A Model Estimating Spotted Wing Drosophila Overwintering Mortality

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Given massive SWD fall population buildup:

-using data on cold susceptibility, and
-an understanding about their habit of seeking insulating refuges,

What levels of overwintering mortality can we expect? Can relative winter mortality rates help us in timing of monitoring programs in the Spring? Can they help us initialize models of population build-up in different cropping systems?

50,000,000 flies → 1,000,000? 100? 0?

Basis of Model:

Research Article

SCI

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Laboratory survival of *Drosophila suzukii* under simulated winter conditions of the Pacific Northwest and seasonal field trapping in five primary regions of small and stone fruit production in the United States

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Spotted Wing Drosophila – Overwintering Mortality

Approach Used

-Our modeling philosophy is that models are like hypotheses: you seldom “validate” or “prove” them but rather you “confront them with data” in order to “support”, “disprove” or “improve” them. A model should be judged primarily by its usefulness in addressing its intended goals and objectives.

-This model is under development – while it is beginning to reflect our current understanding of lab and field behaviors;
we hope it can help shape the conversation of how SWD behaves during wintertime under varying climates and habitat.

-Degree-day models depend on a linear response to temperature (at least between thresholds). Over time, errors due to non-linear responses are expected to cancel out.

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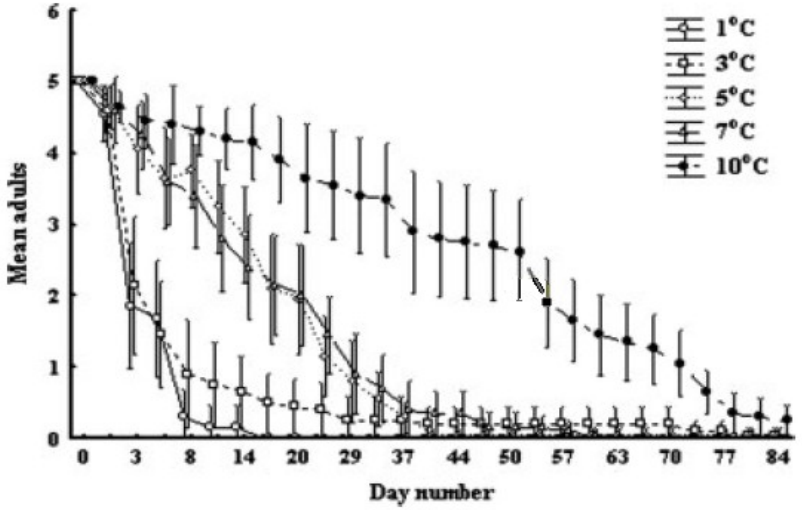
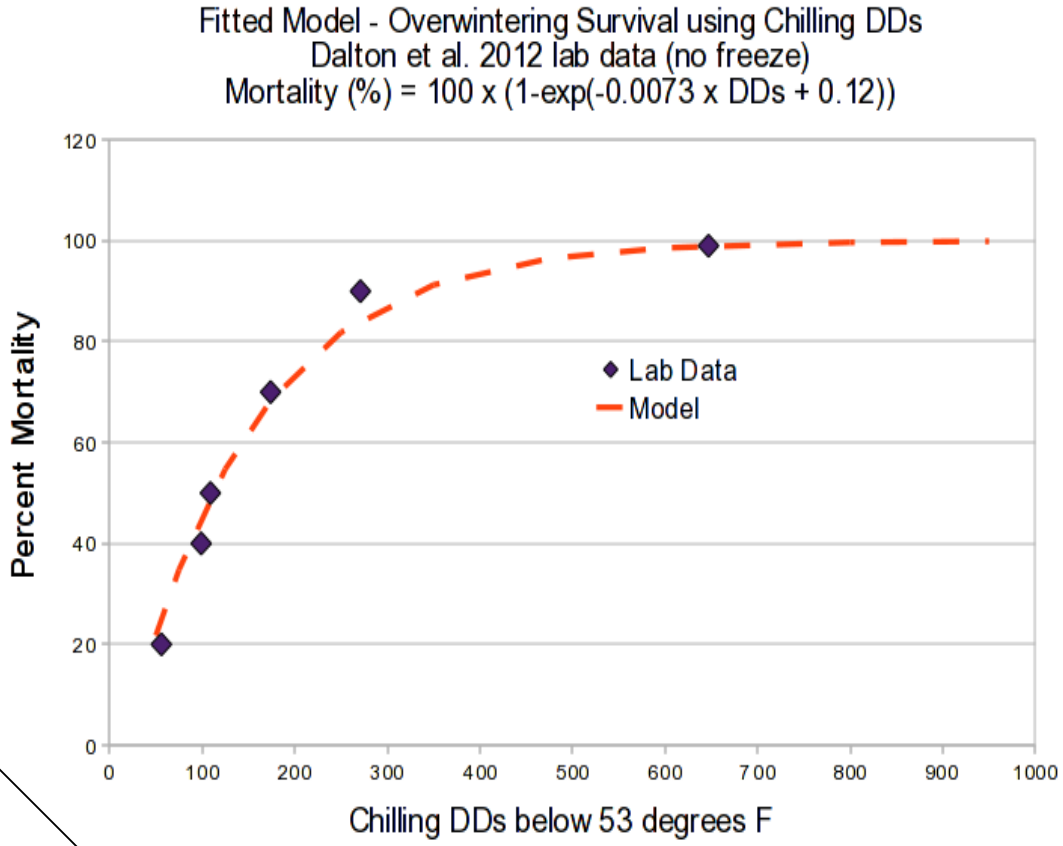
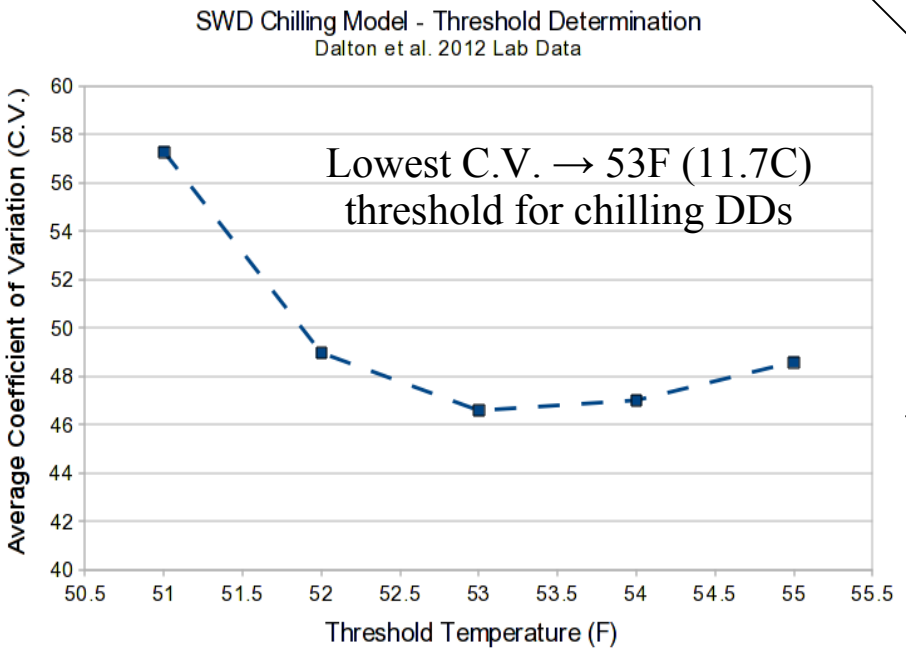
Spotted Wing Drosophila – Overwintering Mortality Model

OSU Walton et al. laboratory data represent cases with no chilling refuges



Dalton et al. 2012 Fig. 1

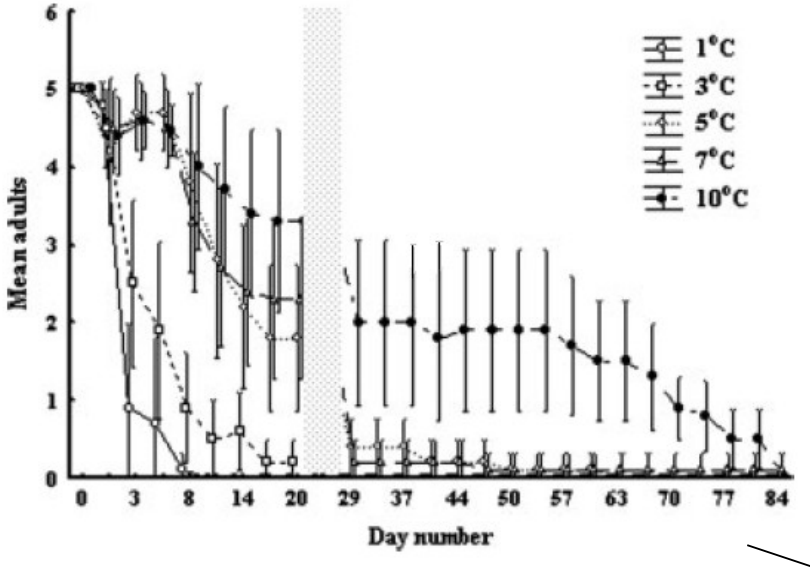




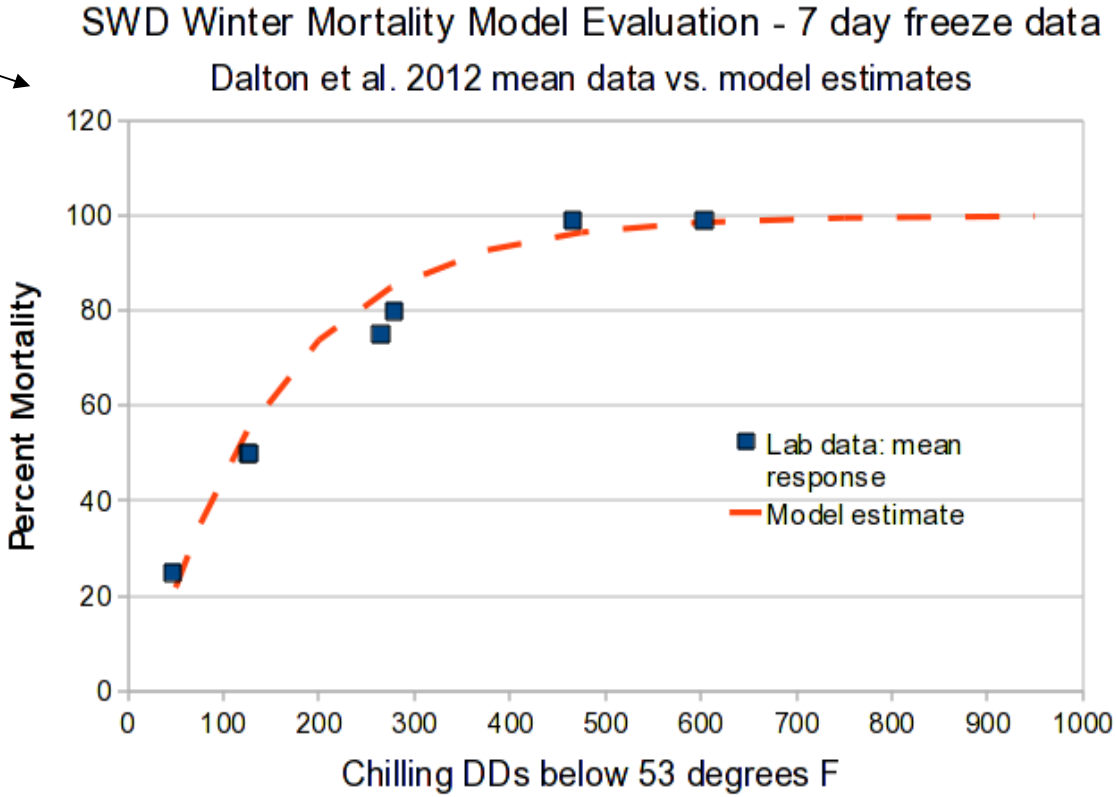
Chilling DDs	%mortal
56	20
99	40
109	50
174	70
271	90

Spotted Wing Drosophila – Overwintering Mortality Model

Evaluation I. Confront model with data from Dalton et al. Fig. 2 (same study w/7-day freeze)



Dalton et al. 2012 Fig. 2



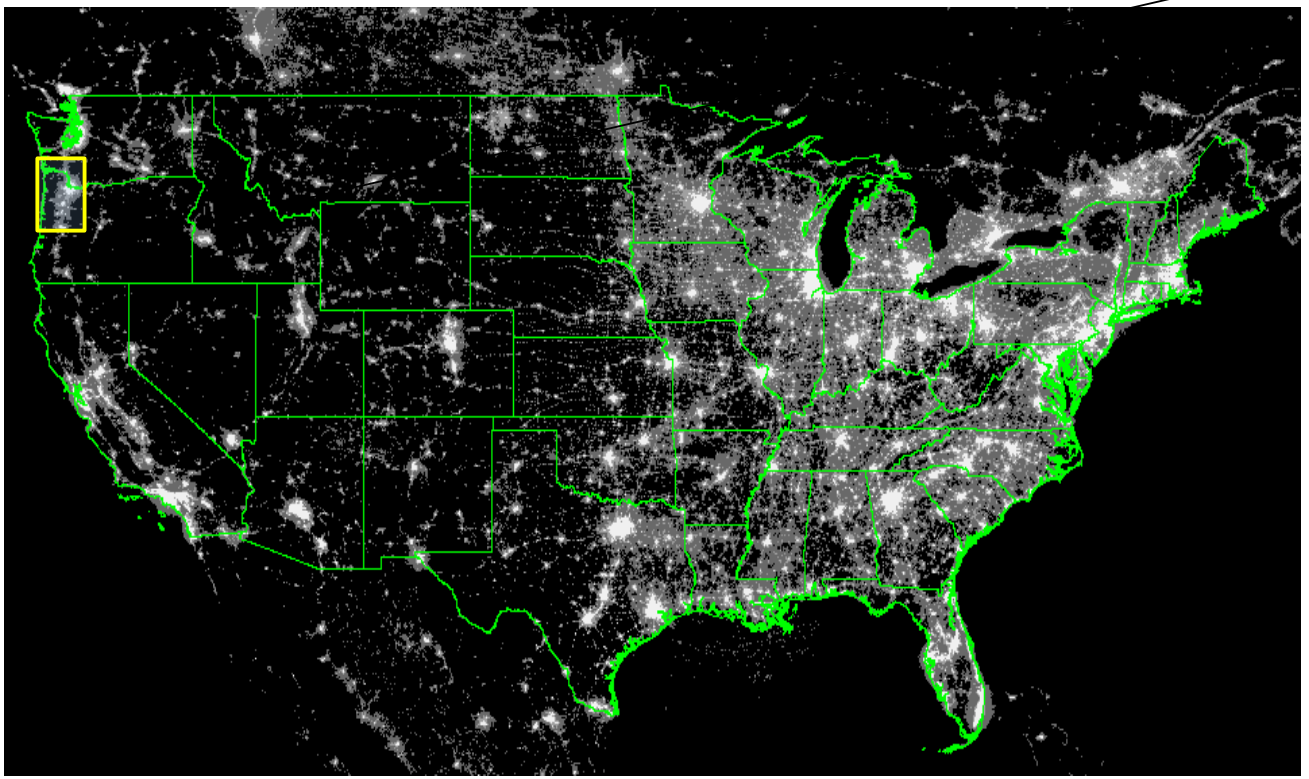
Spotted Wing Drosophila – Overwintering Mortality Model

Model Development II. Add a refuge factor (Rf) ranging from rural to urban influences

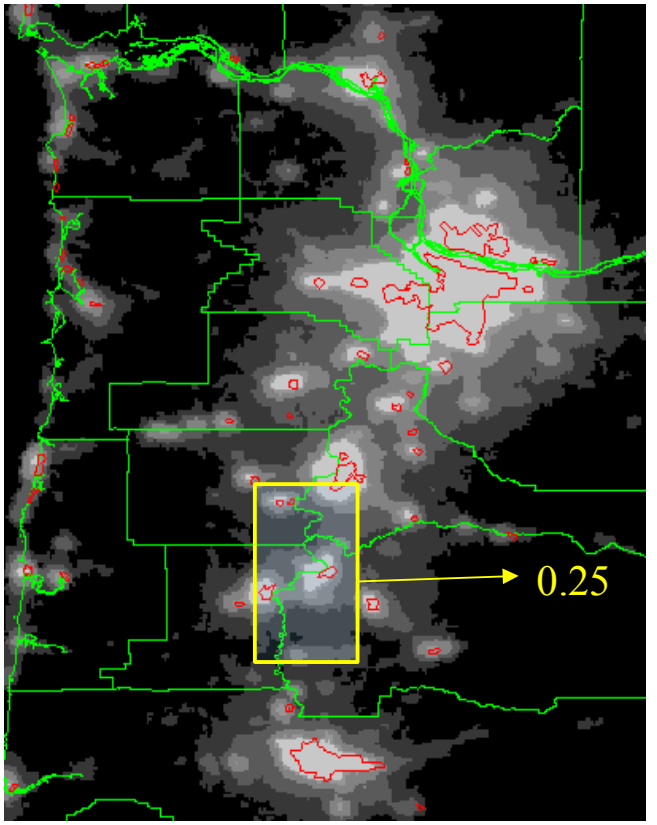
"To overcome deficiencies in cold tolerance, it is possible that *D. suzukii* may be behaviorally adapted to overwinter in man-made protected habitats"

Dalton et al. 2012 citing Kimura 2004 *Oecologia*

"*D. melanogaster* was shown to be increasingly abundant in more urban environments" Avondet et al. 2003 Env. Ent.



NOAA Earth Observation Data Center "2010 Stable lights"
Varying light intensity, currently calibrated to range from 15% (most rural) to 60% (most urban) reduction in chilling DDs



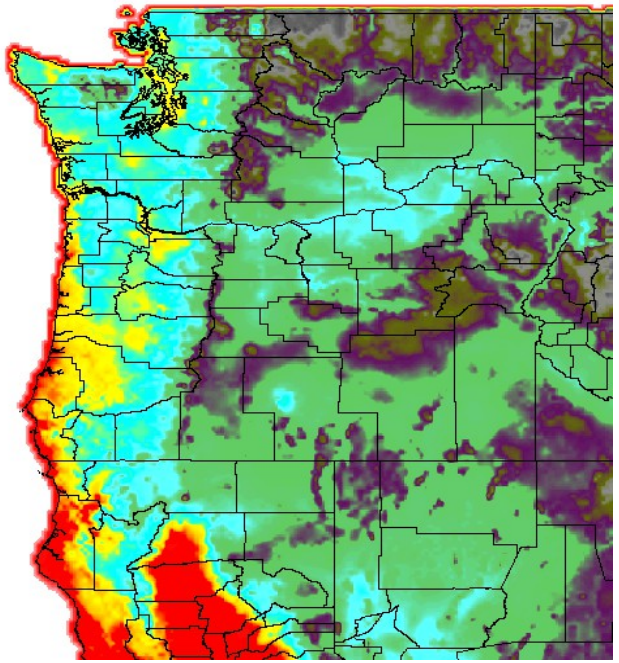
NW Oregon closeup with alternative urban boundaries (red) vector data.

Mean value in region of Dreves et al. trapping, estimate an overall 25% reduction in Chilling DDs (Rf=0.25).

Spotted Wing Drosophila – Model of Overwintering Mortality

Due to Chilling Effects – based on OSU Walton Lab Data & 30 year normal temperatures

Chilling DDs (<53F)

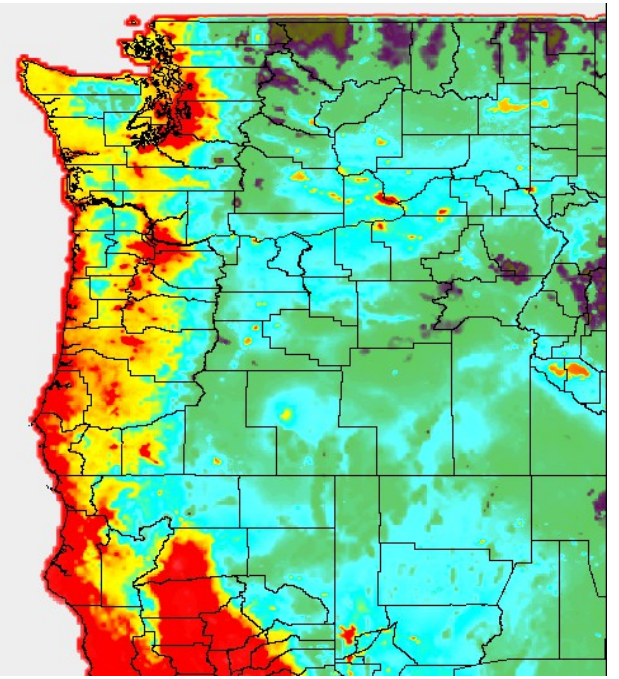


+

Refuge Factor (Rf) 15% to 60%
Reduction in chilling DDs

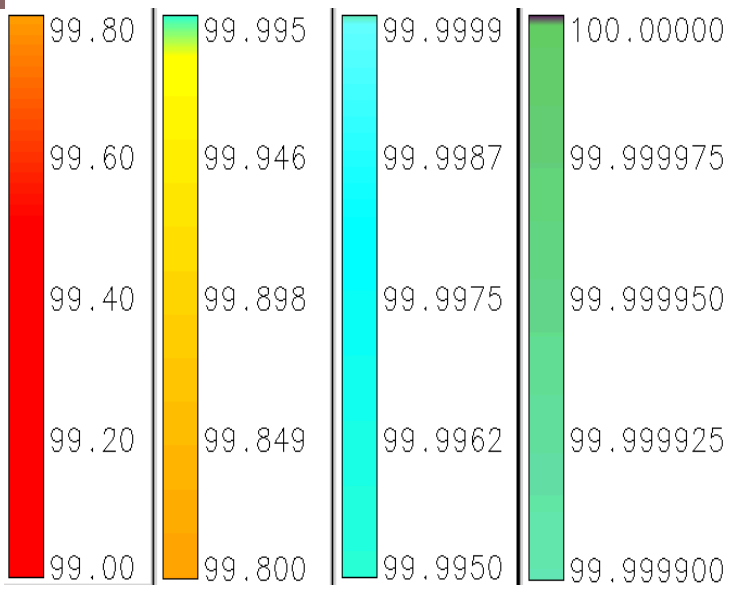
=

Combined Model



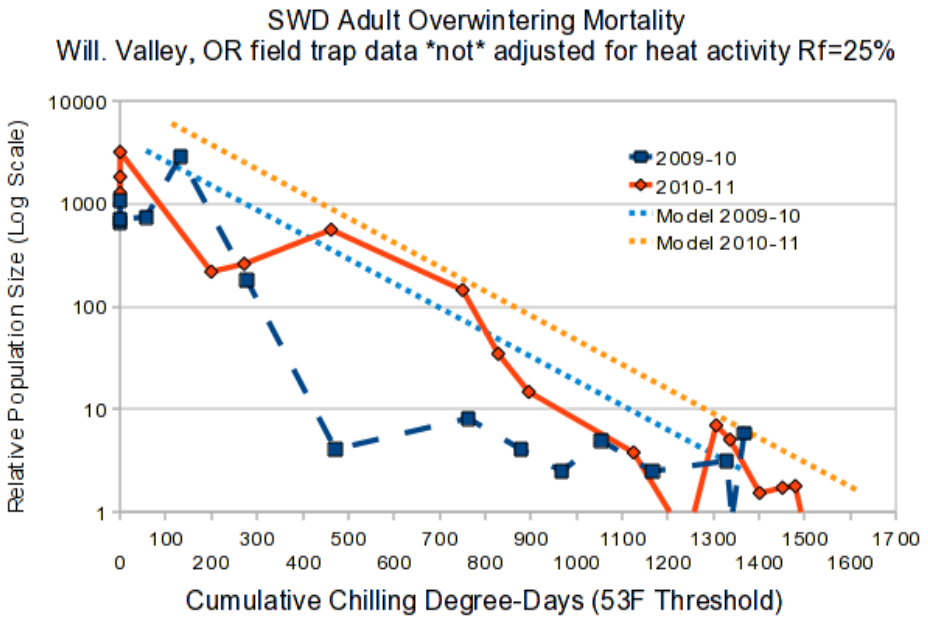
Legend interpretation:

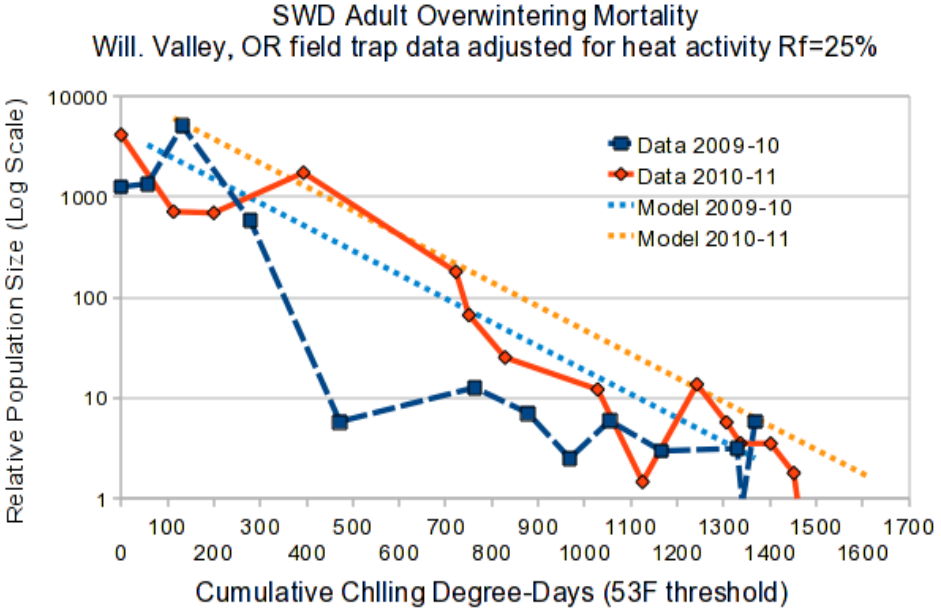
Red areas: 25 to 100 out of 10,000 survive
Yellow areas: 2 to 10 out of 10,000 survive
Blue areas: 1 to 5 out of 1 million survive
Putty green areas: 1 to 10 out of 10 million survive
Darker areas: less than 1 out of 10 million survive

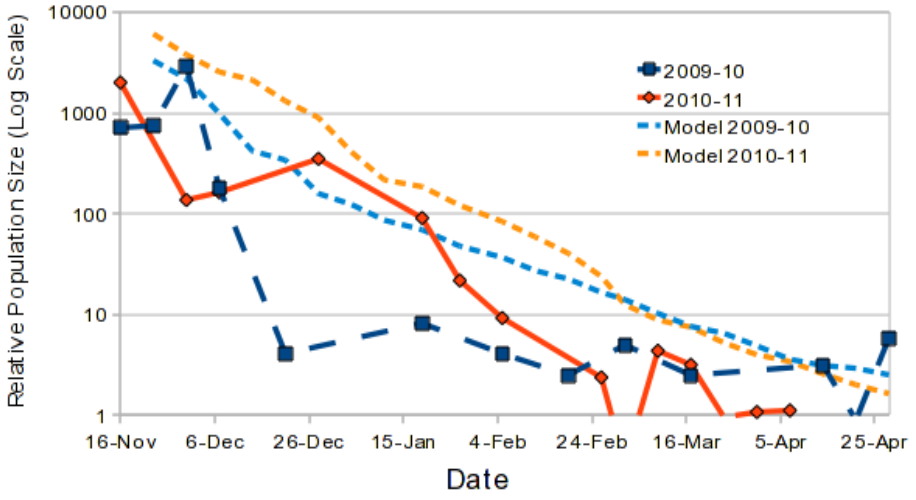


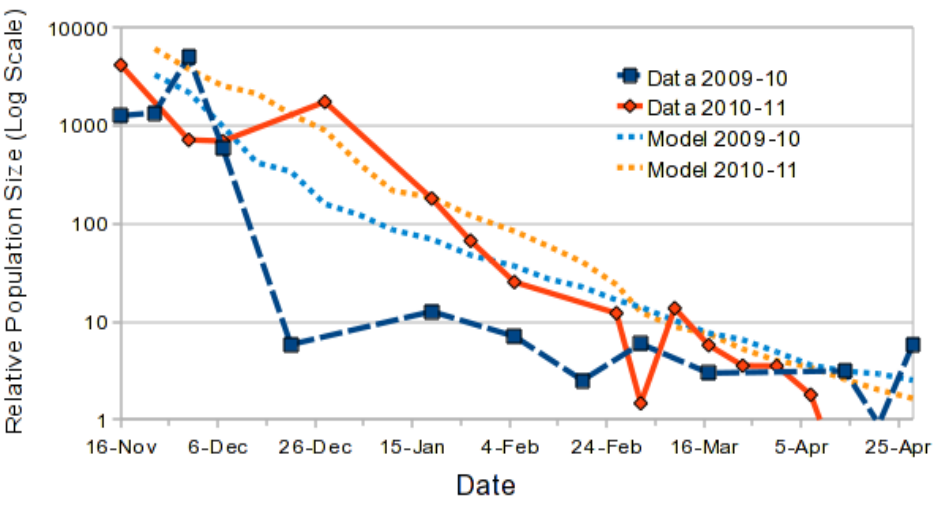
Spotted Wing Drosophila – Overwintering Mortality Model

Evaluation II. Confront model with field data from Dreves et al. 2009-2011
(mid-Willamette Valley trapping data; N=11 to 46 traps)







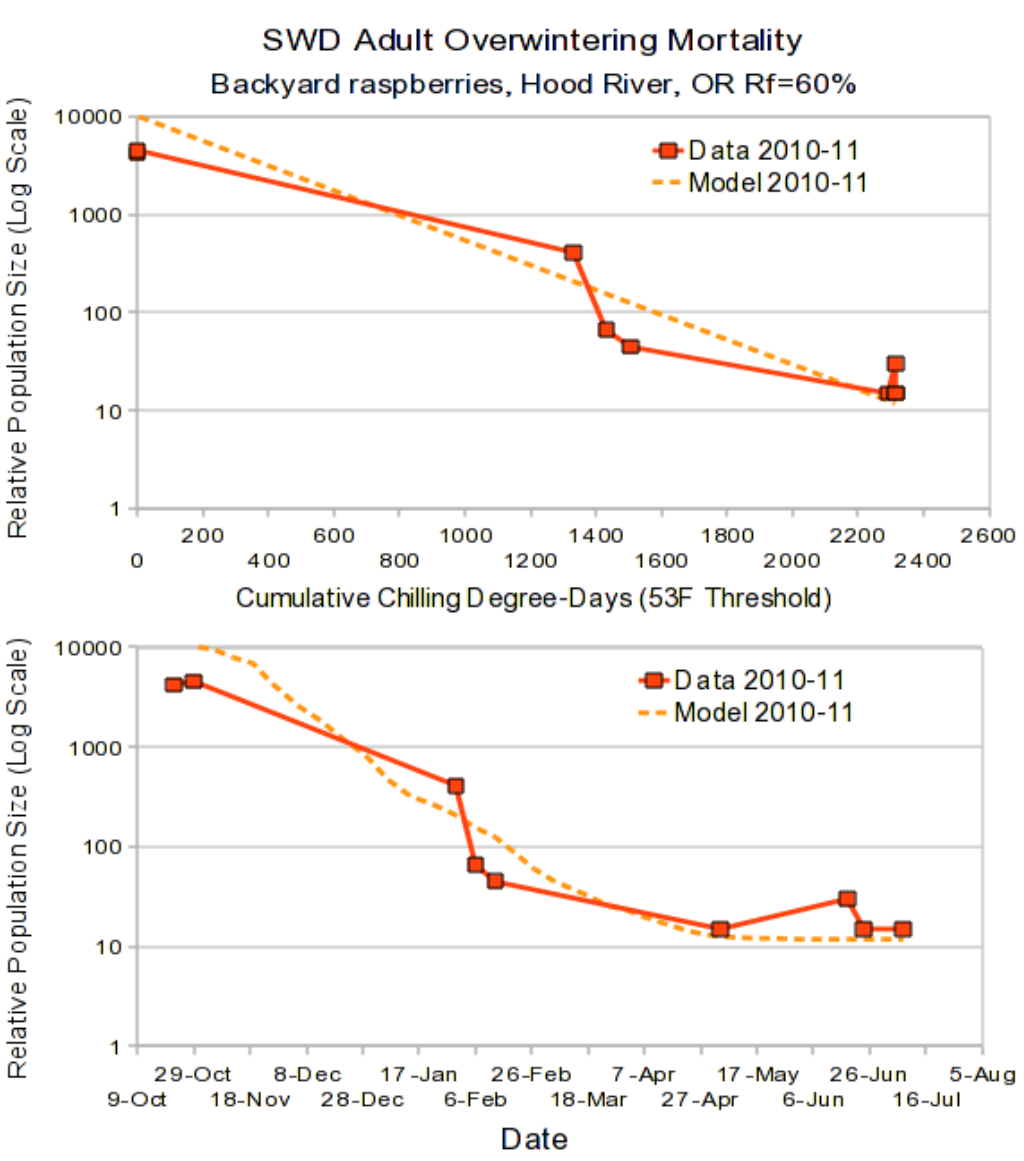


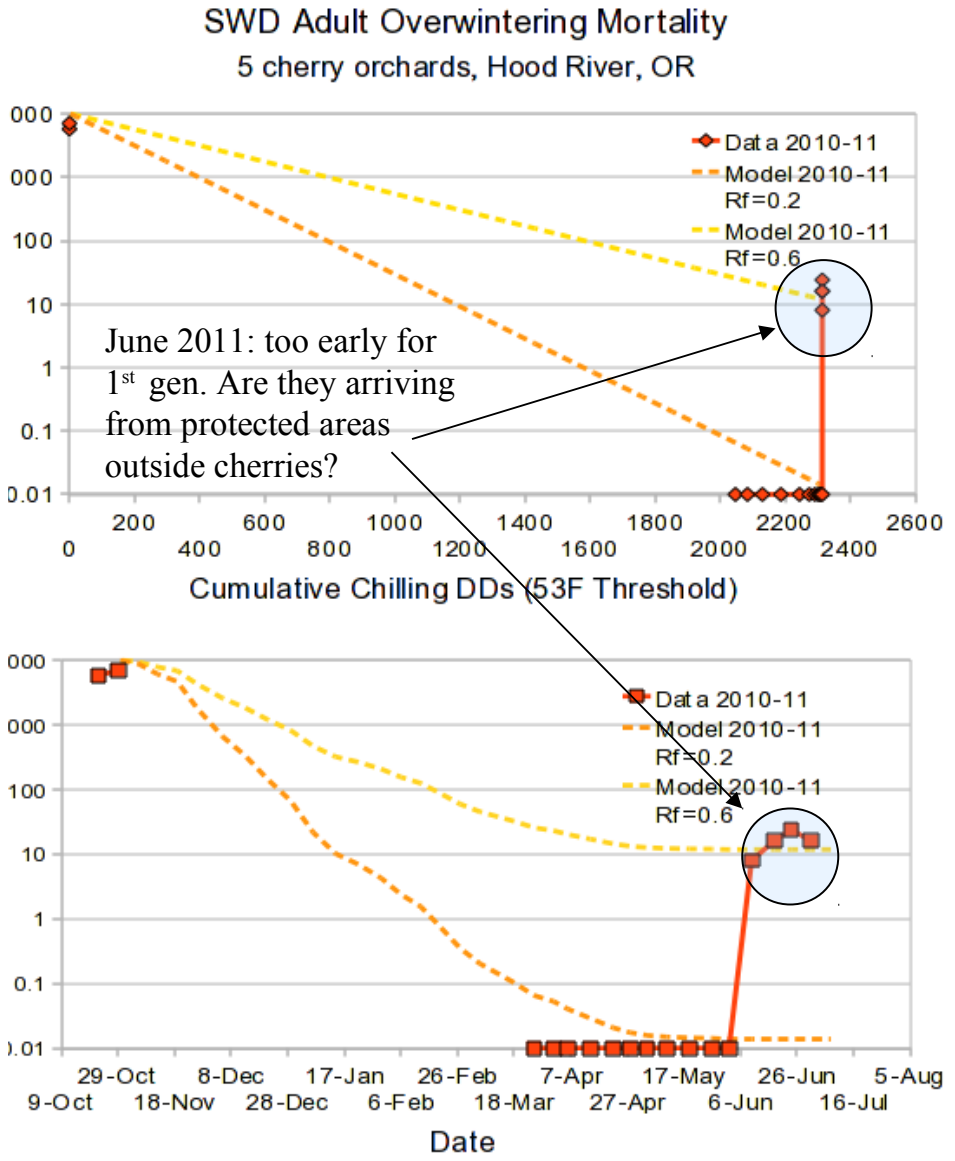
Low counts during cool periods occur because flies are simply not active

Heat units used to standardize trap count data based on daily Tmax > 50F

Spotted Wing Drosophila – Overwintering Mortality Model

Evaluation III. Confront model with field data from Hood River (Shearer and Castagnoli, SWD Monitoring Program) (1 trap in backyard raspberries and 5 traps in cherry orchards)



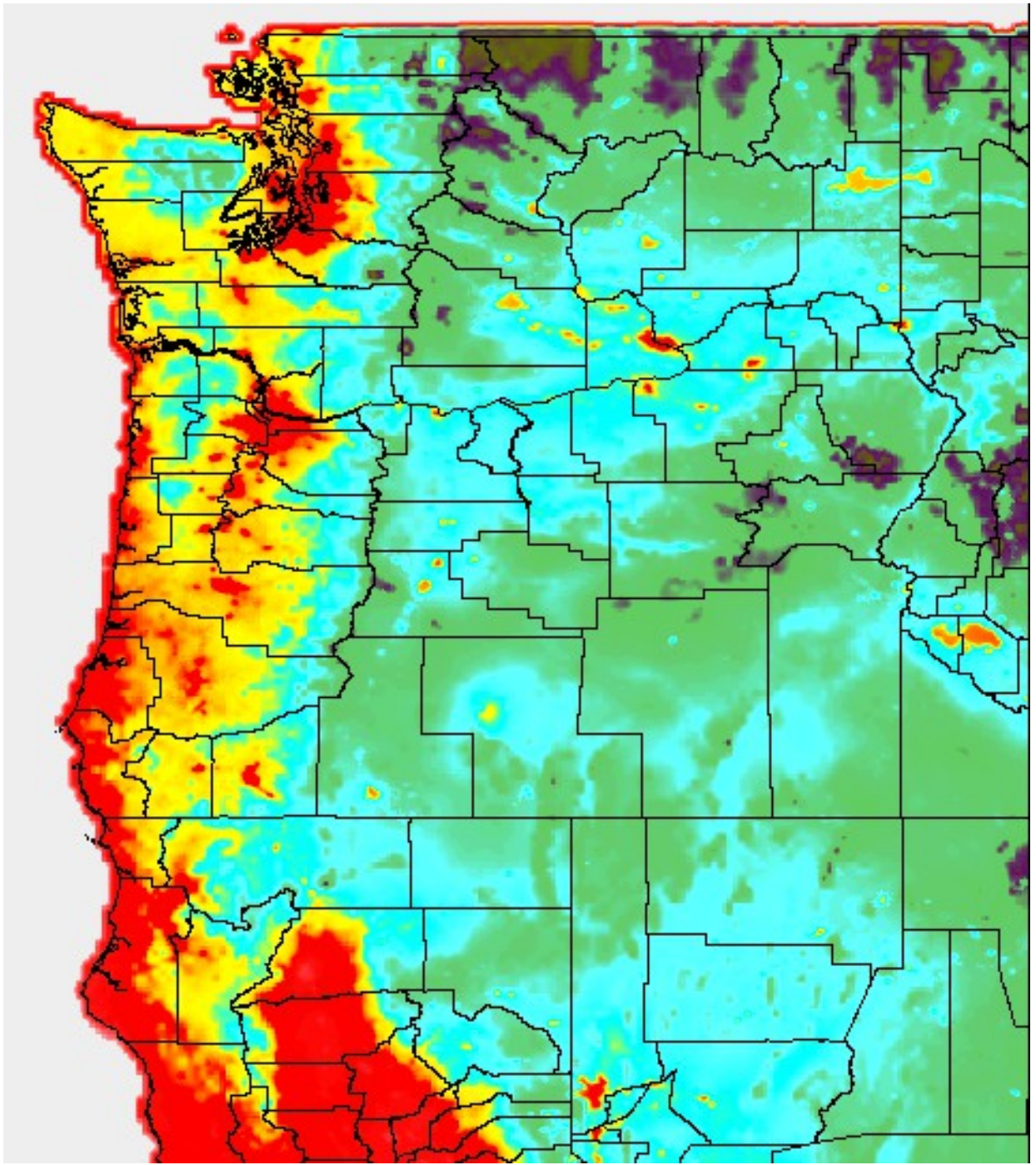


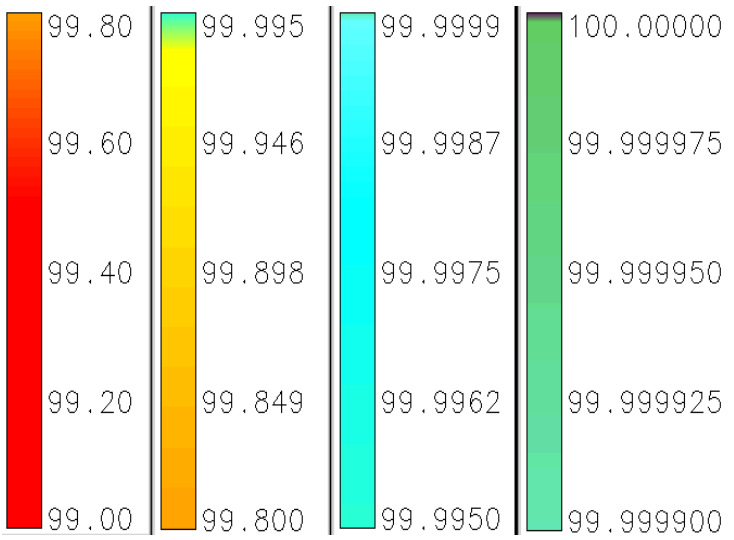
Only one trap out of 40 total in numerous settings produced flies during winter-early spring; it was in a backyard (Left); a few others in cherry had flies only by June (Right)

Spotted Wing Drosophila – Initial model of Overwintering Mortality

Due to Chilling Effects – based on OSU Walton Lab Data

Pacific Northwest focus - shown here with Rf (refuge factor; chilling DDs reduced by 25-60%)





Legend interpretation:

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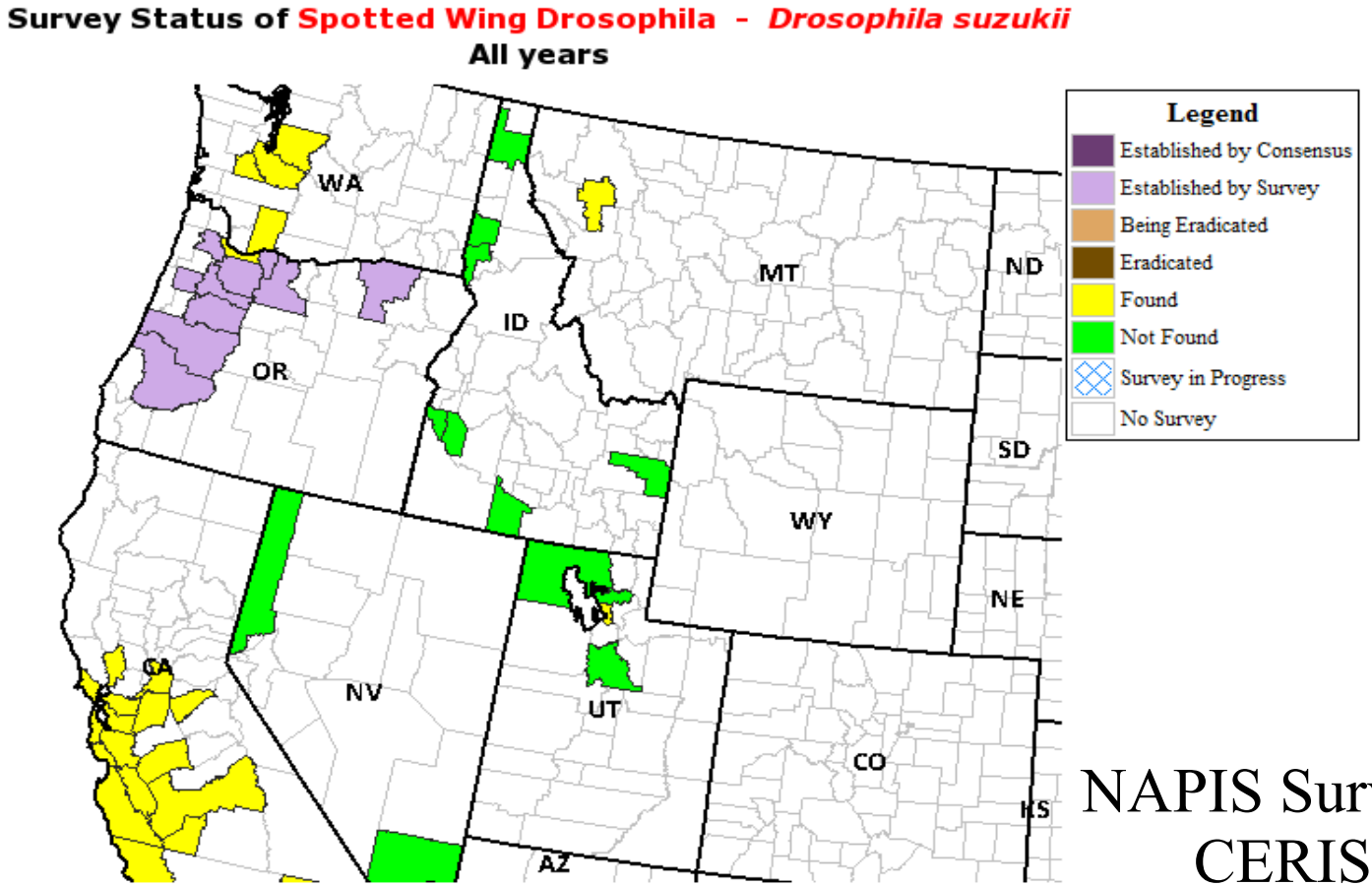
Darker areas: less than 1 out of 10 million survive

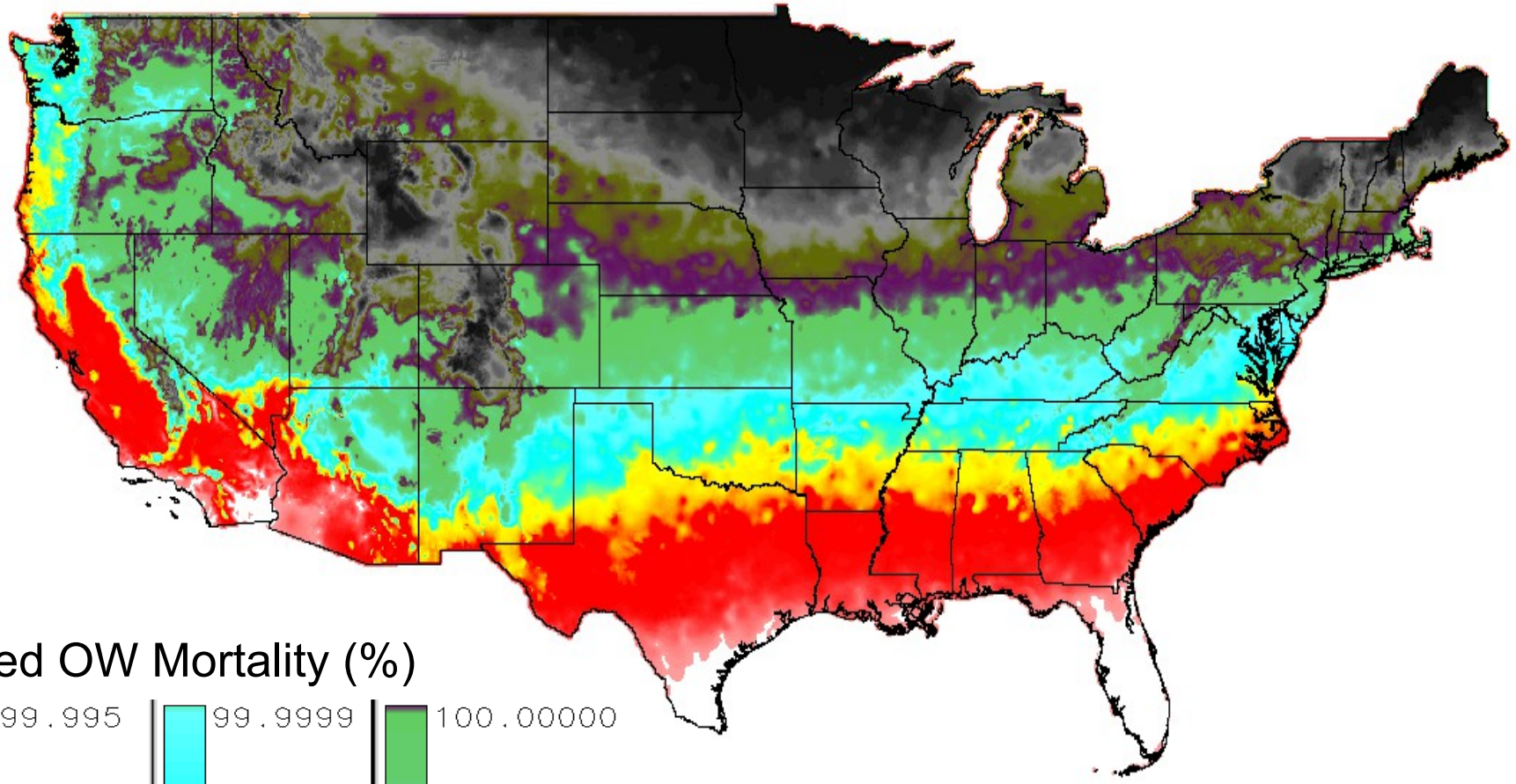
Spotted Wing Drosophila – In coastal areas of PNW overwintering is highly likely to be successful – other regions (Columbia Basin, high elevation mountain valleys) – not as likely



NAPIS Survey Database Map
CERIS Purdue Univ.
Last accessed 12/12/2011

Spotted Wing Drosophila – Initial model of Overwintering Mortality Due to Chilling Effects – based on OSU Walton Lab Data

48 State USA - shown here without Rf (refuge factor)



Estimated OW Mortality (%)

99.80	99.995	99.9999	100.00000
99.60	99.946	99.9987	99.999975
99.40	99.898	99.9975	99.999950
99.20	99.849	99.9962	99.999925
99.00	99.800	99.9950	99.999900

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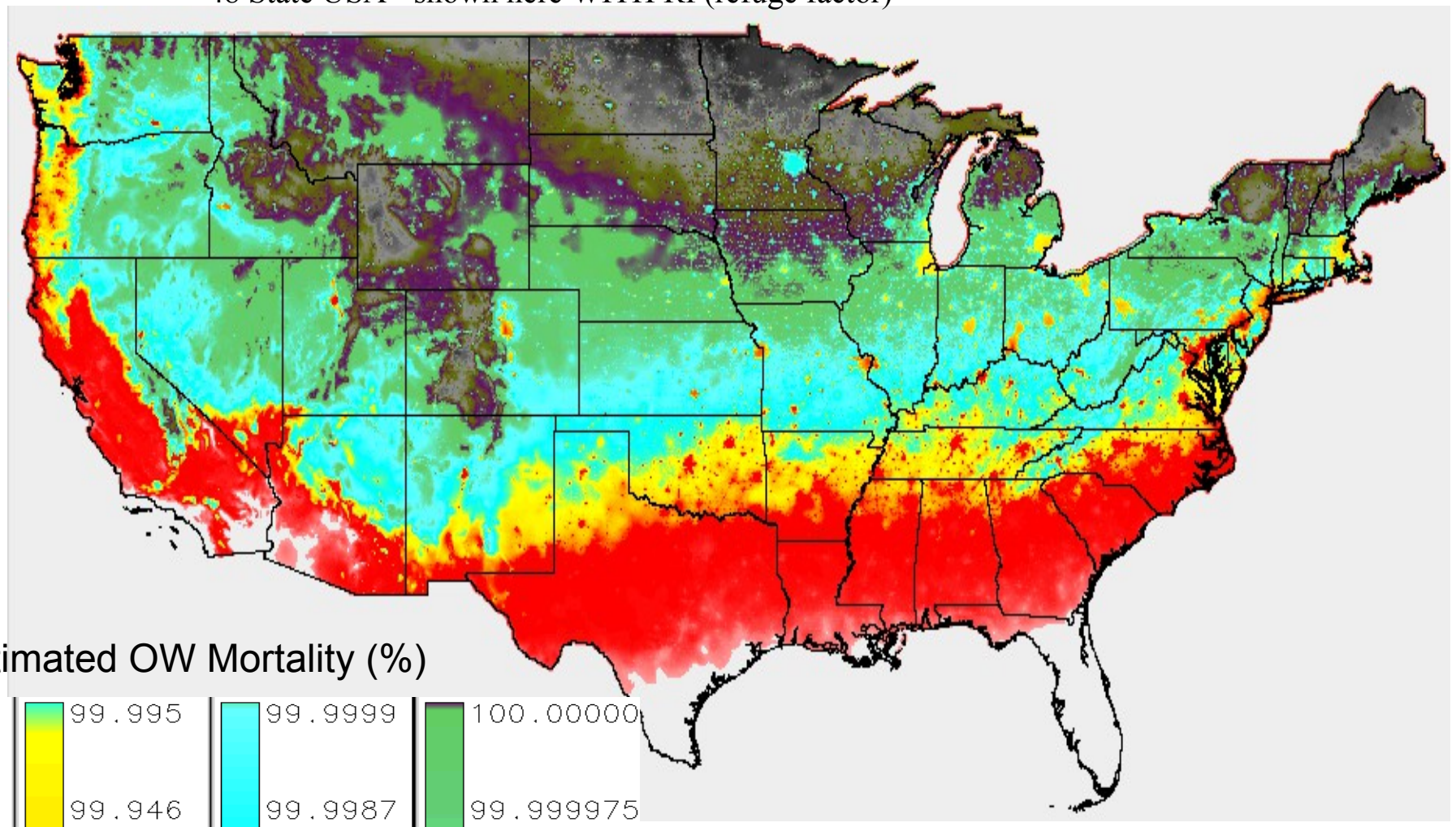

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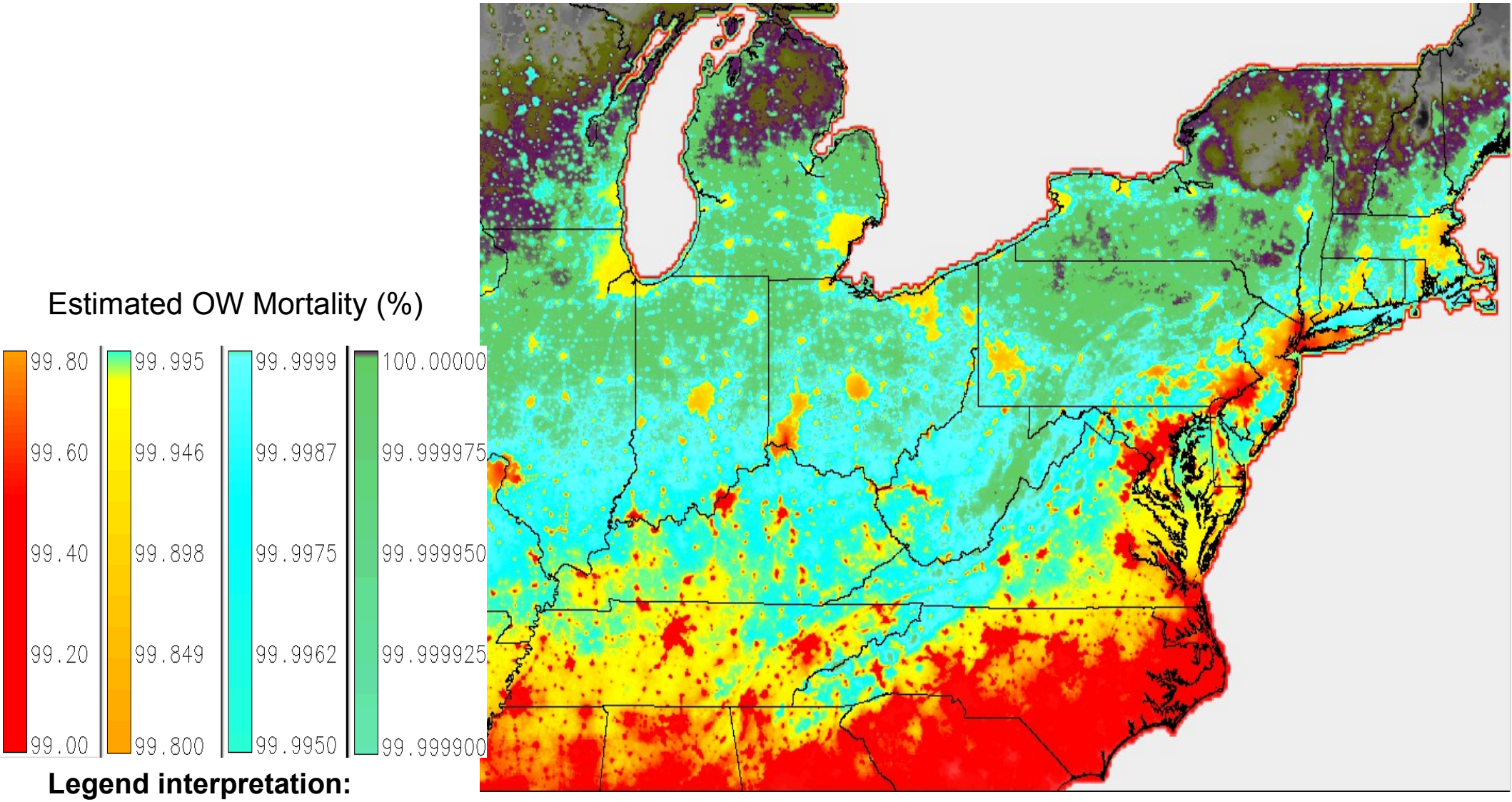
Spotted Wing Drosophila – Initial model of Overwintering Mortality Due to Chilling Effects – based on OSU Walton Lab Data

Wisc. to Maine - shown here with refuge factor (Chilling DDs reduced by 15-60%)



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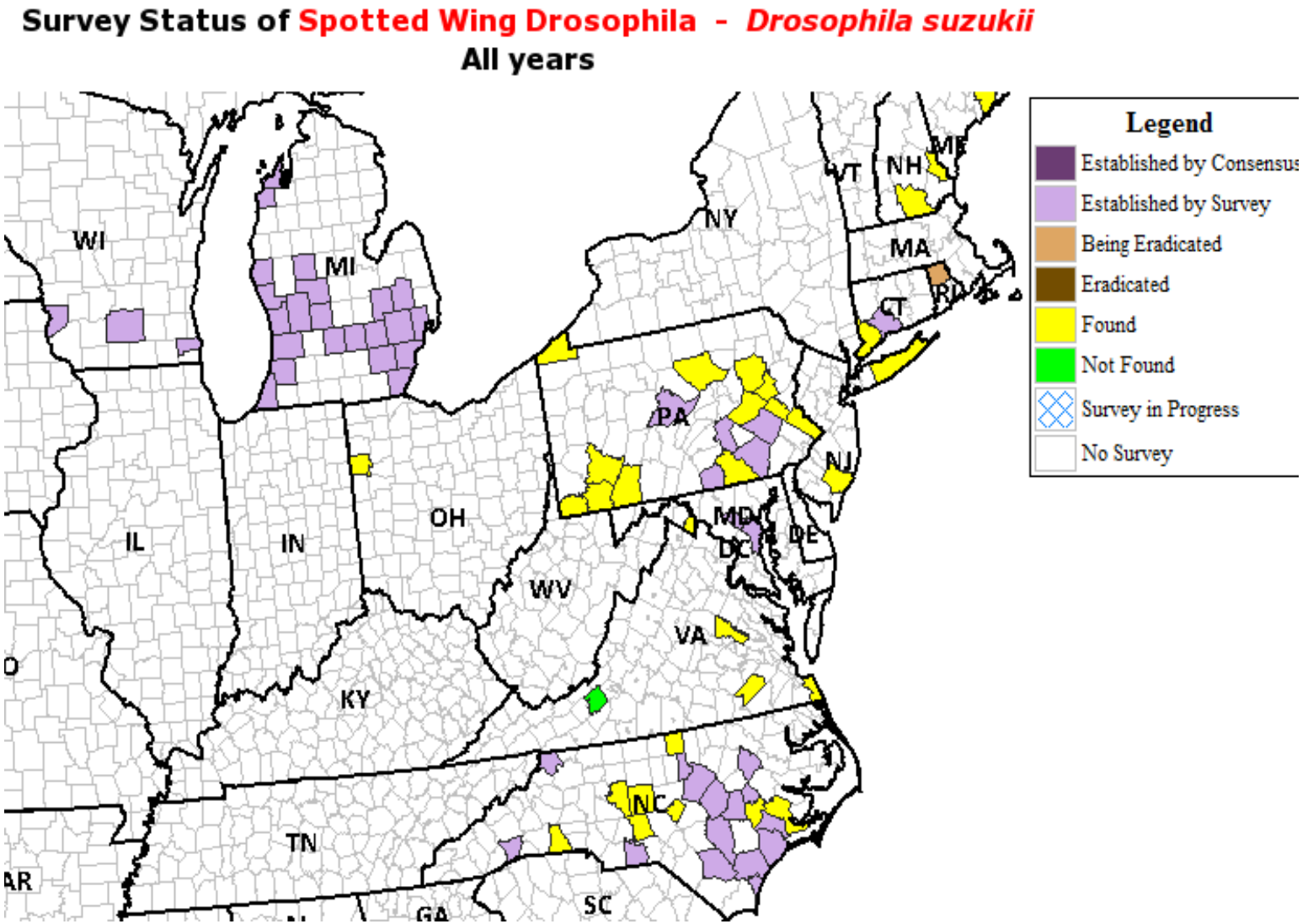
Spotted Wing Drosophila – Will overwintering be successful in states such as Michigan where populations have been recently reported? Will it be due in part to urban influences? Insulation under snowcover?



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Spotted Wing Drosophila – Overwintering Mortality

Data to be incorporated (pending)

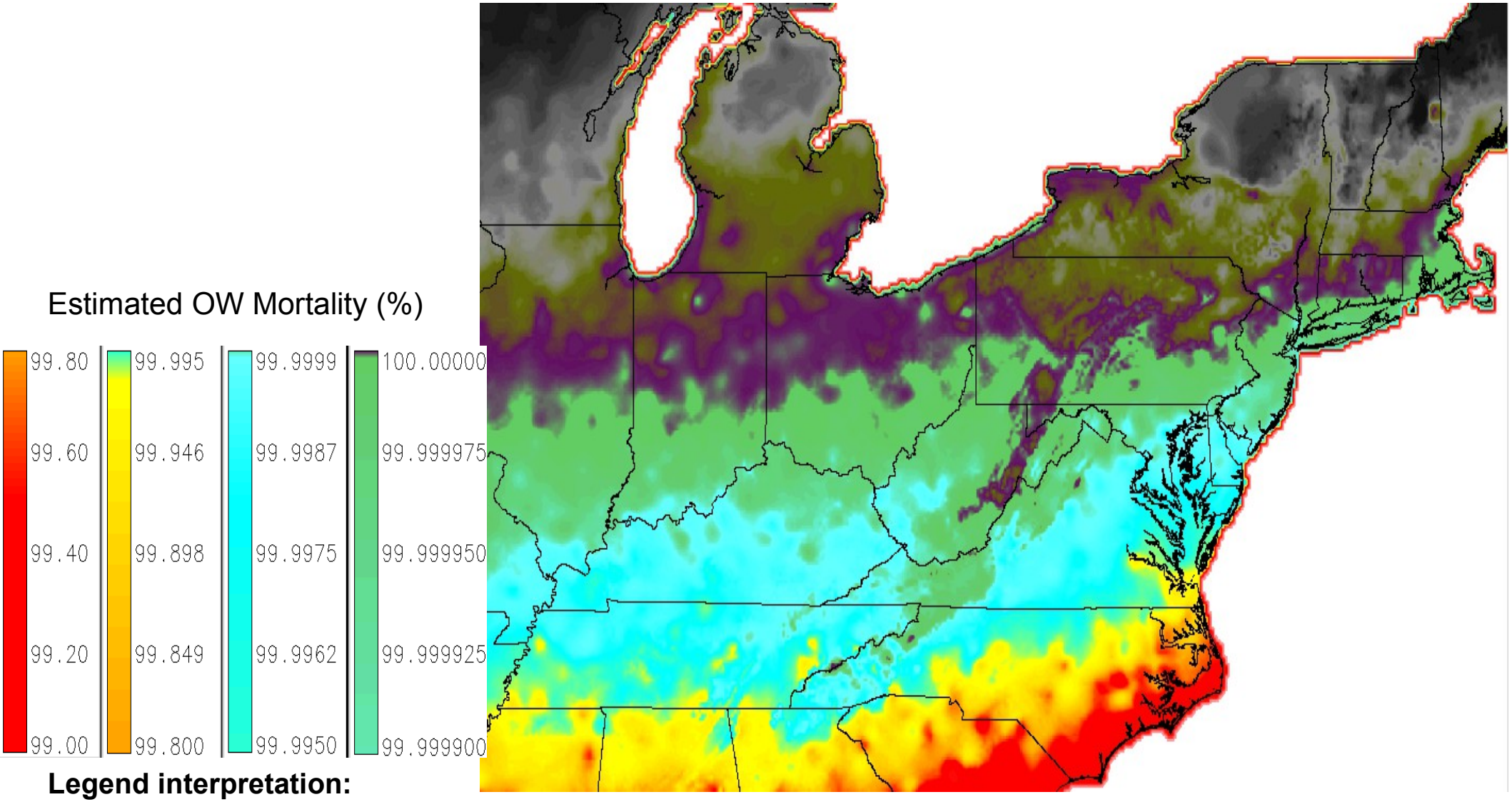
- Dreves et al: Field cage studies – overwintering condos – vs. freezing and chilling hours in protected and semiprotected environments

- Walton Lab: Cage studies in a variety of situations

- Field data: Medford & N. Willamette Valley, other locations especially for climates that favor SOME survival in unprotected habitats.

Spotted Wing Drosophila – Initial model of Overwintering Mortality Due to Chilling Effects – based on OSU Walton Lab Data

Wisc. to Maine - shown here without refuge factor



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Spotted Wing Drosophila – Overwintering Mortality

Assumptions and factors used in developing a model for CONUS USA

-Populations of D. suzukii taken from cool vs. warm temperate climates of Japan were found to have no difference in cold tolerance. Kimura 2004 Oecologia. This helps justify building a model meant to be robust for all of N. America.

-D. suzukii is in the same subgenus and species group as D. melanogaster and they are considered to be “closely related”. D. melanogaster in particular was shown to be increasingly abundant and diverse in more urban environments. Avondet et al. 2003 Environ. Entomol. Does D. suzukii share this trait to the same or a lesser Extent at least in regard to overwintering success?

Spotted Wing Drosophila – Overwintering Mortality

Areas where model improvements/more research are needed:

-Better understanding of specific SWD adult behaviors: temperature (and perhaps solar radiation) thresholds for feeding, movement to traps, movement between habitats, energetics of temperature vs. burning of fat reserves.

-A better model to standardize trap catch data for daily temperatures would be helpful.

-Genetic variability: are there traits to disperse out of fields to overwinter in dense vegetation, in addition to traits to seek out urban heated refuges?

-Should continued wintertime adult recruitment from larval and pupal stages be considered for regions with milder climates?

-Refuge factor (Rf) improvements: compare other data sources to “stable lights at night” to estimate landscape and human-influenced effects on overwintering survival. Candidates include landcover (30m raster) data, population densities (vector data), riparian network (vector) data, EPA ecoregion data, others?

-Study OW success for various habitats: cull piles, hoop houses, field hegerows, thick riparian vegetation, old vs. new bramble thickets, backyard compost piles?

Spotted Wing Drosophila – Population Dynamics

Overwintering flies generally not trapped at temperatures below 45-50 degrees F

Weekly trapping data – adjusted for adult activity levels using simple cumulative heat units: AAHUs = Tmax-50F