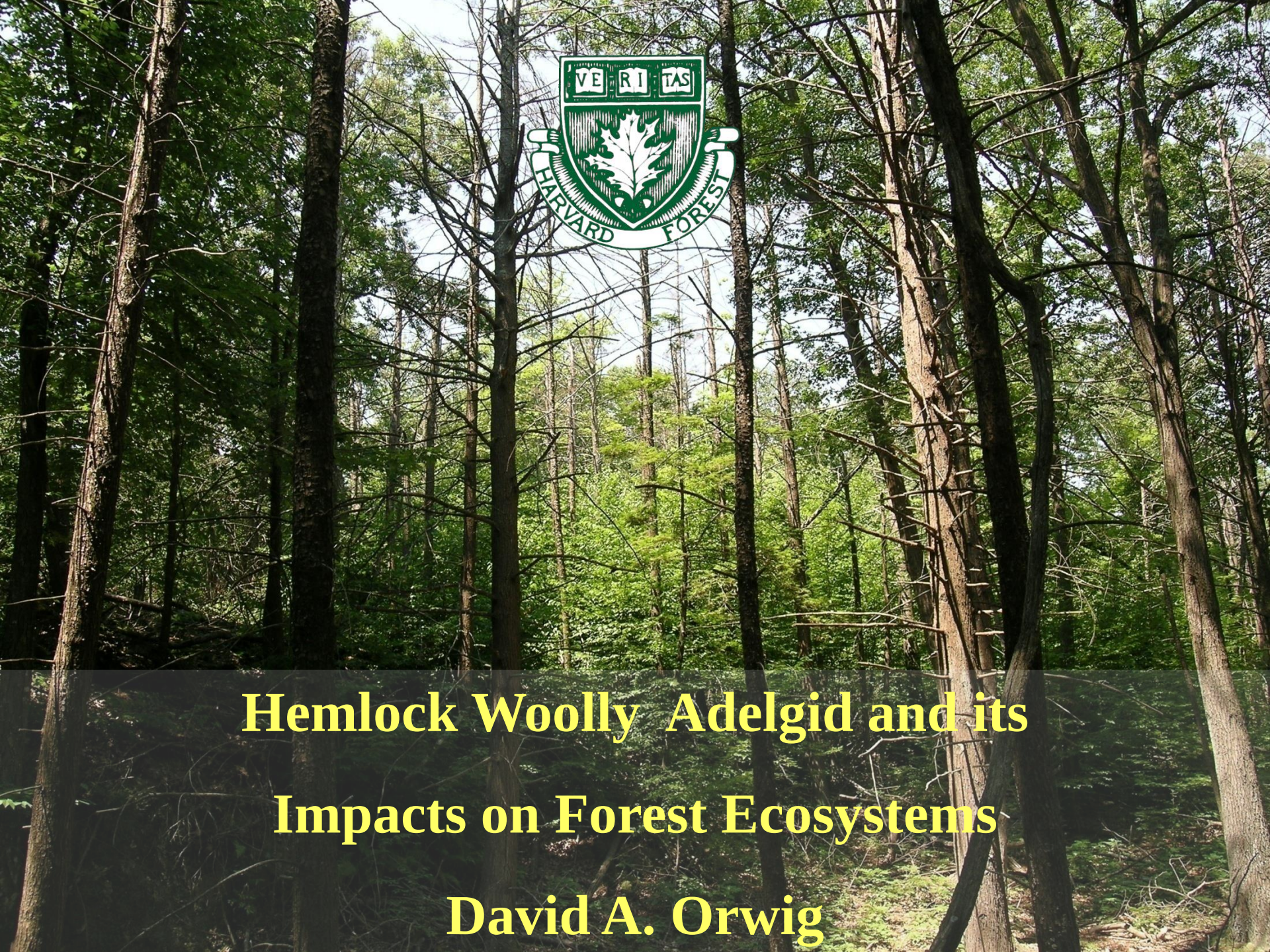
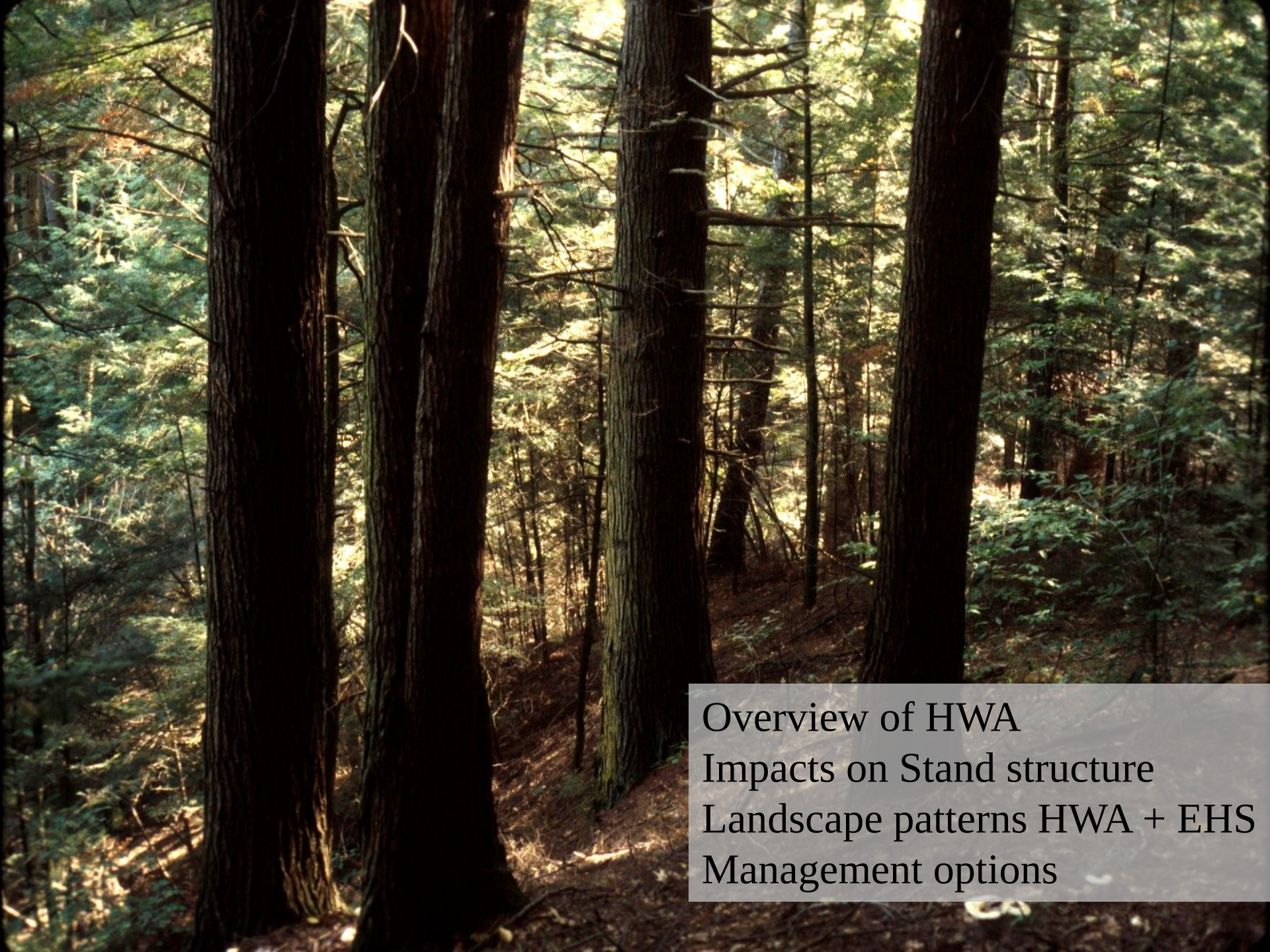
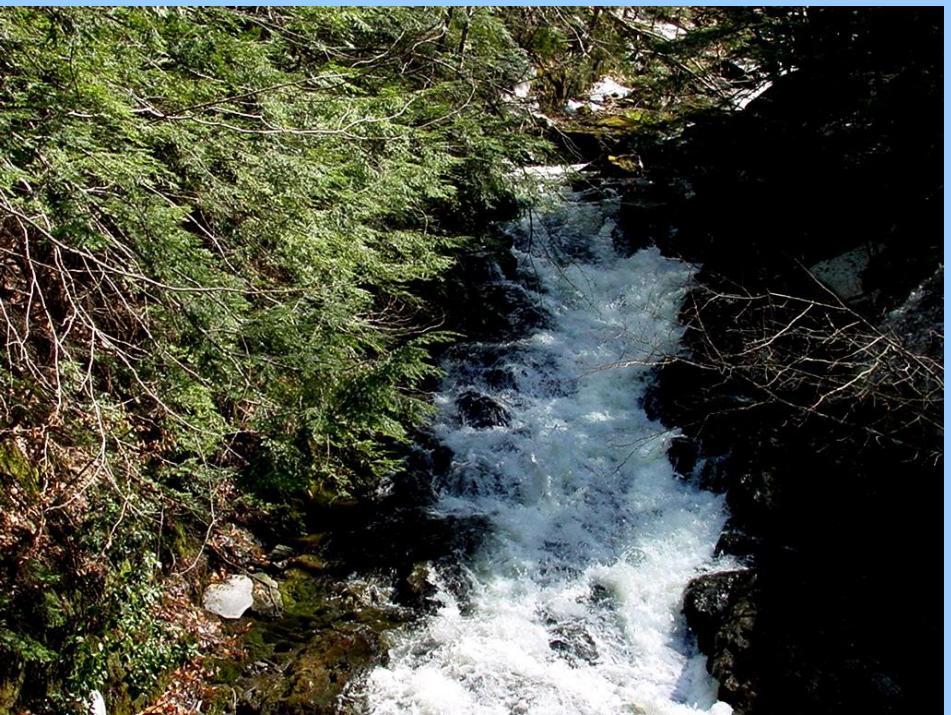


Hemlock Woolly Adelgid and its Impacts on Forest Ecosystems

David A. Orwig



Overview of HWA
Impacts on Stand structure
Landscape patterns HWA + EHS
Management options



Hemlock is important for:

Old-growth forests

CWD to upland and streams

Moderation of stream temps important for trout

Black-throated green warbler

Hemlock regeneration is limited by deer browsing.

Ward et al. 2004

Blackburnian warbler

Hemlock provides valuable habitat for a variety of wildlife species

USDA Forest Service

Hemlock woolly adelgid (*Adelges tsugae*)

2 generations /year

rapid dispersal

hemlock resistance?

Parthenogenetic

feed and kill all sizes and ages

No effective native predators

HWA life cycle in E. North America (USDA)

Recent work
Shows egg
Laying as early
As Dec/Jan!!

HWA life cycle in E. North America (USDA)

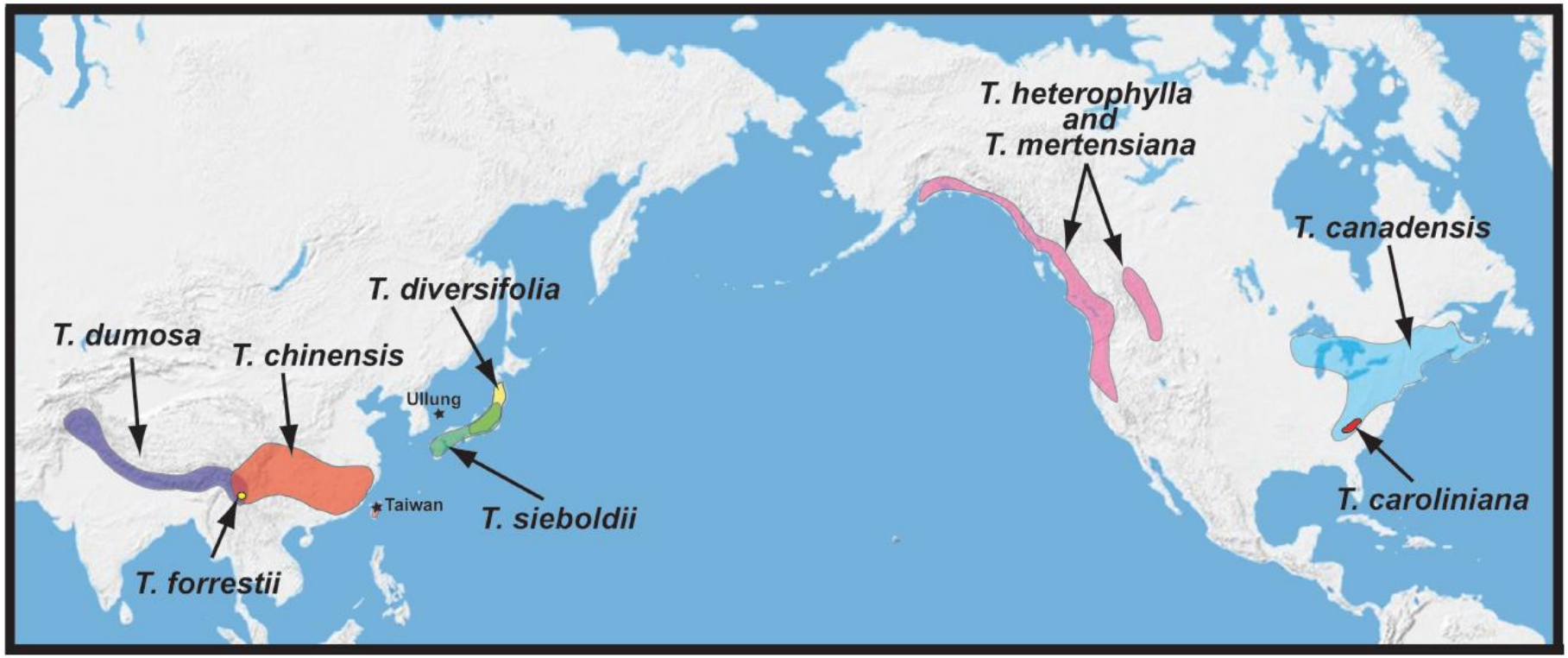
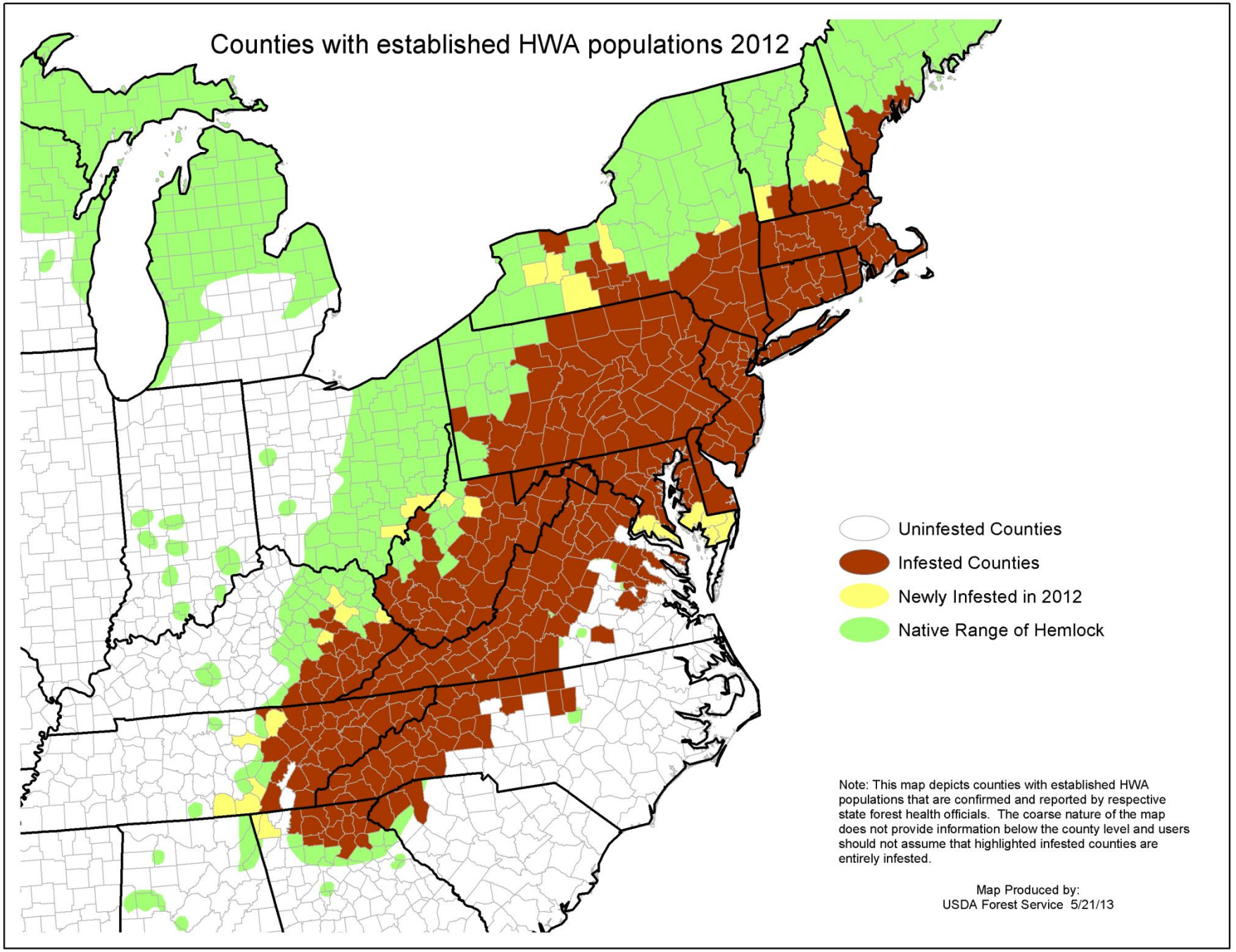
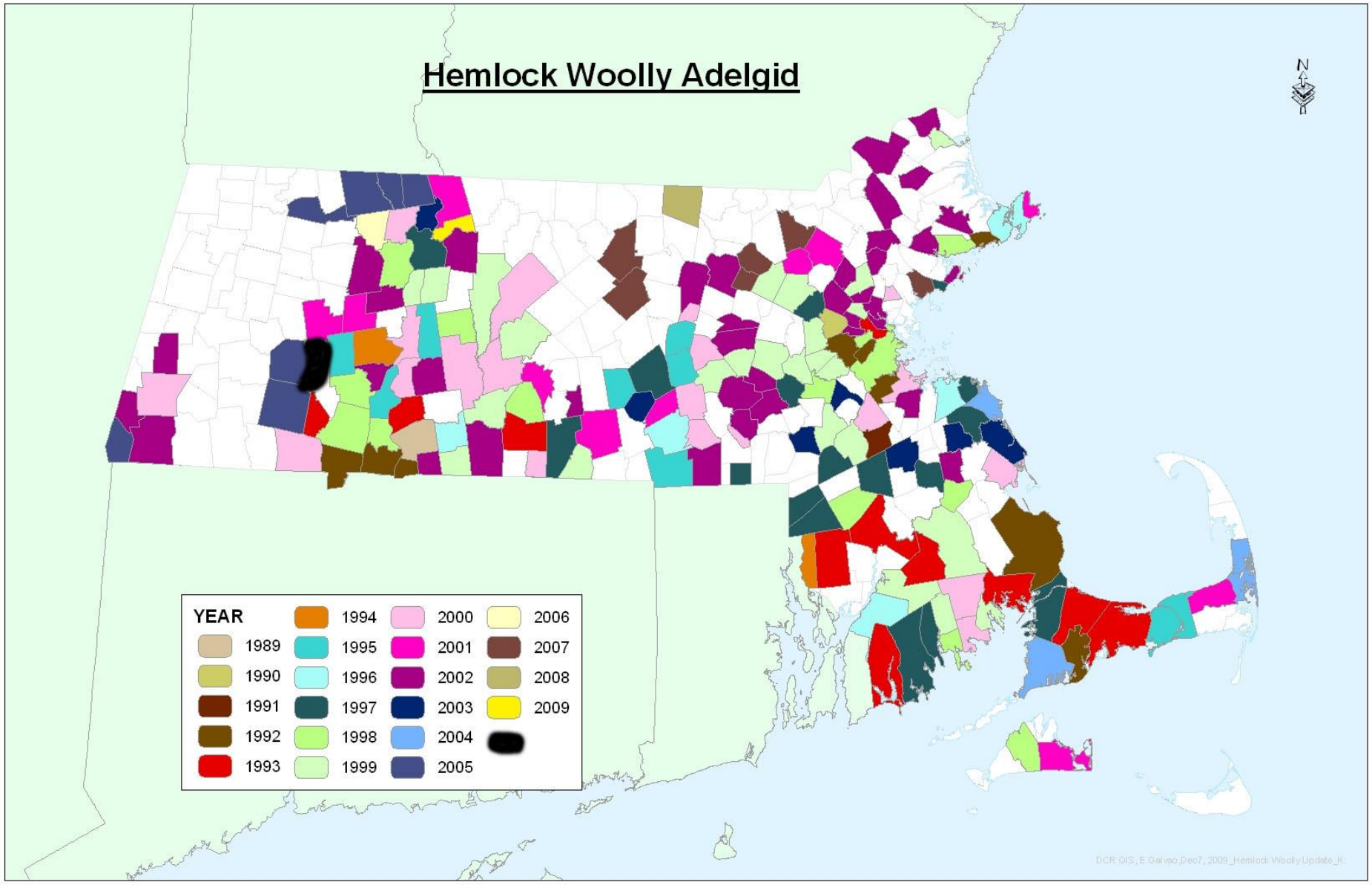


FIG. 1. Map showing the ranges of extant *Tsuga* species based on Little (1971), Hirokawa (1972; 1976), and Farjon (1990). The distributions of *T. mertensiana* and *T. heterophylla* are shown as sympatric for graphical simplicity although *T. mertensiana* generally occurs at higher elevations and in some regions such as the Sierra Nevada where *T. hererophylla* is not present. The islands of Ullung and Taiwan are indicated with stars.

Nathan Havill, Yale University

Adelges tsugae documented on all 9 hemlocks worldwide
Recent genetics: from So. and low elevations in Japan
Serious pest only in Eastern U.S.


Counties with established HWA populations 2012
Uninfested Counties
Infested Counties
Newly Infested in 2012
Native Range of Hemlock
Note: This map depicts counties with established HWA populations that are confirmed and reported by respective state forest health officials. The coarse nature of the map does not provide information below the county level and users should not assume that highlighted infested counties are entirely infested.
Map Produced by:
USDA Forest Service 5/21/13


Hemlock Woolly Adelgid
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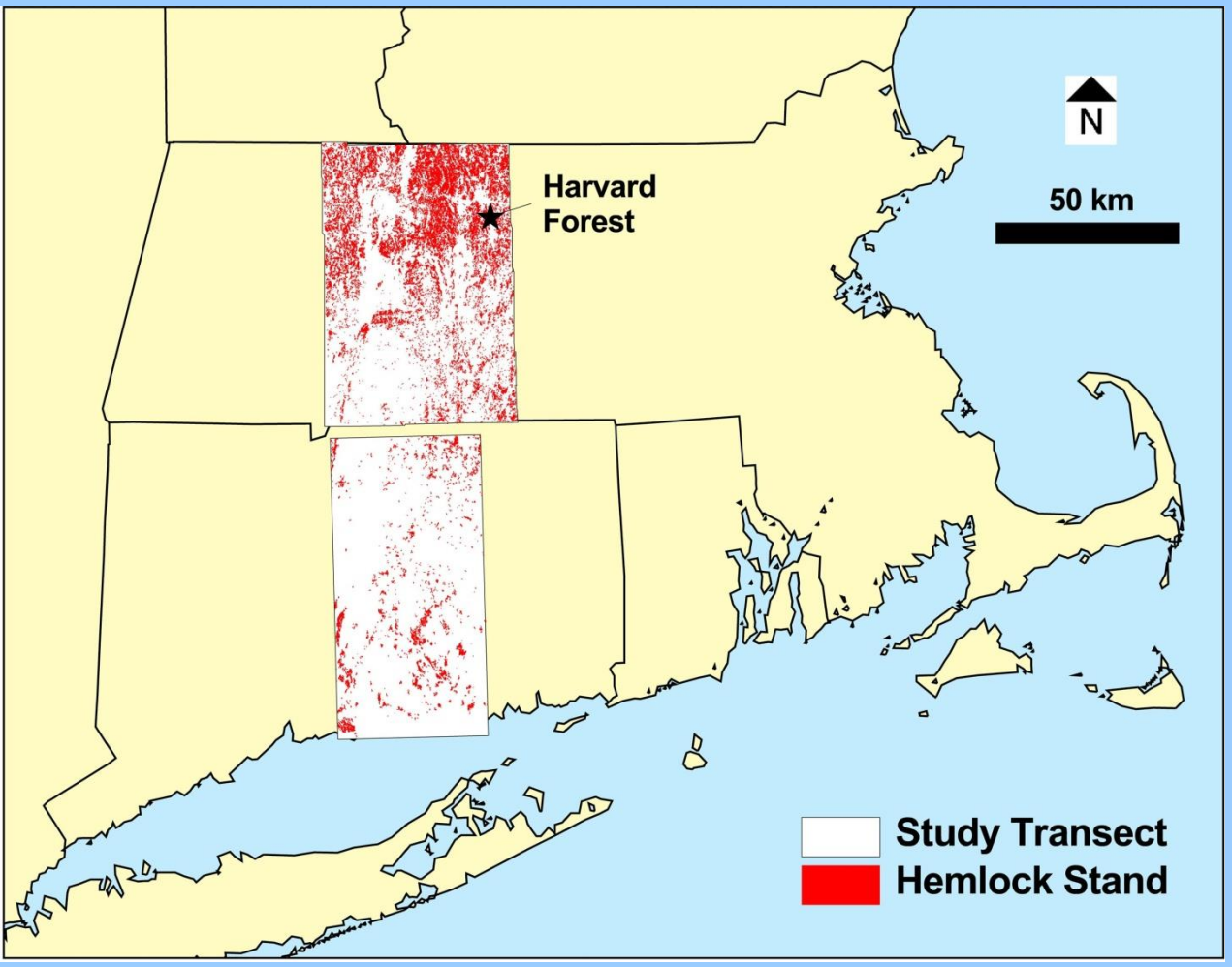


Figure 1. HWA space-for-time study area, representing 7500 km^2. Hemlock represents >86,000 ha or 21% of the mapped area in MA (up to 36% in northern MA), and 16,500 ha or ~5% of the mapped area of CT.

Harvard Forest HWA studies include:

1) Stand and community analyses

2) Landscape investigations of hemlock structure and HWA infestation patterns

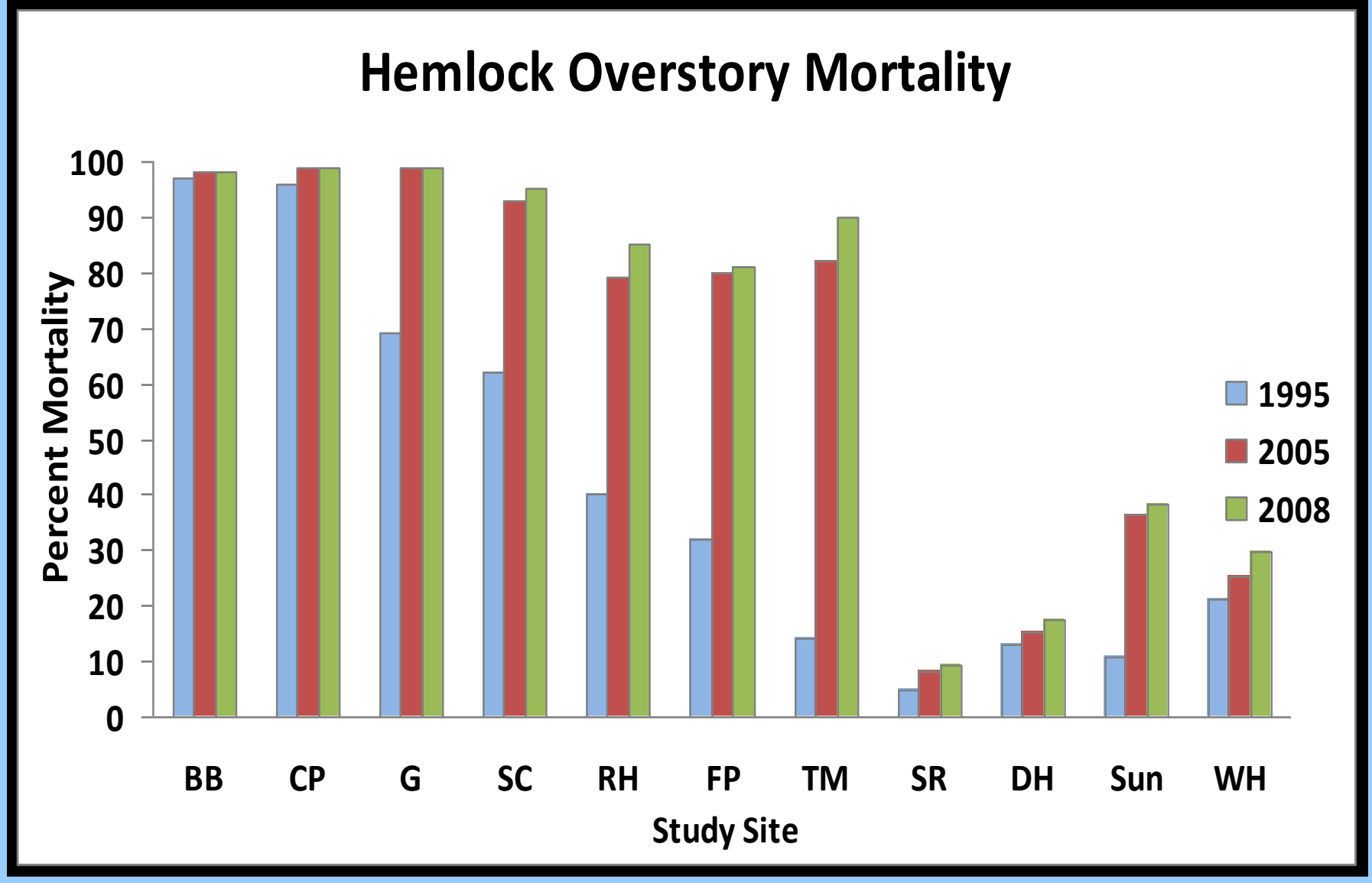
3) Ecosystem analyses of HWA infestations including n cycling, decomp, throughfall chemistry

4) Comparisons of HWA vs. Hemlock Logging

5) Wildlife studies

6) Hydrological Investigations

7) HWA dispersal



Overstory mortality trends, high in many, but not all stands

Crowns continue to deteriorate, with no sign of recovery

However, at some sites, decline is slower (cold temps.?)
Variability in winter temps important (esp. cold following warm)

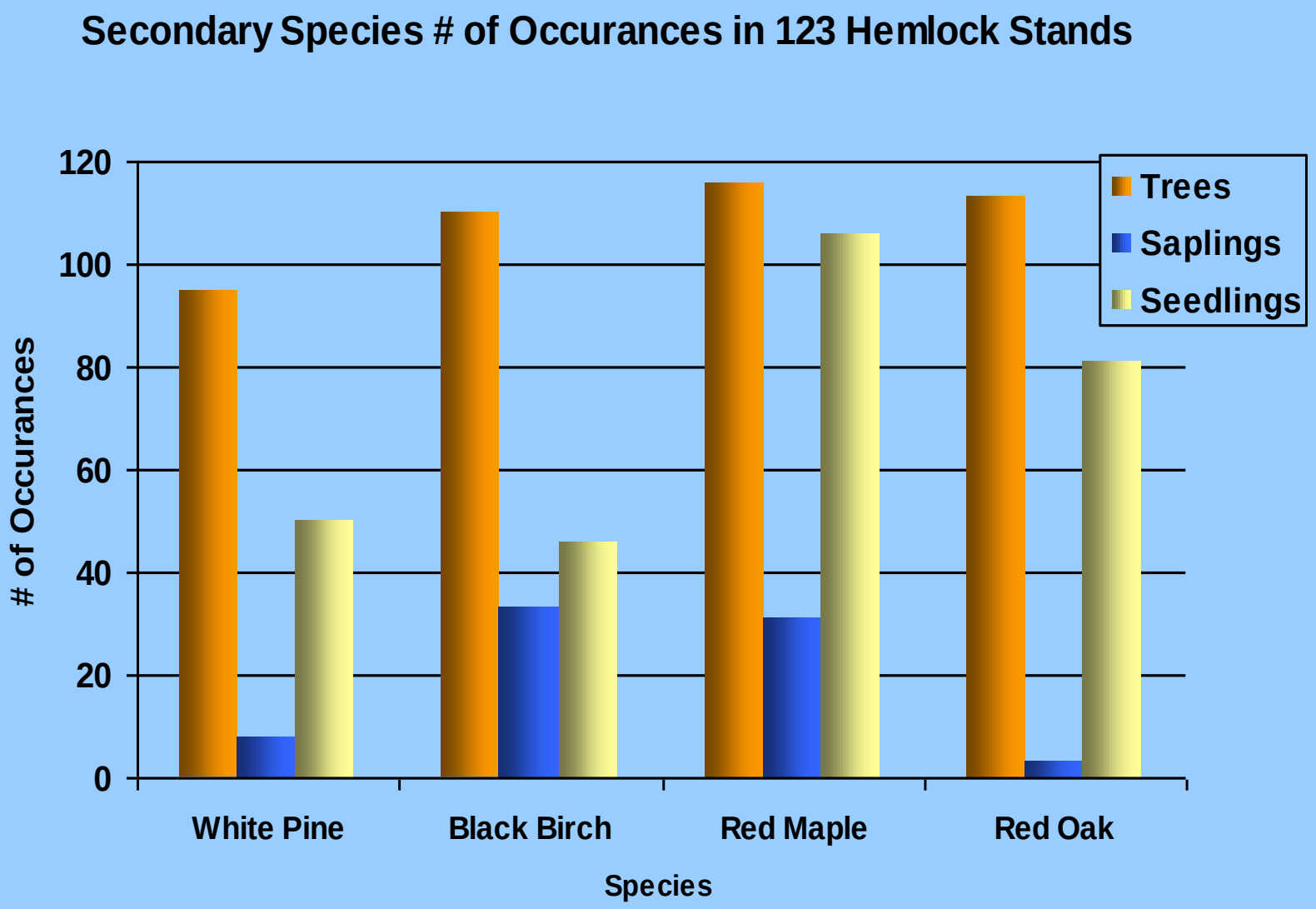
Rapid birch establishment
Occurs with canopy thinning

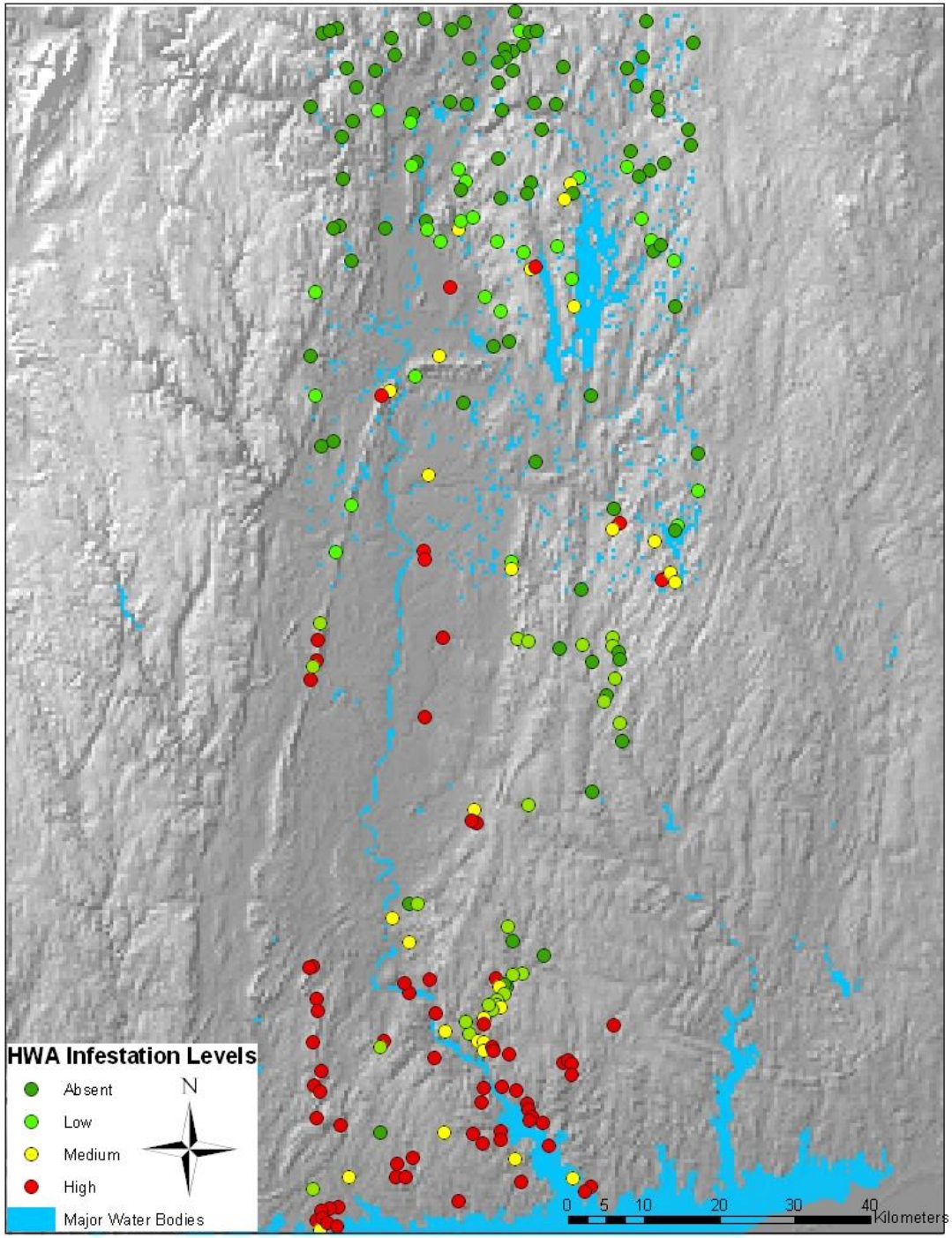
Invasives and ferns can also increase tremendously

Trees remain standing for 5-8 years; branches, then tops fall off; then boles.

Birch forms the new forest

What will replace hemlock in Massachusetts?





LANDSCAPE PATTERNS

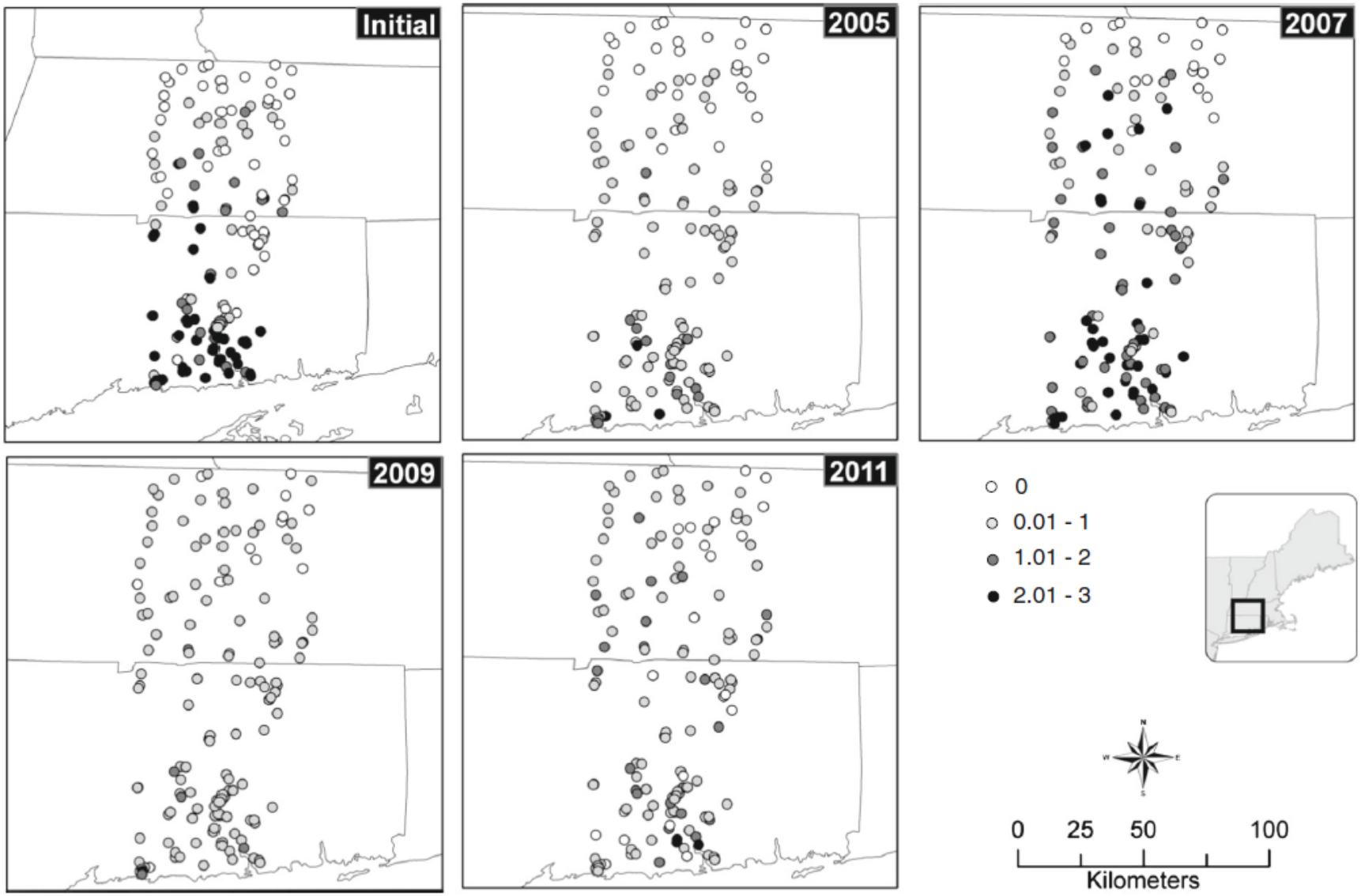
CT: 114 stands
MA: 123 stands

HWA found within a few km of Vermont (2004)!
[now 1/3 way up VT & NH]

Latitudinal pattern present
But damage not as rapid

Only 2 stands > 50%
Overstory mortality in MA

HWA change in abundance over time



Northern Massachusetts Sites with major infestation- 2013

Along Swift River, Petersham MA

Bernardston, MA

Harvard Forest 2016
Overstory and understory thinning

7 years after initial infestation

First ha; > 400 dead trees found

Photo: David Foster

ARBORjet

So, what can be done?

Imidacloprid (Merit) pesticide of choice:

Tree I.V.
Kioritz soil injection
Soil drench
Stem injection-important near streams
CoreTect time-release tablet
often provides 2 to 4+ years protection

Soil application widely used

There is also a time-release tablet

New Hampshire's Forest Health Program Coordinator Conducts a Basal Bark Application of Dinotefuran (Credit NH DFL)

Safari (Dinotefuran) Fast-acting systemic, spring applications Effective, not persistent, often used first, then Merit

Biological Controls

Carol Cheah

Sasajiscymnus tsugae

From Japan, over 1.5 million have been
Released in over 100 sites in 15
Eastern sites including MA

USDA

Laricobius nigrinus

Native to British Columbia, over 7000
Adults have been released at 19 sites
In 8 eastern states-recovery 2 years later

Others being evaluated:
Scymnus sinuanodulus
Tetraphleps galchanoides
Pathogenic fungi
Uncertain success, impact

So, how can we incorporate the study of invasive species into a school curriculum?

what can students do to add to this body of work?

Student research can provide:

year by year assessments of HWA densities

year to year branch growth, related to HWA

important data at the northern extent of HWA range

new discoveries of HWA at their homes, schools, towns

Katherine Bennett's 5th Grade class

Measuring snow depth

A co-occurring pest on the rise! Students can also contribute here

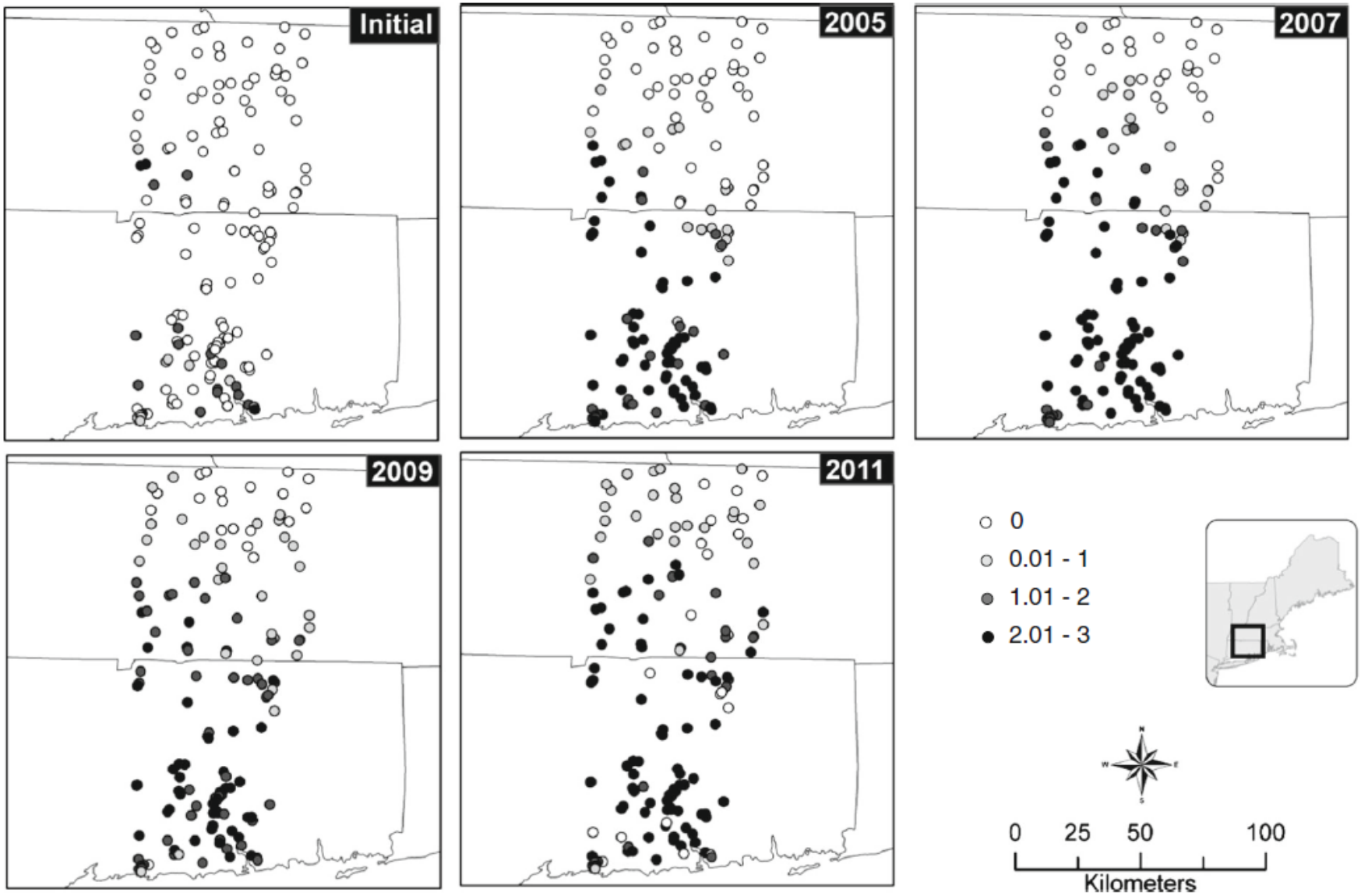
Elongate Hemlock Scale (EHS;*Fiorinia externa*)

Also from Japan, introduced in NYC in 1908

Now located in 14 eastern states, range overlaps with HWA

Often co-occur with HWA on same tree: uncertain consequences

EHS trends over time



Facilitation by HWA??

Gomez et al. 2015

Woolly Bully Protocol revolves around 2 measurements:

1) Measurement of new branch growth in early Autumn

Core measurements:

Spring counts of HWA egg sacs along outer 10 cm

HF provides data sheets, protocols