

Key Factors Involved in Establishment of Invasive Weedy Species in the US and Australia



Leslie A. Weston

Charles Sturt University

Wagga Wagga NSW

Ecology and Biology of Invasive Weeds

- What are the factors that allow a non-native invasive to become most successful in an invaded site?
- What is the time frame required for invasion success?
- Which mode(s) of reproduction and dissemination contribute to successful establishment?
- Does rapid genetic change contribute to success; i.e. genotypic diversity?
- Is this accompanied by hybridization with other spp.?

Black and pale swallow-worts (Vincetoxicum spp.) – A Case Study In NY State

- Apocynaceae
- Perennial vines
- Closely related to the milkweeds
- Insect or self-pollinated
- Prolific seed producers
- Polyembryonic seed
- Invasive in Eastern US & Southern Canada



Invasion of Two Related Species in Eastern US – *V. rossicum* and *nigrum*

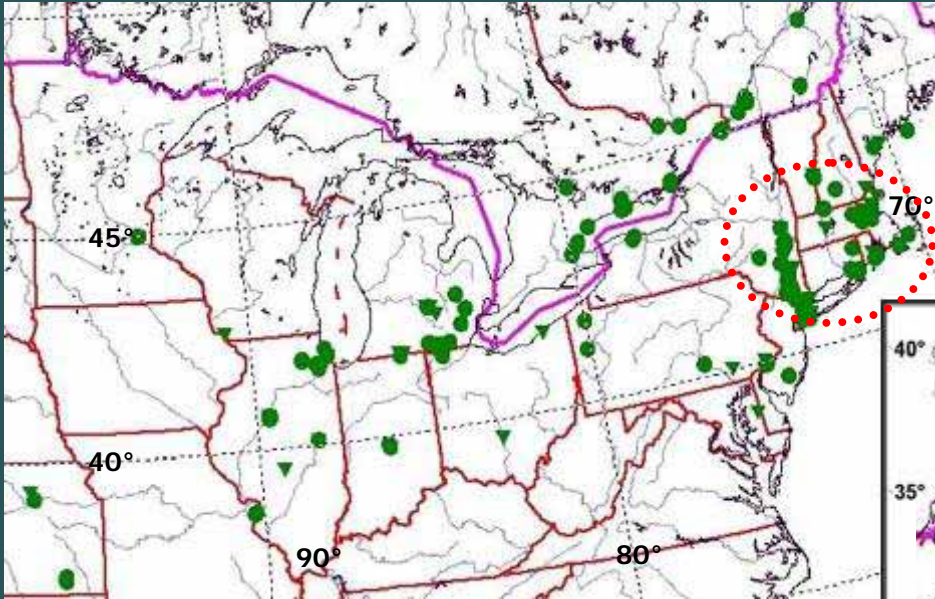
- ❖ Ecological Impacts
 - Decreased floral & faunal diversity
 - Habitat modifiers



- ❖ Economic Impacts
 - Invaded nurseries, pastureland, no-till crops
 - Decreased land values

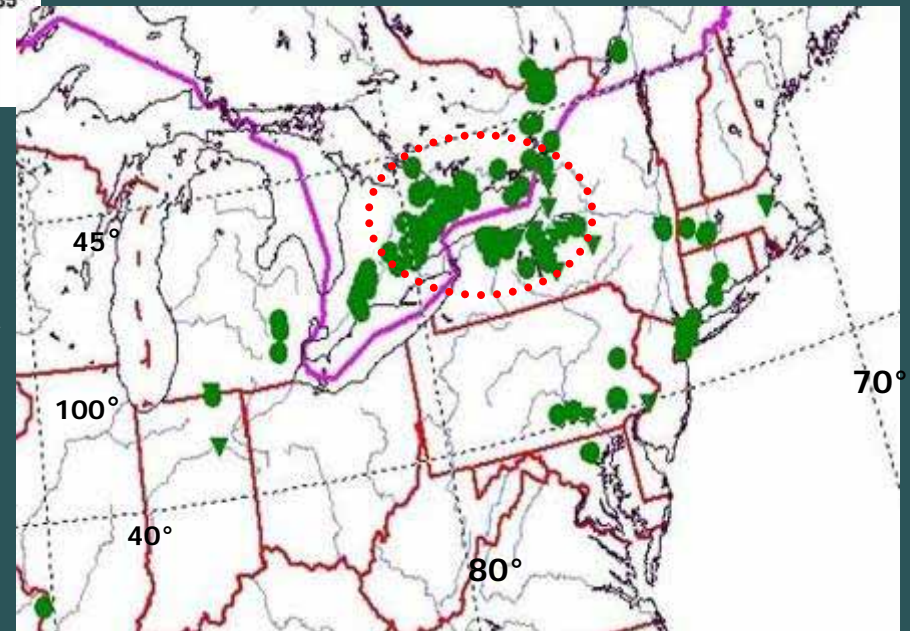


Recent invasion has resulted in a convergence of both species across NY State



◀ BSW

- Native to Iberian peninsula
- First reported in N. America in 1854 (Mass.)



PSW ➤

- Native to Eastern Ukraine
- First reported in N. America in 1885, and NYS in 1897

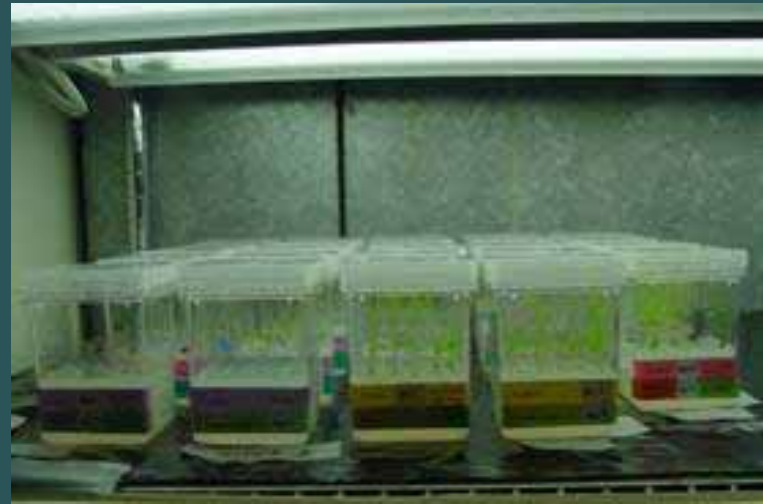
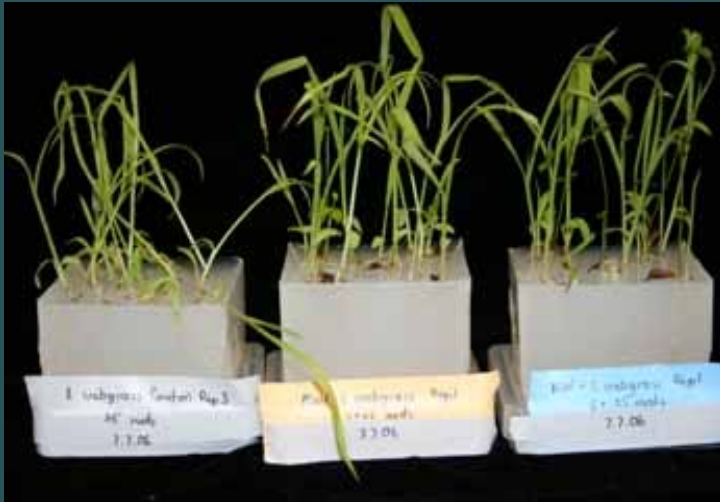
Project Objectives

1. Determine whether swallow-wort root exudates and tissue leachates have allelopathic activity accounting for monocultural dominance
2. Characterize genetic and morphological diversity of swallow-wort populations throughout New York State



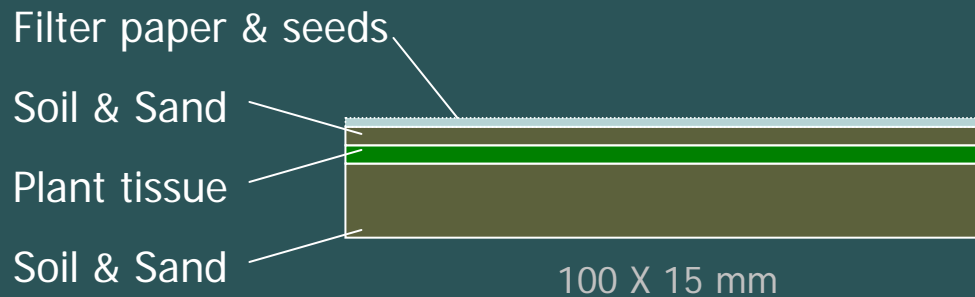
Allelopathy Methodology: Agar Assays

Designed agar assays for living swallow-wort seedlings in co-habitation studies with other species

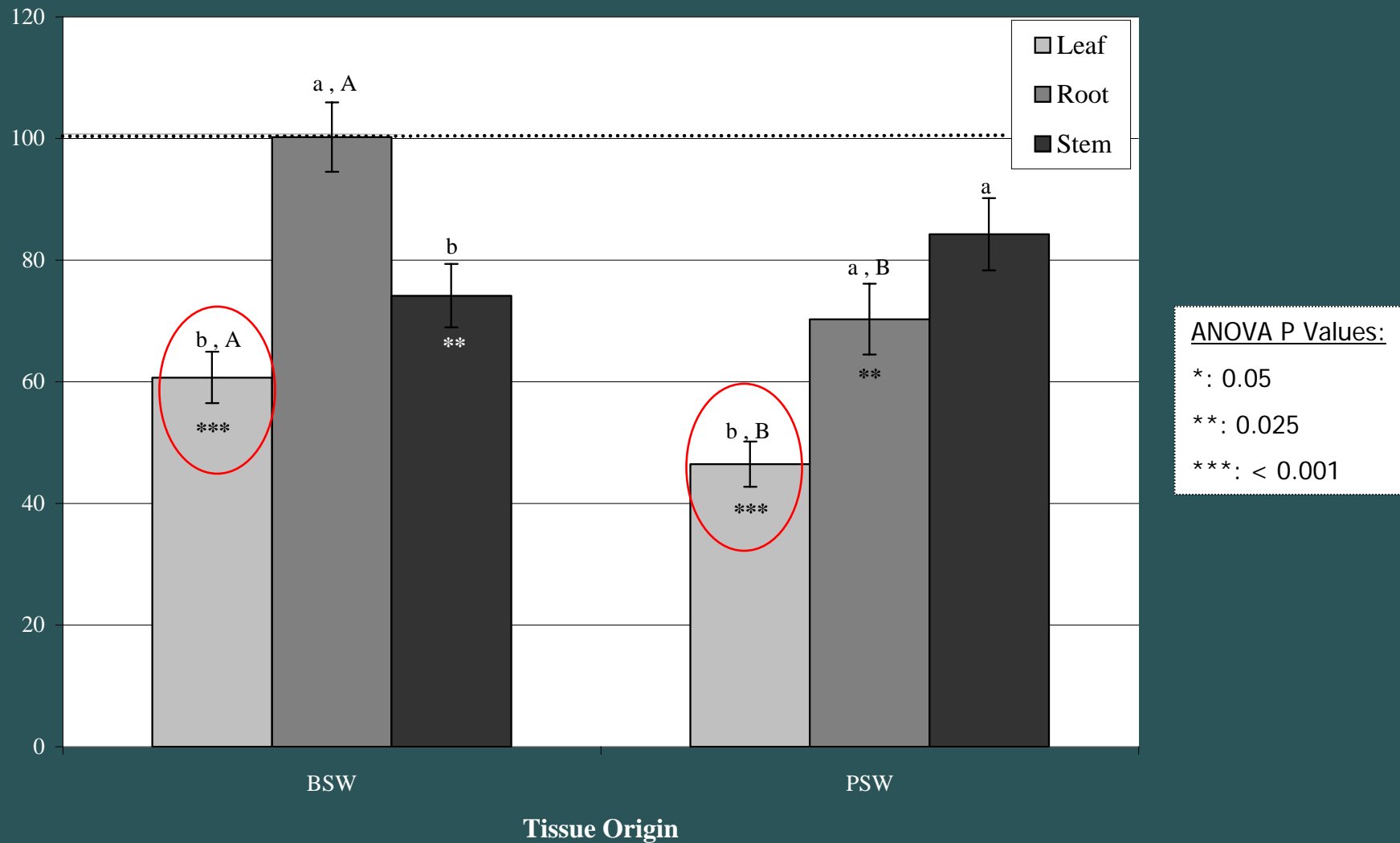


All growth assays conducted under fluorescent lighting in ambient laboratory conditions

Assessment of phytotoxic activity of leaf, stem and root tissue of SWs

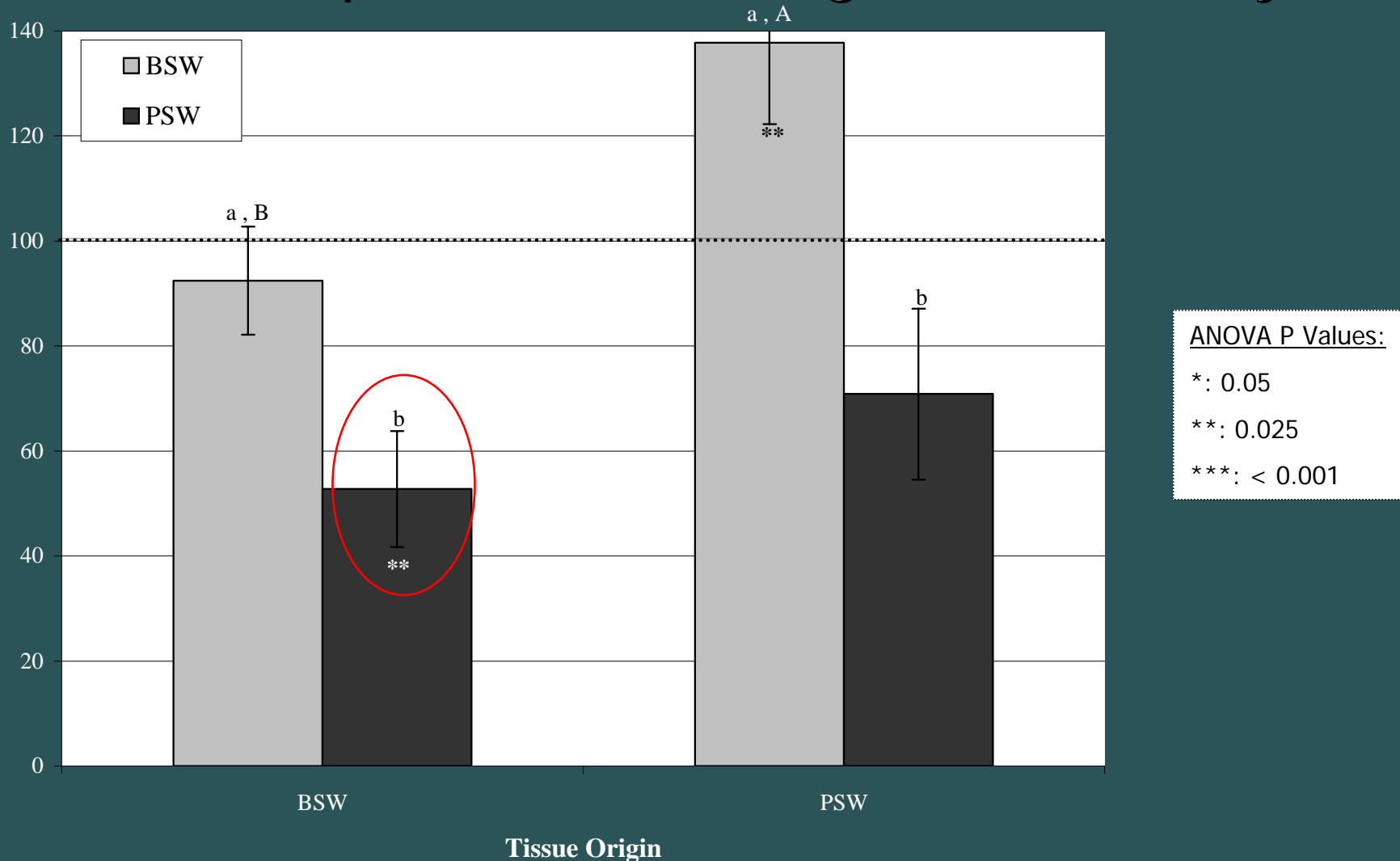


SW leaf tissues were most phytotoxic



~ Parker assays - indicators grown for 7 days ~

PSW leaf tissue was most phytotoxic to black and pale SW seedlings- autotoxicity



~ Parker assays - indicators grown for 7 days ~

Allelopathy Conclusions

1. SW root exudates and tissue leachates are inhibitory
2. PSW causes more inhibition than BSW to seedling indicators
3. Leaf tissues are more inhibitory than root or stem tissues
4. Allelopathy due to exudates and leachates could confer some competitive advantage to result in increased invasivity. Further field studies remain to be conducted.

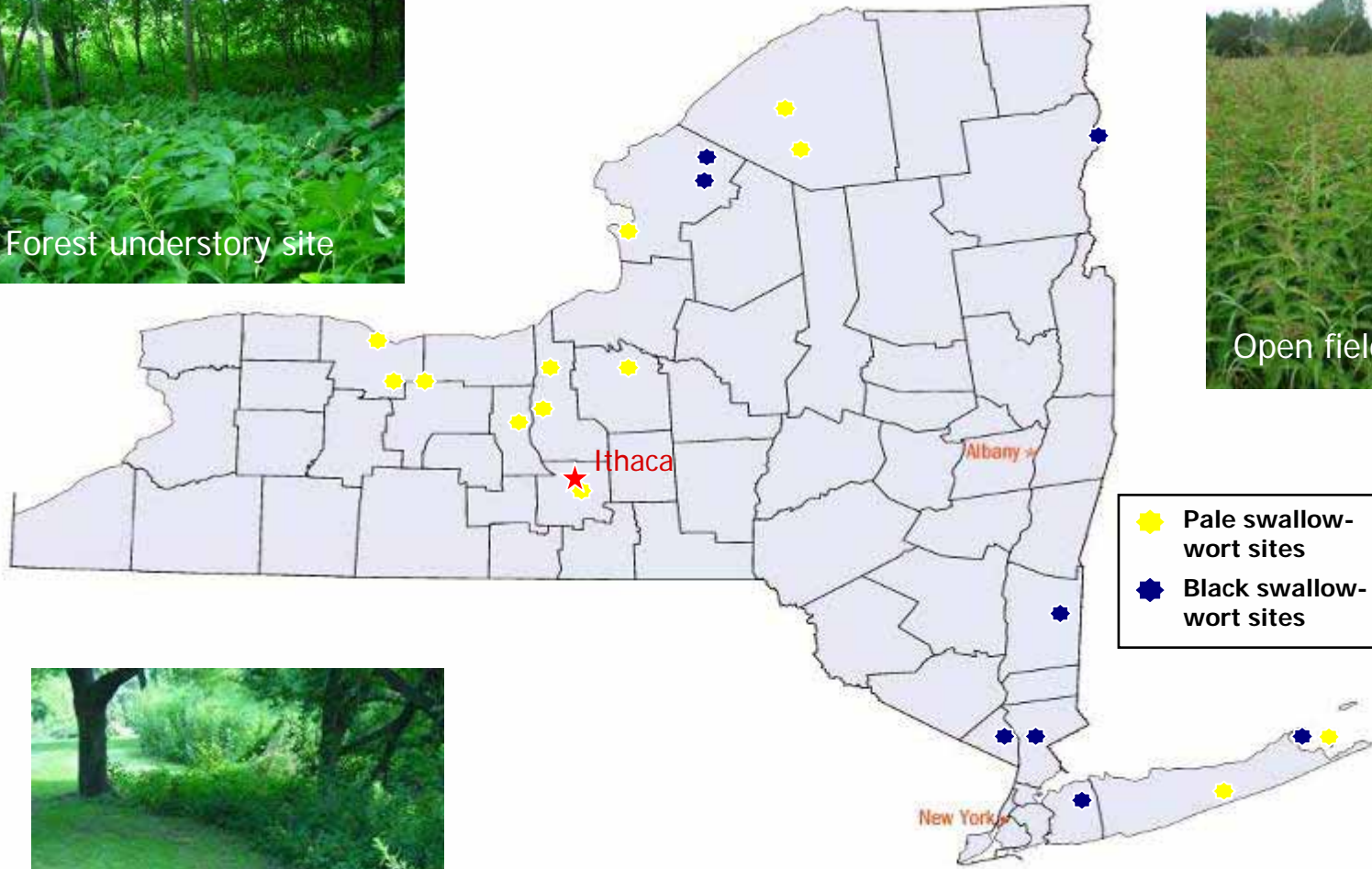
Morphological diversity observed among species and SW populations



Forest understory site



Open field site



- ★ Pale swallow-wort sites
- ★ Black swallow-wort sites



Site with both habitats

Map courtesy US Census Bureau

Is Morphological Diversity Due to Phenotypic or Genotypic Diversity?

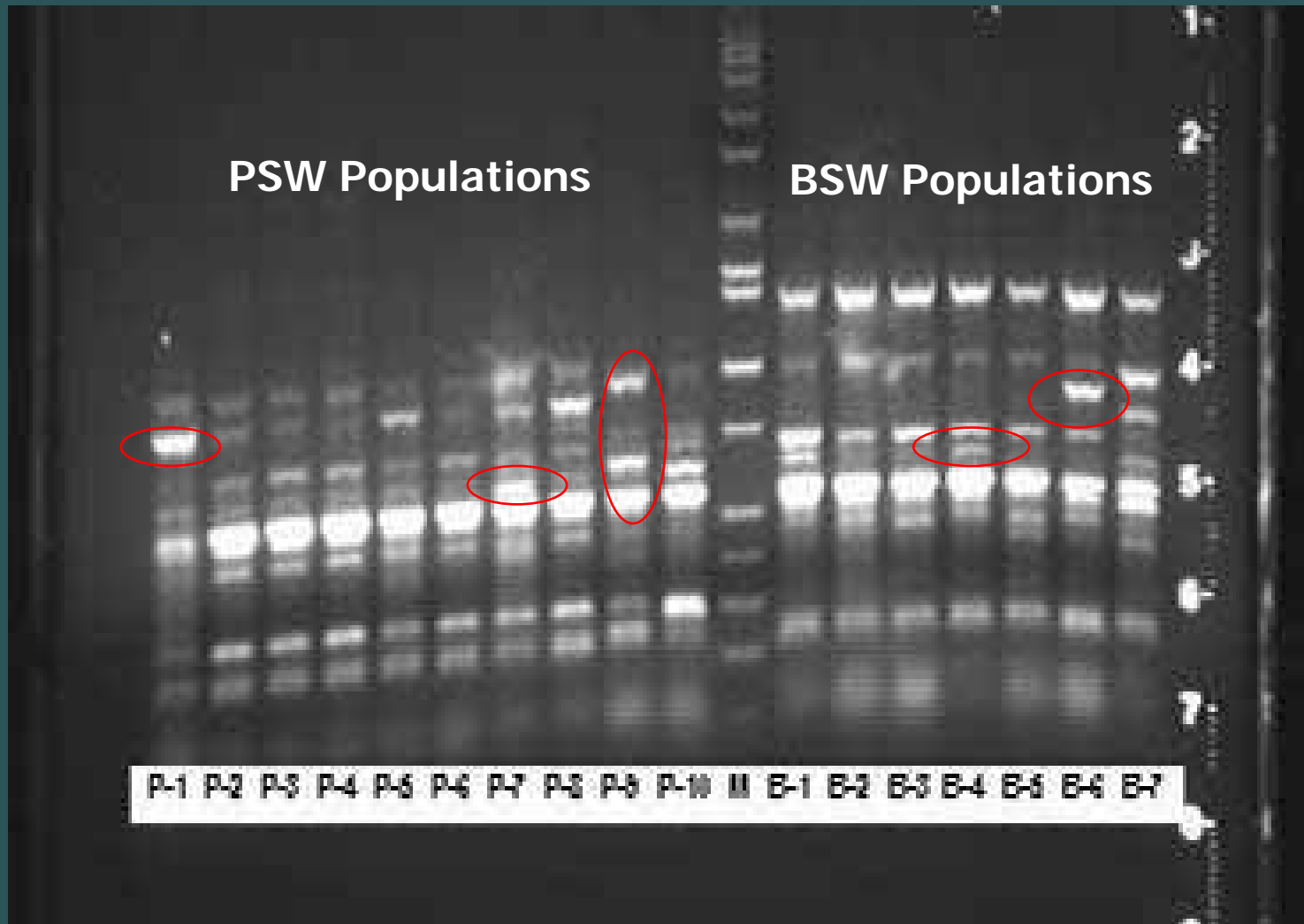


Open field



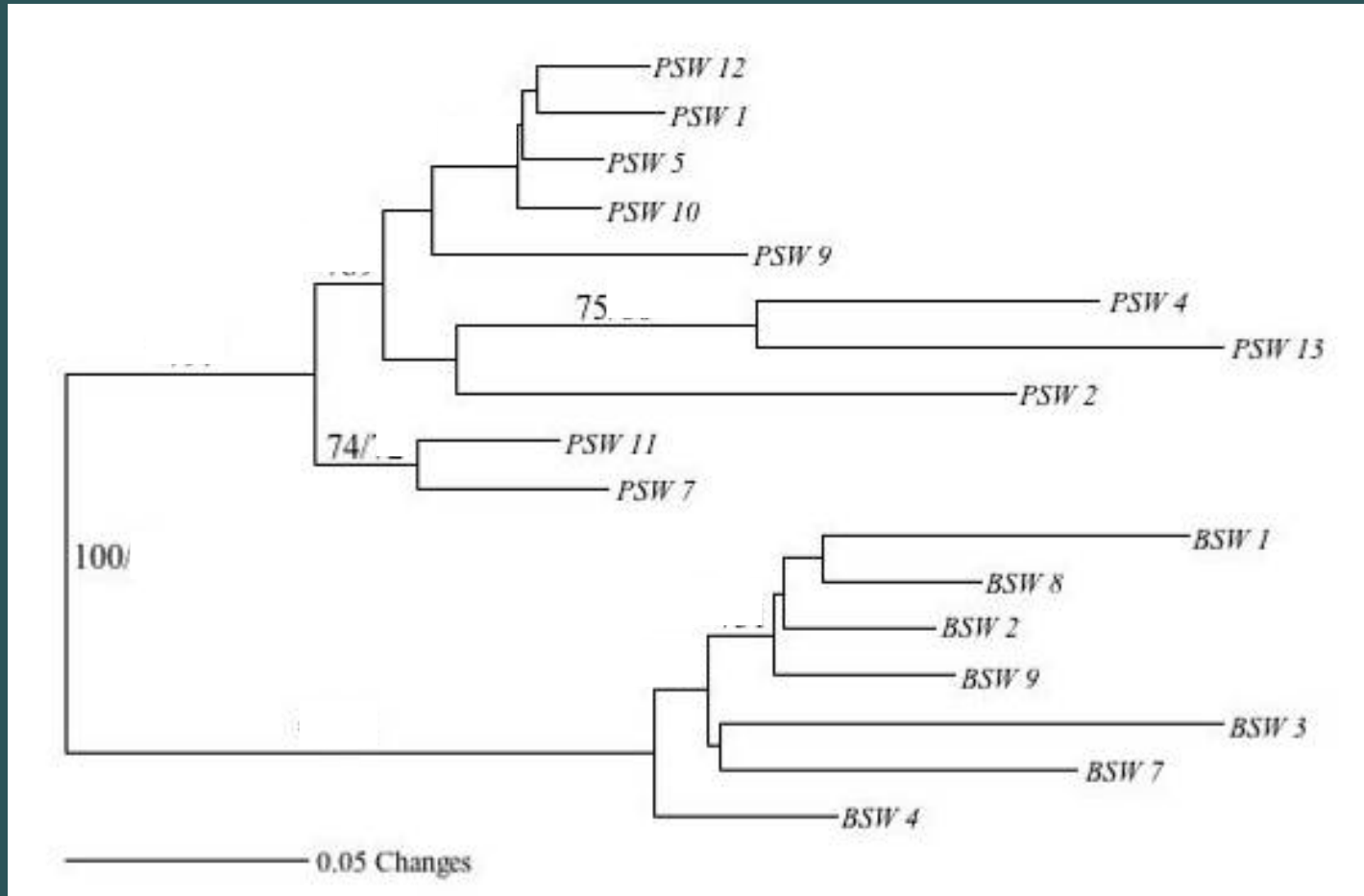
Forest understory

Analysis of species and pops RAPD primers



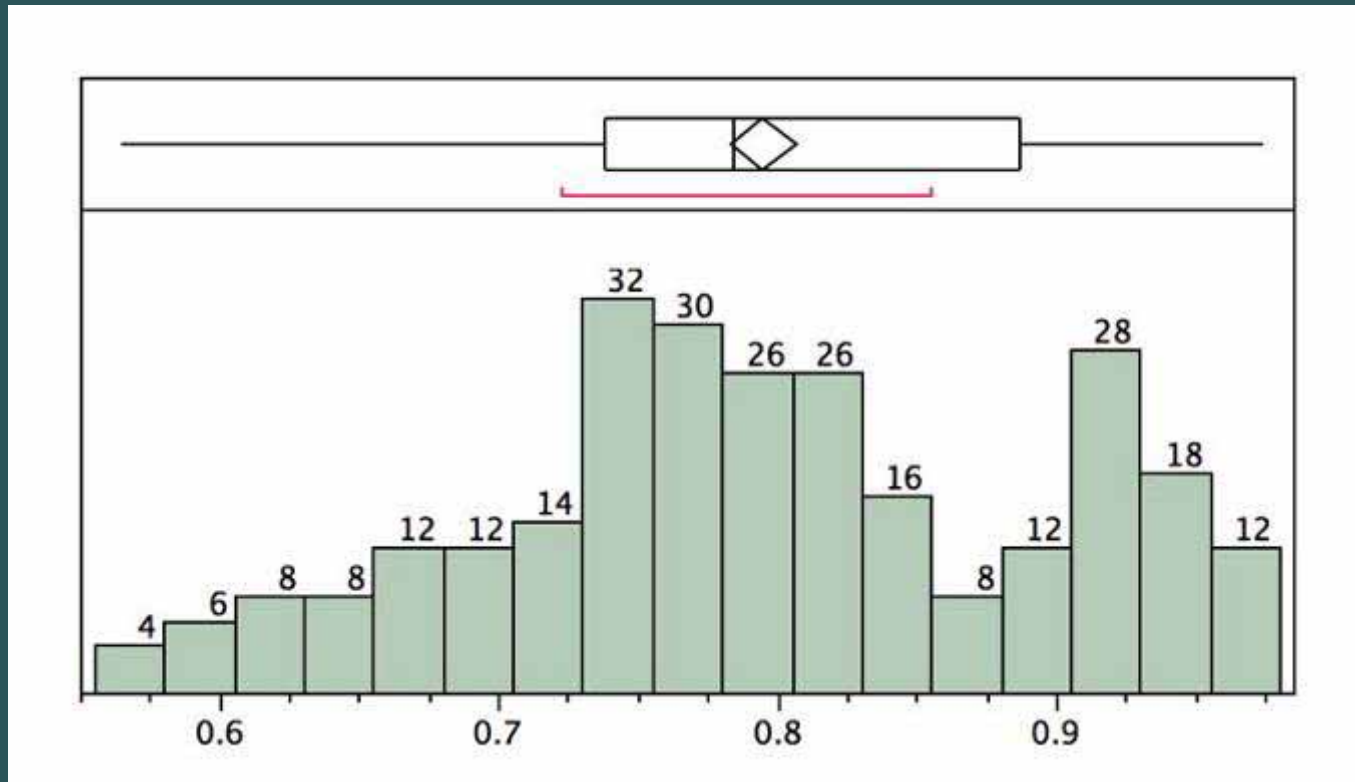
~ Primer MC 571 ~

Phylogenetic Relatedness



~ Tree constructed using neighbor-joining (NJ) method, two species are definitely monophyletic giving first genetic evidence for this taxonomic division

Genetic Diversity



~ However, statistical analysis of genetic similarities found that overall all black and pale populations sampled in New York exhibit remarkable genotypic similarity with a mean estimate of 0.78 for genetic similarity 0: not at all similar; 1: identical

SW Species Comparisons

	BSW	PSW		BSW	PSW
Mean Indiv Leaf Width (cm)	4.55	4.93	P (mg/kg)	1.63	8.83
Mean Indiv Leaf Length (cm)	8.34 b	9.77 a	K (mg/kg)	57.17	76.53
Mean Leaf Pair SI	0.55	0.5	Mg (mg/kg)	127.63	168.85
Plant Height (cm)	119.10	112.90	Ca (mg/kg)	862.17 b	4098.73 a
# of Nodes	16.42 a	12.33 b	Fe (mg/kg)	2.98	4.58
Internode Length (cm)	7.19 b	9.34 a	Al (mg/kg)	22.77 b	83.98 a
			Mn (mg/kg)	14.93	23.92
			Zn (mg/kg)	2.19	3.07
			pH	6.03 b	6.81 a
			% OM	3.74	5.24
			NO3 (mg/kg)	9.97	15.54

Conclusions on Genetics and Morphology

1. Two SW species are monophyletic – clearly separate species based on our molecular marker analysis
2. Intra-species genetic diversity is low
3. High soil pH, Al and Ca levels characterize sites invaded by PSW
4. Soil pH levels are negatively correlated with SW plant height
5. Environment these plants are grown in likely impacts their apparent morphological diversity

What is my focus in Australia?

Paterson's Curse

Echium plantagineum

Native to
Europe

Member of
Borage
Family

Spread in
Pastures,
Roadsides,
Rangeland

Related to
Viper's
bugloss

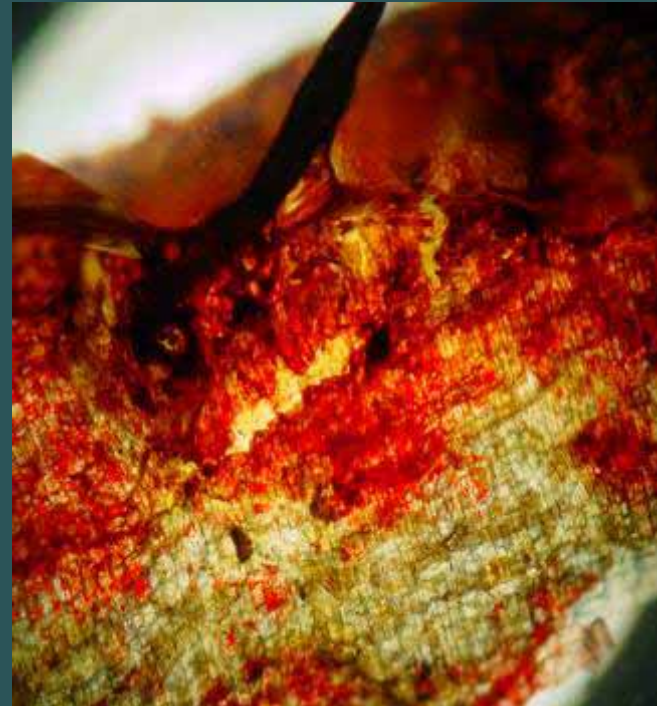
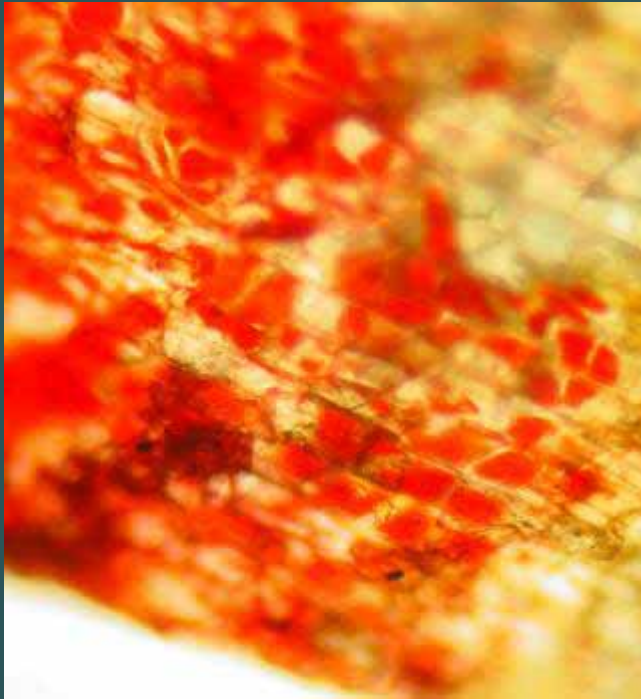


Paterson's Curse

- Distributed across millions of acres of pasture and rangeland in Southern Australia
- Reproduces by seed, is a biennial and in some cases perhaps perennial
- Deep tap root and fibrous roots which we have discovered to produce unique naphthoquinones – bright red compounds in epidermis

Root epidermal tissue of Paterson's curse- localization of naphthoquinones

photo taken by M. McCully collaborator CSIRO



Paterson's Curse


- Exudates likely contribute to plant defense properties; novel chemistry in Boraginaceae
- Morphological diversity observed among populations; in leaf size and shape, flower color, plant size
- Despite ability to control with selective blf herbicides, this weed continues to spread

Toxicity to grazing livestock

- Horses are particularly sensitive to its toxic alkaloids
- Trials are planned at CSU with sheep and other ruminants to determine long term effects on grazers; liver and kidney damage and determine if and when grazers selectively eat this plant
- Interested in further chemical evaluation development of diagnostic metabolomic tests to identify poisoning early on in valuable livestock

Evaluation of Genotypic Diversity

- Using RAPD as well as focused DArT analyses we can perform very specific evaluations of population genotypes to determine if indeed the plant has evolved genetically following introduction in mid 1800's and if intrapopulation diversity is great.
- This may in fact help explain its ability to adapt and spread so rapidly across Australian landscape

A lush green forest scene with many trees and dense undergrowth. The text is overlaid on the image.

" The natural habitat, ..., is far too intricate a system of influences and factors ... to hope that there may be found a single factor controlling the complicated life of perennial species. "

- R. Muller (1953)

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