

Swallow-wort Biological Control

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ARS Biological Control of Swallow-wort

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Cornell	Antonio DiTommaso, Scott Morris, Chuck Mohler, Kristine Averill, Lillian Magidow <i>Weed Ecologists</i>
Russia	Margarita Dolgovskaya, Sergey Reznik, Mark Volkovitsh, Vadim Zaitzev <i>Entomologists</i> (St. Petersburg)
Canada	Stephen Darbyshire, <i>Plant Taxonomist</i> (AAFC, Ottawa)
China	Jianqing Ding, Jialiang Zhang <i>Entomologists</i> (Wuhan)

URI/CABI program

Rhode Island	Aaron Weed, Alex Hazlehurst, Richard Casagrande, Lisa Tewksbury <i>Entomologists</i>
Switzerland (CABI)	Andre Gassmann <i>Entomologist</i>
Canada	Rob Bouchier, Sandy Smith <i>Entomologists</i>

Swallow-wort (*Vincetoxicum* spp.)

Family Apocynaceae: Asclepiadoideae

Pale swallow-wort (*V. rossicum* = *Cynanchum rossicum*)

Black swallow-wort (*V. nigrum* = *C. louiseae*, *C. nigrum*)



- *Vincetoxicum* is distinct from *Cynanchum* (different subtribes)
- Sister genus is Old World *Tylophora*

(Liede 1996, Liede 1997, Civeyrel et al. 1998, Sennblad and Bremer 2000, Liede 2001, Liede et al. 2002)

No hybridization expected with “American” swallow-worts



Black Swallow-wort

Pale Swallow-wort

Native distribution

*Vincetoxicum
hirundinaria*

V. rossicum +
others

V. nigrum



- Hairy & blunt petals
- Corona inconspicuously 5-lobed
- Buds rounded apex & not twisted

- Hairless & strap-like petals
- Corona distinctly 5-lobed
- Buds pointed apex & twisted



White Swallow-wort
(*V. hirundinaria* =
C. vincetoxicum)

Black Swallow-wort
(*Vincetoxicum nigrum*)

Flowers **dark purple** to blackish



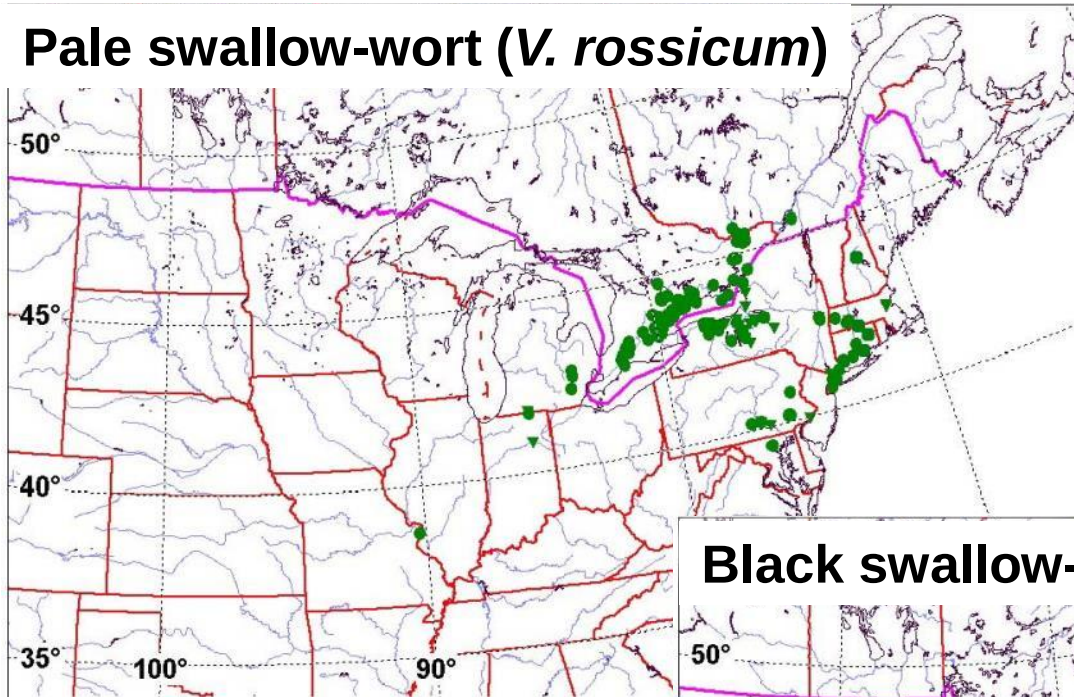
Pale Swallow-wort
(*Vincetoxicum rossicum*)

Flowers **pink** to **maroon**

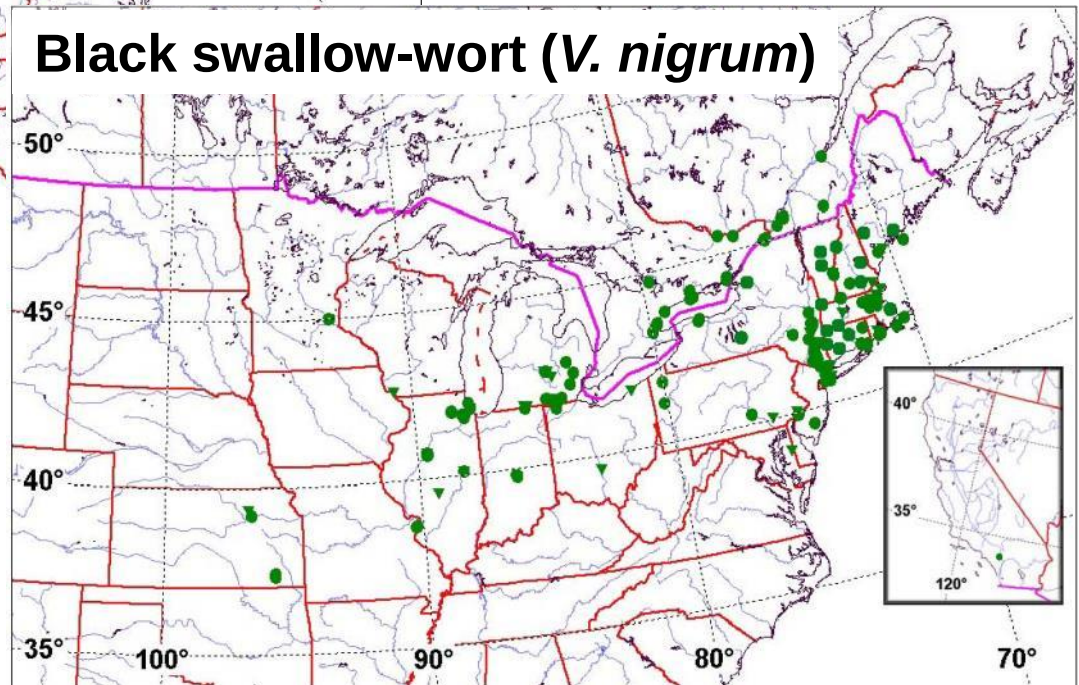
North American distribution

mainly 40-46°N latitude

Pale swallow-wort (*V. rossicum*)



Black swallow-wort (*V. nigrum*)



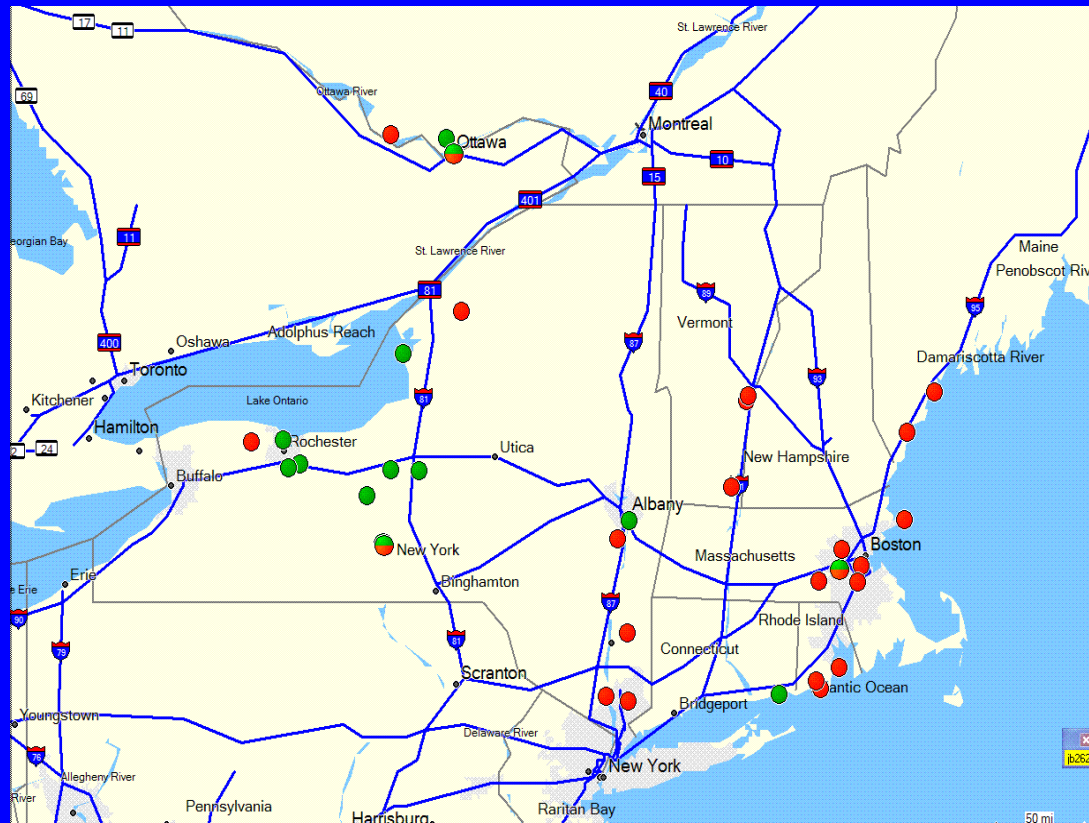
S. Darbyshire, unpublished data; with additions by L. Milbrath

Genetic characterization of Swallow-worts

M-C Bon, ARS-EBCL

Distribution of genotypes in North America

Identify geographic origin in Europe of North American genotypes



● Pale SW locations

● Black SW locations (also WI, CA)

Genetic studies in Europe & North America

M-C Bon, ARS-EBCL

North America

1 haplotype/1 major genotype for each species

BSW no match with Europe

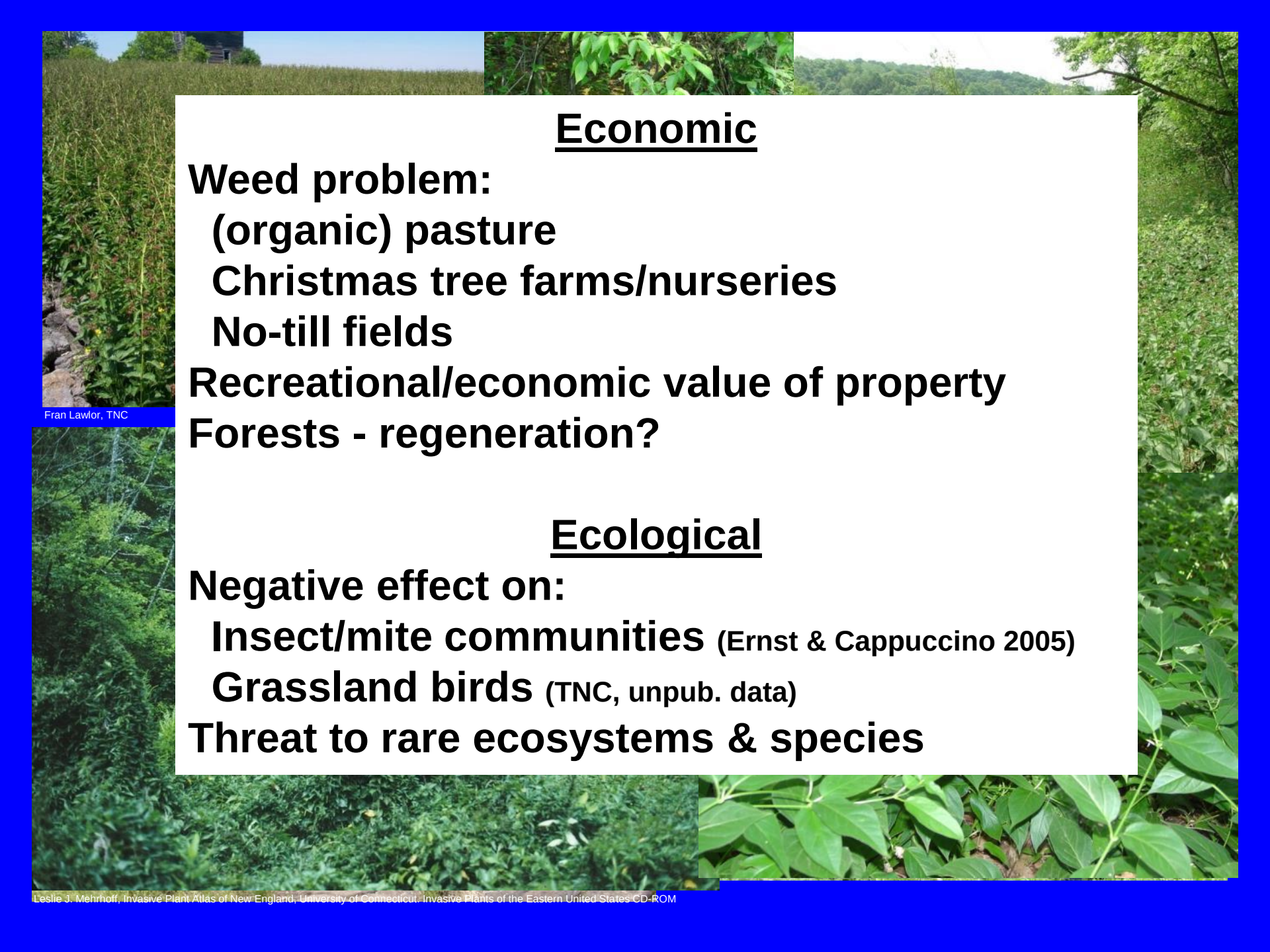
PSW match with Ukraine

- single or limited # introductions

BSW (France, U.S.A., Canada) = tetraploid (44 chromosomes)

PSW (Ukraine, U.S.A., Canada) = diploid (22 chromosomes)

- Novel hybrids unlikely

The background of the slide features several photographs of invasive plant species. On the left, there's a tall, dense stand of reeds or grasses. Below that, a smaller image shows a dense thicket of green foliage. On the right, there's a large, vertical image of a dense forest with green leaves. At the bottom, there are two more images: one showing a dense thicket of green plants, and another showing a close-up of green leaves with small white flowers.

Economic

Weed problem:

(organic) pasture

Christmas tree farms/nurseries

No-till fields

Recreational/economic value of property

Forests - regeneration?

Ecological

Negative effect on:

Insect/mite communities (Ernst & Cappuccino 2005)

Grassland birds (TNC, unpub. data)

Threat to rare ecosystems & species

Fran Lawlor, TNC

Biological Control of Swallow-wort

Genetic diversity-"No"

Effective?

Safe?



Weed Biological Control

use of a living organism (natural enemy) to suppress the population of another organism that is considered to be a pest

Goal: release natural enemies that

1) pose no or little risk to non-target plants and

2) are effective in suppressing populations of the target weed

Near-relatives to Eurasian swallow-worts

Class Magnoliopsida

Subclass Asteridae

Order Gentianales

Family Apocynaceae (includes Asclepiadaceae)

Subfamily Asclepiadoideae

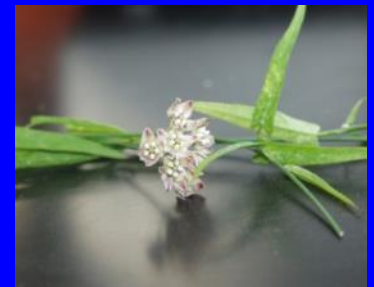
Tribe Asclepiadeae

Subtribe Tylophorinae - *Vincetoxicum* spp. (Target weeds)

7 other Subtribes - 21 genera, ~370 species

Native milkweeds and milkvines

Asclepias, *Cynanchum*, *Gonolobus*, *Matelea*, *Funastrum*, *Metastelma*



Class Magnoliopsida

Subclass Asteridae

Order Gentianales

**Family Apocynaceae (includes
Asclepiadaceae)**

Subfamily Asclepiadoideae

Tribe Asclepiadeae

Subtribe Tylophorinae

Vincetoxicum spp.

7 other Subtribes

21 genera, ~376 species

3 other Tribes

10 genera, ~51 species

Subfamily Secamonoideae

none

Subfamily Periplocoideae

2 genera, 3 species

Subfamily Apocynoideae

30 genera, ~111 species

Subfamily Rauvolfioideae

28 genera, ~125 species

Order Gentianales cont)

Family Gentianaceae

23 genera, ~220 species

Family Loganiaceae

9 genera, ~63 species

Family Gelsemiaceae

1 genus, 2 species

Family Saccifoliaceae

1 genus, 2 species

Family Rubiaceae

~129 genera, ~1160 species

Order Lamiales

Family Scrophulariaceae

3 genera, 37 species

formerly in Loganiaceae

**~2150 species total in North America
67 spp. to test + plants attacked by
agent congeners**

(Milbrath & Biazzo 2006 TAG)

New York: Insects and Mites found on Swallow-wort



twospotted spider mite
Tetranychus urticae



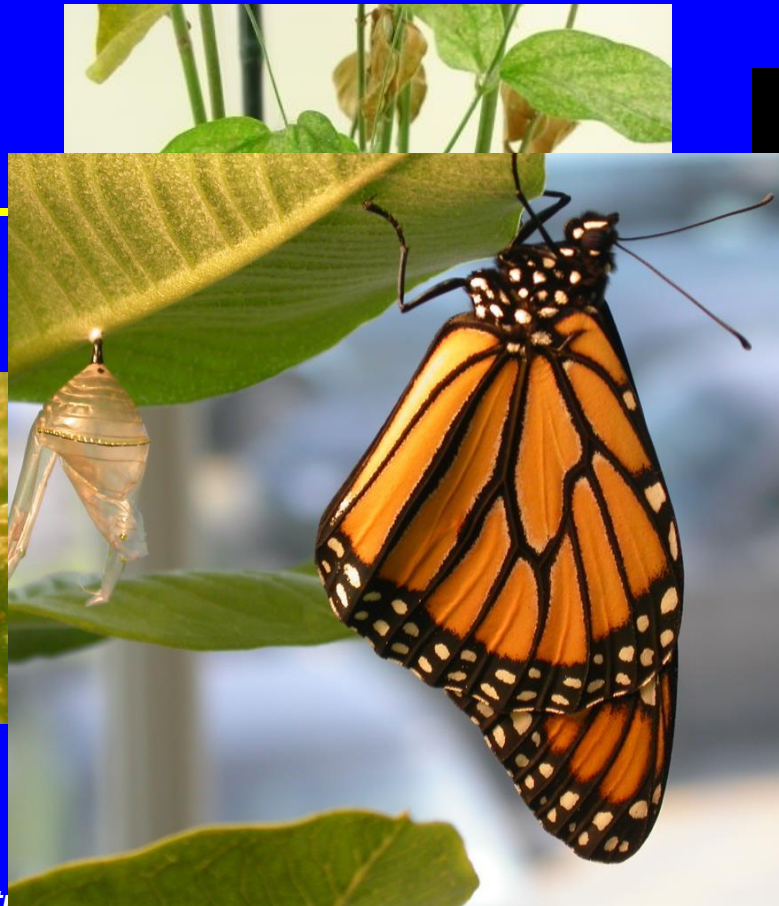
onion thrips
Thrips tabaci



mealybugs
Chorizococcus sp. prob. *dentatus*
Heliococcus osborni



leaf-tier moth
(Tortricidae: Olethreutinae?)



small & large milkweed bug
Lygaeus kalmii & *Oncopeltus fasciatus*



boxglove aphid
ulacorthum solani



fourlined plant bug
Poecilocapsus lineatus



flatid planthopper
Anormenis septentrionalis

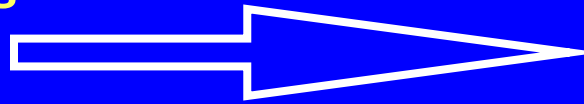


oystershell scale
Lepidosaphes ulmi

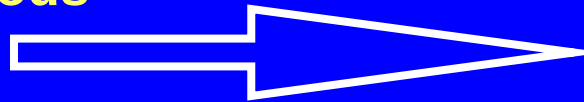
European/Asian Insects on Swallow-wort



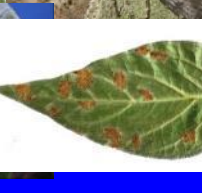
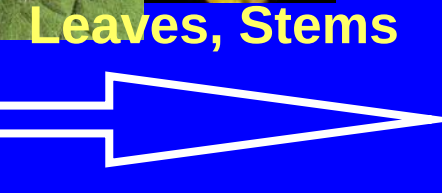
Flowers



Seedpods



Leaves, Stems



Roots



Foreign surveys and host range tests

René Sforza (ARS-EBCL, Montpellier, France)

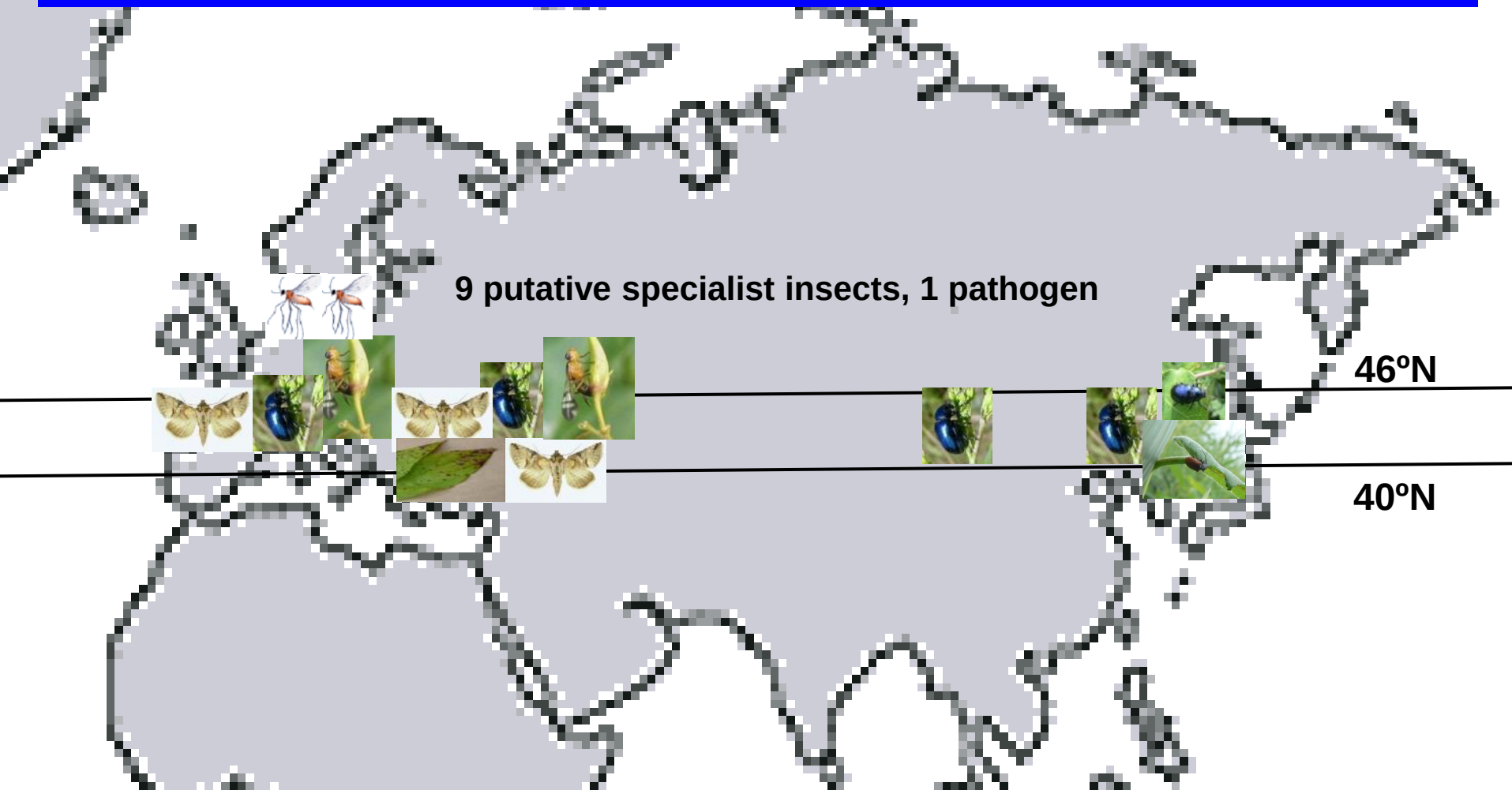
Margarita Dolgovskaya, Sergey Reznik, Mark Volkovitsh

(Zoological Institute, St. Petersburg, Russia)

Jialiang Zhang, Baoliang Tian, Jianqing Ding

(Wuhan Botanical Garden/Institute, Wuhan, China)

Dana Berner (ARS-Ft. Detrick)



Root-feeding Leaf beetles, *Chrysochus* spp. (Coleoptera: Chrysomelidae)



Successful larval development

Milkweeds (*Asclepias* spp.) + other species

Adult use of plants

Swamp milkweed (*As. incarnata*), butterfly weed (*As. tuberosa*)

CABI/Univ. Rhode Island, Gassmann et al. 2008-2011 reports

USDA-ARS-EBCL, Sforza 2009 & 2011 report

Zoological Inst., St. Petersburg, Dolgovskaya et al. 2009-2012 report

Rejected

Leaf beetle, *Chrysolina aurichalcea asclepiadis* (Coleoptera: Chrysomelidae)

Defoliator

Swiss population



- **Developed on butterfly weed (*Asclepias tuberosa*), mugworts (*Artemisia spp.*), tansy (*Tanacetum vulgare*)**

(Weed & Casagrande 2011 Environ. Entomol. 40:1427-1436)

Rejected

Root-feeding Flea beetle, *Liprus punctatostriatus* (Coleoptera: Chrysomelidae)

Open fields

Far East Russia & China



- **Developed on** native milkweeds (*Asclepias* spp.) and other species
(Dolgovskaya et al. 2011 & 2012 reports, Zhang et al. 2012 & 2013 reports)

Rejected

Defoliating moth, *Abrostola asclepiadis* (Lepidoptera: Noctuidae)



Sunny to shaded areas

One, maybe two generations per year

Non-target survival on one species to date

(Gassmann et al. 2008 report; unpubl. data)

**Defoliating moth, *Hypena opulenta*
(Lepidoptera: Erebidae)**



Ukraine, forests

Multiple generations per summer

No non-target survival

****Released in Canada 2013**

Waiting for federal approval in U.S.

(Hazlehurst et al. 2012 Environ. Entomol. 41:841-848)

Seed-destroying fly, *Euphranta connexa* (Diptera: Tephritidae)



Destroys most seed
Some Host range tests





Leaf anthracnose, *Colletotrichum lineola*
Krasnodar area, Russia

Berner et al. 2011 Plant Disease 95: 1586

Efficacy in doubt
Host range tests in progress



Biological Control of Swallow-wort

Genetic diversity-"No"

Effective?

Safe?



Weed Biological Control

Goal: release natural enemies that

1) pose no or little risk to non-target plants and

2) are effective in suppressing populations of the target weed

33-83% success rate (McFadyen 1998, Fowler 2000, Culliney 2005)

agent doesn't establish

established agent attacked by predators/diseases

****agent can't affect population growth of the plant**

ARS Swallow-wort Research Activities

Plant population model

Identify points in the life cycle of greatest importance to swallow-wort population growth (weak links)

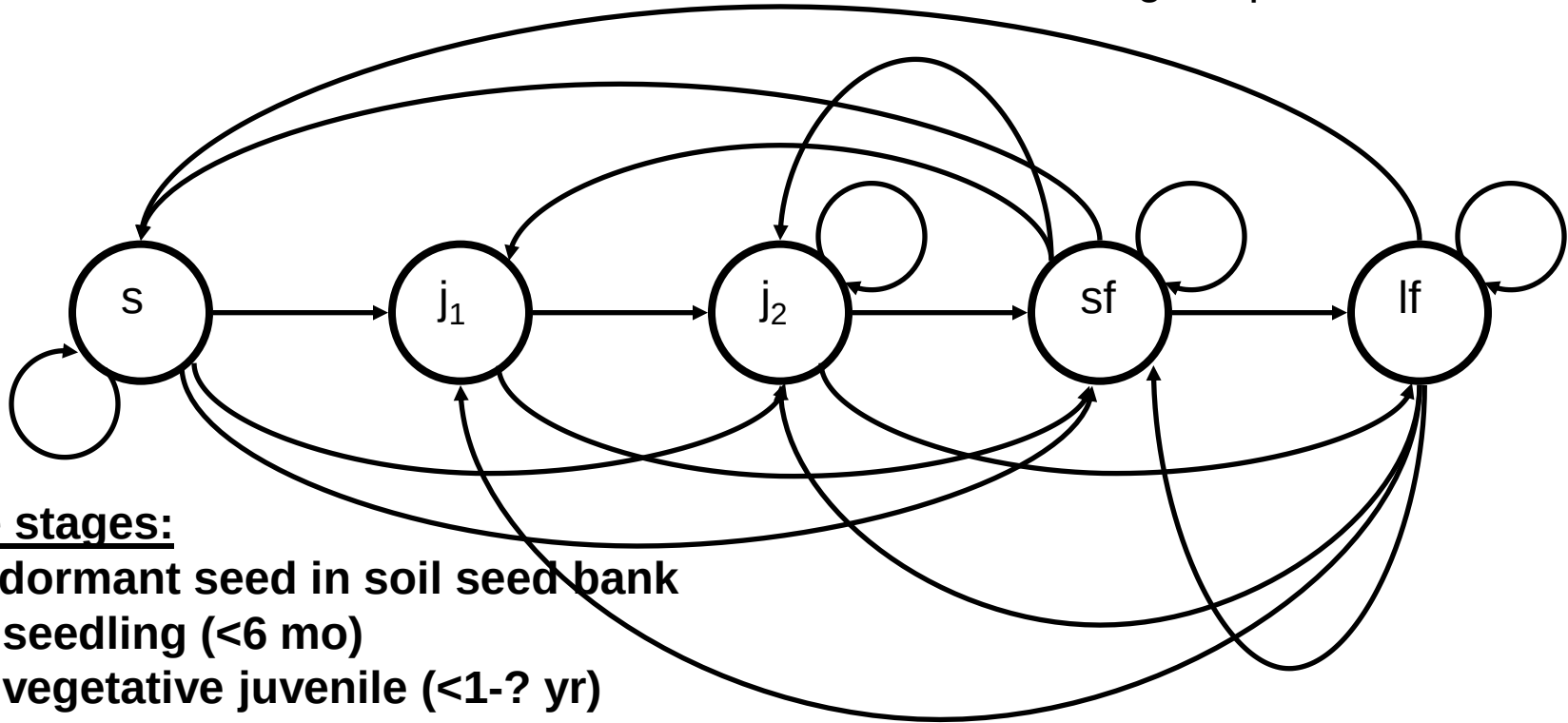


Target these key points for disruption with biocontrol agents and/or other control measures

Guide the selection of effective biological control agents

Pale/black swallow-wort Life Cycle

census time = August, prior to seed dispersal



Life stages:

s = dormant seed in soil seed bank

j₁ = seedling (<6 mo)

j₂ = vegetative juvenile (<1-? yr)

sf = small flowering, 1-2 stems (3-? yr)

lf = large flowering, 3+ stems (?-? yr, rare in forests)



Pale/black swallow-wort A Matrix

	seed	seedling	juvenile	small flowering	large flowering
seed	$s_s * (1 - (g_3 + g_4)) = s_s - s_s * g_3 - s_s * g_4$	0	0	$f_s * s_s * (1 - (g_1 + g_2))$	$f_l * s_s * (1 - (g_1 + g_2))$
seedling	$s_s * g_4 * s_{sdl1} * (1 - m_{jf})$	0	0	$f_s * s_s * g_2 * s_{sdl1} * (1 - m_{jf})$	$f_l * s_s * g_2 * s_{sdl1} * (1 - m_{jf})$
juvenile	$s_s * g_3 * s_{sdl2} * s_{juv1} * (1 - m_{vs1})$	$s_{juv2} * (1 - m_{jf})$	$s_v * (1 - m_{vs2}) * (1 - m_{vl})$	$f_s * s_s * g_1 * s_{sdl2} * s_{juv1} * (1 - m_{vs1})$	$f_l * s_s * g_1 * s_{sdl2} * s_{juv1} * (1 - m_{vs1})$
sf	$s_s * g_4 * s_{sdl1} * m_{jf} +$ $s_s * g_3 * s_{sdl2} * s_{juv1} * m_{vs1}$	$s_{juv2} * m_{jf}$	$s_v * m_{vs2}$	$s_{sf} * (1 - m_{sl}) +$ $[f_s * s_s * g_2 * s_{sdl1} * m_{jf} +$ $f_s * s_s * g_1 * s_{sdl2} * s_{juv1} * m_{vs1}]$	$r_{ls} + [f_l * s_s * g_2 * s_{sdl1} * m_{jf} +$ $f_l * s_s * g_1 * s_{sdl2} * s_{juv1} * m_{vs1}]$
lf	0	0	$s_v * m_{vl}$	$s_{sf} * m_{sl}$	$s_{lf} * (1 - r_{ls})$

where

g. = germination rates (new or dormant seed)

s. = survival rates

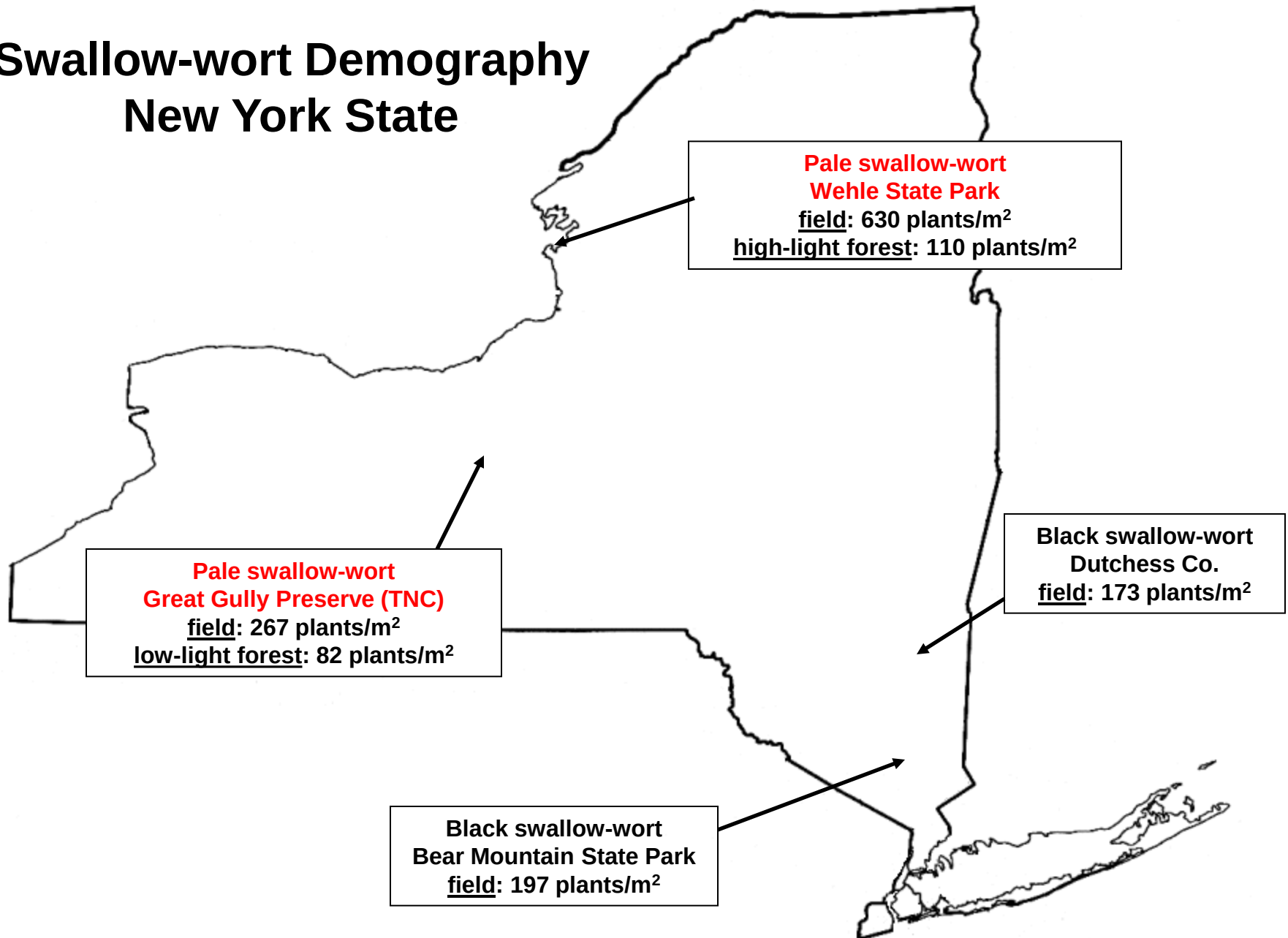
m. = maturation rates (growth to later stages)

r. = reversion rates (large flowering to small flowering)

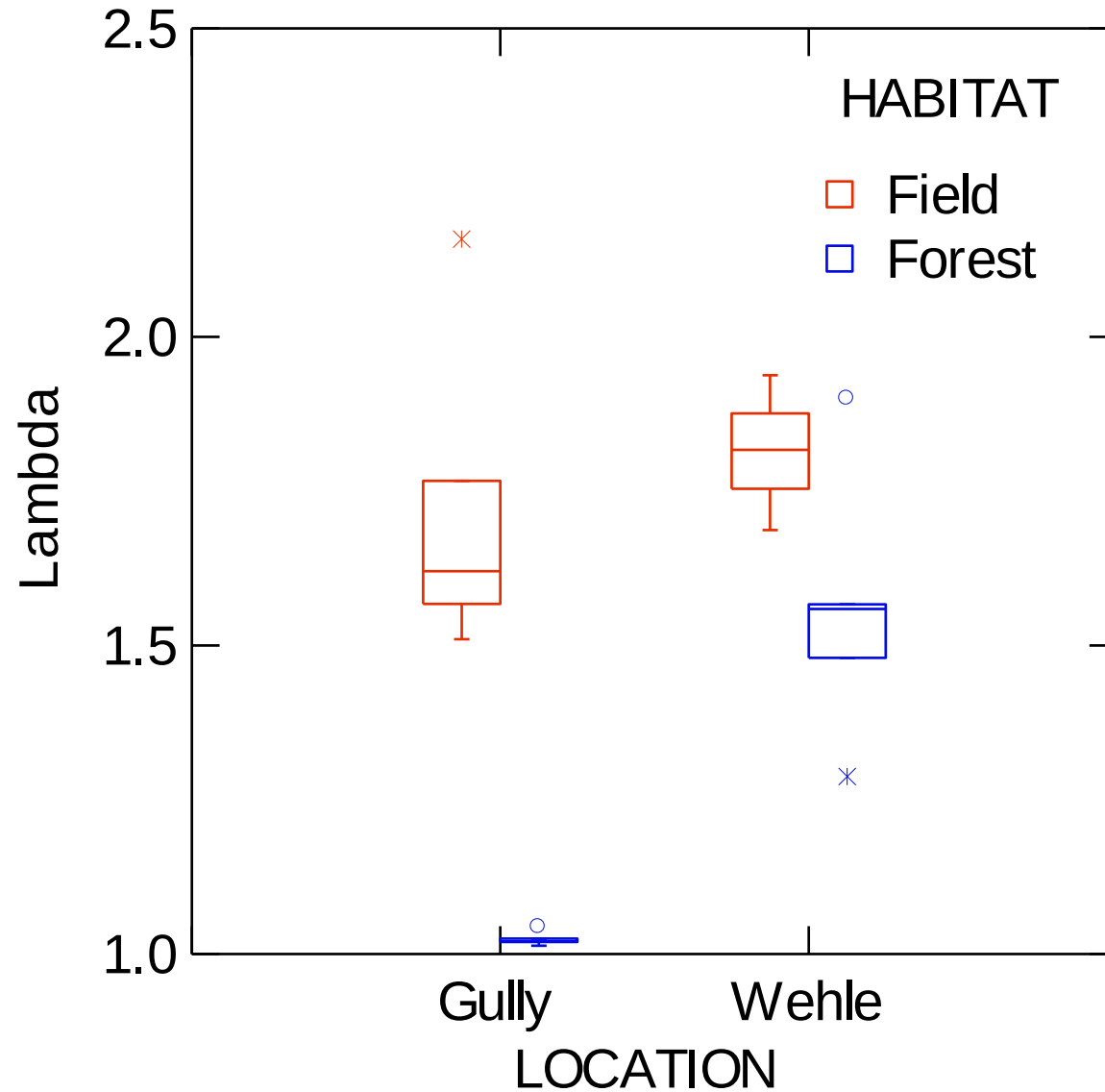
f. = fecundity (viable seeds per plant)

Swallow-wort Demography

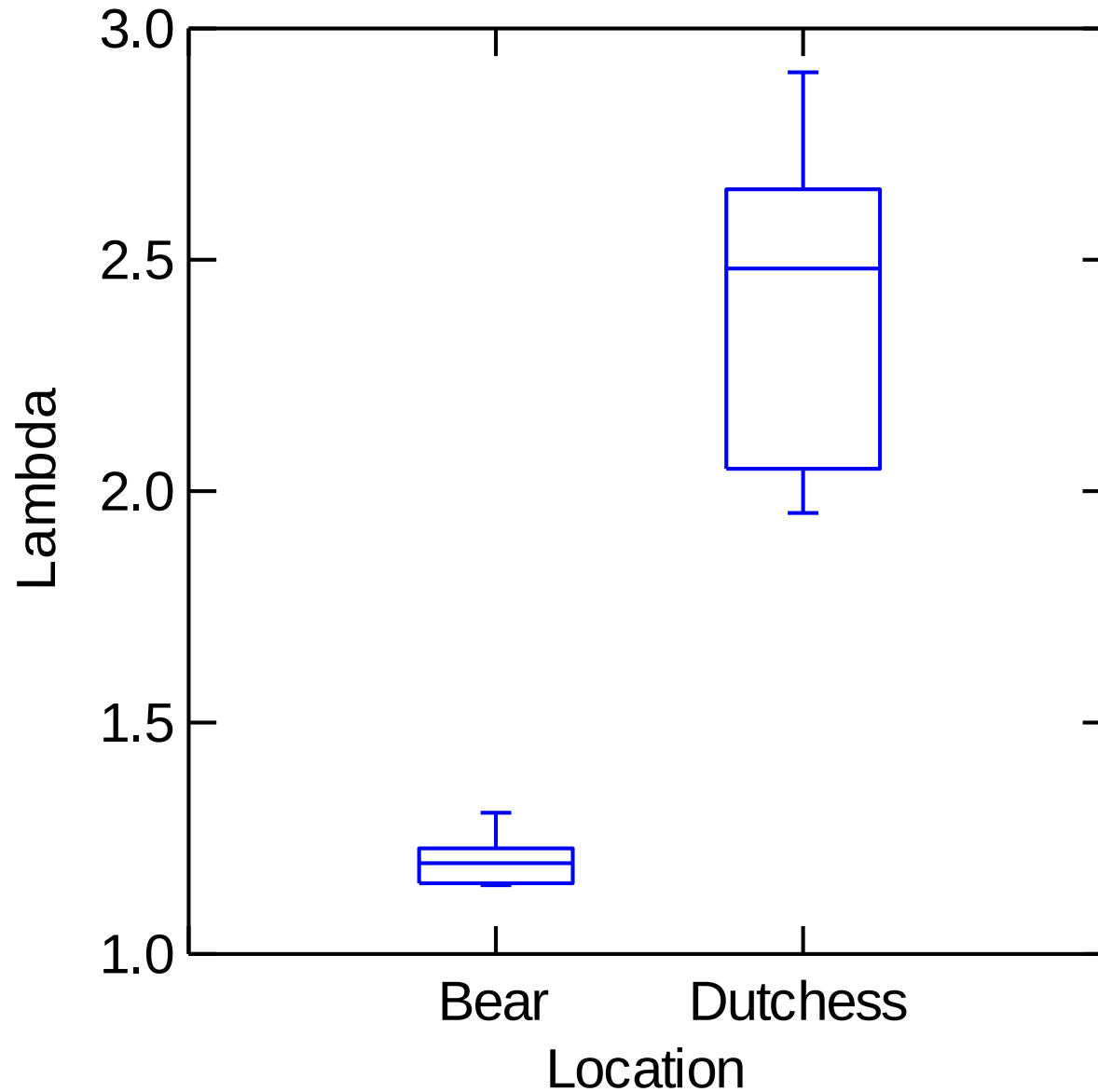
New York State



Pale swallow-wort Population Growth Rates (λ)



Black swallow-wort (field) Population Growth Rates (λ)

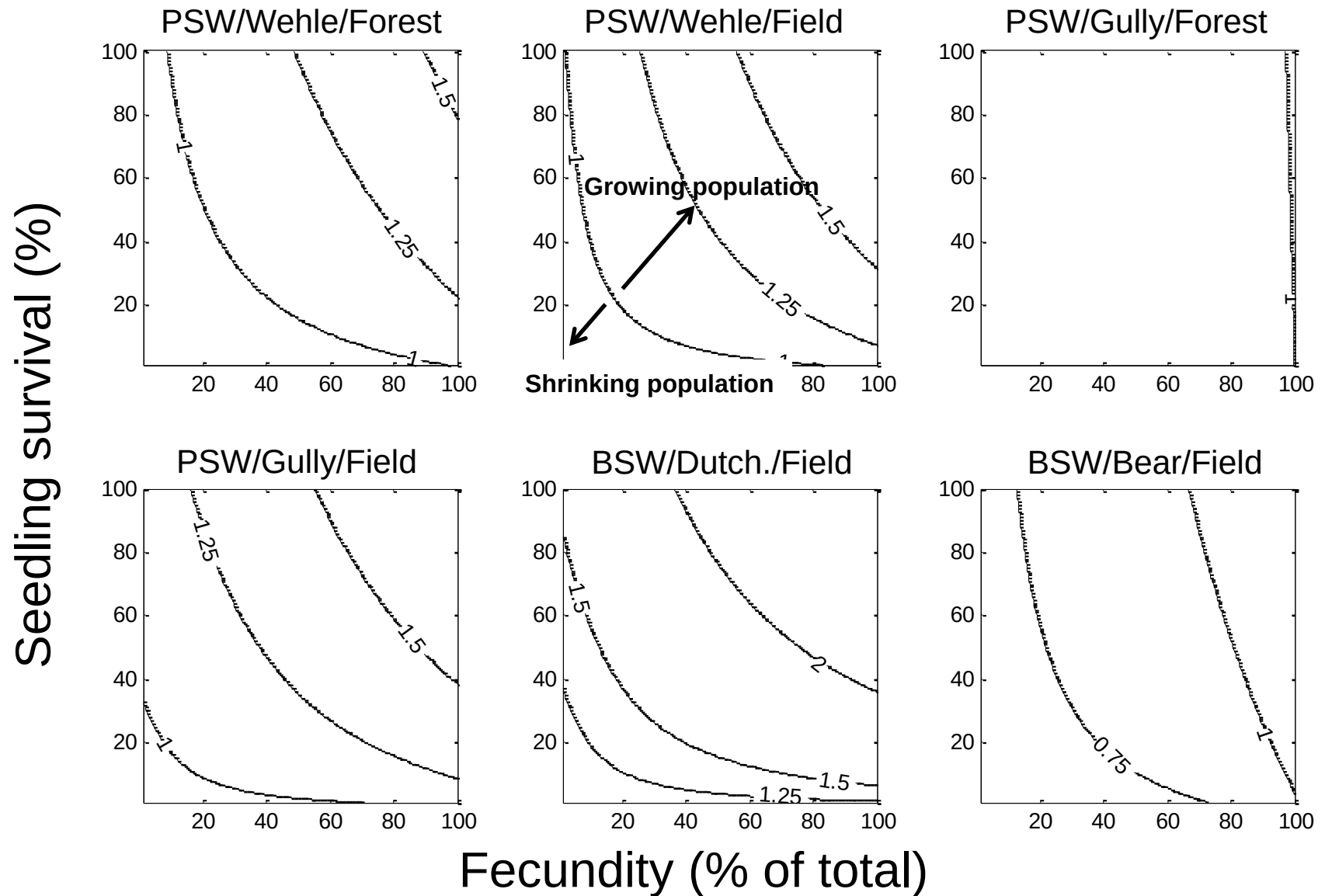


Target transitions: Swallow-wort matrix model

	Pale Swallow-wort				Black Swallow-wort	
Transitions to target	Wehle-field	Wehle-forest	Gully-field	Gully-forest	Bear Mountain	Dutchess
<u>Survival</u>						
Juveniles	X	X	X	X	X	
Small flowering	X	X	X	XX	X	
Large flowering						X
<u>Growth</u>						
Seedling to juvenile	X	X	X		X	X
Juvenile to small flowering	X	X	X		X	X
Small to large flowering						X
<u>Reproduction</u>						
Small flowering	X	X	X		X	
Large flowering						X

Impact of biocontrol agents on swallow-wort

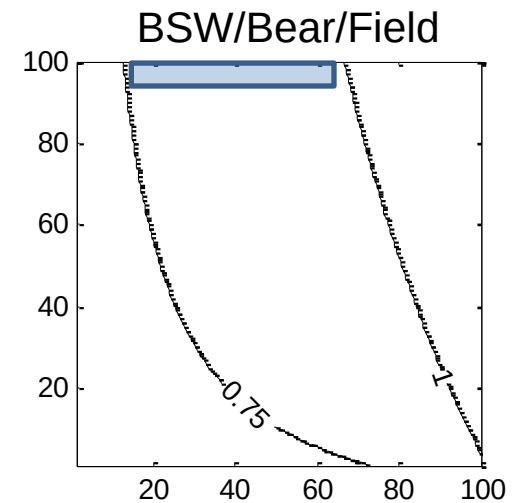
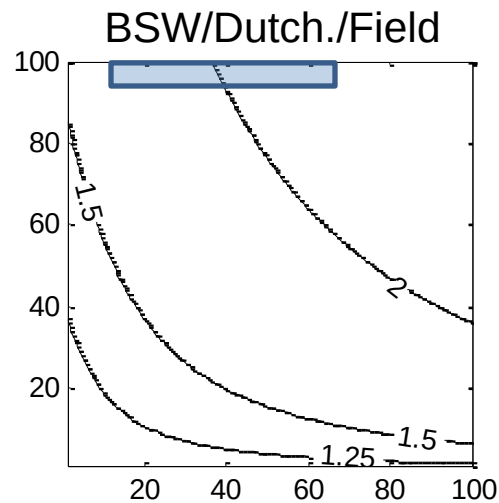
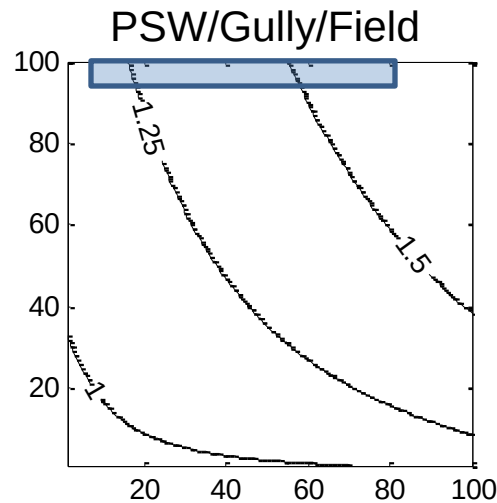
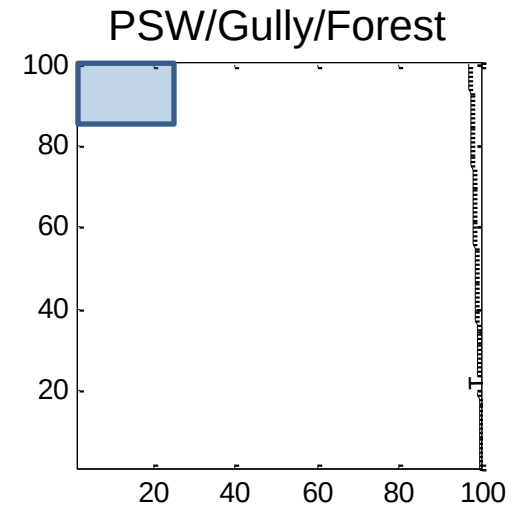
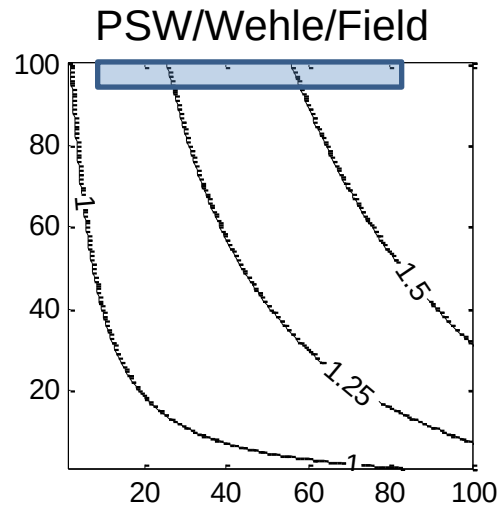
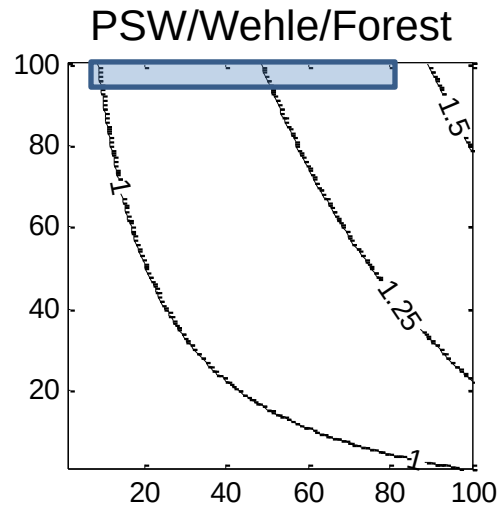
Contours of lambda: seedling survival vs fecundity



Contours of lambda. Agent: *Hypena opulenta* (Weed & Casagrande 2010; Milbrath, unpub. data)



Seedling survival (%)

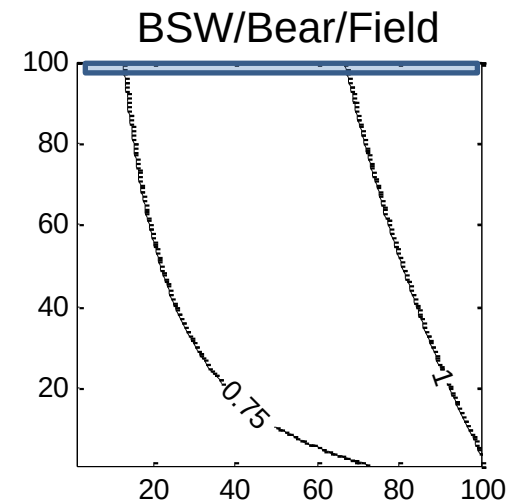
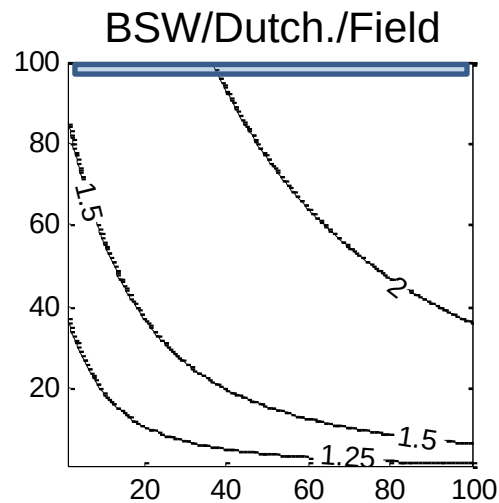
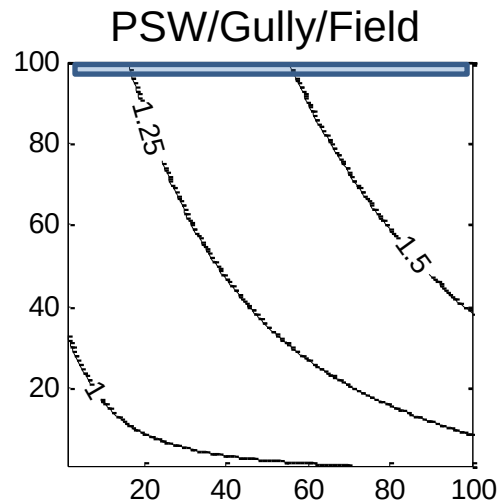
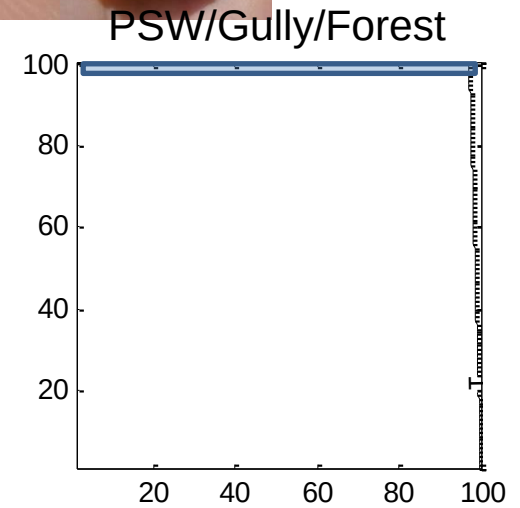
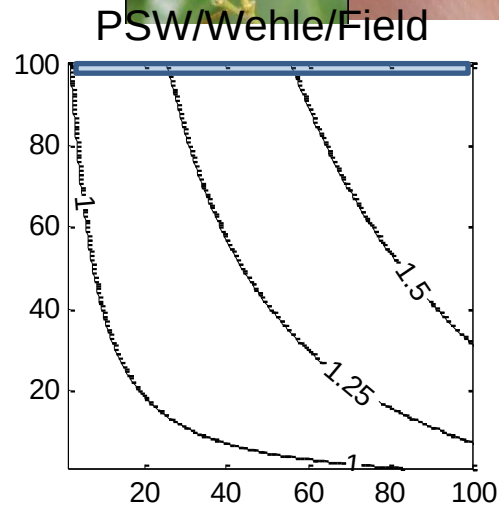
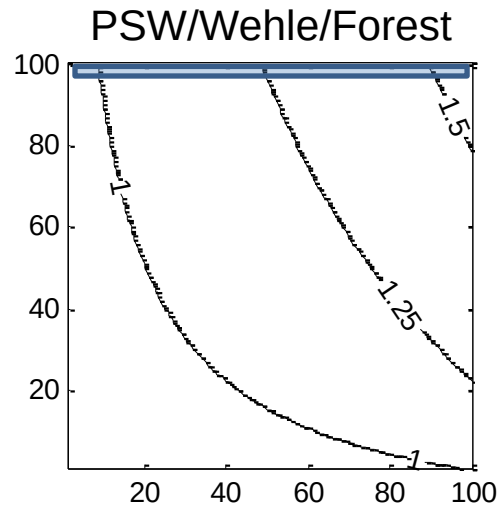


Fecundity (% of total)

Contours of lambda. Agent: *Euphranta connexa* (multiple sources)



Seedling survival (%)



Fecundity (% of total)

Biological Control of Swallow-wort

Genetic diversity-"No"

Effective?

Safe



Yes/no but...



No but...

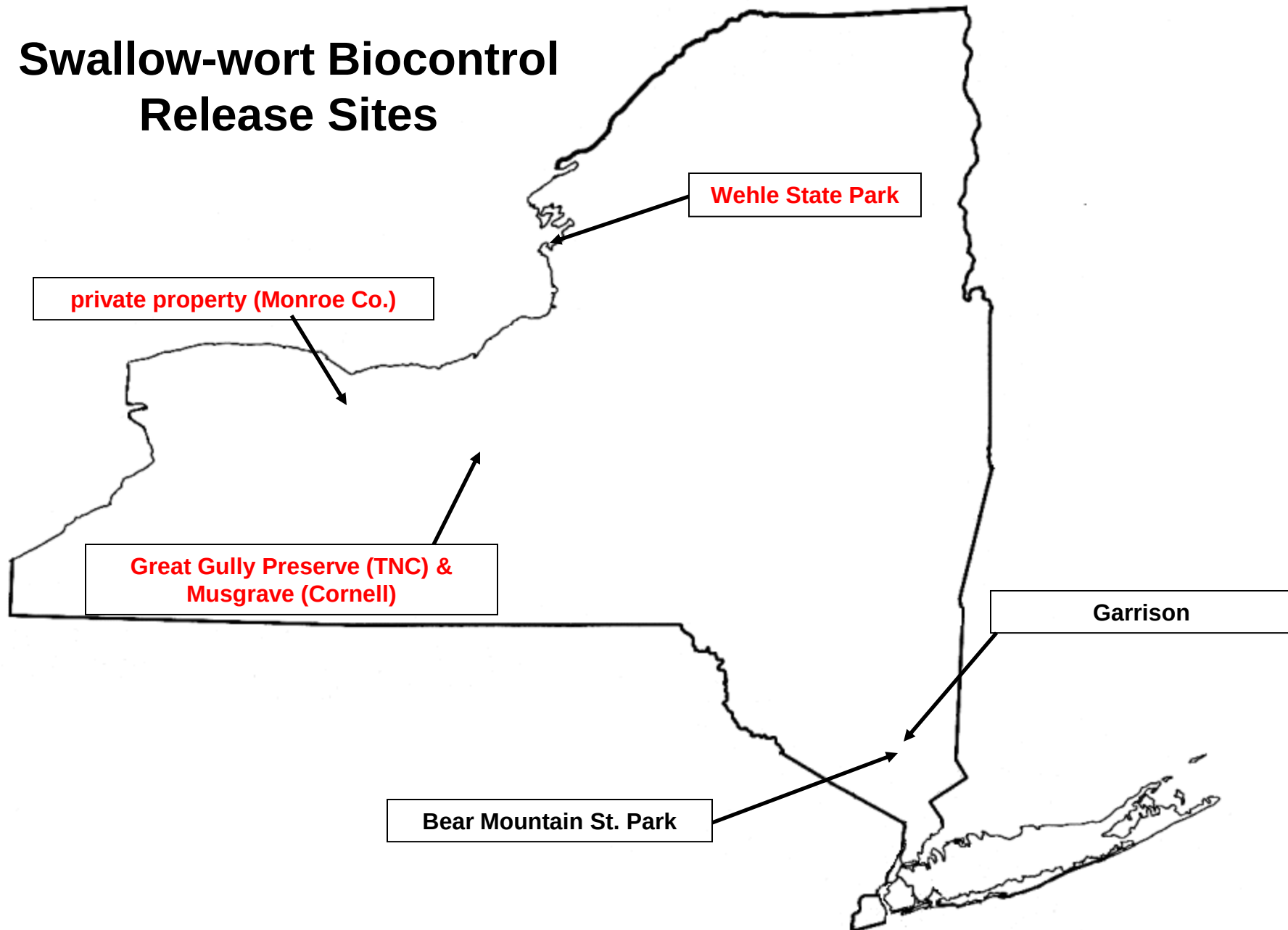


Yes

IWM

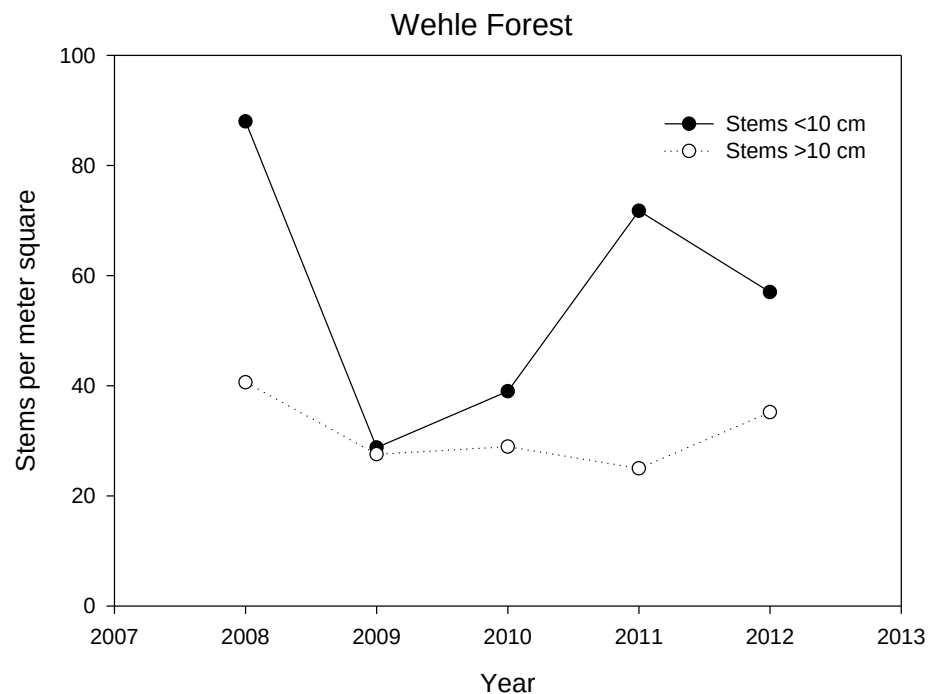
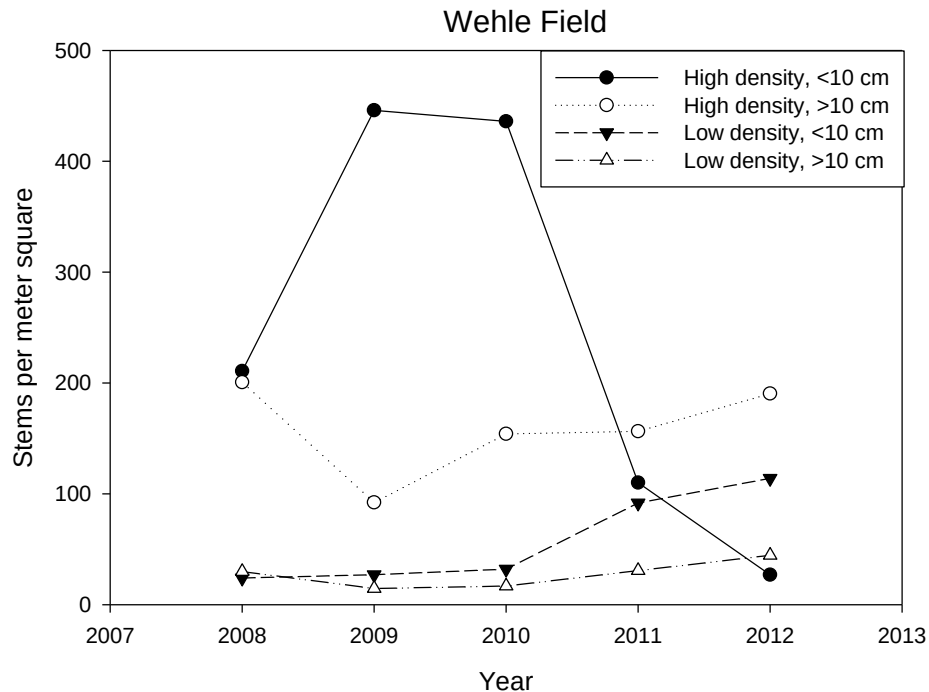


Swallow-wort Biocontrol Release Sites



Pre-release Plant Monitoring

PSW densities (2 size classes of stems)



Pre-release Plant Monitoring

Plant community 2011 data

Species Richness

Site-Habitat	PSW density class	Species Richness			Percent Cover	Simpson's Index of Diversity (1-D)
		Native	Introduced	Total		
Wehle-field	High	1.3 a	6.8 b	8.2 b	143 a	0.37 b
	Not-high	2.0 a	10.0 a	12.0 a	151 a	0.73 a
	None	1.8 a	11.3 a	13.2 a	181 a	0.84 a
Wehle-forest	Present	11.8	6.1	17.9	108	0.64

- **High-density PSW (Wehle-field) decreases richness and diversity although most species in the plots are introduced**

Field

Family	Scientific	common	Native Status
Apiaceae	<i>Daucus carota</i>	Queen Anne's lace	i
Asteraceae	<i>Carduus crispus</i>	Wetted Thistle	i
Asteraceae	<i>Carduus nutans</i>	Musk thistle	i
Asteraceae	<i>Centaurea stoebe</i>	spotted knapweed	i
Asteraceae	<i>Hieracium piloselloides</i>	tall yellow hawkweed	i
Asteraceae	<i>Taraxacum officinale</i>	dandelion	i
Asteraceae	<i>Tragopogon pratensis</i>	Meadow Salsify	i
Boraginaceae	<i>Echium vulgare</i>	common viper's bugloss	i
Brassicaceae	<i>Barbarea vulgaris</i>	yellowrocket	i
Brassicaceae	<i>Berteroa incana</i>	Hoary allium	i
Brassicaceae	<i>Cardaria draba</i>	hoary cress	i
Brassicaceae	<i>Hesperis matronalis</i>	dames rocket	i
Brassicaceae	<i>Lepidium campestre</i>	field pepperweed	i
Caryophyllaceae	<i>Arenaria serpyllifolia</i>	thymeleaf sandwort	i
Caryophyllaceae	<i>Cerastium fontanum</i>	mouse-ear chickweed	i
Caryophyllaceae	<i>Dianthus armeria</i>	Deptford Pink	i
Caryophyllaceae	<i>Stellaria graminea</i>	grass-like starwort	i
Clusiaceae	<i>Hypericum perforatum</i>	common St. Johnswort	i
Convolvulaceae	<i>Calystegia sepium</i>	hedge bindweed	i
Fabaceae	<i>Medicago lupulina</i>	black medic	i
Fabaceae	<i>Trifolium aureum</i>	hop clover	i
Fabaceae	<i>Vicia cracca</i>	cow vetch	i
Fabaceae	<i>Vicia tetrasperma</i>	slender (lentil) vetch	i
Fabaceae	<i>Vicia villosa</i>	hairy vetch	i
Lamiaceae	<i>Acinos arvensis</i>	Basil thyme	i
Lamiaceae	<i>Clitropodium vulgare</i>	wild basil	i
Lamiaceae	<i>Leonurus cardiaca</i>	common motherwort	i
Lamiaceae	<i>Nepeta cataria</i>	catnip	i
Plantaginaceae	<i>Plantago lanceolata</i>	narrowleaf plantain	i
Polygonaceae	<i>Polygonum aviculare</i>	prostrate knotweed	i
Polygonaceae	<i>Rumex crispus</i>	curly dock	i
Ranunculaceae	<i>Ranunculus acris</i>	common buttercup	i
Rosaceae	<i>Rosa eglanteria</i>	sweetbriar rose	i
Rosaceae	<i>Sanguisorba minor</i>	Salad burnet	i
Scrophulariaceae	<i>Verbascum thapsus</i>	common mullein	i
Scrophulariaceae	<i>Veronica officinalis</i>	common speedwell	i
Scrophulariaceae	<i>Veronica peregrina</i>	purslane speedwell	i
Scrophulariaceae	<i>Veronica persica</i>	field speedwell	i
Apocynaceae	<i>Asclepias syriaca</i>	common milkweed	n
Asteraceae	<i>Achillea millefolium</i>	yarrow	n
Asteraceae	<i>Antennaria neglecta</i>	Field Pussetoes	n
Asteraceae	<i>Erigeron strigosus</i>	Rough fleabane	n
Caryophyllaceae	<i>Cerastium arvense</i>	field chickweed	n
Lamiaceae	<i>Isanthus brachiatus</i>	False Pennyroyal	n
Ranunculaceae	<i>Ranunculus fascicularis</i>	early buttercup	n
Rosaceae	<i>Fragaria virginiana</i>	common strawberry	n
Rosaceae	<i>Potentilla argentea</i>	Silvery Cinquefoil	n
Rosaceae	<i>Potentilla recta</i>	sulphur cinquefoil	n
Rosaceae	<i>Rosa carolina</i>	Carolina rose	n
Rubiaceae	<i>Galium aparine</i>	catchweed bedstraw	n
	Status	count	percent
	Native	12	24%
	Introduced	38	76%

Alvar plant species



early buttercup *Ranunculus fascicularis*



field chickweed *Cerastium arvense*

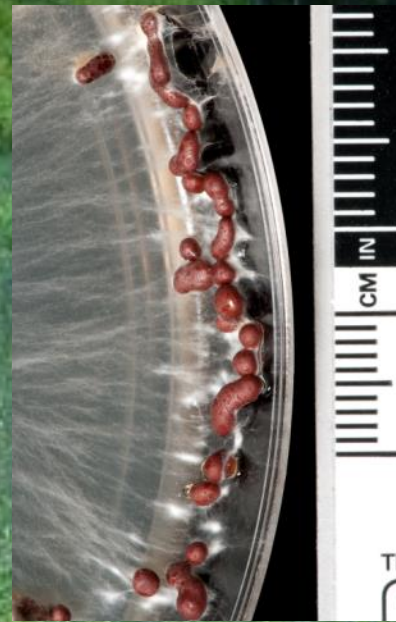


False Pennyroyal *Isanthus brachiatus*

Forest

Family	Scientific	common	Native Status
Asteraceae	<i>Lapsana communis</i>	nipplewort	i
Boraginaceae	<i>Cynoglossum officinale</i>	gypsyflower	i
Brassicaceae	<i>Alliaria petiolata</i>	garlic mustard	i
Brassicaceae	<i>Hesperis matronalis</i>	dames rocket	i
Caprifoliaceae	<i>Lonicera sp.</i>	honeysuckle sp.	i
Caryophyllaceae	<i>Cerastium fontanum</i>	mouse-ear chickweed	i
Caryophyllaceae	<i>Stellaria media</i>	common chickweed	i
Clusiaceae	<i>Hypericum perforatum</i>	common St. Johnswort	i
Fabaceae	<i>Medicago lupulina</i>	black medic	i
Lamiaceae	<i>Leonurus cardiaca</i>	common motherwort	i
Lamiaceae	<i>Olinopodium vulgare</i>	wild basil	i
Lamiaceae	<i>Nepeta cataria</i>	catnip	i
Orchidaceae	<i>Epipactis helleborine</i>	helleborine	i
Ranunculaceae	<i>Ranunculus acris</i>	common buttercup	i
Scrophulariaceae	<i>Veronica officinalis</i>	common speedwell	i
Apiaceae	<i>Sanicula marilandica</i>	Maryland sanicle	n
Asteraceae	<i>Achillea millefolium</i>	yarrow	n
Asteraceae	<i>Ageratina altissima</i>	white snakeroot	n
Asteraceae	<i>Eriqeron philadelphicus</i>	Philadelphia fleabane	n
Asteraceae	<i>Prenanthes sp.</i>	lion's foot	n
Asteraceae	<i>Solidago caesia</i>	bluestem goldenrod	n
Asteraceae	<i>Symphyotrichum lateriflorum</i>	Calico Aster	n
Asteraceae	<i>Symphyotrichum lowianum</i>	Lowrie's blue wood aster	n
Asteraceae	<i>Taraxacum officinale</i>	dandelion	n
Caryophyllaceae	<i>Cerastium arvense</i>	field chickweed	n
Caryophyllaceae	<i>Moehringia lateriflora</i>	Grove Sandwort	n
Geraniaceae	<i>Geranium robertianum</i>	Herb Robert geranium	n
Grossulariaceae	<i>Ribes cynosbati</i>	eastern prickly gooseberry	n
Hydrophyllaceae	<i>Hydrophyllum virginianum</i>	eastern waterleaf	n
Liliaceae	<i>Trillium grandiflorum</i>	Large-flowered Trillium	n
Liliaceae	<i>Uvularia perfoliata</i>	perfoliate bellwort	n
Melanthiaceae	<i>Veratrum viride</i>	False Hellebore	n
Polemoniaceae	<i>Phlox divaricata</i>	wild blue phlox	n
Ranunculaceae	<i>Aquilegia canadensis</i>	Wild Red Columbine	n
Ranunculaceae	<i>Hepatica nobilis Schreb. var. acuta</i>	sharplobe hepatica	n
Ranunculaceae	<i>Ranunculus abortivus</i>	kidneyleaf buttercup	n
Ranunculaceae	<i>Thalictrum thalictroides</i>	rue anemone	n
Rosaceae	<i>Fragaria virginiana</i>	common strawberry	n
Rosaceae	<i>Geum canadense</i>	white avens	n
Rosaceae	<i>Rosa blanda</i>	Early wild rose	n
Rosaceae	<i>Rubus occidentalis</i>	black raspberry	n
Rubiaceae	<i>Galium circaezans</i>	forest bedstraw	n
Rubiaceae	<i>Galium mollugo</i>	smooth bedstraw	n
Rubiaceae	<i>Gallium lanceolata</i>	6-leaved bedstraw	n
Violaceae	<i>Viola sp.</i>		n
Brassicaceae	<i>Cardamine concatenata</i>	Cutleaf Toothwort	n
Brassicaceae	<i>Cardamine douglassii</i>	Purple Cress	n
Portulacaceae	<i>Claytonia virginica</i>	Spring Beauty	n
Fumariaceae	<i>Dicentra cucullaria</i>	Dutchman's breeches	n
Saxifragaceae	<i>Mitella diphylla</i>	Mitenwort	n
Papaveraceae	<i>Sanguinaria canadensis</i>	bloodroot	n
Liliaceae	<i>Uvularia sessilifolia</i>	Sessile-leaf bellwort	n
	Status	count	percent
	Native	37	71%
	Introduced	15	29%

**Declining Pale Swallow-wort stand, 2008-present
Monroe Co., NY**



Blight, *Sclerotium rolfsii*
Gibson et al. 2012 Plant Disease 96:456

Host range tests, *Sclerotium rolfsii*

Growth chamber trials (6 wk, conetainers)

- Pale and black Swallow-wort
- Milkweeds (*Asclepias curassavica*, *As. syriaca*)
- Hemp dogbane (*Apocynum cannabinum*)
- Hairy coneflower (*Rudbeckia hirta*)
- Wild bergamot (*Monarda fistulosa*)
- Little bluestem (*Schizachyrium scoparium*)
- Corn
- Soybean



Host range tests, *Sclerotium rolfsii*

Results:

67-100% mortality in all *S. rolfsii*-treated plants



EXCEPT

Little Bluestem, Corn, Soybean

Do you see a possible use for this pathogen?

lrm32@cornell.edu

A photograph of a dense field of green wildflowers, likely milkweed, in the foreground. In the background, there is a line of trees and a forested hill under a bright sky. A utility pole is visible on the left side of the image.

Thank you.