Impacts of Invasive Pests on Forest Carbon and Nitrogen Dynamics in the Catskills

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Facts:

➤ Catskill forests are experiencing, or are threatened by, multiple invasions of forest pests that will reduce or eliminate some tree species.

- Beech bark disease
- Hemlock woolly adelgid
- Emerald ash borer
- Asian longhorned beetle
- And the list goes on and on…

➤ Tree species vary substantially in their influence on ecosystem processes such as carbon storage and nitrogen leaching.

Questions:

1. How will tree species composition in the Catskills change as a result of insect and pathogen invasions?

2. How will this tree species change affect forest carbon and nitrogen cycling?
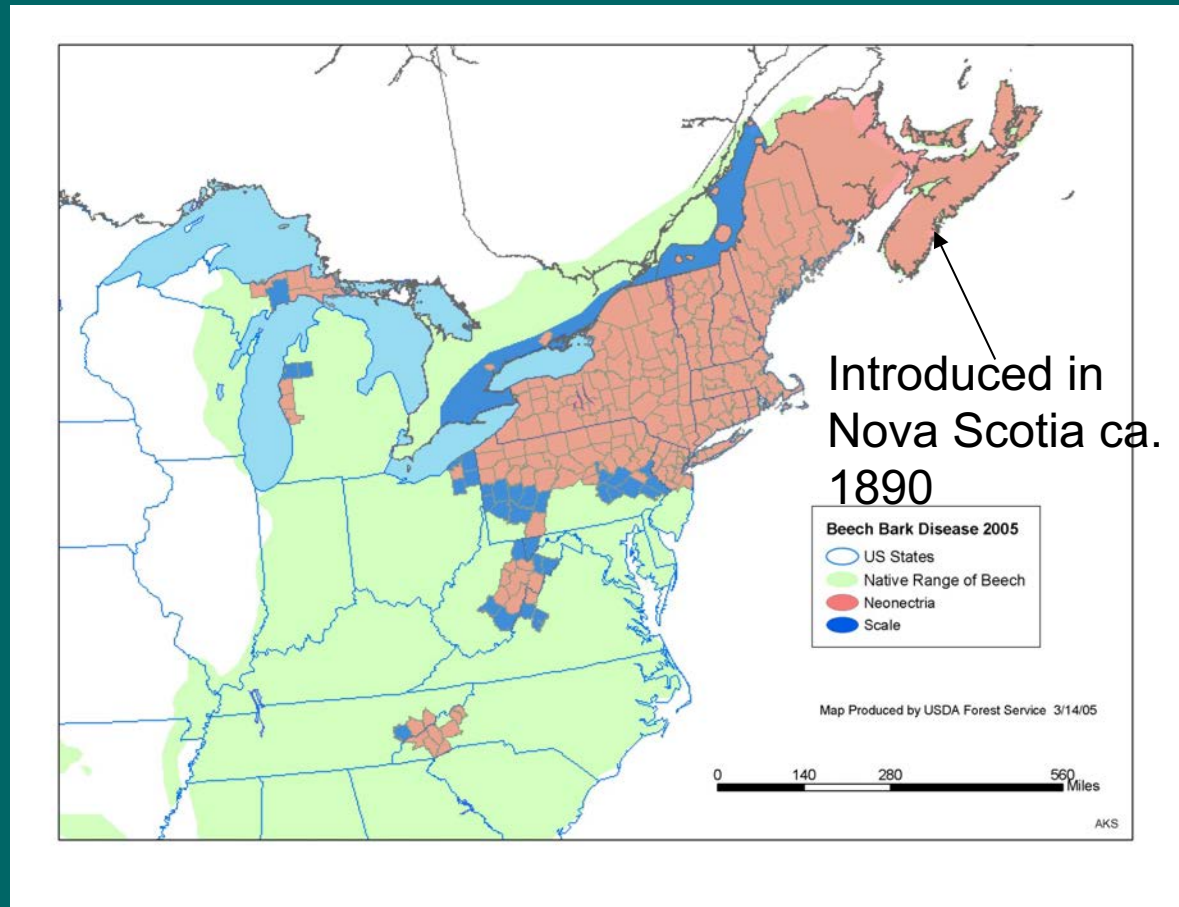
Beech Bark Disease

Interaction of scale insect (*Cryptococcus fagisuga*) and fungi (*Neonectria sp.*)

Beech scale adult with outer covering removed

Neonectria fruiting bodies on beech bark

Introduced in Nova Scotia ca. 1890

Beech Bark Disease 2005
- US States
- Native Range of Beech
- Neonectria
- Scale

Map Produced by USDA Forest Service 3/14/05

0   140   280   560 Miles

AKS

Effects of Beech Bark Disease

• Kills trees slowly over 10 years or more

• Shifts in forest composition and structure

• Shifts in carbon and nitrogen cycling and retention
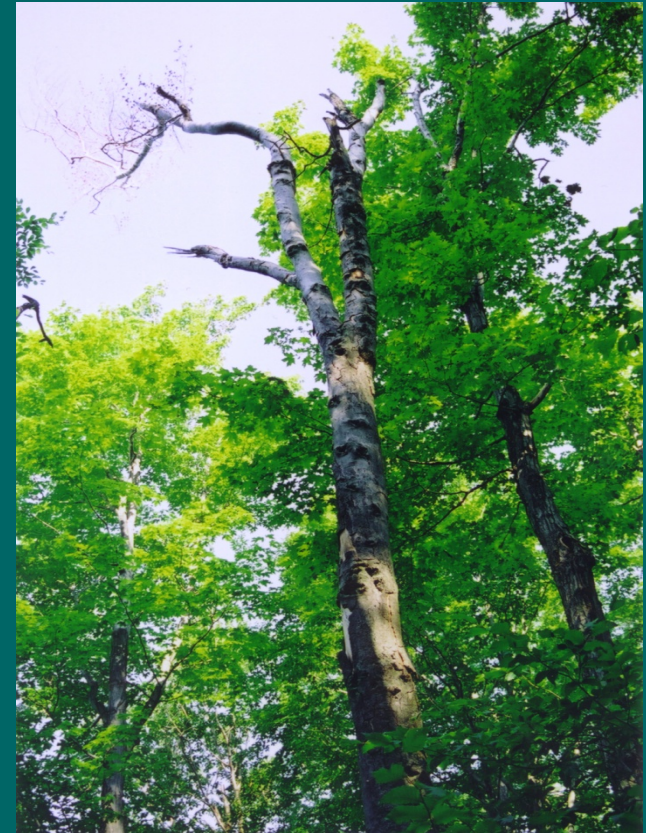
• Loss of food source for wildlife

In the Catskills:

o   BBD affects >99% of beech trees

o   About 20% seem to be tolerant of the disease

o   Most of the larger beech trees (>20 inches diameter) are gone

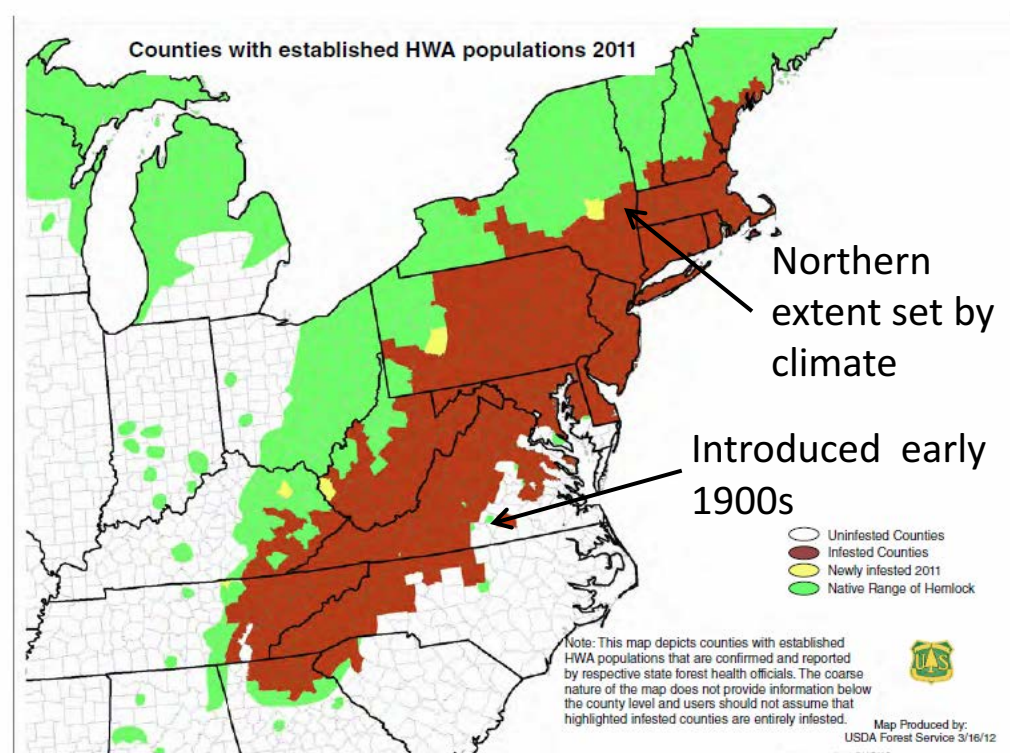o   Overall shift in species composition toward sugar maple

Griffin et al. 2003 Can.J.For. Res.
Lovett et al. 2010 Ecosystems
Lovett et al. 2013 Annals NY Acad. Sci.

Hemlock Woolly Adelgid
(Adelges tsugae)

Counties with established HWA populations 2011

Northern extent set by climate

Introduced early 1900s

Uninfested Counties
Infested Counties
Newly infested 2011
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 3/16/12

Impacts of HWA Reverberate Though the Ecosystem

Death of trees

Change in tree species composition

Hemlock
Woolly Adelgid

Warming of streams may impact fish

Short- and long-term changes in carbon storage and nutrient losses

Decline of some bird species

What Controls the Path of Vegetation Change After Beech Decline?

BBD plot study

- Plots centered on stump of former canopy beech tree, where canopy has closed the gap
  - Camera-based measurements of LAI by species
 - Soils: Organic, Surface Mineral and Deep Mineral
  - Vegetation

White Mts.
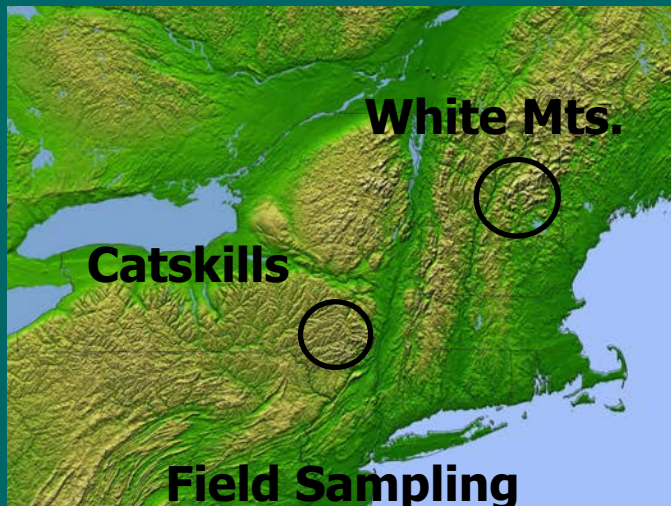
Catskills

Field Sampling Locations

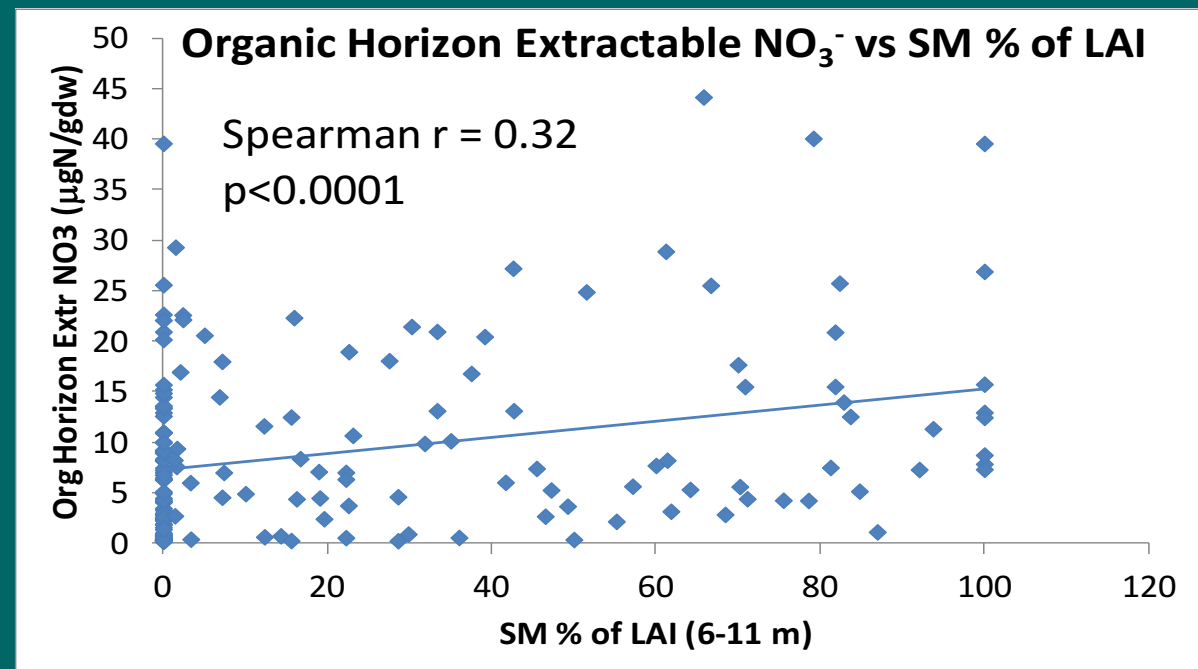- Catskills: 186 plots
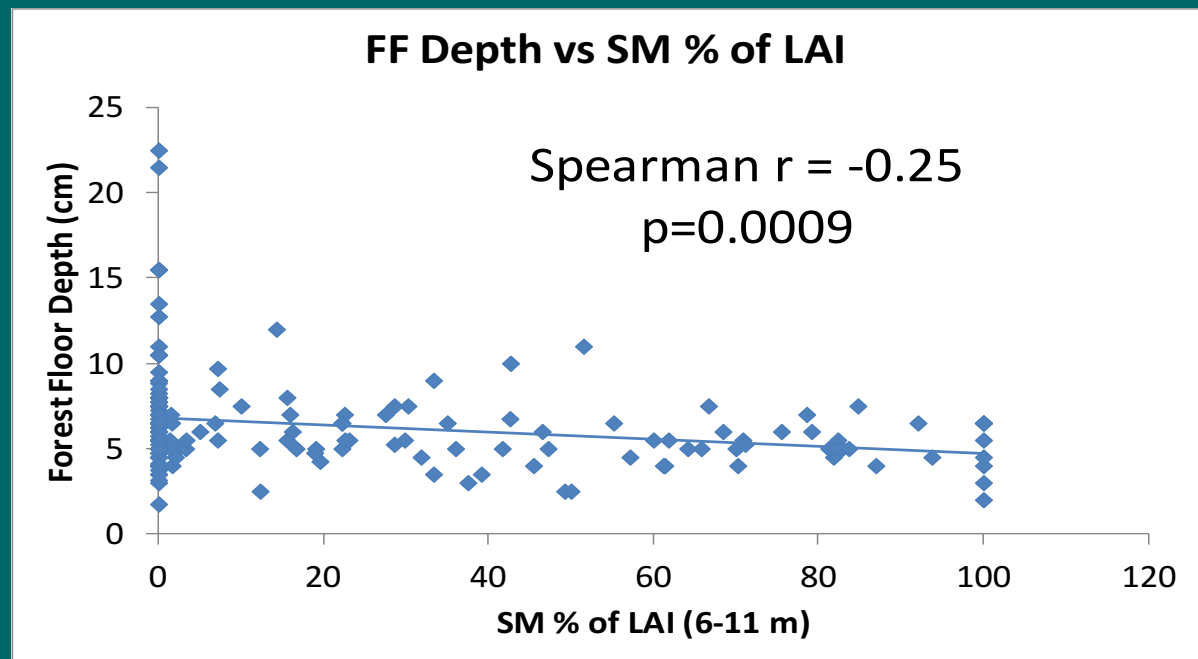- White Mts.:   111 plots

How does the vegetation respond to the death of beech trees?

- In the Catskills, NMS ordination based on percent LAI identifies a cluster of responding tree species – SM, WA, HH, and BW– associated with higher soil Ca and %BS

- Sugar maple is the most common responder

Lovett and Arthur, in prep.
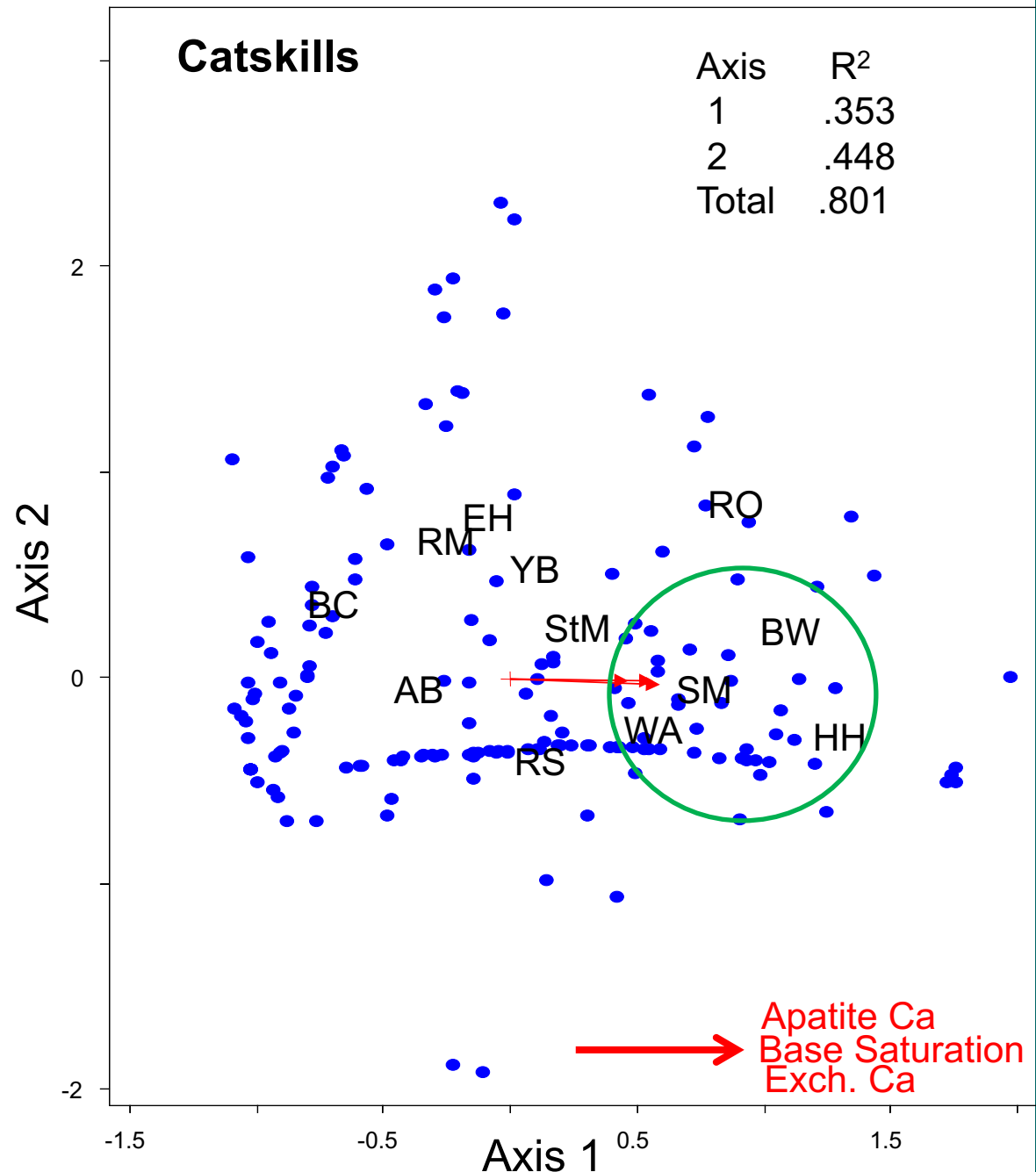
Sugar maple colonization is negatively correlated with forest floor depth, C stock, and C:N ratio…

…and positively correlated with soil nitrate.

FF Depth vs SM % of LAI

Spearman r = -0.25
p=0.0009

Forest Floor Depth (cm) — SM % of LAI (6-11 m)

Organic Horizon Extractable NO_3^- vs SM % of LAI

Spearman r = 0.32
p<0.0001

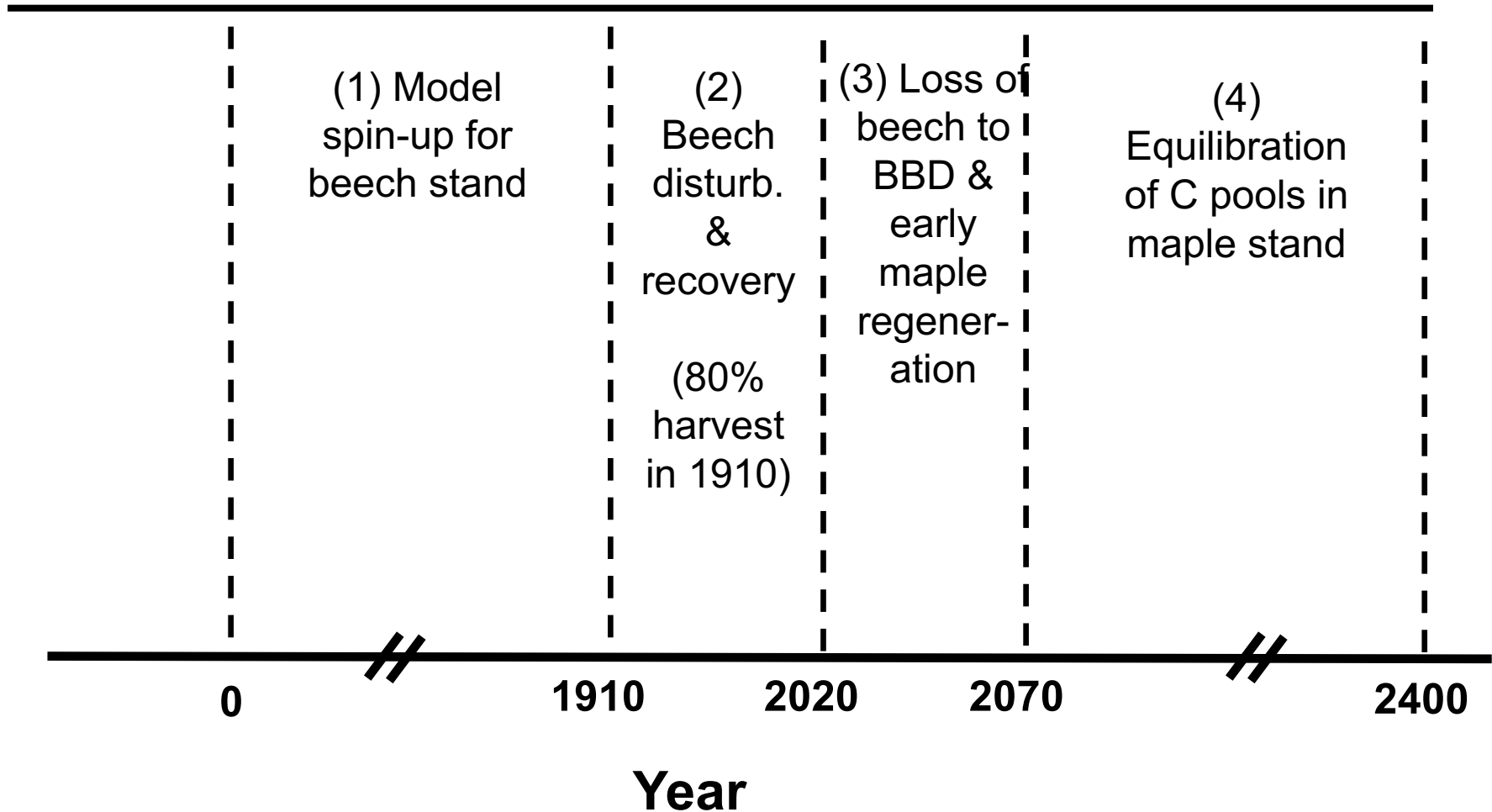Org Horizon Extr NO3 (µgN/gdw) — SM % of LAI (6-11 m)

Prediction of forest ecosystem function in the future, with multiple interacting environmental changes, requires computer models. But current ecosystem models (e.g., PnET, CENTURY) do not allow changing species composition.

A new forest ecosystem model: Spe-CN

- Forest C and N simulation model with C and N pools in plants, detritus, and soil (includes species, but not individual trees)

- Process rates and pathways mostly from field data, mainly from the Catskills

- Monthly time step

- User sets scenarios:
  - Single- or multi-species stand
  - Rate and type of change in species over time
  - N deposition
  - Disturbance regime

- Coming soon: climate change and hydrology

Structure of SPE-CN Model

Scenario 1: Replacement of American beech with sugar maple due to beech bark disease (BBD)


(1) Model spin-up for beech stand

(2) Beech disturb. & recovery

(80% harvest in 1910)

(3) Loss of beech to BBD & early maple regener-ation

(4) Equilibration of C pools in maple stand

0   1910   2020   2070   2400

Year

Nitrogen deposition increases from 0.2 in 1940 to 0.9 in 1990, then declines to 0.6 by 2010 and is held constant thereafter
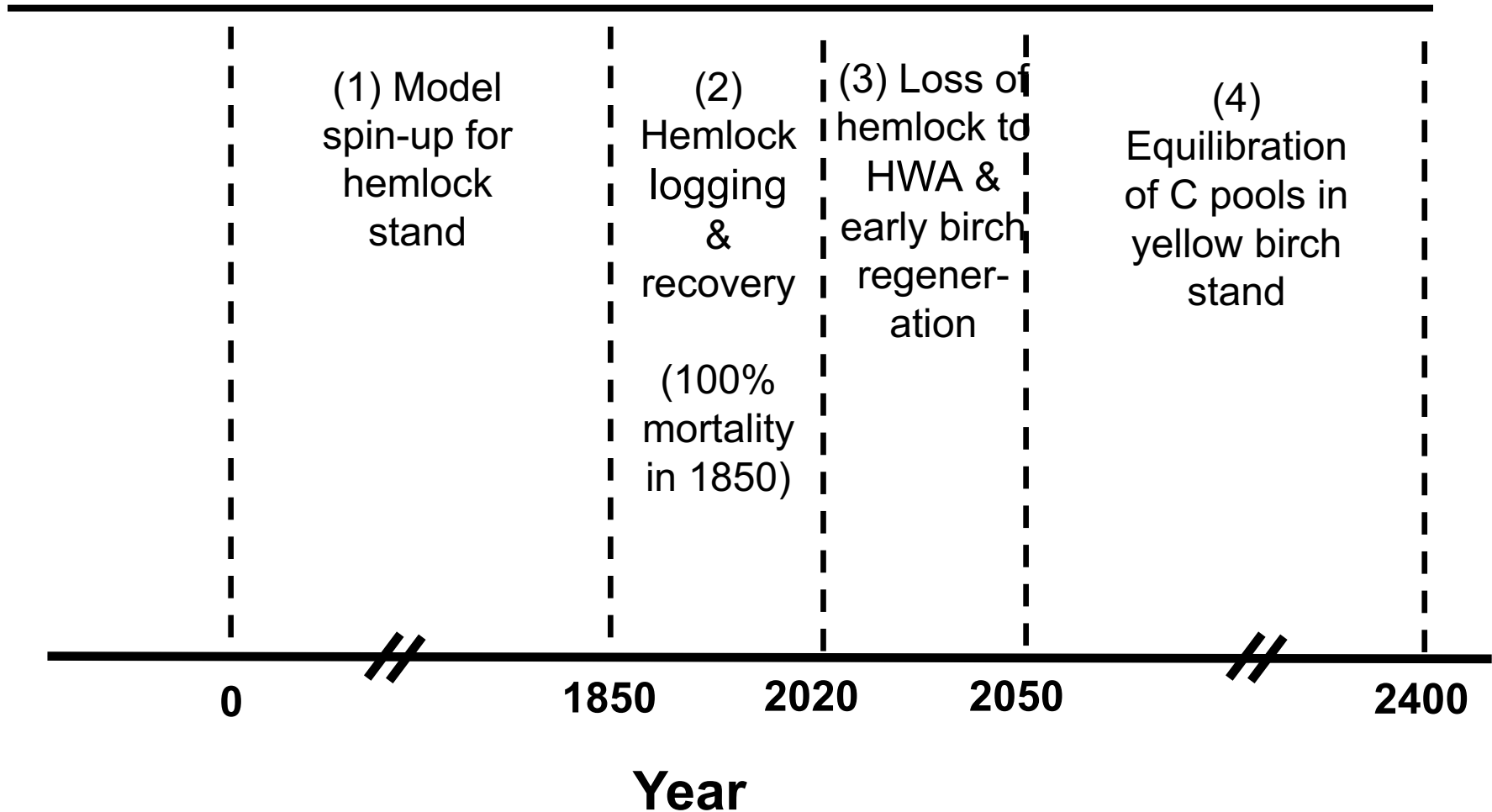
With replacement of beech by maple, Spe-CN predicts a 21% decrease in forest floor C, but a 53% increase in plant C
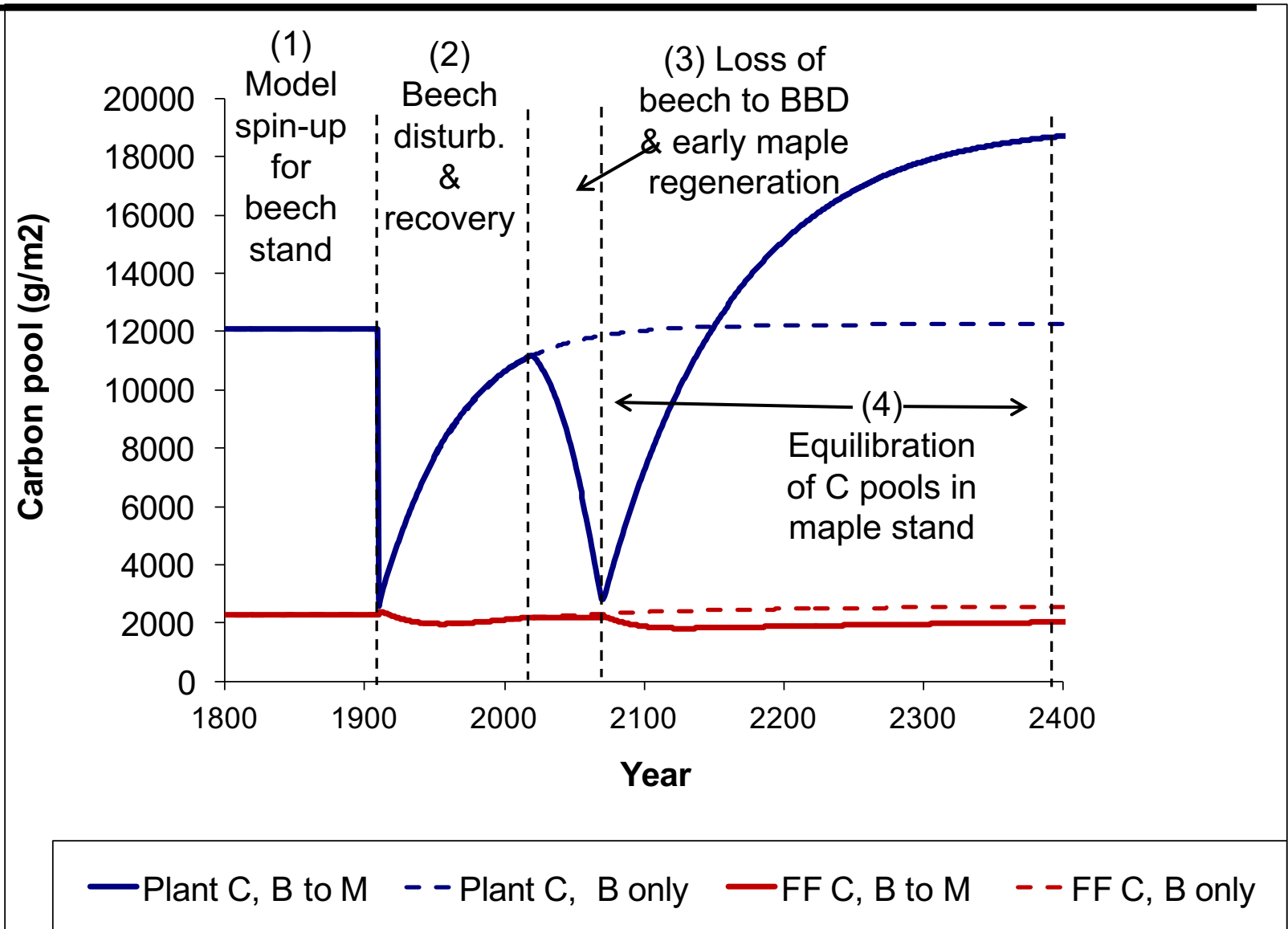
With replacement of beech by maple, Spe-CN predicts an increase of up to 70% in nitrate leaching
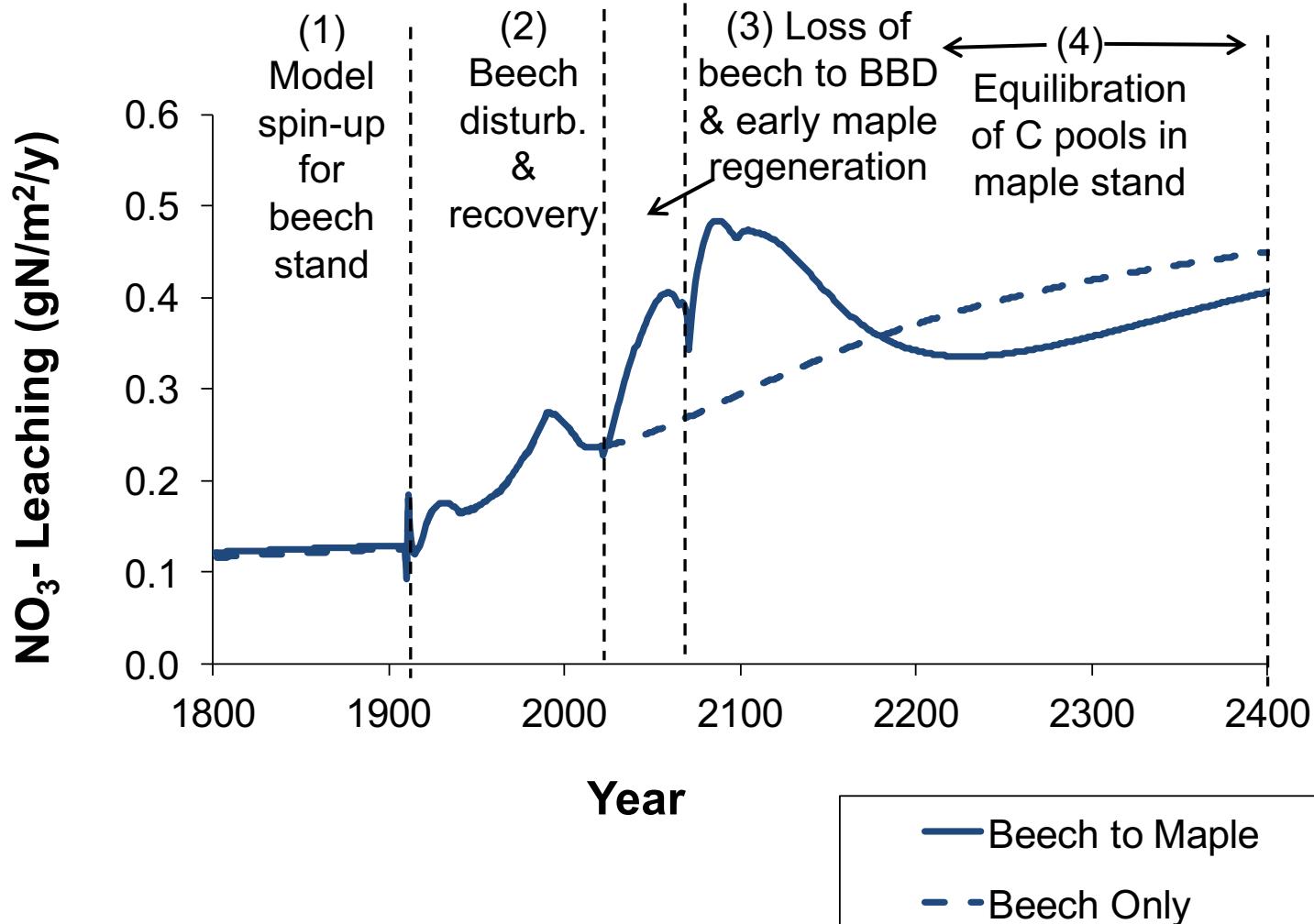
Scenario 2: Replacement of eastern hemlock with yellow birch due to hemlock woolly adelgid (HWA)

(1) Model spin-up for hemlock stand

(2) Hemlock logging & recovery

(100% mortality in 1850)

(3) Loss of hemlock to HWA & early birch regener-ation

(4) Equilibration of C pools in yellow birch stand

0   1850   2020   2050   2400

Year

Nitrogen deposition increases from 0.2 in 1940 to 0.9 in 1990, then declines to 0.6 by 2010 and is held constant thereafter

With replacement of hemlock by yellow birch, Spe-CN predicts a 59% decrease in forest floor C, but a 29% increase in plant C
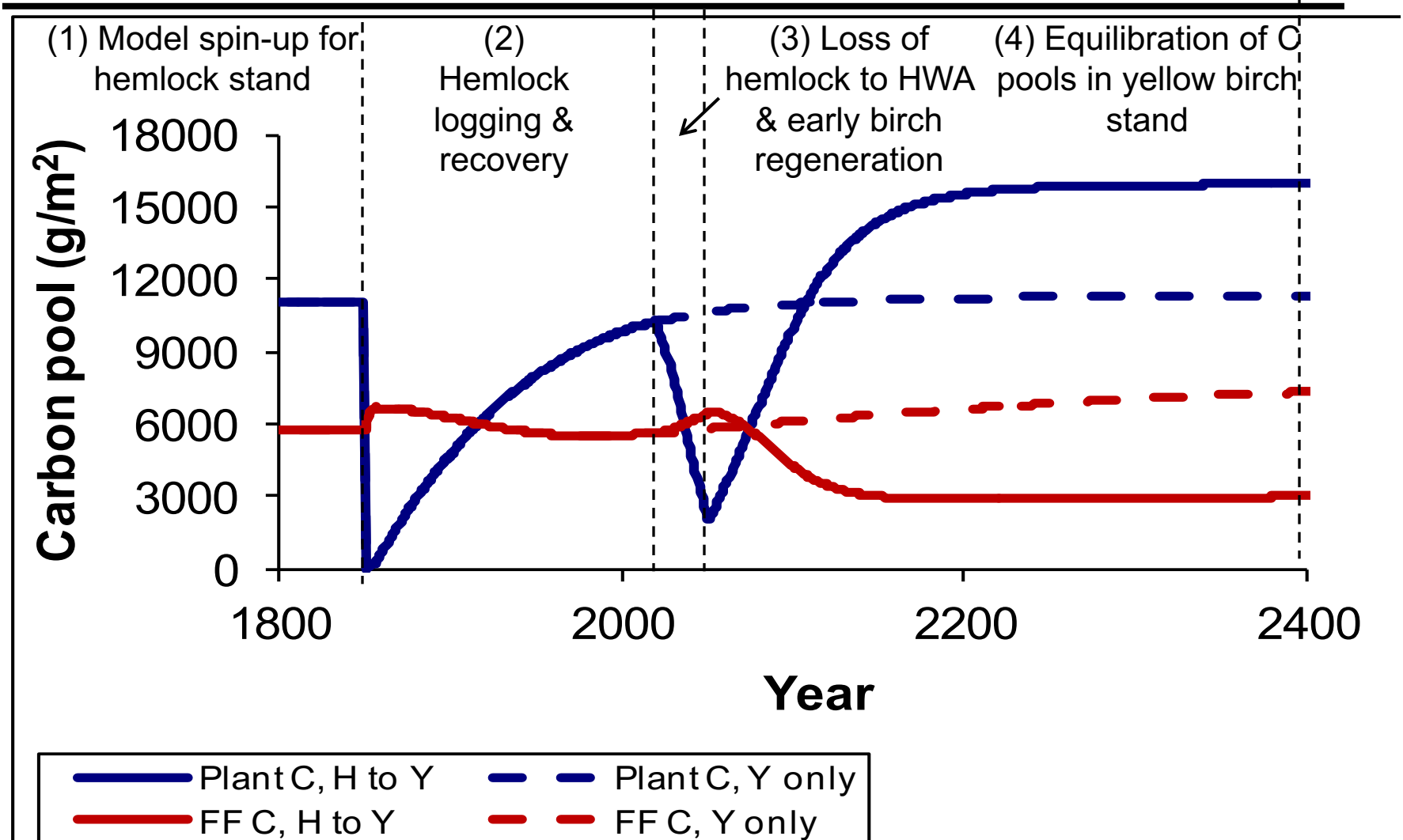
With replacement of hemlock by yellow birch, Spe-CN predicts an increase of up to ___% in nitrate leaching
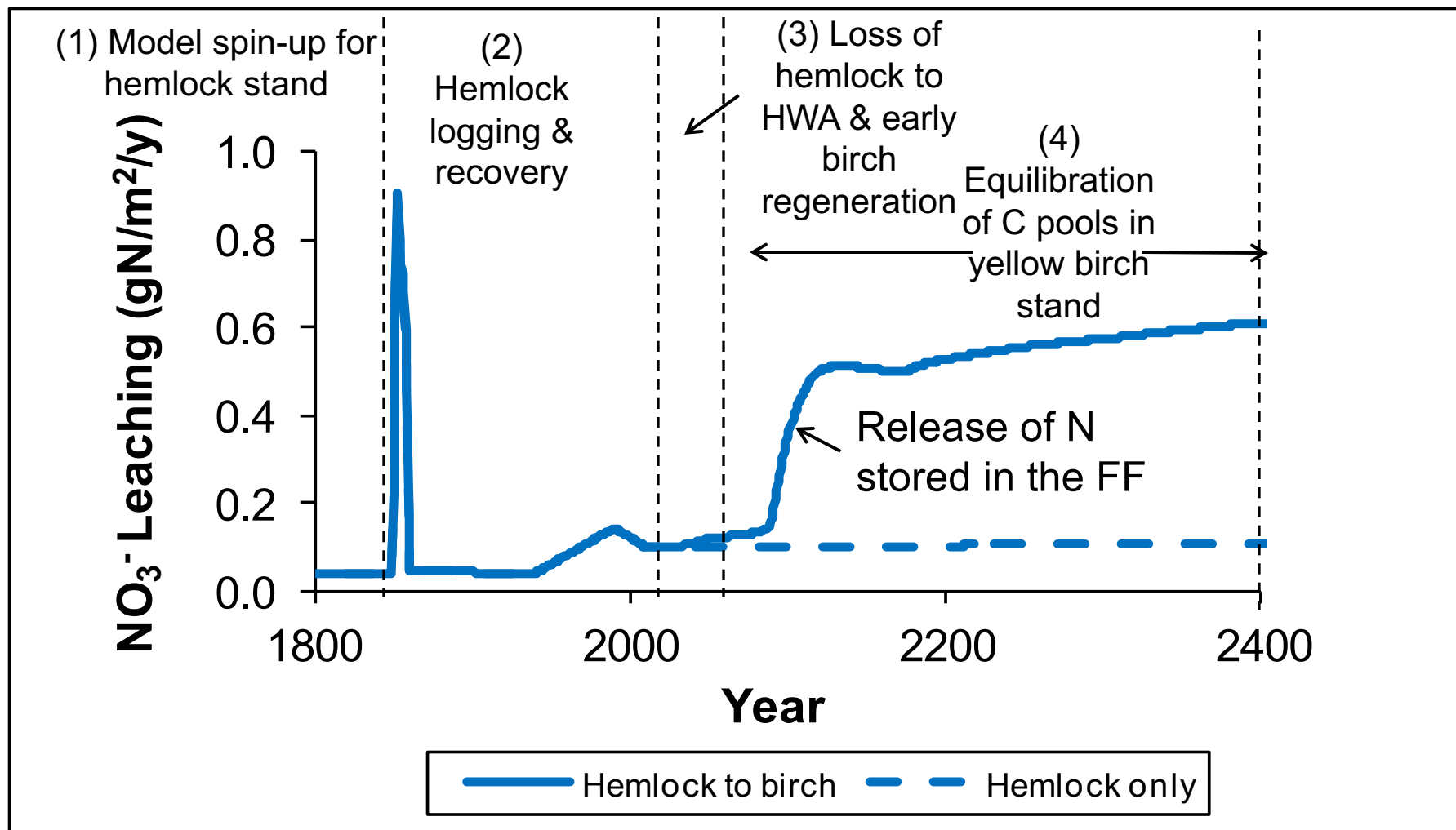
Assessing and Communicating the Impact of Introduced Forest Insects and Diseases

Goals:

1) Synthesis of ecological and economic impacts and evaluation of policy alternatives. Policy focus is on preventing establishment, and on the two major import pathways: live plants and wood packing material.

2) Outreach effort designed to reach legislators, agencies, media, and the public.

Chief collaborator:
Kathy Fallon Lambert
Science Policy Exchange/
Harvard Forest

Plus a team of 20 experts on entomology, ecology, economics and policy

Conclusions and parting shots

- Invasive insects and pathogens are arguably the most serious and urgent threat to Catskill forests.

- They will produce changes in species composition that have consequences for wildlife, forest ecosystem function, and water quality.

- Species-specific modeling can improve predictions of impacts on ecosystem function and can help forest managers balance production needs against goals for C storage and N retention.

- Policy action is needed at the federal level to minimize future invasions. We should be focusing on the <u>next</u> pest, not the <u>last</u> one.