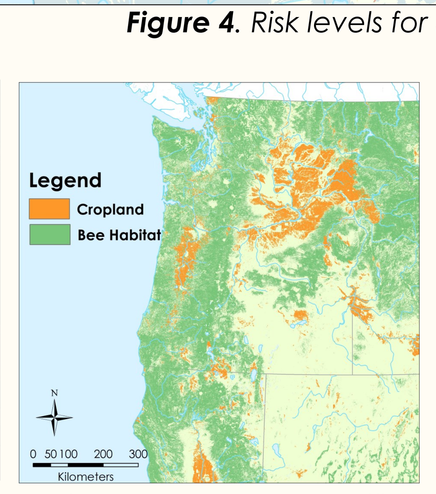


Figure 6. Land cover classified as cropland and bee habitat

This dataset was obtained by using Moderate-resolution Imaging Spectroradiometer, a remote sensing instrument, to classify global land cover according to the IGBP global vegetation classification scheme of 16 different classes. It has a cell size of 30 meters.

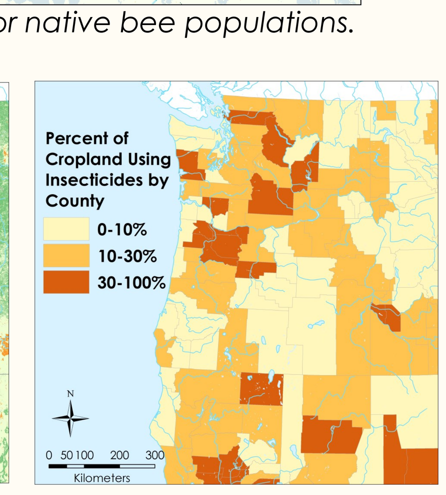


Figure 7. Percent of county cropland with insecticide use

This dataset was obtained from the 2012 USDA census of agriculture, which asks farmers how many acres they use chemicals on to control insects on their cropland. These data then take that total and report it as a percentage of the total acres of cropland in a given county.

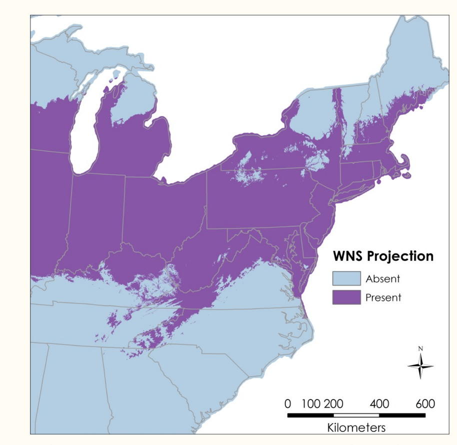


Figure 2. Temperature projection of WNS distribution: 7-14° Celsius

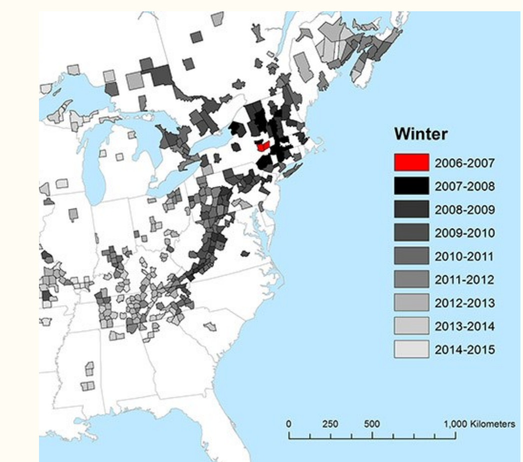


Figure 3. True East Coast WNS Distribution, www.sciencenews.org

Conclusions

Neonicotinoids, one of the main classes of insecticide used in the US, are particularly harmful to bees, and are thought to be one of the causes of CCD. Education and outreach to farmers about limiting neonicotinoid usage on their cropland will be critical in the event of a large-scale bat die-off in the Pacific Northwest. Figure 4 suggests that the Willamette Valley may be an especially fruitful area to focus these efforts. These recommended areas should, of course, be updated as the true pattern of WNS emerges, and combined with on-the-ground information about farmers' insecticide practices and willingness to explore alternative farming techniques.

Overlap between cropland and regions that meet WNS temperature requirements signals areas that may show increased insecticide use as WNS spreads through the PNW. There are also many factors beyond temperature that will influence the spread of WNS, which should be included to improve the accuracy of future models.

Beneficial insects, namely bees, are harmed along with pests as a result of insecticide use. As insecticide use increases, bees will experience an elevated colony health risk, particularly in native populations, which are sensitive to insecticides at lower levels than domesticated honey bees (Connolly, 2016). Given that native bee populations are most likely to be found within a 3km flight range of forest, cropland within 3km of this preferred habitat is of particular concern. NLCD data from 2011 is used in the current model, and should be updated and combined with on-the-ground observations of native bee presence in order to better pinpoint areas of risk.

If we can expect insecticide use to increase proportionally to the levels that are currently used, areas that currently show higher usage will be of particular concern for native bee populations. We then must ask whether those insecticides are--and will continue to be--neonicotinoids. Future models should include this more detailed level of insecticide analysis. In addition, data on insecticide use at the county level can only get us so far, and would ideally be updated to be farm-, or even field-specific.

Summary

Though further updates and research are critical, the Willamette Valley, along with other areas of high risk, should be examined further and watched closely by bee conservationists in the coming years.

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