Perspectives on Garlic Mustard (*Alliaria petiolata*) Biocontrol in the Midwest

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Why biocontrol?

- An introduced European biennial plant that has spread to 37 states and 6 Canadian provinces
- One of the few introduced herbaceous species that invades and dominates forest understory communities
- Sites dominated by garlic mustard frequently have low native herbaceous richness and cover.

Table 1. Top five most inventoried forest invasive plants by the FIA program within each region of the United States.

Rank	South	North	Intermountain West	Pacific
1	*Lonicera japonica*	*Rosa multiflora*	*Bromus tectorum*	*Bromus tectorum*
2	*Ligustrum sinense/vulgare*	*Phalaris arundinacea*	*Cirsium arvense*	*Rubus armeniacus*
3	*Rosa spp.*	*Alliaria petiolata*	*Centaurea biebersteinii*	*Hypericum perforatum*
4	*Lespedeza cuneata*	*Lonicera japonica*	*Cynoglossum officinale*	*Cirsium arvense*
5	*Microstegium vimineum*	*Rhamnus cathartica*	*Carduus nutans*	*Taeniatherum caput-medusae*

Garlic Mustard Biocontrol

CABI-Europe Switzerland

Minnesota Agriculture Experiment Station/Minnesota Dept. Agriculture High Security Containment Facility

- Blossey, Hinz, Gerber, and Nuzzo began the program in 1998
- Initial agent selection and host range testing conducted at CABI-Switzerland
- In 2003, supplemental host range testing initiated in High Security Containment Facility at University of Minnesota

Potential Biocontrol Insects for Garlic Mustard

Ceutorhynchus scrobicollis

- crown miner estimated to provide 80% control

- *Ceutorhynchus constrictus* – seed feeder estimated to provide 20% control
- *Ceutorhynchus roberti* – stem miner
- *Ceutorhynchus alliariae* – stem miner

C. scrobicollis specificity

- Tested 125 species / subspecies
- 22 different families
- 85 within Brassicaceae (mustard) family
  - 23 tribes
  - 7 threatened and 1 endangered
    - plus 18 surrogates

Results of *C. scrobicollis* host-specificity testing

Based on our testing results + lack of field records of *C. scrobicollis* attack on plants

- the ecological host range appears restricted to the target plant
- Limited larval feeding and occasional partial larval development under no-choice conditions on a few species
  - extremely limited risk of non-target effects as they grow in habitats unlikely to support *A. petiolata*

Testing conclusions

- We consider the root-crown weevil *C. scrobicollis* a safe and effective control agent for garlic mustard in North America
- Recommend releasing *C. scrobicollis* in eastern and Midwestern USA in areas with garlic mustard
- unlikely to establish on West Coast, Southwest and Southeast
  - Low climate match and low dispersal ability of *C. scrobicollis*

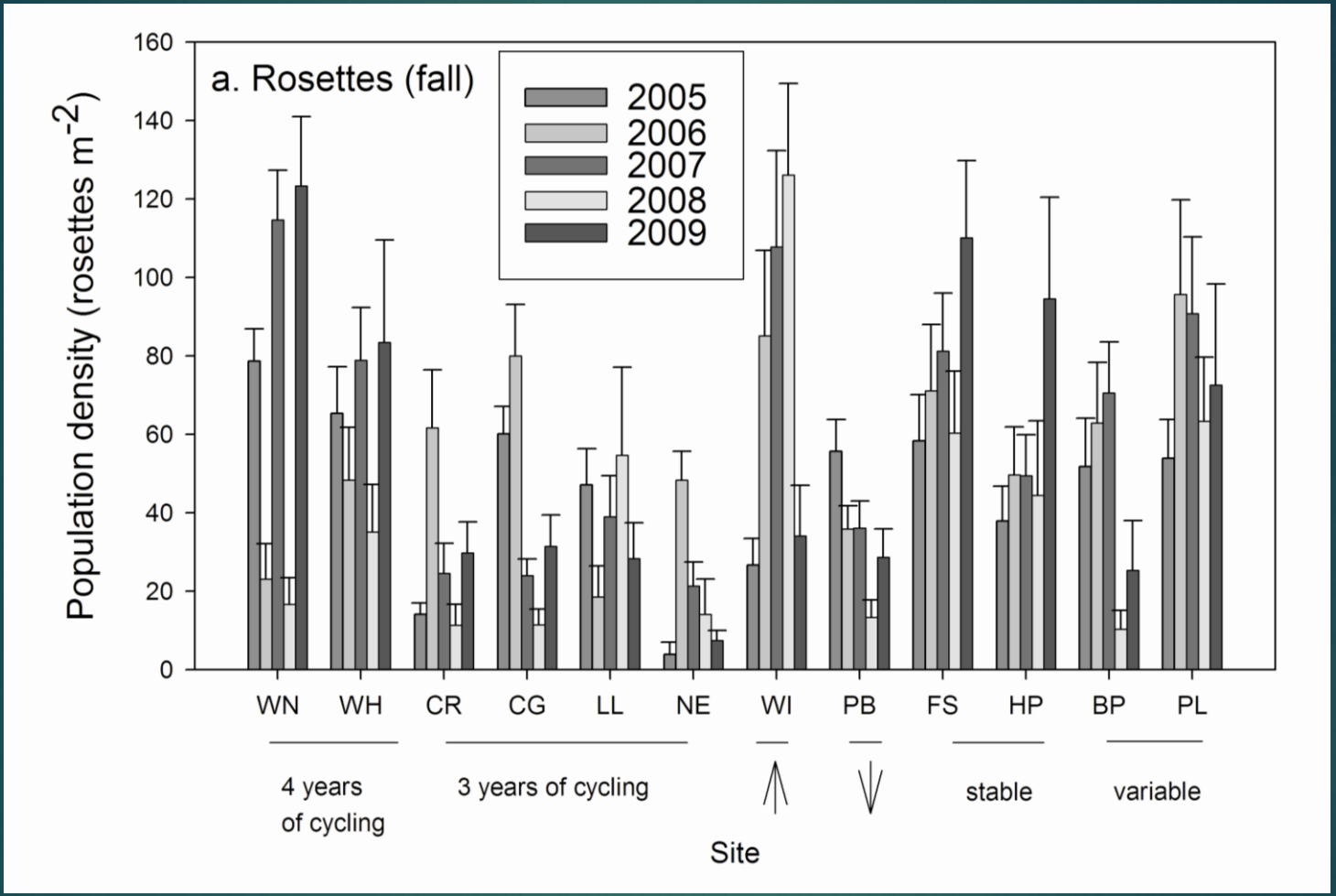
Meanwhile….

- We’ve been monitoring garlic mustard populations in Minnesota

Long-term population monitoring

- 12 MN sites established 2005-2006
  - Followed national protocol (Nuzzo 2003)
    - Forced transects to heavy garlic mustard populations at each site
    - Forced individual quadrats along transects so every quadrat contained garlic mustard
    - Assumed would release agents within a few years

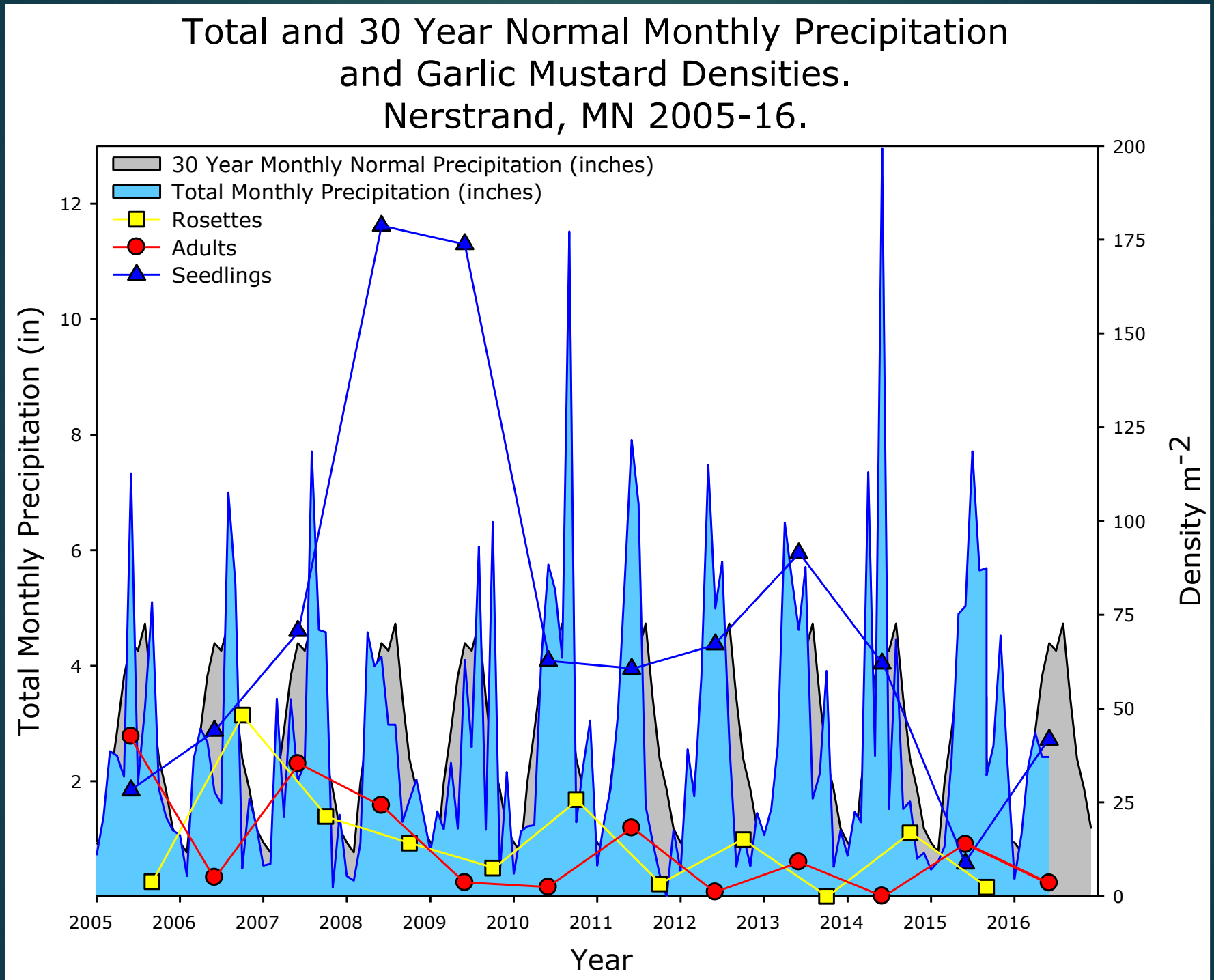
Dynamic life-cycle



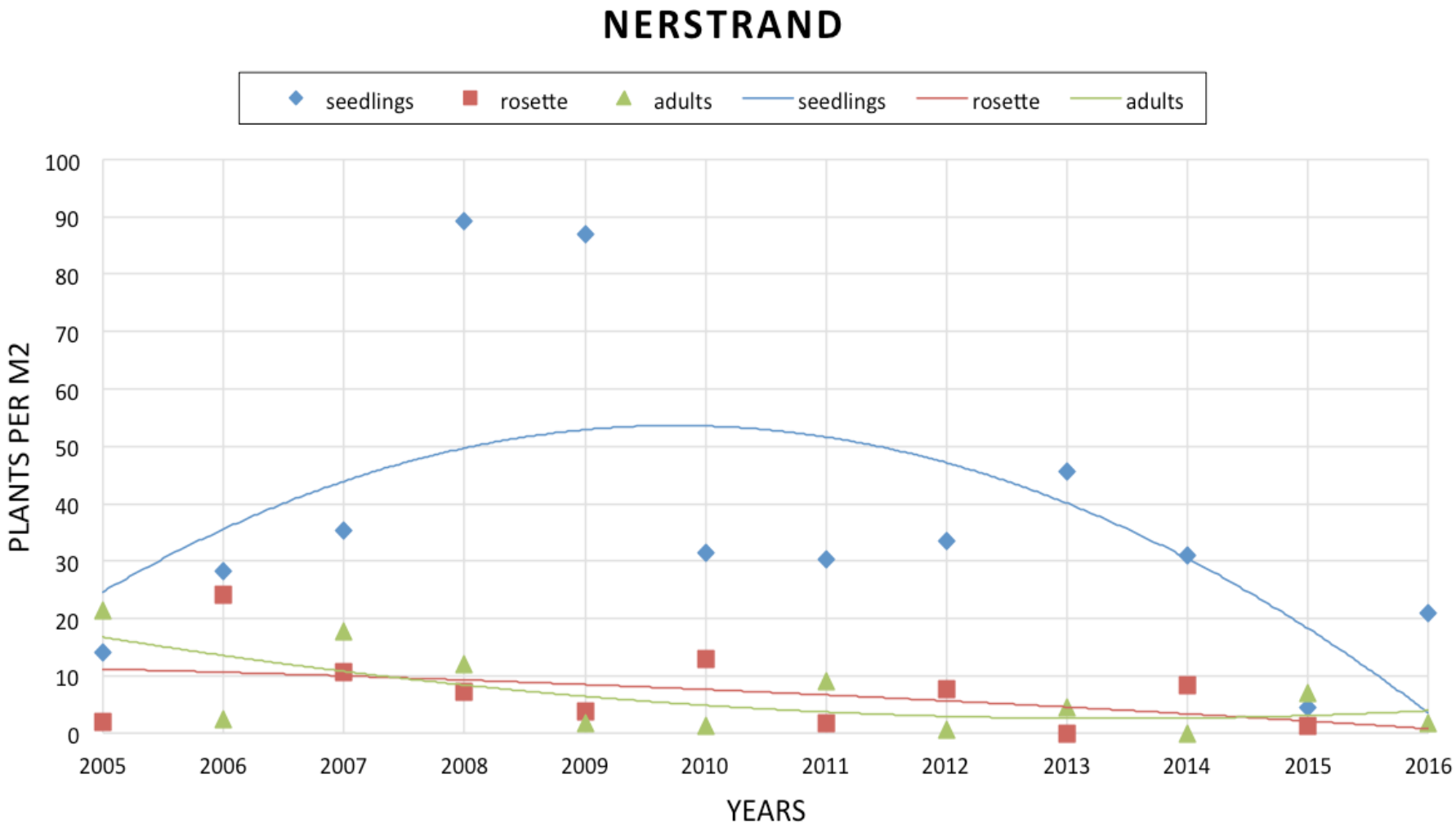
The previous years' patterns did not necessarily predict the next.

BP=Baker Park, CR=Coon Rapids, CG=Cottage Grove, FS=Fort Snelling, HP=Hilloway Park, LL=Luce Line, NE=Nerstrand, PB=Pine Bend, PL=Plainview, WN=Warner Nature, WH=Westwood Hills, WI=Willmar.

Van Riper et al. Invasive Plant Sci.Mgt. 2010. 3:48-59.

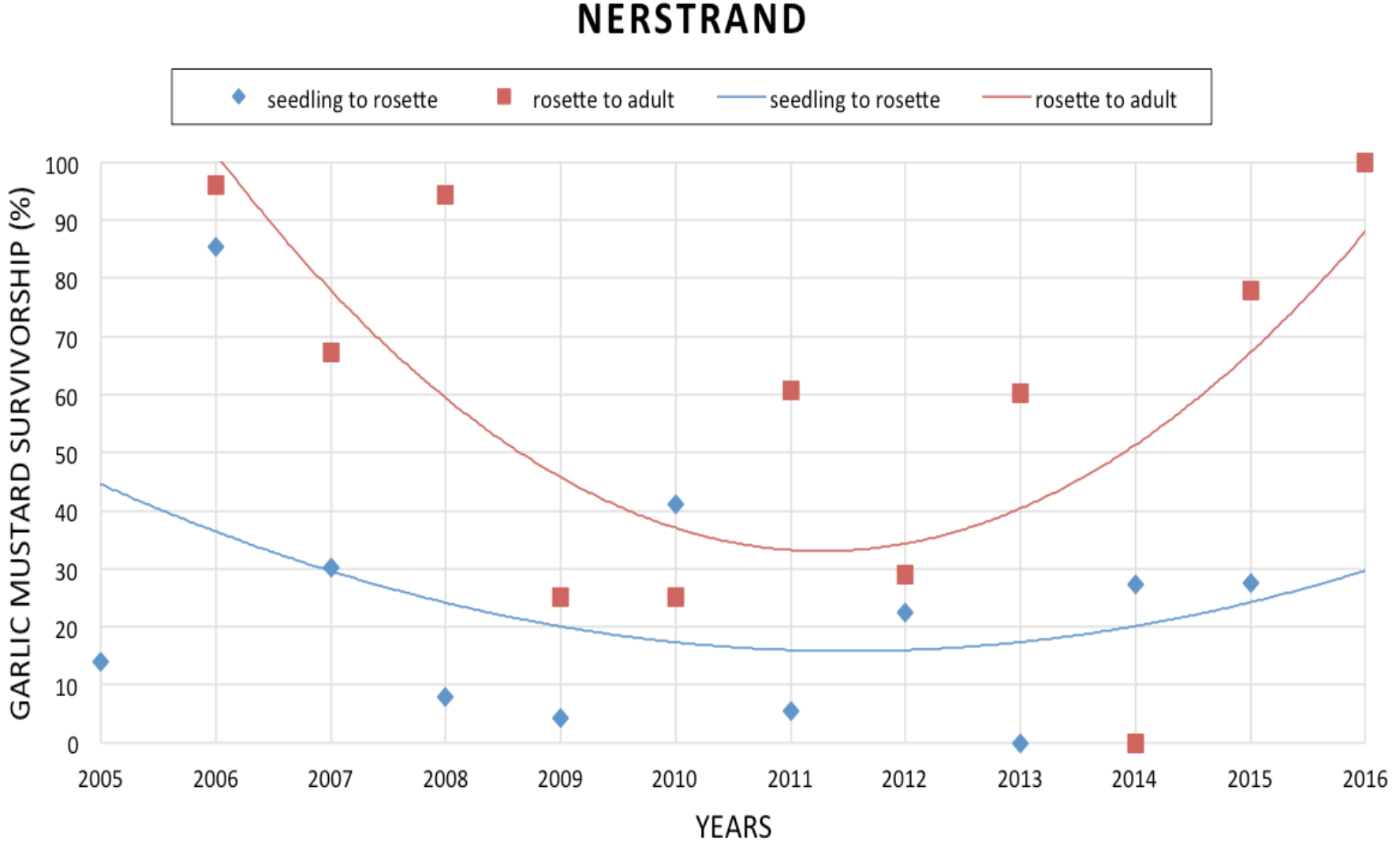

Total and 30 Year Normal Monthly Precipitation
and Garlic Mustard Densities.
Nerstrand, MN 2005-16.
30 Year Monthly Normal Precipitation (inches)
Total Monthly Precipitation (inches)
Rosettes
Adults
Seedlings
Total Monthly Precipitation (in)
Density m-2
Year
0
2
4
6
8
10
12
0
25
50
75
100
125
150
175
200
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Garlic Mustard Population Densities
by Life-Cycle Stage, MN 2005-2016



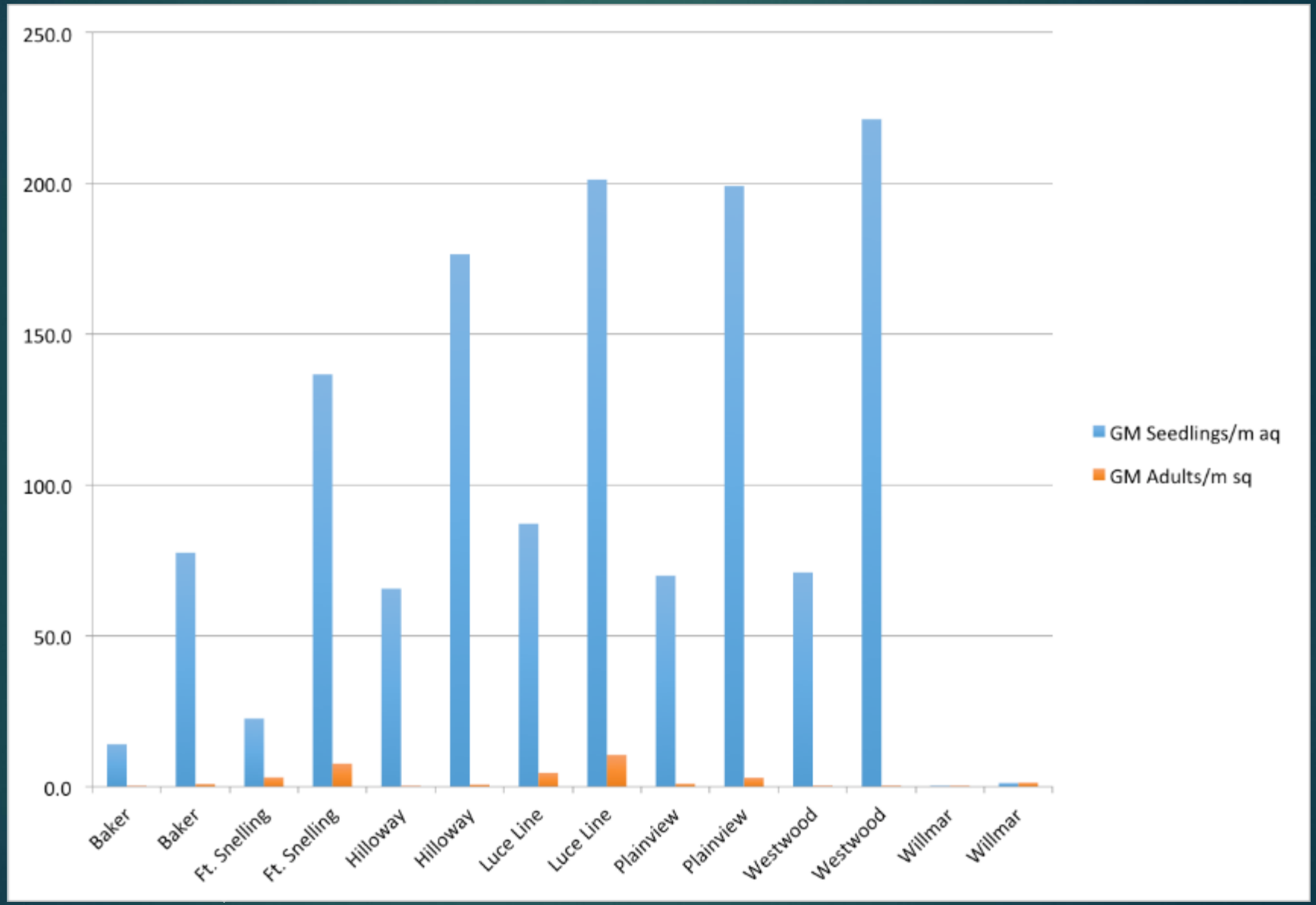
Garlic Mustard Survival to Subsequent Life-Cycle Stage,

MN 2005-2016



Garlic Mustard May No Longer Be In The Quadrat But.....

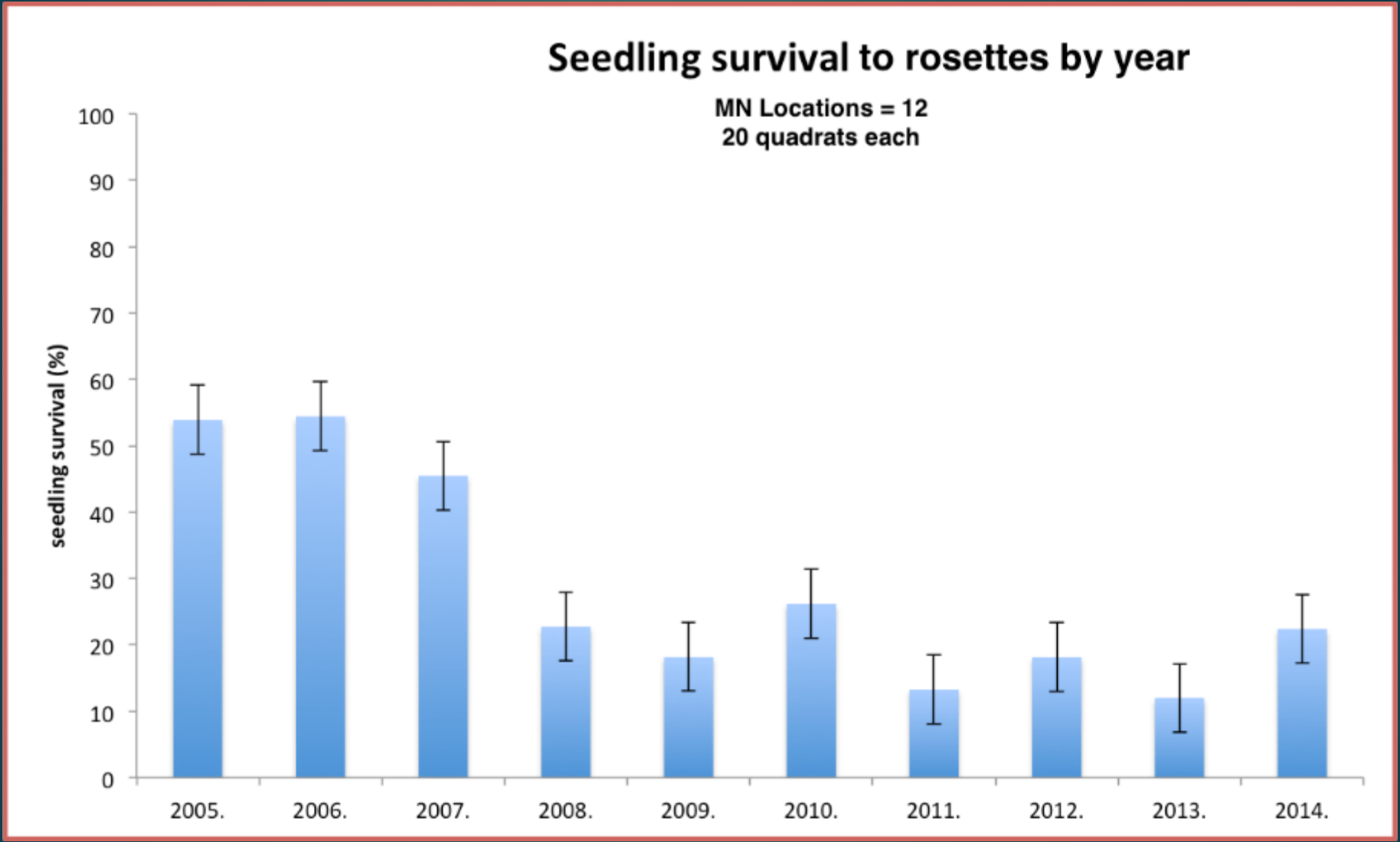
(June 2016 Ratings at 7 MN sites - 10 ft. dia. Circle Surrounding Permanent Quadrats)



Abundant garlic mustard near plots

Garlic Mustard Seedling Survival to Rosettes

- vulnerable life stage, high mortality possible



Little disease or herbivory seen, soil moisture can be very limiting in surficial soil zone.

Resurgence of GM in MN 2015-2016

Long-term population monitoring

Garlic mustard:

- Biennial, seed-driven population dynamics
  - Extremely variable compared to perennial species for which permanent quadrats work well
- Knowledge gained will inform and improve the monitoring techniques that will be used following release of biological control weevils once approved
- Monitoring has afforded us insight of the behavior of a biennial invader in a perennial system

After ten to eleven years of monitoring.....

- Very little herbivory or incidence of disease in Minnesota
- Populations vary considerably from year to year
- After a noticeable decline
  - three successive years of late-summer/fall droughts?
  - populations increased in 2015 to 2016
    - with a noticeable increase of new garlic mustard infestations beyond the monitoring sites
- Still present in 88.8% all of the plots originally established in 2005/2006

Perspectives: National

- Discussions are ongoing at the national level
  - Is garlic mustard still a major invasive pest?
  - Is garlic mustard in decline?
  - What are the impacts of garlic mustard?
  - Are there benefits to preventing a boom in garlic mustard at sites without garlic mustard?
  - What tools should we be using to manage forests?
  - How much host-specificity testing is “enough”?

Perspectives: Protocol

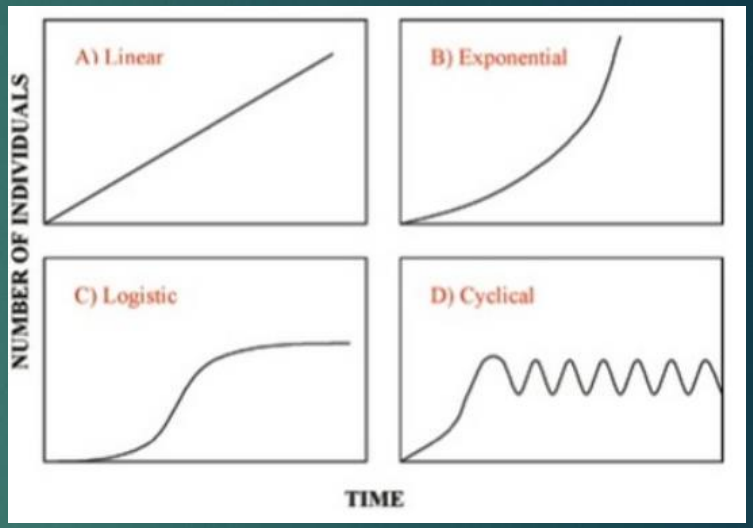
- Our monitoring plots were not a randomly placed on a landscape to characterize population dynamics on a landscape scale over time
  - Established to gauge the effectiveness of insects released for biocontrol
  - The study designed to start with 100% of the plots containing garlic mustard.
    - After 10 to 11 years, 88% of all plots sill contain garlic mustard.

Perspectives: Typical patterns

Garlic mustard seems to be following the typical patterns of invasive plant populations

- populations start small
- grow exponentially until plateau
- then decline reaching an equilibrium where the population stays fairly steady - but at a lower density than the highest recorded point

Garlic mustard seems fairly unremarkable in following this typical pattern



http://woodlandhighag.weebly.com/ecology.html

Perspectives: Biennial

Biennials are known to be patchy and move around

- Observations at our sites conform to the population dynamics of biennials - dependent on natural or man-made disturbances (Meijden et al. 1992)
- There are a number of sites where garlic is still present at the site, but the patches may no longer be in the plots

Perspectives: Abundance vs. Impact

- Abundance studies are not the same as impact studies
- Garlic mustard has been and continues to be a well-studied species with a strong body of research

Perspectives: Multiple Stressors

Forests are subject to multiple stressors:

- Land-use changes
- Climate change
- High deer populations
- Invasive species
  - Plants
  - Insects
  - Earthworms

For many stressors we have few tools to help mitigate impacts

Conclusions

- Garlic mustard continues to be present in Minnesota
- Many parts of Minnesota (and the US) have not been invaded by garlic mustard at this time
- Garlic mustard continues to be extremely challenging for land managers to manage

Conclusions – cont.

- *Ceutorhynchus scrobicollis* is a highly host-specific insect that could be a biocontrol insect for garlic mustard
- The USDA APHIS Technical Advisory Group is currently reviewing the petition for release of *C. scrobicollis*
- We support the addition of *C. scrobicollis* as another tool in the toolbox for forest management

Major funding sources 1998 - present

- USDA Forest Service (Technology Development for the Biological Control of Invasive Native and Non-Native Plants)
- Minnesota Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Natural Resources
- Strategic Environmental Research Development Program (SERDP), Department of Defense
- Minnesota Department of Natural Resources
- USDA APHIS Center for Plant Health Science Technology (CPHST)
- Wisconsin Department of Natural Resources


Questions?