Ecological Approaches for Weed Management
or
How Not to Reinvent the Wheel

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Outline

• Weed Science
  – Broadly defined
  – The Research-Extension continuum
  – Relevance to invasive plants

• Weed and Invasive Plant Management
  – Methods
  – Ecological principles
  – Integrated approaches

• Examples
What is Weed Science?

- Discipline defined by organisms studied
- Combines basic and applied sciences
- Includes continuum from research to extension of knowledge
- Traditionally focused on agricultural and managed lands
- 50+ year history as a scientific discipline
Components of Weed Science

Research-Extension Continuum

- Land grant universities
  - Basic research
    - Agricultural Experiment Station researchers
  - Applied research
    - Cooperative Extension Specialists
  - Extension/outreach
    - Cooperative Extension Advisors
Weeds and Invasive Plants

• Weed
  • A plant growing where it is not desired
  • A plant that is objectionable or interferes with the activities or welfare of humans

• Invasive Plant
  • Exotic plant that occurs and spreads outside of its native range
  • Plant that negatively impacts wildlands

• Weed Science applies to both agricultural and wildland ecosystems
Management of Weeds (and Invasive Plants)

• Minimize weed presence to achieve desired land use goal
• Grow or foster desired vegetation
• Suppress or remove weeds without injuring crop or desirable species
Weed Management Techniques

- Prevention
- Eradication
- Control
  - Biological
  - Chemical
  - Cultural
  - Mechanical, Physical
- Integrated Weed Management
Ecological Principles in Weed Management

- Ecological principle → Weed control practice
  - Reduce seed bank inputs
    - Prevention, solarization, control before seed set
  - Allow crop (native) earlier resource capture
    - Plant early, cultivate early, plant crop transplants
  - Reduce weed growth and resource capture
    - Cultivate, mow, mulch, apply herbicides
  - Maximize competitive effects of crop (native) on weed
    - Plant smother or cover crops, intercrops
  - Modify environment to make weeds less well-adapted
    - Rotate crops, control methods, herbicides
Weed Seed Bank

Seed-rain Dispersal → Nondormant seeds → Germination

Nondormant seeds

Dormant seeds

Predation & death
Critical Period for Weed Control

- Cultural control of annual weeds using optimal timing
Carbohydrate Reserves in Perennial Weeds

- Cultural control of perennial weeds using optimal timing

[Diagram showing the seasonal change in stored carbohydrates in roots.]
Integrated Weed Management

• Weed suppression by combination of methods
• Based on knowledge of weed biology and ecology
• Cost effective and environmentally sustainable
• Herbicides are one tool among many
Conceptual Framework for IWM

I—Single weed control tool
  • Plant-field scale

II—Multiple weed management tools
  • Plant-field-farm scale

III—Cropping system design
  • Farm-landscape scale

IV—Landscape and regional management
  • Landscape-region scale

V—Agro-ecoregion policy management
  • Regional-global scale

(Cardina et al. 1999. In Buhler, ed., Expanding the Context of Weed Management)
Innovative Approaches to IWM

- Ecological
  - Management based on weed thresholds
    - Site specific management
    - Predictive models
- Agronomic
  - Improving soil quality
    - Breeding crop competitiveness
- Economic
  - Weed forecasting
    - Decision models
Examples....
Ecological Approaches for Management

• *Arundo*
  – Mike Rauterkus, M.S.
  – Lauren Quinn (Ph.D. December)
  – Dr. Virginia White, Post doc

• Artichoke thistle
  – Robin Marushia, M.S. (Ph.D. candidate)
  – Dr. Virginia White
**Arundo donax Control**

- Mechanical removal in monocultures
- Hand removal in sensitive areas
- Herbicide (Rodeo©) in some sites
  - Aerial or ground application in monocultures
  - Selective use in mixtures with natives
Objectives of *Arundo* Research

- Resource use of *Arundo* and natives
  - Invasiveness of *Arundo*
  - Response of native species
- *Arundo* impacts on riparian habitat
  - Effects on habitat of natives
- Control and habitat restoration
  - Alter habitat to favor natives

*Salix gooddingii*
Goodding’s willow

*Scirpus americanus*
American bulrush
Percent Full Sun vs. A. donax Cover

\[ y = -0.3666x + 62.131 \]
\[ R^2 = 0.096 \]

\[ y = -0.903x + 80.404 \]
\[ R^2 = 0.8295 \]

\[ y = -0.8689x + 77.788 \]
\[ R^2 = 0.7922 \]

\[ y = -1.0639x + 98.912 \]
\[ R^2 = 0.8658 \]

\[ y = -0.6334x + 63.971 \]
\[ R^2 = 0.2263 \]

\[ y = -0.6725x + 63.88 \]
\[ R^2 = 0.5671 \]
Light Effects on Biomass Production

**Dry Weight (g)**

- **S. gooddingii**
- **S. americanus**

- **ambient**
- **73**
- **80**
Riparian Restoration Experiment

- Objective
  - Test ability of native mixtures to resist invasion by *Arundo*

- Simulated riparian community
  - Tree (*Salix gooddingii*)
  - Shrub (*Baccharis salicifolia*)
  - Rhizomatous sedge (*Scirpus americanus*)
  - Alone and in all 7 possible combinations

- *Arundo* planted into ½ plots in 2003 and ½ in 2004
Summary of Results

- Native species identity determined *Arundo* success
  - Shrubs (*Baccharis*) slowed emergence of *Arundo*
  - Shrubs reduced colonization by native species from adjacent experiment
- *Arundo* success not impacted by community composition or diversity
- *Arundo* grows well at UCR Field Station!
Control and Restoration Experiment

- **Objective**
  - Design treatments to favor natives and reduce *Arundo* regrowth

- **Design**
  - Field site with native mixture and *Arundo*
  - 100%, 50%, and 0% *Arundo* removal
    - Cut shoots and treated stumps with (75% glyphosate)
  - ½ plots revegetated with willows, ½ not
  - Data collected before and monthly after treatments
    - Soil temperature, moisture; light; LAI; cover, density
Summary of Results to Date

• Control
  – No resprouting from treated *Arundo*
  – Little to no regrowth from treated *Arundo*
  – Untreated shoots in treated clumps are chlorotic

• Restoration
  – Poor survival of willows
  – Replanting planned following first rains

• Optimal time for control may not be optimal time for restoration
Artichoke Thistle Life History

First years

Later years

Seed → seedling → juvenile → rosette

Tap root

Bolting → flowering → seed set & shed
Artichoke Thistle Research Objectives

• Invasiveness
  – Seed dispersal characteristics
  – Demography and phenology

• Control
  – Herbicide, clipping, burning

• Predict *Cynara cardunculus*
  development
  – Improve timing of control efforts
Downwind Seed Dispersal in Vegetated Site

![Graph showing seed dispersal distances for two conditions: No Pappus and Pappus. The graph displays the average sum of seeds at different distances dispersed (m). There is a significant decrease in seed dispersal as distance increases.]
Downwind Seed Dispersal in Non-vegetated Site

![Graph showing seed dispersal distance vs. average seed sum (no.) with and without pappus. The graph includes data for Poly. (With Pappus) and Poly. (Without Pappus).]
Predictive Management

- Construct phenological model for artichoke thistle development
- Investigate methods of control
- Use phenological prediction to schedule timing of control strategies

Seedling model

Adult resprout model
Conclusions—Don’t Reinvent the Wheel

- Weed Science and research-extension continuum
  - Framework for management of invasive species
- Basic information on biology, ecology, genetics, ...
  - Informs management
  - Required for specific recommendations