Insects and Pathogens in Warmer, Urban Forests

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Value of Urban Plants

Psychological and Aesthetic Values: difficult to quantify

Historic Values: Plants provide important symbolic links with the past. "Witness tree." Gettysburg National Battlefield = many trees still have bullets lodged in them from US Civil War; Anne Frank horse-chestnut tree (*Aesculus hippocastanum*).

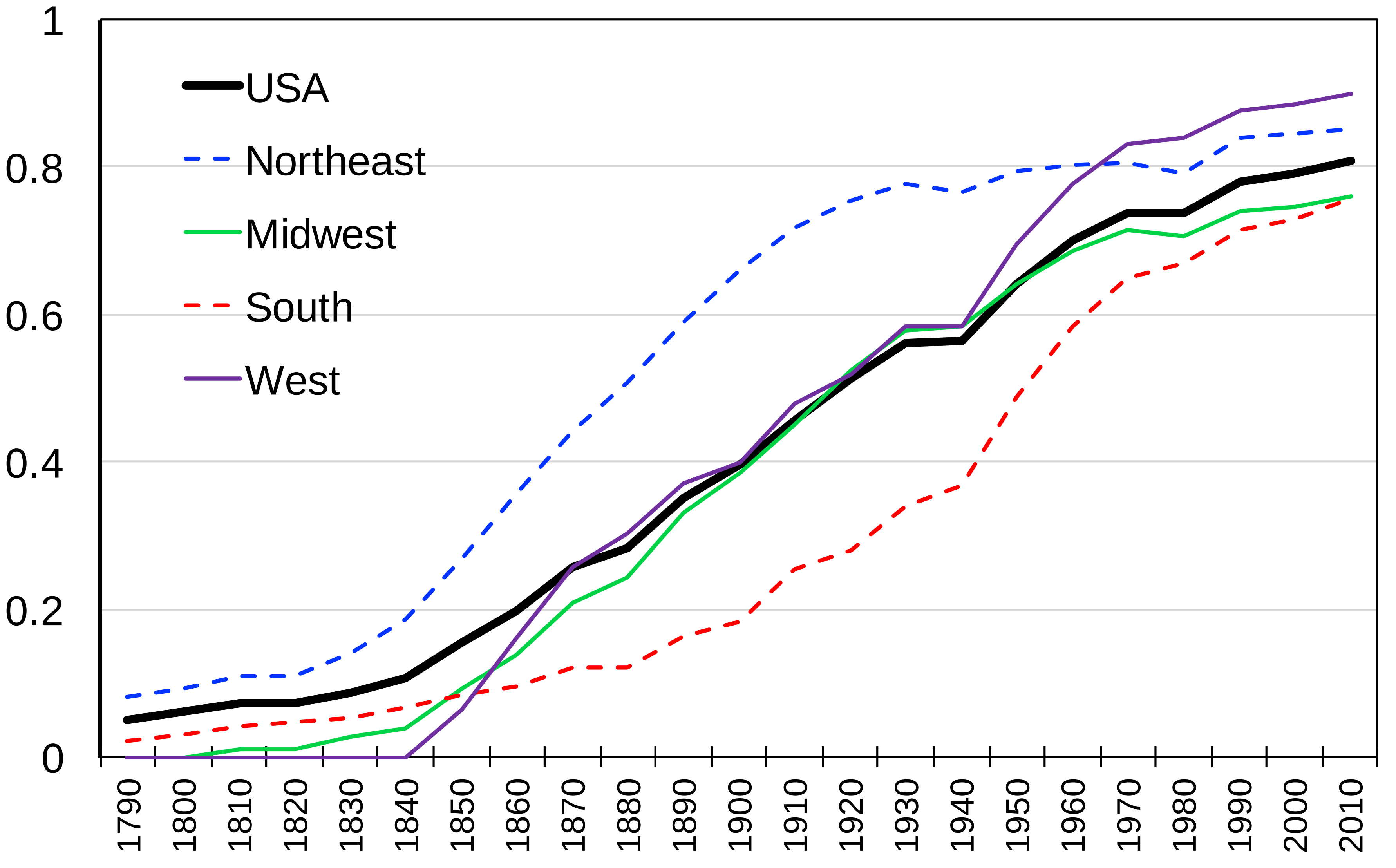
Air pollution control: Plants remove solid and gaseous particulates from the air. Studies show that trees reduced particulates 9-13%, while the amount of dust reaching the ground was 27-42% less under a stand of trees than in an open area. Also, on average an acre of forest can absorb up to 26 pounds of CO_2, which is equal to the amount of CO_2 produced by driving a car 26,000 miles.

Water runoff: For every 5% of tree cover added to a community, storm water runoff is reduced by approximately 2%.

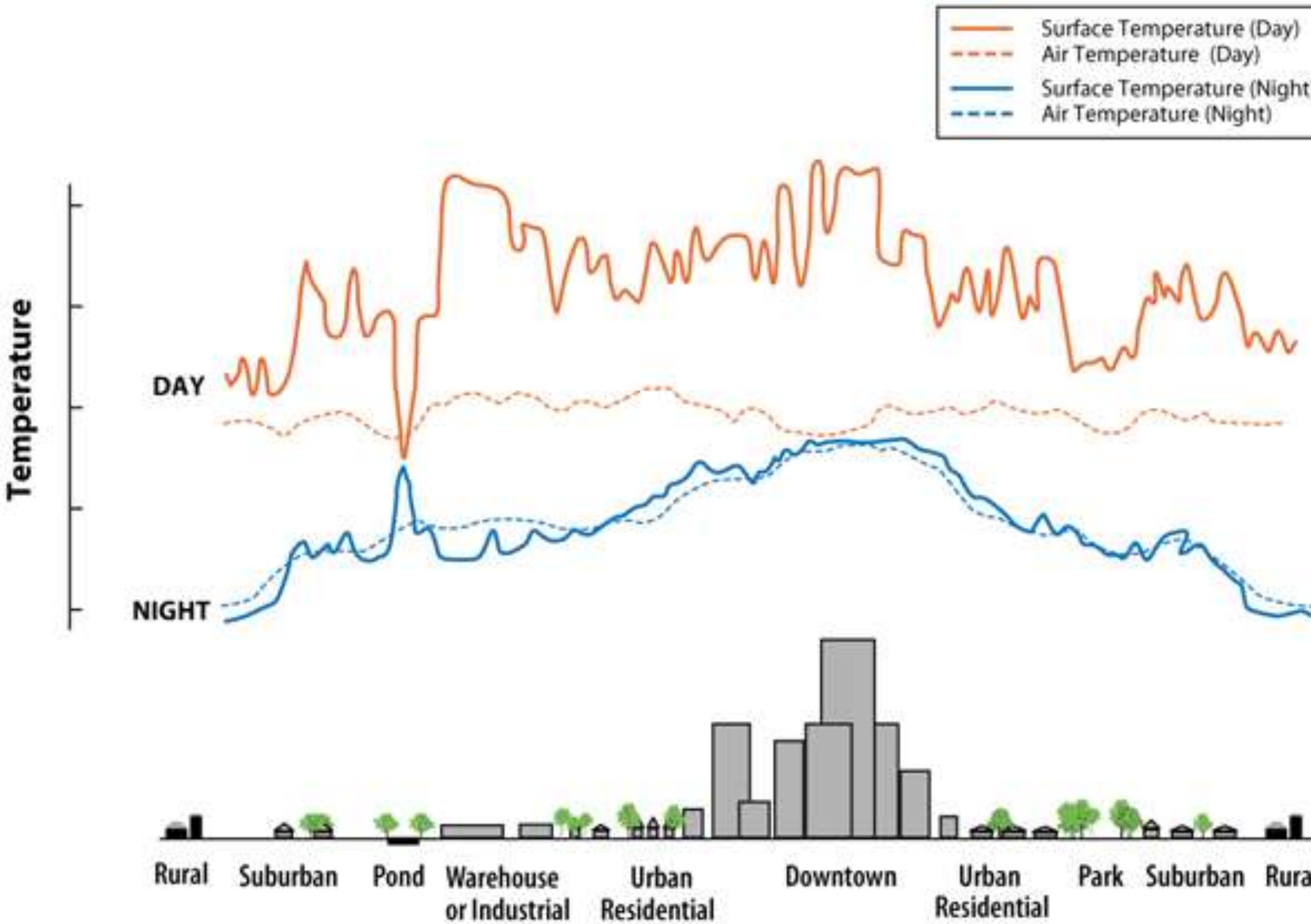
Noise pollution: Plants can reduce traffic noise by up to 50%.

Monetary Values: Studies show that real estate agents and home buyers assign between 10-23 percent of the value of a residence to the plants on the property. Also, plant cover can reduce cooling costs by up to 58%.

Urban population as a proportion of the U.S. population, 1790-2010

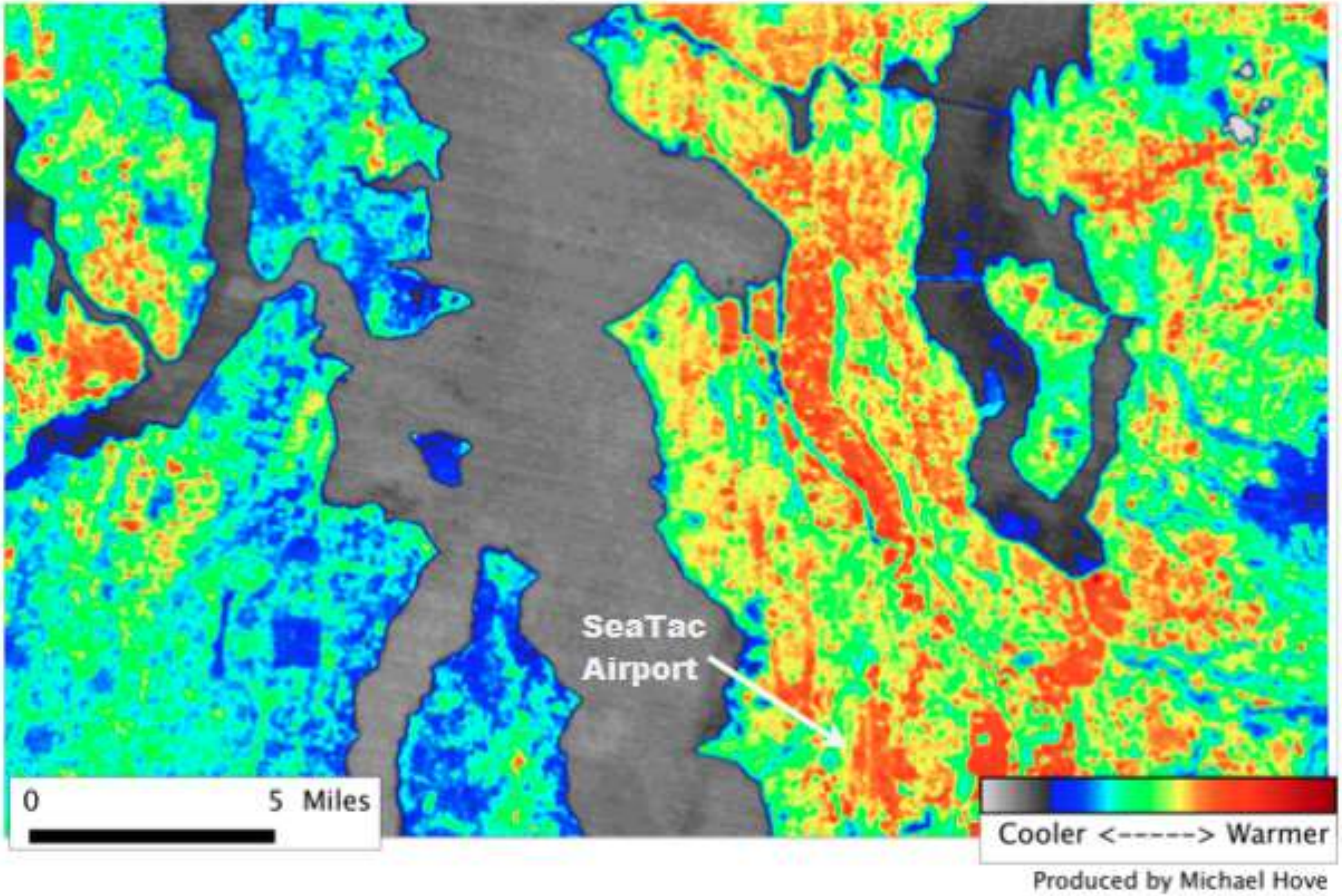


U.S. Census Data



U.S. EPA (http://www.epa.gov/heatisld/about/index.htm)

Landsat of Seattle, WA on May 8. 2010 (Thermal Band-6)



What possibilities might we expect in the Urban Forest?

(1) Increased plant stress/decreased plant defenses → increased insect and pathogen fitness

(2) Biological control services may be reduced in urban environments, thereby removing an important check on pest populations

(3) Warmer urban landscapes decrease generation time (i.e., faster pest reproduction, more generations per year)

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The Role of Drought in Outbreaks of Plant-eating Insects

Drought's physiological effects on plants can predict its influence on insect populations

William J. Mattson and Robert A. Haack

(1987) BioScience 37:110

Substantial evidence indicates that drought stress promotes outbreaks of plant-eating (phytophagous) fungi and insects. Observations and experiments show that colonization success and prevalence of such fungi as root and stalk rots, stem cankers, and sometimes wilts and foliar diseases are much higher on water-stressed plants than on normal plants (Schoeneweiss 1986). The evidence associating insects and drought is more circumstantial, consisting largely of observations that outbreaks around the world of such insects as bark beetles and leaf feeders

We present holistic con to explain may insect

here a more holis to better explai provoke insect guments by Scho plant susceptibi

Volume 67, No. 3 *THE QUARTERLY REVIEW OF BIOLOGY* September 1992

THE DILEMMA OF PLANTS: TO GROW OR DEFEND

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ABSTRACT

Physiological and ecological constraints play key roles in the evolution of plant growth patterns, especially in relation to defenses against herbivores. Phenotypic and life history theories are unified within the growth-differentiation balance (GDB) framework, forming an integrated system of theories explaining and predicting patterns of plant defense and competitive interactions in ecological and evolutionary time.

Constitutive Plant Defenses

Bark

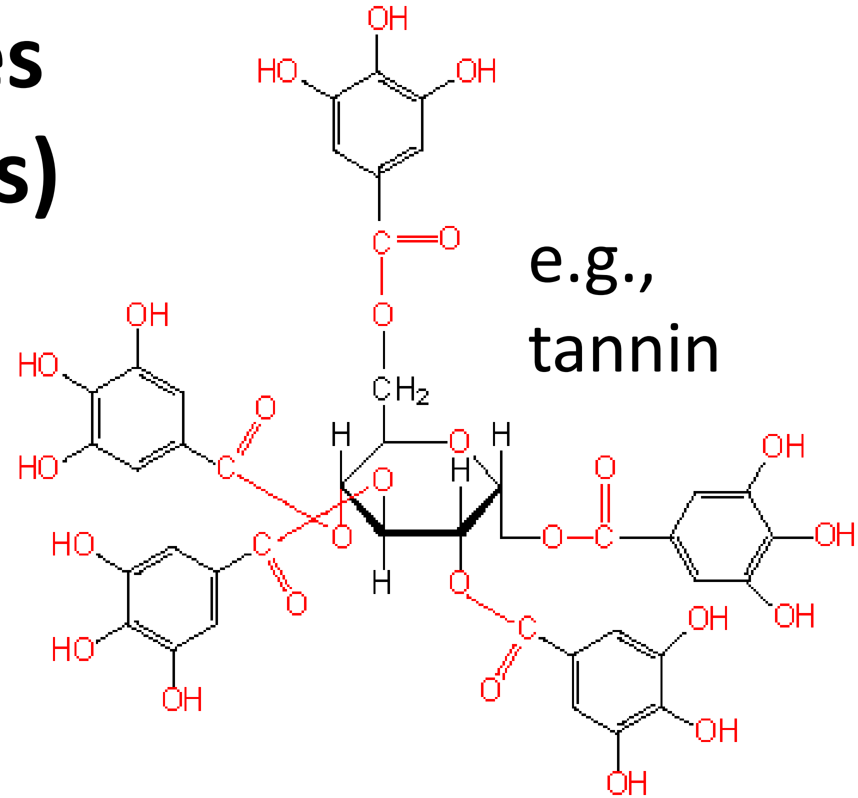
Acacia spp. thorns

Leaf waxy cuticle

Trichomes

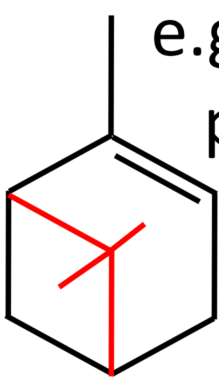
Induced Plant Defenses (secondary metabolites)

In response to herbivore or pathogen attack, plants can produce toxic compounds against the insect, or antimicrobial chemicals, proteins, and enzymes against the pathogen

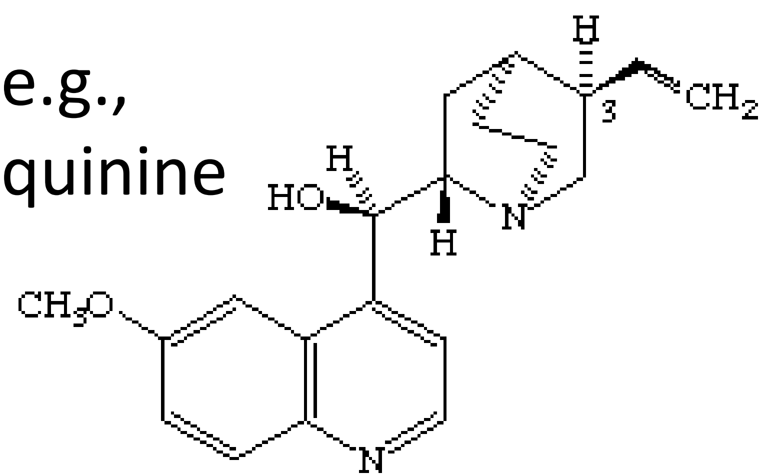


e.g., tannin

e.g., alpha pinene



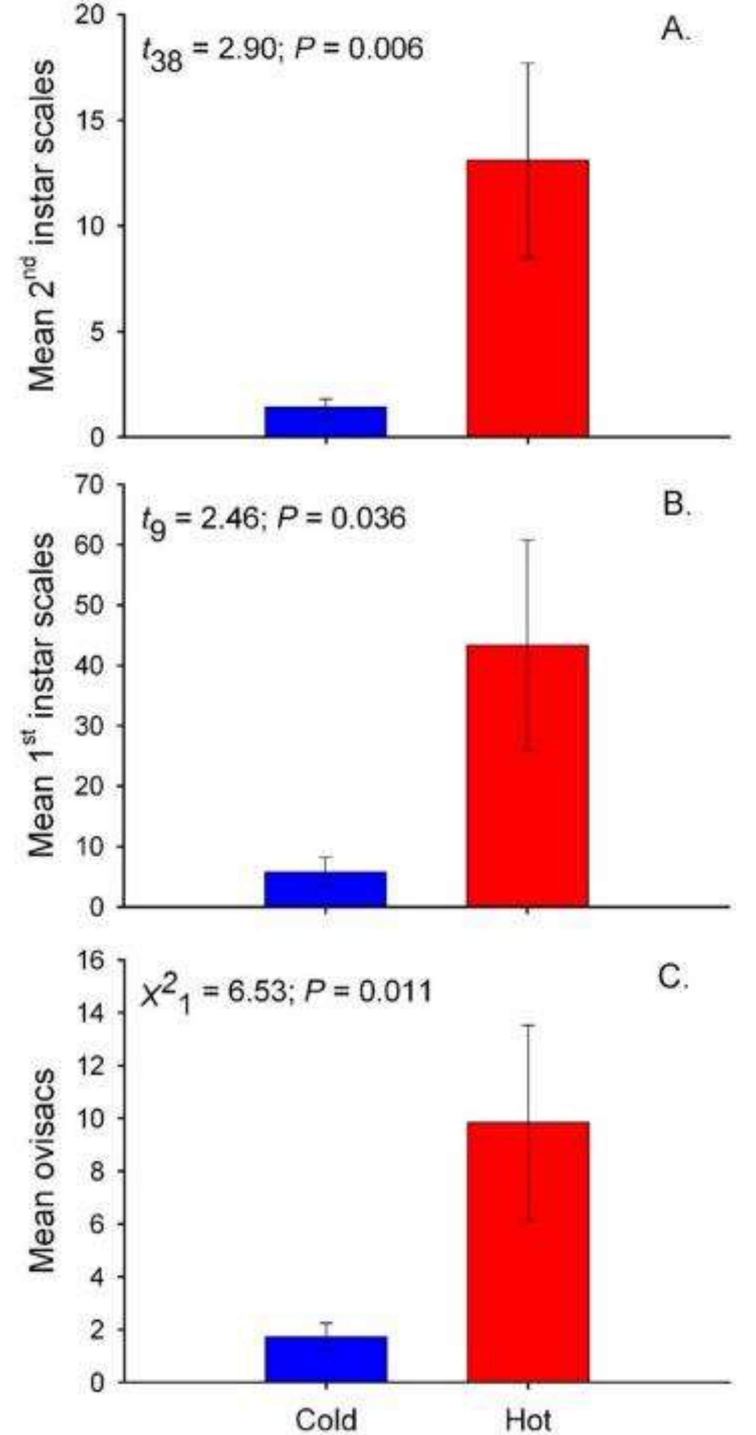
e.g., quinine



Abundance of a scale insect, *Parthenolecanium quercifex*, was significantly greater on willow oak trees in the hottest parts of Raleigh, NC, relative to the cooler areas of the city.

Rates of parasitism of natural enemies were the same at both the hot and cold sites.

Mechanism was proposed to be reduced plant defensive abilities due to increase plant stress.



Meineke et al. (2013) *PLoS One* 8:e59687

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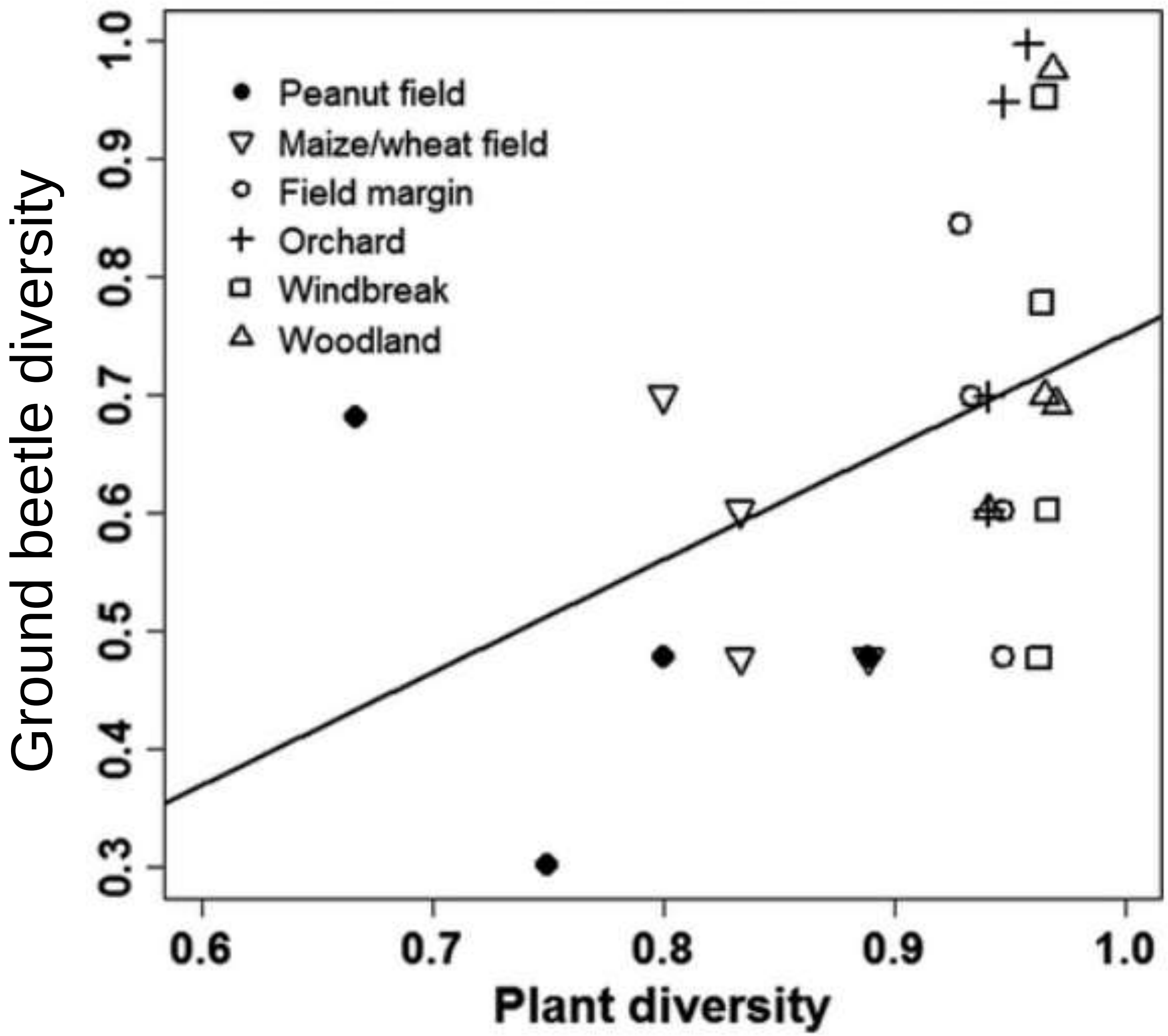
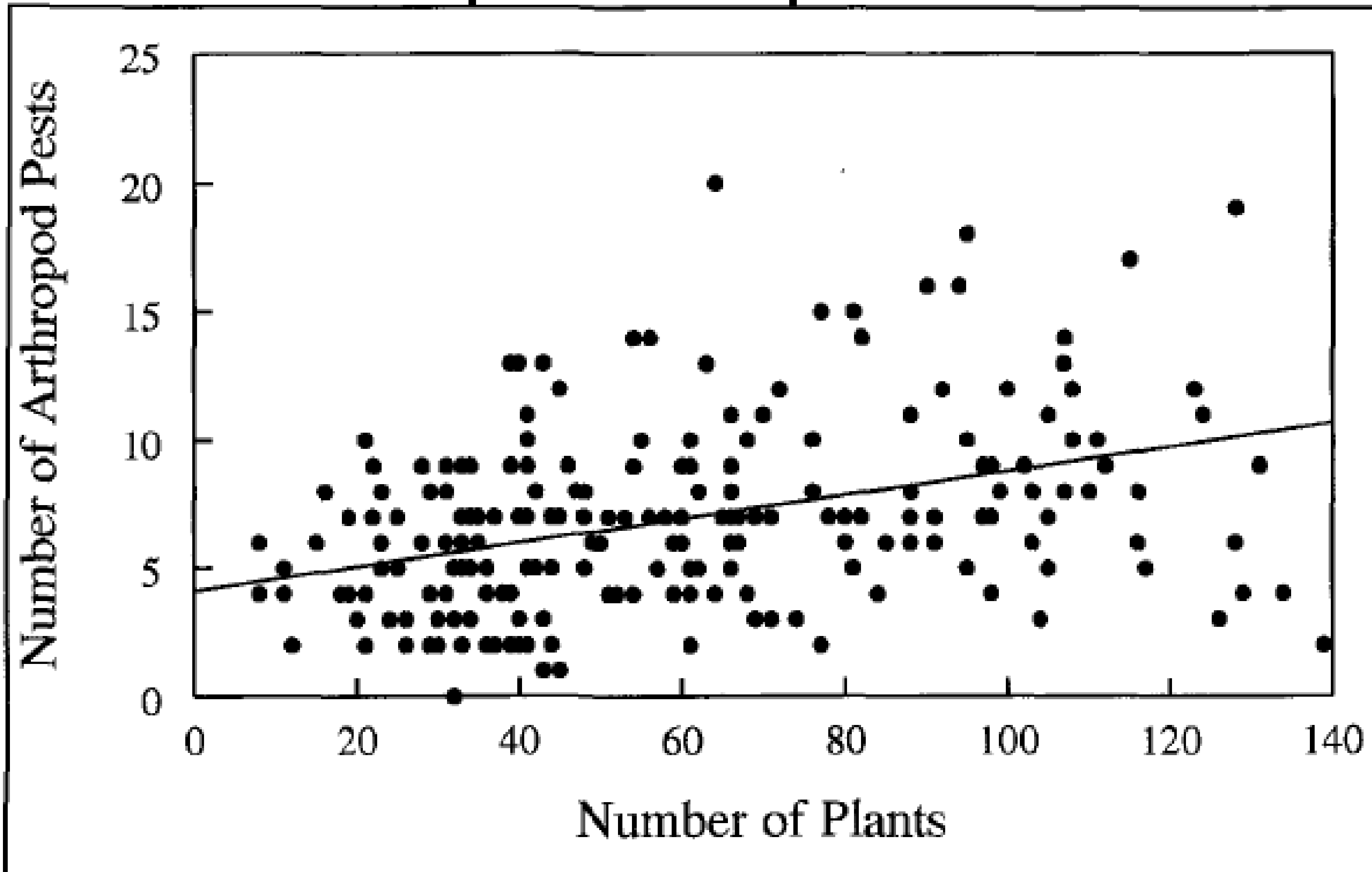
Greater plant diversity tends to result in greater insect diversity



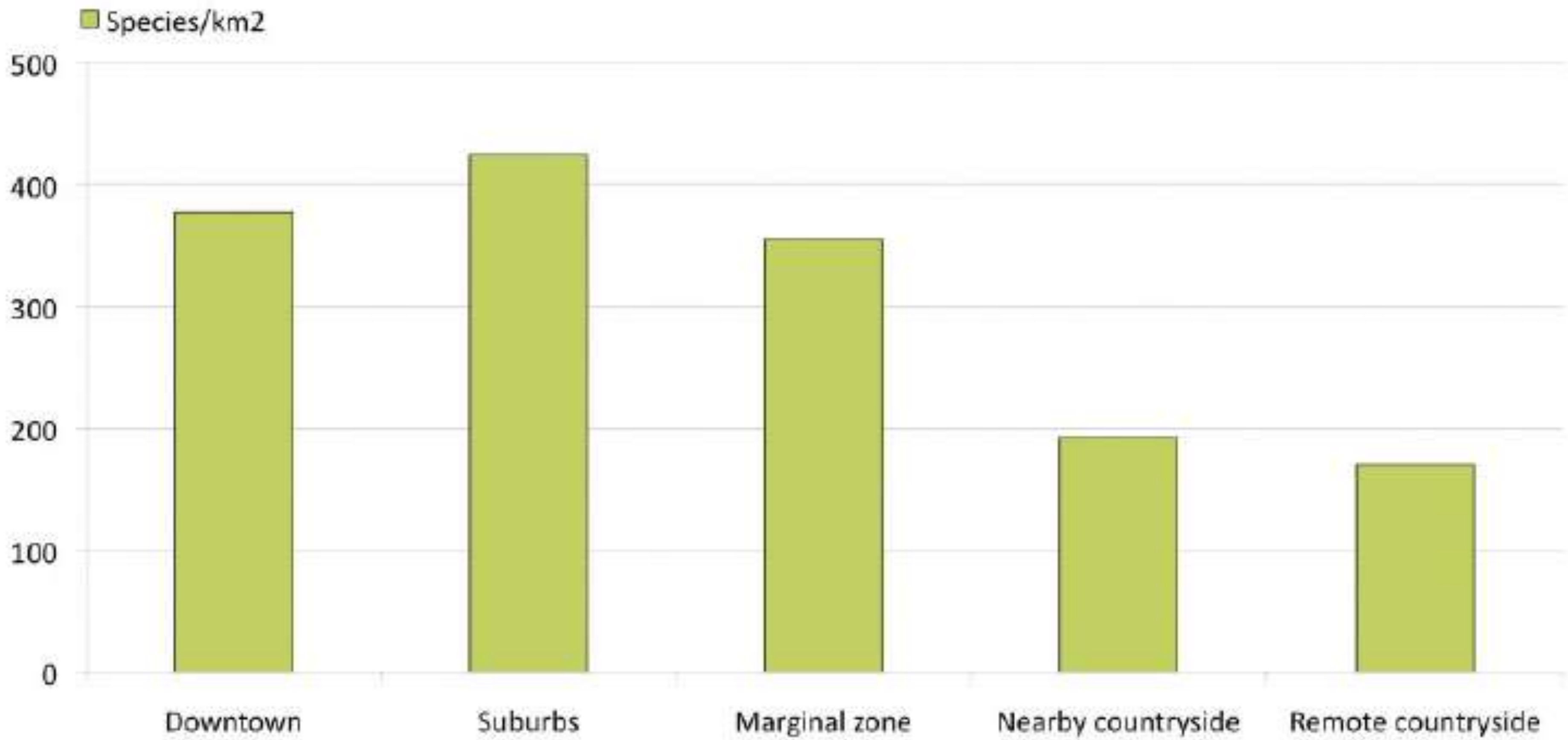
Liu et al. (2015)
Insect Conserv & Diversity 8:163

BUT, greater plant diversity can also increase plant insect pests



Raupp et al. (2001) *J. Arboriculture* 27:222

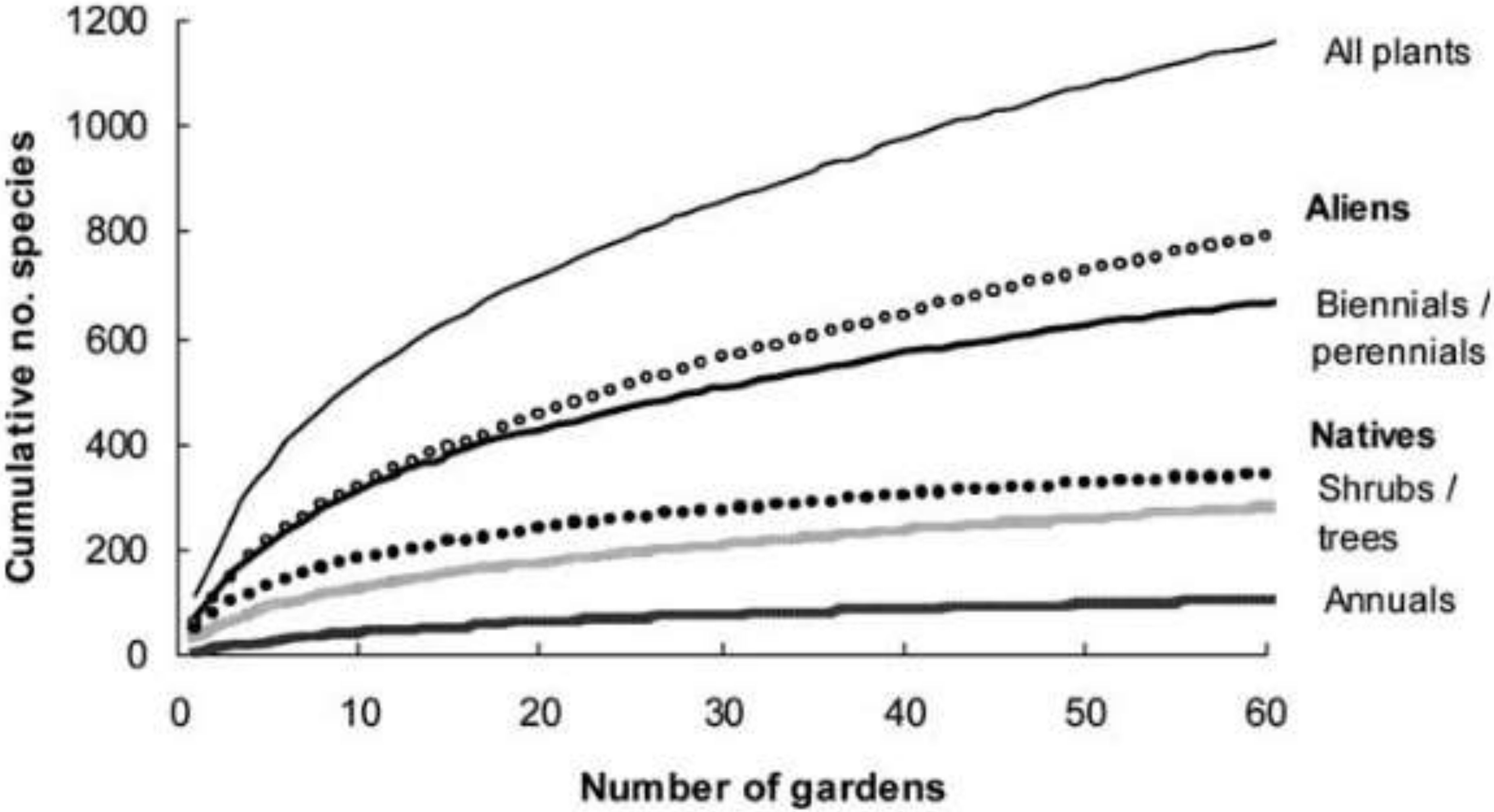
Plant diversity in urban landscapes: not always reduced



Number of plant species/km^2 in and outside of Berlin, Germany

Reichholf (2007)

Composition and richness of the vascular plant flora in Urban domestic gardens in Sheffield, UK



Smith et al. (2005) *Biological Conservation* 129:312

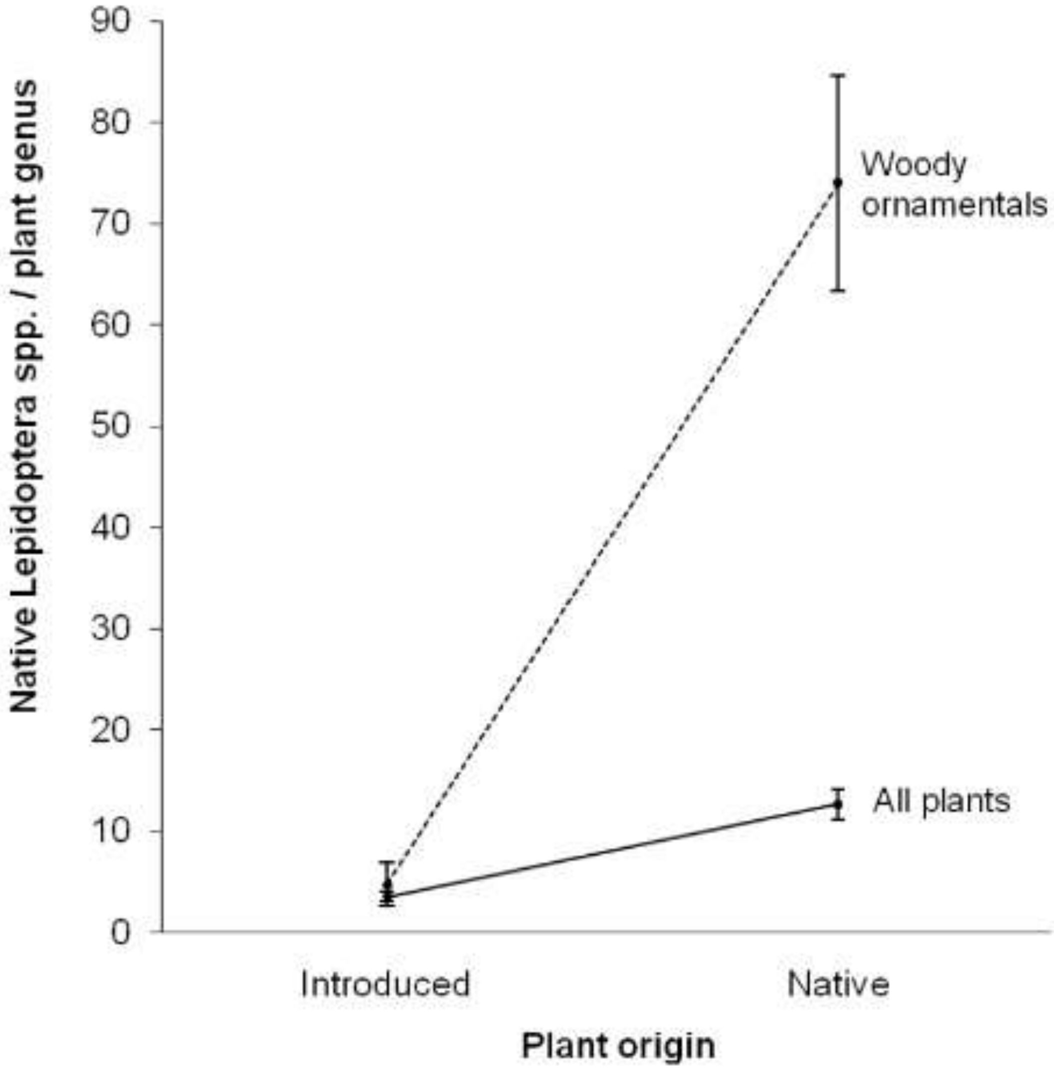


Figure 1. Number of native Lepidoptera species recorded in the mid-Atlantic states (U.S.A.) on all plant genera and on native and introduced woody plant genera used as ornamentals (bars are standard errors).

Not all plants are equal: native plants support greater caterpillar communities, which serve as important components in food webs, such as a food source , for species that provide biocontrol services

Tallamy & Shropshire (2009)
Conservation Biology
23:941-947

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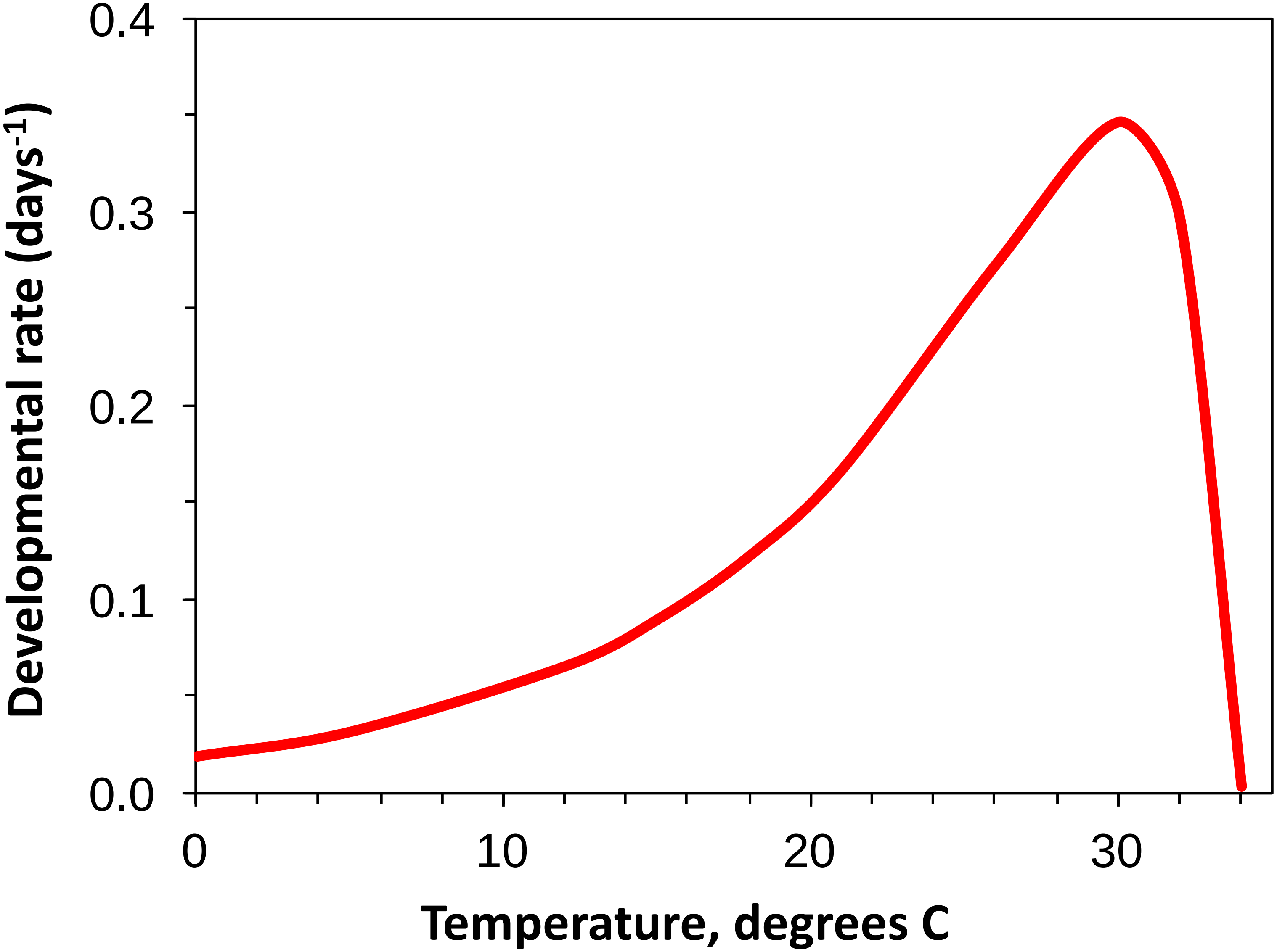
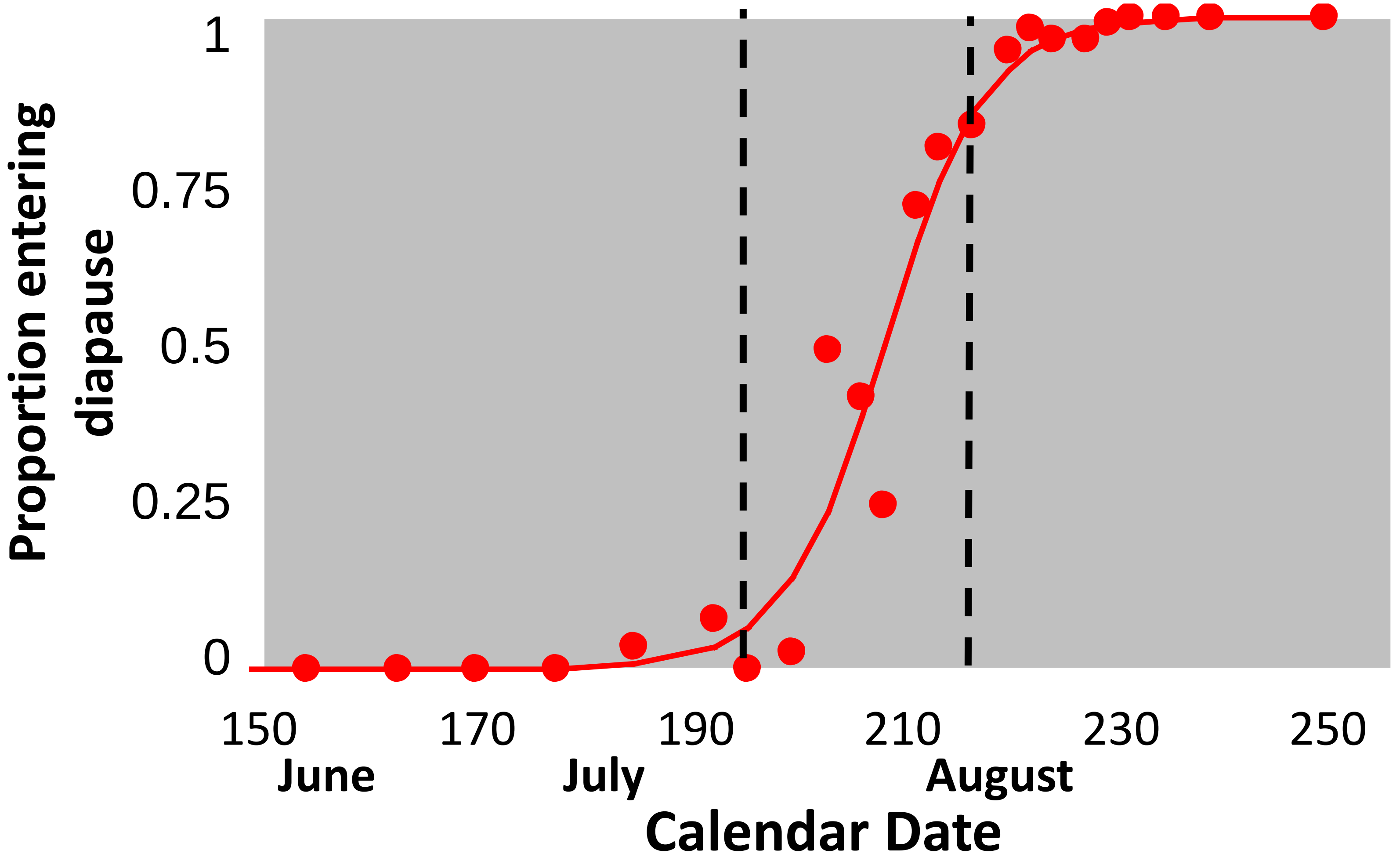
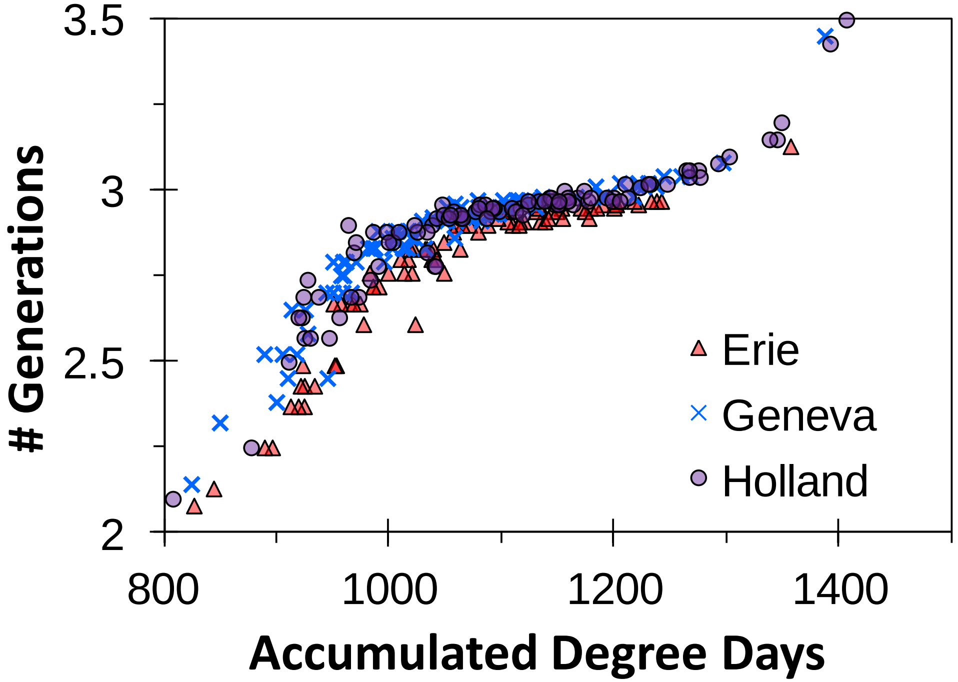
Insect Population Dynamics 101: Insect development is temperature dependent



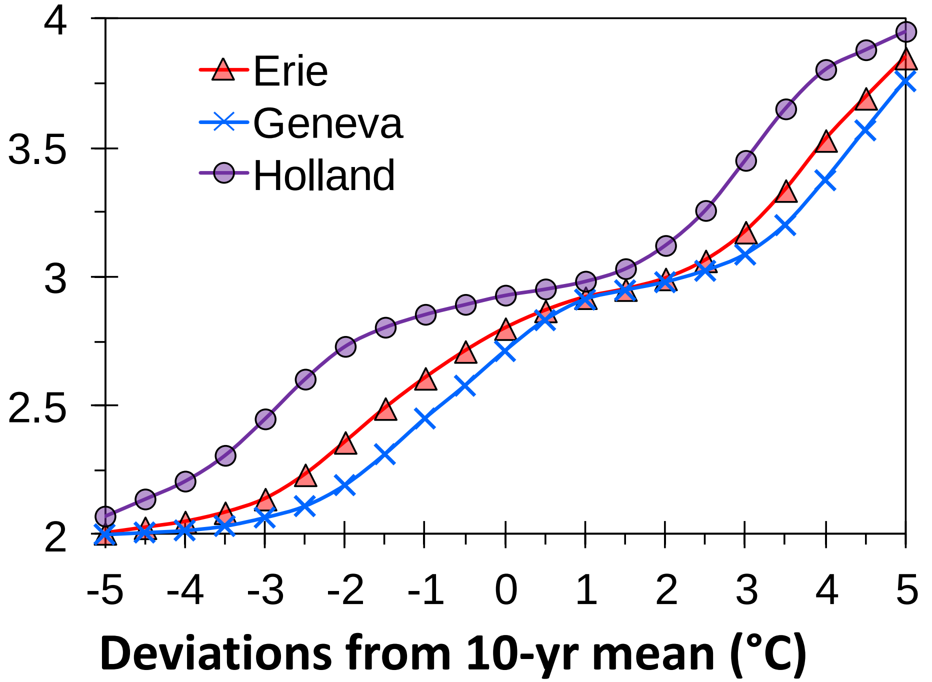
Insect Population Dynamics 101:
Photoperiod tends to be the cue that triggers diapause (i.e., when the insect starts preparing for winter)



Number of insect generations based on accumulated degree days at three locations

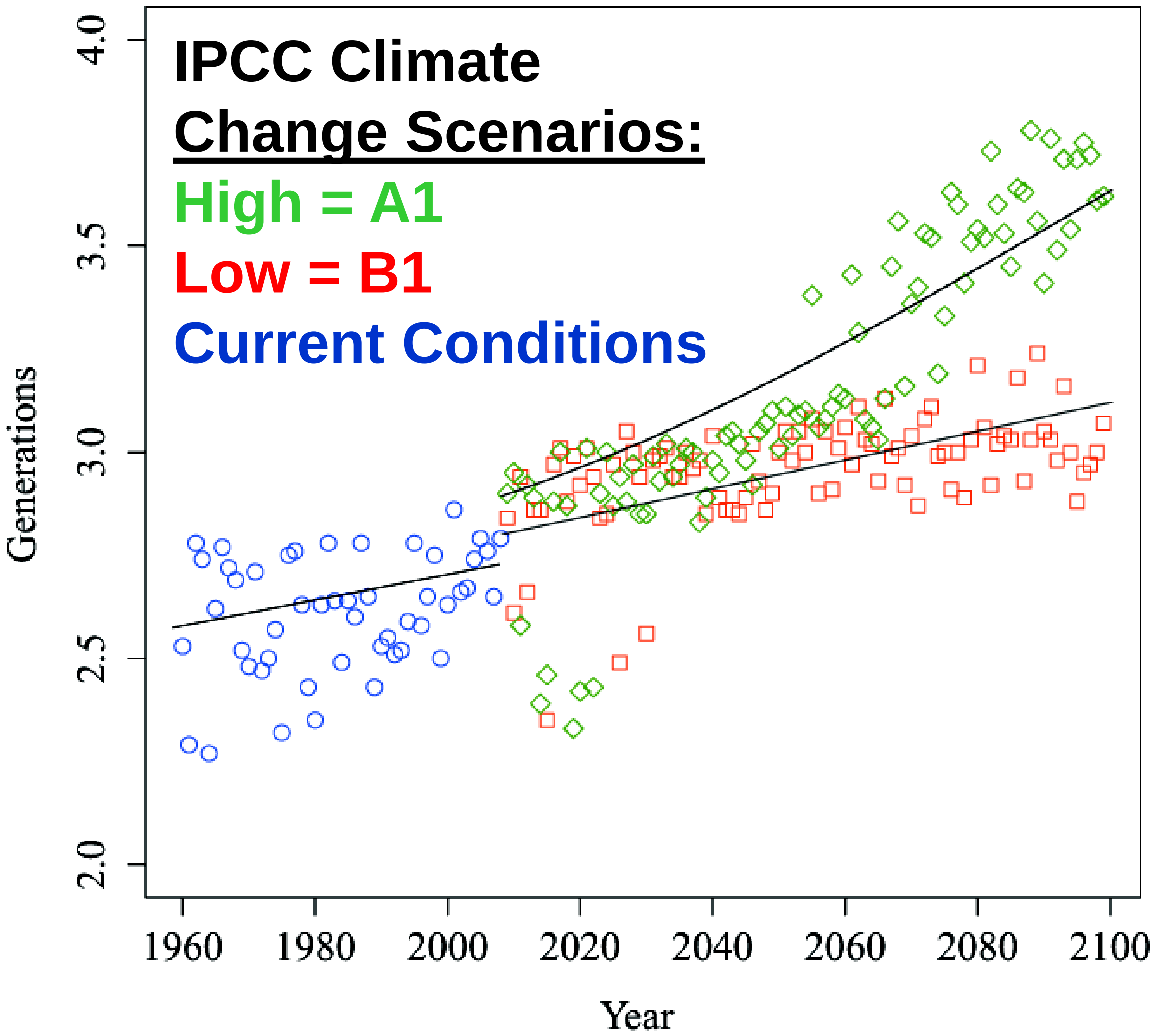


Forecasted number of generations under climate change scenarios based upon a 10-year mean (1996–2005)



Tobin *et al*. (2008) *Global Change Biology* 14:951

Current and projected changes in voltinism under a low and high emission climate change scenarios



Chen *et al*. (2011) *Environ. Entomol*. 40:505

We can likely expect all of the following in a warmer (and drier) Urban Forest

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Case Study: Bigleaf Maple Decline

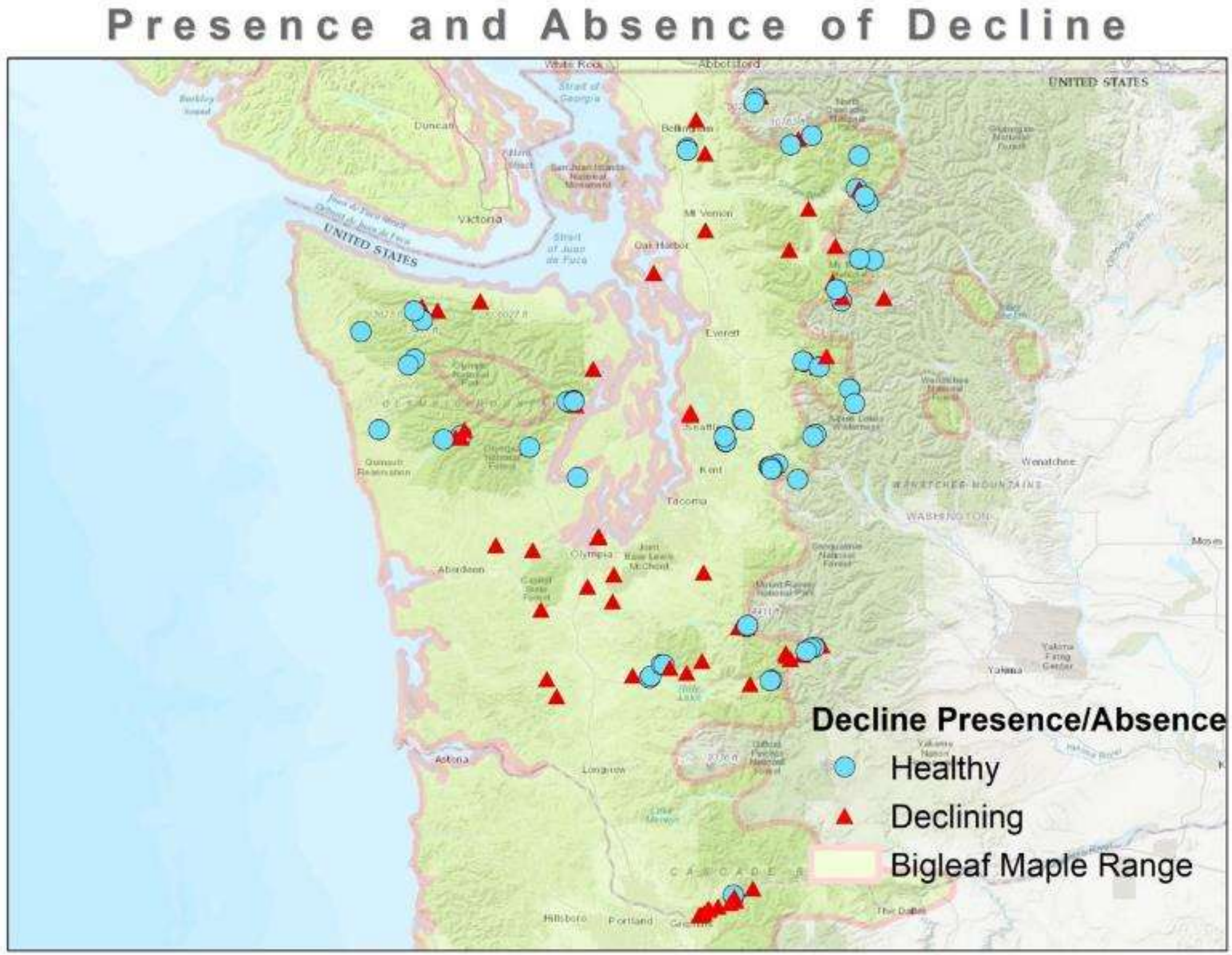
Jake Betzen (MS, 2018), Amy Ramsey (WA DNR), and Dan Omdal (WA DNR)

- Decline first noticed in 2010
- Seemed to occur throughout western WA
- Symptoms
  - Yellow flagging of large branches
  - Partial or entire crown dieback
  - Reduced leaf size
  - Wilted, shriveled leaves
  - Yellow edges, red to brown tips
  - Heavy Seed Crops
  - Death






Spatial Extent of Bigleaf Maple Decline



Pathogen Survey Results

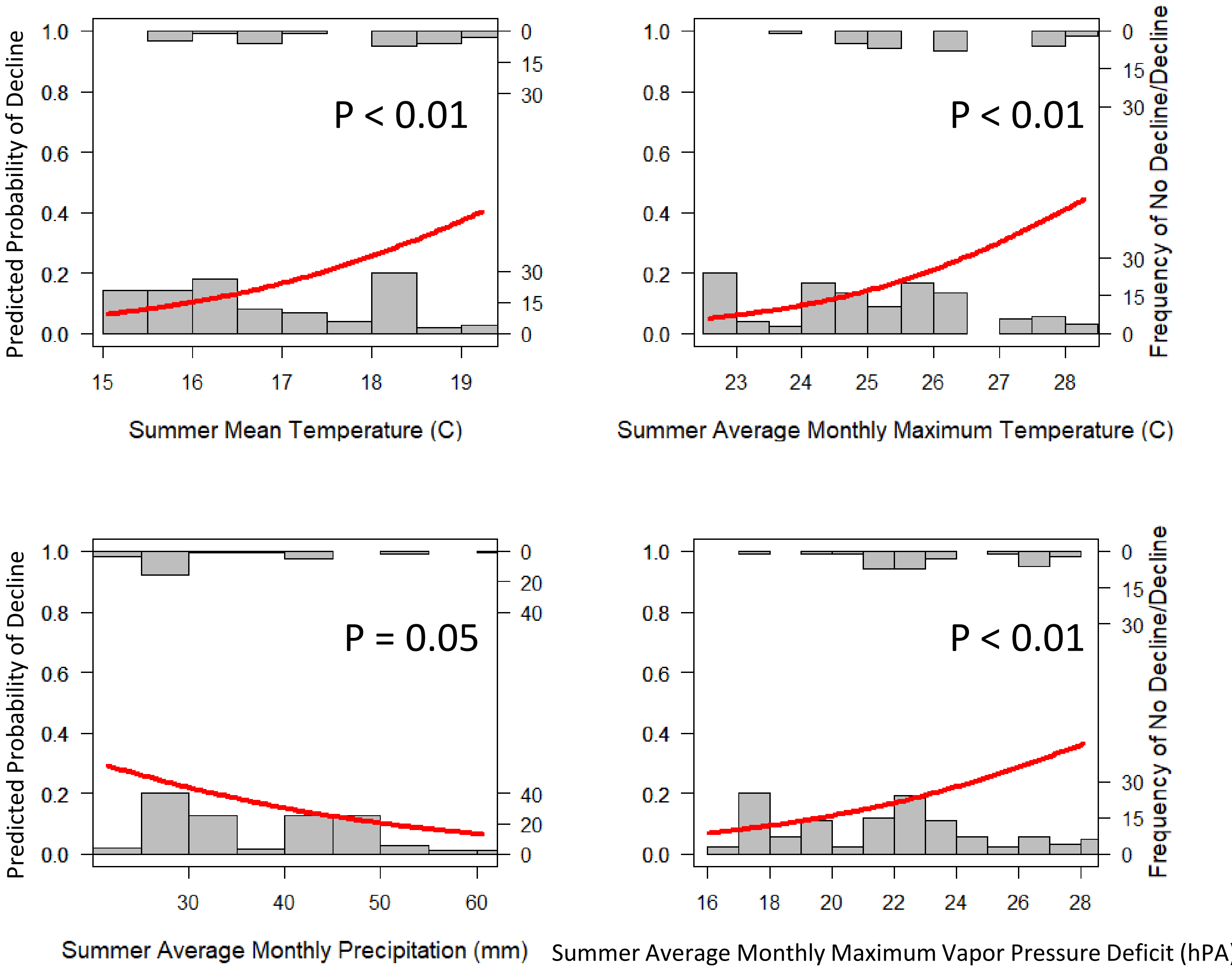
Pathogens (as of 10/2017)	Percentage Presence in Declining Trees
Verticillium sp.	0%
Armillaria sp.	11%
Ganoderma sp.	3%
Xylella fastidiosa	0%
Phytophthora sp.	Not substantial*
Neonectria sp.	Not substantial*
Nectria sp.	Not substantial*

*Forest Health Highlights in Washington (USFS 2016)

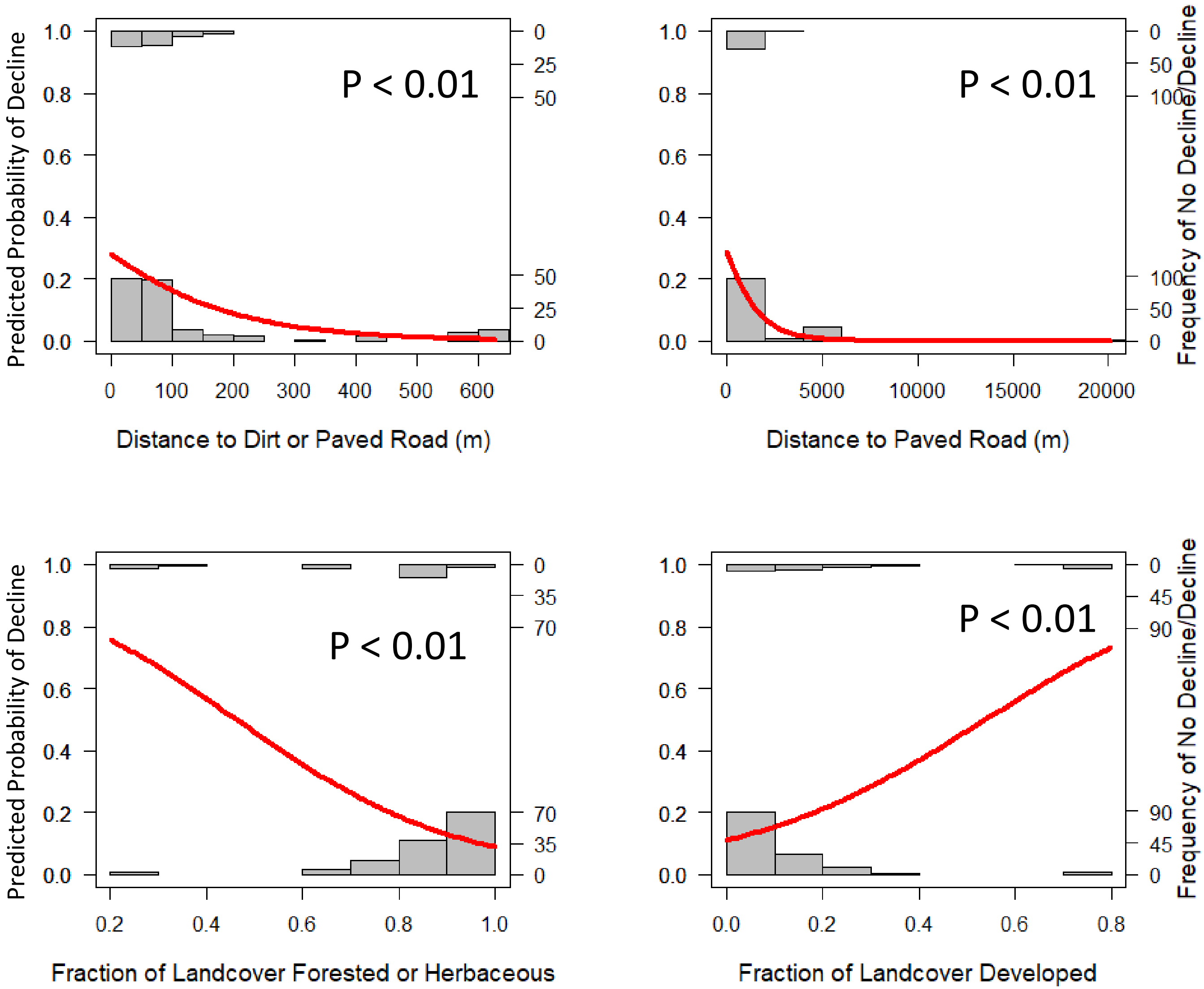
Healthy Bigleaf Maple

Declining Bigleaf Maple

Increased Bigleaf Maple Decline in Warmer and Drier Sites



Increased Bigleaf Maple Decline in Developed Landscapes

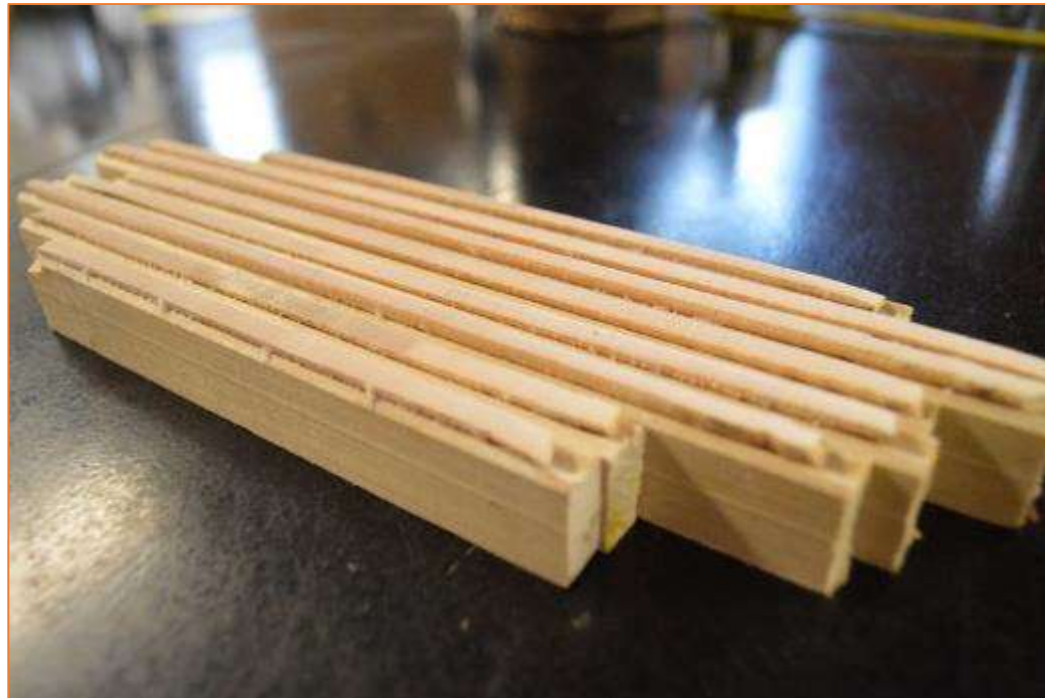


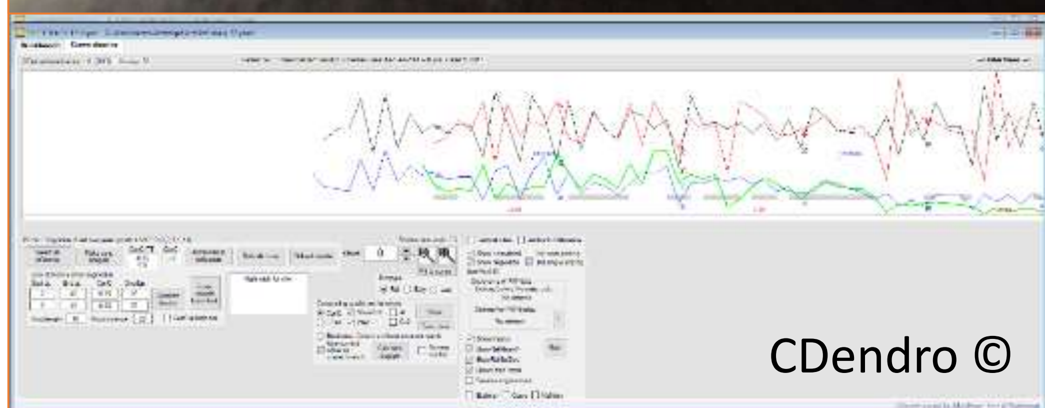
Using dendrochonological methods to estimate the timing of decline

Determine effect of climate variables on bigleaf maple growth

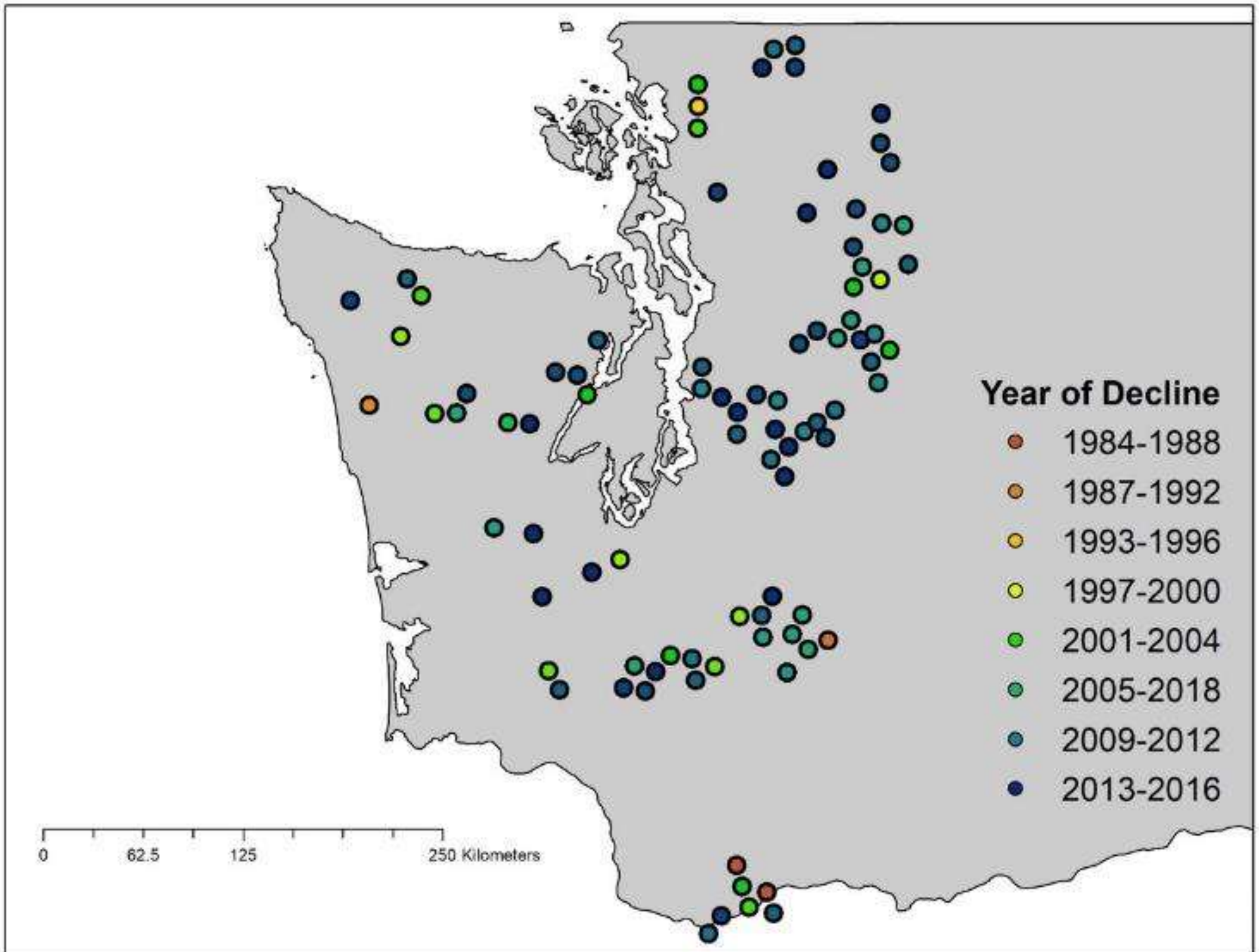
Reconstruct the spatio-temporal patterns of bigleaf maple decline

Compare bigleaf maple to nearby coniferous trees to determine if the decline is species-specific





First Year of Reduced Growth (e.g., Decline) in Bigleaf Maple



Bigleaf maple decline: a harbinger of a warmer climate?

In several cases of tree decline in the past, a causative agent(s) was identified as playing a role (i.e., Chestnut blight, Dutch elm disease, Pacific madrone decline, emerald ash borer)

No specific biotic agent has been implicated in the cause of bigleaf maple decline across western Washington, although we do detect specific agents here and there (i.e., leafhoppers, powdery mildew, *Armillaria* spp.)

Some plant species might be pushed to their limit of tolerance, perhaps more so in urban environments with increased anthropogenically-derived stressors, and are becoming more susceptible to whatever opportunistic organism is around

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