Effects of land-use change and peri-urban development on aquatic weeds

Shon Schooler
30 July 2009

Outline

1) Introduction to aquatic weeds

2) Effects of land-use change and peri-urban development on aquatic weeds

3) Alligator weed invasions: Mechanisms and management

Shon Schooler, Celine Clech-Goods, Lauren Quinn, Rieks van Klinken, Tony Cook, and Graham Prichard

Types of aquatic plants

- Submerged
  - cabomba
  - dense waterweed
- Floating free
  - salvinia
  - water hyacinth
- Floating rooted
  - water lilies
  - watershield
- Emergent
  - hygrophila
  - sagittaria
  - alligator weed

Effects of land-use change and peri-urban development on aquatic weeds

1) Examining herbarium records across Australia

2) Large scale survey around four major Australian cities

3) Experimental examination of the effects of shade on macrophyte biomass

4) Intensive sampling in Southeast QLD

Lauren Quinn and Rieks van Klinken

Assessing effects of land-use using herbarium records

Examined distributions of 22 freshwater plant species that are known invaders and 20 native aquatic plants.

Collected herbarium sample locations from Australian herbaria.

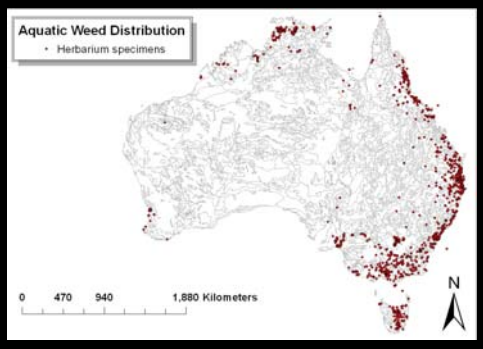
Used GIS to:

1) measure the density of herbarium records with relation to increasing distance from city centre

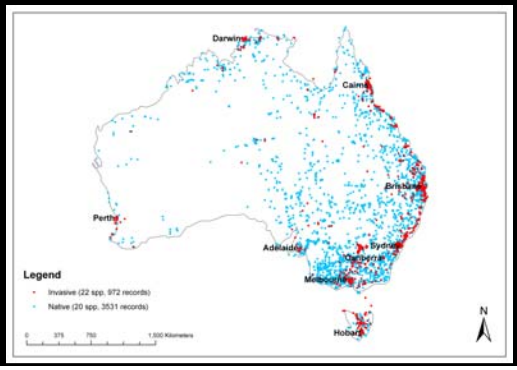
2) examine density related to land-use type

3) examine density related to vegetation cover

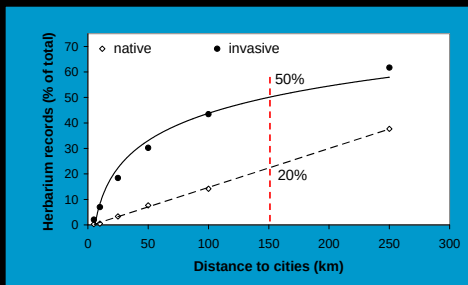
Assessing effects of land-use using herbarium records



Assessing effects of land-use using herbarium records

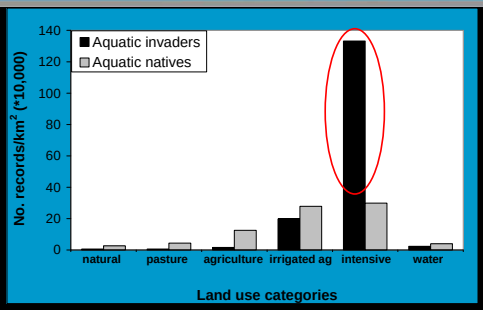


Assessing effects of land-use using herbarium records



Invasive aquatics tend to be found near cities

Assessing effects of land-use using herbarium records



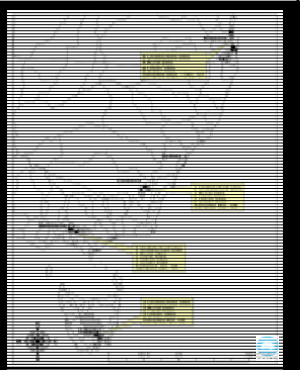
Much higher densities in intensive use types (residential, industrial)
Pattern for natives suggests that this is not simply due to propagule supply

Large scale survey around four major Australian cities

Sampled:

- **invasive and native plant abundance,**
- **water quality, and**
- **canopy cover**

In urban, rural, and undisturbed sites near 4 Australian cities



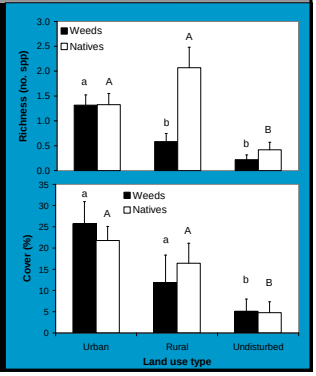
Large scale survey around four major Australian cities

Large scale survey around four major Australian cities

More invasive species in urban than rural or undisturbed sites

More native species in urban and rural sites

Greater abundance of native and invasive species in urban and rural habitats



Large scale survey around four major Australian cities

Environmental factors promoting aquatic plants

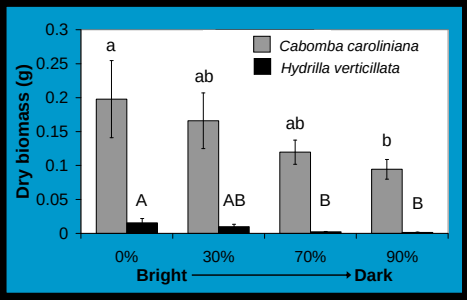
Natives:	Invasives:
reduced canopy cover	reduced canopy cover
high water temperature	high water temperature
high ammonium	high phosphate

Experimental examination of the effects of shade on macrophyte biomass

- Riparian shading was found to be an important drivers of aquatic plant abundance
- We examined the effect of shade on the biomass of the native, *Hydrilla verticillata*, and the introduced invasive, *Cabomba caroliniana*.
- Four shade treatments: 0, 30, 70, 90%.
- Six replicates for each treatment.
- Grown over 4 months.

Experimental examination of the effects of shade on macrophyte biomass

Experimental examination of the effects of shade on macrophyte biomass



In progress: Intensive sampling in SEQ

Surveys of aquatic plants matched with data from 110 EHMP sites in SE QLD in 2008

Land-use in SEQ

Effects of land-use change and peri-urban development on aquatic weeds

Conclusions

- invasive plants are likely to be found in urban land use types and these locations can be targeted for early detection efforts.
- restoring riparian canopies will reduce the abundance of invasive aquatic plants.
- invasive plant abundance is predicted to decline with reductions in nutrients, specifically phosphate levels.

Alligator Weed

Alternanthera philoxeroides

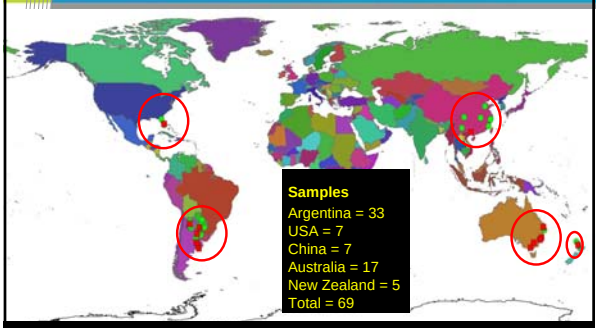
Alligator weed: Ecological studies

Origin of Australian populations

Mechanisms of invasion

Management strategies

Genetic analysis: Where is our alligator weed from?



Collaboration with Dr. Andrew Mitchell, NSW DPI and CSIRO
Preliminary analysis funded by Weed CRC

Genetic analysis (13 populations, ISSR)

Country	ID	1	2	3	4	5	6
S. America	1			x	x		
	10						
	27	x					
	31		x				
	34	x					
	106				x		
Australia	3	x					
	4				x		
	8	x					
	15				x		
	17			x			
New Zealand	3					x	
China	4						x

At least 3 introductions, all originate from Buenos Aires north to Chaco

Origin of Australian populations

Mechanisms behind plant invasions

Why are alligator weed and lippia invasive?

Enemy escape?
Resource availability?

Mechanisms behind plant invasions

Enemy release? Examine herbivore regulation in native and introduced ranges.

Investigate the interaction between resource availability and herbivore regulation: how does it affect the invasive weed?

Investigate how availability of limiting resources affects plant growth (invasive vs. closely related native).

Celine Clech-Goods, PhD student, Weed CRC, CSIRO, UQ
Alejandro Sosa, USDA-SABCL, Argentina

CSIRO.

Implications for management

Resource availability

Enemy release?	Environmental Conditions	High soil fertility	Low soil fertility
	Absence of enemies	A	C
	Presence of enemies	B	D

Letters indicate conditions in which the invader outcompetes the native.

Implications for management

How does mechanism of invasion inform potential control methods?

Environmental Conditions	High soil fertility	Low soil fertility
Absence of enemies	Biological control and nutrient management	Biological Control
Presence of enemies	Nutrient management	Chemical and Physical removal

Boxes indicate conditions in which the invader outcompetes the native.

Does herbivore escape occur for alligator weed?

Experiment 1

Examine influence of herbivores in the native (Argentina) and introduced (Australia) ranges.

Plant alligator weed and native species individually and together and exclude natural enemies.

Does alligator weed increase its biomass in Argentina, but not Australia, when natural enemies are excluded?

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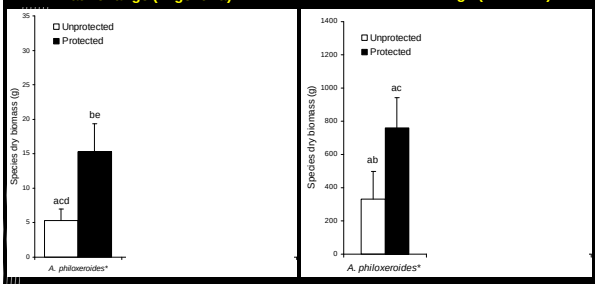
Does herbivore escape occur for alligator weed?

Native range (Argentina) | **Introduced range (Australia)**



Examine influence of herbivores in the native (Argentina) and introduced (Australia) ranges.

Effect of resource availability and herbivore escape

Experiment 2

Plant alligator weed and two native species together in field plots.

Two treatments:
Nutrient levels (low and high fertility)
Simulated herbivory on the invasive

Three replicates of each treatment
Grown for one field season

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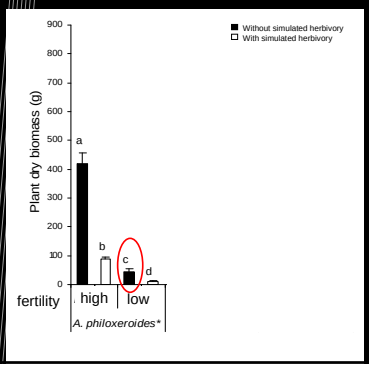
Effect of resource availability and herbivore escape

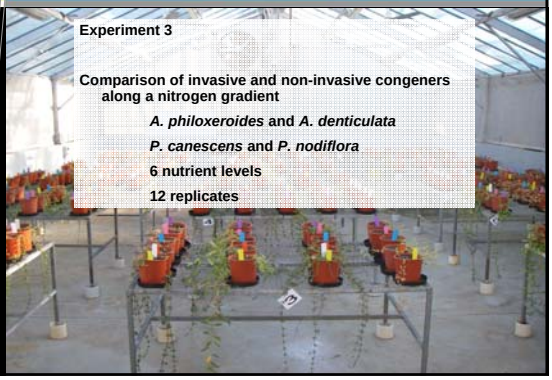


All treatments reduced alligator weed growth.

Decrease in fertility had a greater impact on Alligator weed (P<0.05)

Simulated herbivory on alligator weed resulted in increased biomass of a native in low fertility plots.

Plant growth response to resource abundance



Experiment 3

Comparison of invasive and non-invasive congeners along a nitrogen gradient

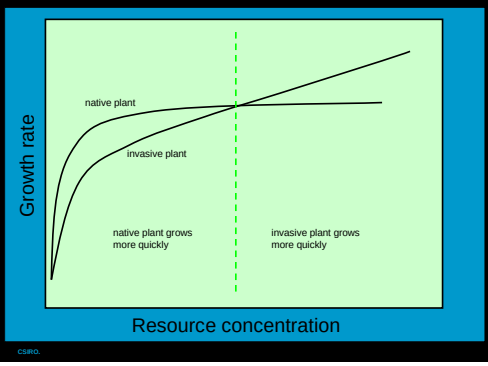
A. philoxeroides* and *A. denticulata

P. canescens* and *P. nodiflora

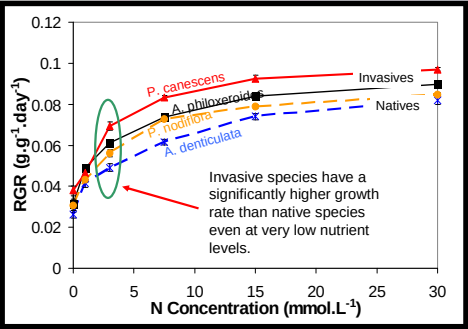
6 nutrient levels

12 replicates

Plant growth response to resource abundance



Plant growth response to resource abundance



Implications for management

How does mechanism of invasion inform potential control methods?

Environmental Conditions	High soil fertility	Low soil fertility
Absence of enemies	Biological control and nutrient management	Biological Control
Presence of enemies	Nutrient management	Chemical and Physical removal

Letters indicate conditions in which the invader outcompetes the native.

Alligator weed control experiments

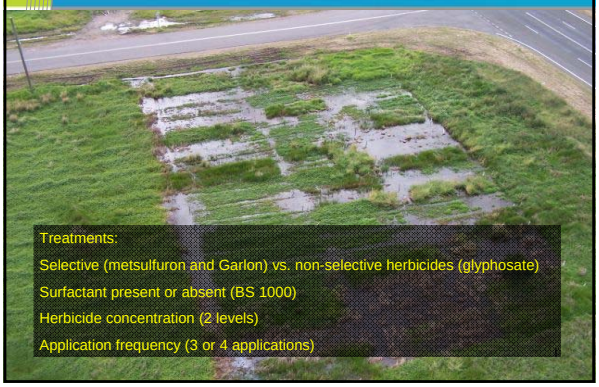
Tony Cook, NSW DPI

Graham Prichard, Port Stephens Council

1) Effects of broad spectrum and selective herbicides

2) Effects of selective herbicides, mowing, and inundation regime

Alligator weed herbicide trials



Treatments:

Selective (metsulfuron and Garlon) vs. non-selective herbicides (glyphosate)

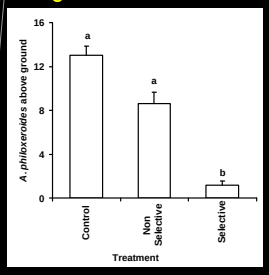
Surfactant present or absent (BS 1000)

Herbicide concentration (2 levels)

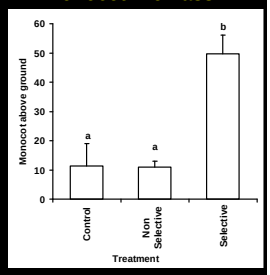
Application frequency (3 or 4 applications)

Above Ground

Alligator weed Biomass



Monocot Biomass



Selective herbicides promote grasses above ground.

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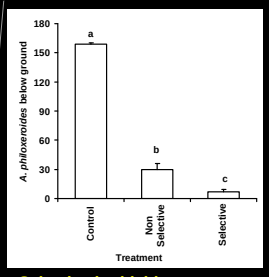
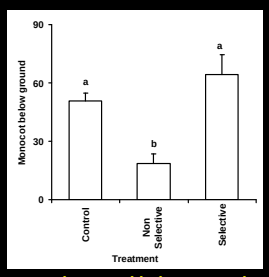
Below Ground

Alligator weed Biomass



Monocot Biomass



Selective herbicides promote grasses above and below ground. Also 50% concentrations had same effect as full strength and 3 treatments had same effect as 4 treatments.

Alligator weed mowing and selective herbicide along an inundation gradient

Can repeated selective disturbance:

1) create a continued drain on alligator weed resources,
2) promote desired competitor species, and
3) result in local elimination of alligator weed in infested paddocks?

Treatments:

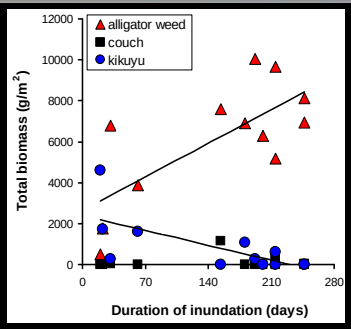
Selective herbicide (metsulfuron), 5 applications

Mowing, 4 applications

Inundation gradient, 20-282 days

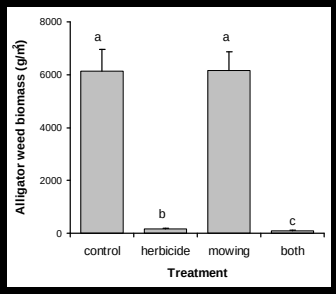
2-year period

Alligator weed mowing and selective herbicide along an inundation gradient



Alligator weed favoured by inundation

Alligator weed mowing and selective herbicide along an inundation gradient



Inundation didn't influence the treatments, mowing had no effect, but herbicide plus mowing had a greater effect than herbicide alone.

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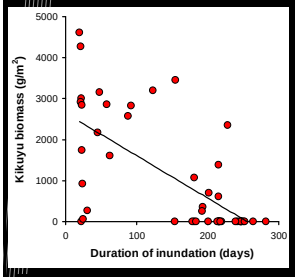
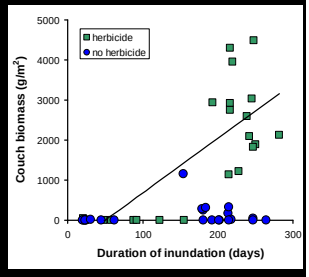
Alligator weed mowing and selective herbicide along an inundation gradient



Kikuyu biomass wasn't affected by herbicide or mowing, just inundation.



Couch biomass increased with inundation, but only in herbicide plots.

Alligator weed mowing and selective herbicide along an inundation gradient

Conclusions:

Alligator weed invasion is assisted by inundation, which allows it to dominate kikuyu.

The native plant, couch, is outcompeted in dry habitats by kikuyu and in wet habitats by alligator weed.

Repeated application of selective herbicides greatly reduces alligator weed abundance (97.5%) and promotes a native species.

The combination of mowing (or grazing?) and herbicide reduces alligator weed 56% more than selective herbicide alone.

Mowing alone had no effect (and might increase spread).

Alligator weed conclusions

Mechanisms behind invasions:

- **Release from herbivores and pathogens**
- **High soil fertility**
- **Inundation duration**
- **High competitive ability**

Management implications:

- **Biological control**
- **Catchment management for nutrients**
- **Flood management**
- **Selective herbicides (plus mowing/grazing)**

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Overall Conclusions

Aquatic weeds have different reproduction, spread, impact, and management than terrestrial plants.

Aquatic weeds are clustered around cities and human-caused environmental alterations are a key factor in aquatic plant invasions.

Ecological studies can identify invasion mechanisms that can be used to identify effective management strategies.

Experiments help to test effects of control methods, refine strategies, and reduce the effects of counter-productive methods.

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Acknowledgements

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