Unraveling the Economics of a Wicked (Weed) Problem

David Ervin, Prof. Emeritus, Economics and Env. Mgmt. Senior Fellow, Institute for Sustainable Solutions
Portland State University
The Impact of Genetically Engineered Crops on Farm Sustainability in the United States

Pest Resistance

• Weed resistance to Roundup increasing at fast rate
• 12 weed species resistant in the U.S. including Palmer Amaranth, Common Water Hemp, Giant Ragweed, and Horseweed
• Alternative controls include more toxic compounds, more tillage, or both.
• Insect resistance not (yet?) present in the U.S.
Conclusions

#1 Weed problems in fields of HR crops will become more common as weeds evolve resistance to glyphosate.

**Recommendation**: Multi-stakeholder group needed to document emerging weed-resistance problems and develop cost-effective practices to increase longevity of HR technology.
Seminar Outline

- Scoping herbicide resistance
- Why is it a “wicked problem”?
- Why should we care?
- Common pool resource economics
- Community-based approaches

- Acknowledgment: George Frisvold, economist at U. Arizona
Global Increase in Unique Resistant Cases

Number of Unique Resistant Cases

Year

Dr. Ian Heap, WeedScience.org 2015
Increase in Glyphosate-Resistant Weeds Worldwide

Number of Species

Year


Dr. Ian Heap, WeedScience.org 2015
Harvesting ragweeds and corn!

Glyphosate Resistant Giant Ragweed (Ambrosia trifida) infesting Roundup Ready Corn. Photo: Dr. Bill Johnson
Scoping the global HR problem

- 461 unique HR cases (i.e., weed species times the site of action), up from 5 in 1975.
- HR reported in 86 crops in 66 countries.
- Approximately 100 weed species are now resistant to multiple sites of action.
- Vast majority occurred since 1995 and the trend will continue without effective intervention.

Source: Heap, 2015
How did this HR explosion occur?

- HR is not new -- has occurred since 1950s due to selective ecological pressure on weeds.
- GE crop revolution accelerated HR, especially the Glyphosate (Roundup®) tolerant varieties.
- Current voluntary HR management programs have proven ineffective in the U.S.
- However, the full set of causes is wickedly unclear!
Characteristics of wicked problems (Rittel and Weber; Batie)

1. No definitive formulation; much uncertainty
2. No stopping rule; cannot eliminate resistance; requires learning and adaptation
3. No true/false solution; solutions are based on “judgments” of multiple stakeholders.
4. No ultimate test of a solution; no shared values re societal goals.
5. Every solution is one-shot operation; biophysical and social context matters.
Characteristics of wicked problems (Rittel and Weber; Batie)

6. Do not have enumerable solutions
7. Every wicked problem is essentially unique.
8. Every wicked problem is a symptom of another problem.
9. Wicked problems have multiple potential and viable causes.
10. Person proposing solution has no right to be wrong.
Costs of food, fiber and bioenergy will increase.

For example, in 2006-2010, 92% of Georgia growers hand-weeded 52% cotton acres at $23.70/A, compared to 17% of growers in 2000-2005 at $2.40/A (Culpepper 2011)
2000-2005: 17% of growers hand-weeded 5% cotton acres at $2.40/A

2006-2010: 92% of growers hand-weeded 52% cotton acres at $23.70/A

Source: S. Culpeper. U. Georgia
“The proportion of farmers in the sample who indicated they had total weed control costs of $50 or more per acre nearly doubled with the emergence of herbicide-resistant weeds on their farm.” (Zhou et al, AgBioForum 2015)
Why should we care -- environment?

- Loss of herbicide efficacy will force growers to use alternative weed control measures
  - More toxic compounds
  - Potential human health and wildlife effects
  - More tillage
    - More erosion and polluted runoff
    - More carbon dioxide released
  - Likely some of both!
Some research and policy responses

- Formed interdisciplinary task force of scientists, crop advisers and industry representatives.
- Co-hosted two national summits with the NRC on the “wicked” HR problem
- Secretary of Agriculture promulgated new programs of assistance to combat HR.
- Diversify tactics to slow resistance
- EPA deregulated Enlist Duo stacked herbicide with HR label provisions and reregistration reqs.
Due to geographic mobility of many resistant weeds, the genetic pool of weeds susceptible to herbicides is a **common pool resource** (CPR).

If farmers feel their control actions will not be matched by their neighbors, they have less incentive to manage HR on their lands.

It’s an assurance problem! Farmer’s decisions depend on neighbors’ actions; gaming ensues.
Strategies to control resistance farmer by farmer will not optimize welfare; some form of collective action is necessary (Garrett Hardin).

If CPR conditions hold, individual farmer profit maximizing decisions will not optimize social welfare due to the externalities.

In a non-cooperative game, the collection of individual decisions leads to degradation of the susceptible weed gene pool.
Hypothetical HRM payoffs

<table>
<thead>
<tr>
<th>B:  NO MANAGEMENT</th>
<th>A: NO MANAGEMENT</th>
<th>A: MANAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10,10)</td>
<td>(12, 8)</td>
<td>(8,12)</td>
</tr>
<tr>
<td>(12, 8)</td>
<td></td>
<td>(15,15)</td>
</tr>
</tbody>
</table>
The challenge is to build cost-effective CPR management institutions to transform the situation into a positive sum cooperative game. Elinor Ostrom, Co-Recipient of the 2009 Nobel Prize in Economics, studied experiments around the world to distill lessons for developing sustainable community-based approaches to CPR management.
Possible Approaches

1. Voluntary education and tech assistance for individual farmers have been ineffective.

2. Top-down regulation could be used, but……
   - lack of flexibility increases control expense
   - prescriptive practices often stymie innovation
   - high monitoring and enforcement costs to check compliance across the landscape (Do we really want a weed police?)
3. Public or private practice subsidies also have problems ……
   – Difficult to identify strategic targets
   – Additionality? Will payments just become income transfers without altering behavior?
4. Resource privatization is generally infeasible due to geographic scope of weed mobility.
5. What’s left? -- Community-based CPR management, an exercise in institutional (socio) economics (Ostrom et al)
Some Economic Variables in Community-Based Approaches

- Transaction cost of organizing the community is a critical variable.
- Benefit function of participation is localized and uncertain; costs also vary by crop and region.
- Assurance of cooperative behavior is essential to encourage community stewardship.
- Noncompliance penalties must be well defined.
- The benefit and cost functions for farmers will adjust over time with learning and adaptation.
Feasibility of Self Organization
(Ostrom, Science 2009)

Key variables:

1. Size of resource system (-)
2. Productivity of resource system (+)
3. Predictability of system dynamics (+)
4. Resource unit mobility (-)
5. Number of users (-)
6. Norms/social capital (+)
7. Leadership (+)
8. Knowledge of socio-ecological system (+)
9. Importance of resource to user (+)
10. Collective governance rules (+)
Design Principles for CPR Mgmt
(Ostrom et al 2012)

1. Clearly define resource boundaries
2. Adapt rules to local conditions
3. Ensure broad participation by “resource appropriators”
4. Monitor accountability to resource appropriators with sanctions
5. Employ graduated sanctions
6. Use cheap and easy conflict resolution mechanisms
7. Recognize self-determination of the community, e.g., state statute
8. Consider “polycentric” governance (multiple layers) for larger issues
Meta analysis of 91 CPR studies found good empirical support for all principles.

Suggested refinement of principles 1, 2 & 4:

1a. Clearly defined boundaries: Individuals or households who have rights to withdraw resource units from the common-pool resource (CPR) must be clearly defined.

1b. Clearly defined boundaries: The (geographical) boundaries of the CPR must be well defined.
2a. Congruence between appropriation and provision rules and local conditions: Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions.

2b. Congruence between appropriation and provision rules and local conditions: The benefits obtained by users from a CPR, as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules.
4A. Monitoring: Monitors are present and actively audit CPR conditions and appropriator behavior.

4B. Monitoring: Monitors are accountable to or are the appropriators.
Some U.S. CPR initiatives

- *Public initiatives* (e.g., invasive and noxious weed control)
- *Joint private-public* strategies (e.g., boll weevil eradication)
- *Producer associations* with sanctions written in state law (e.g., AZ pink bollworm control)
- *Zero Tolerance Program* – Community-based effort for Palmer Amaranth control
Insights from literature

- Exchange of information important
  - Multi-directional vs. uni-directional flow
  - Listening is underrated

- Building institutional capacity takes time and requires maintenance (even after crises subside).

- “If/then” statements based on scientific information that show economic consequences are more effective than exhortations of what people “should” do.
Closing Observations

1. HR is a *wicked problem* (interacting biophysical, technological, economic and social systems) that defies simple solutions.

2. Individual actions can help, but collective approaches needed to deal with mobility.

3. Ostrom’s design principles can help guide CPR management.

4. The feasibility of self organized community-based efforts depends on local conditions.

5. Progress will require local knowledge of benefits and costs and adaptation over time.
References


References


References


Thank you! Dave Ervin  dervin@pdx.edu
$1M interdisciplinary project funded by USDA to study HR causes and food security impacts

USDA Agricultural Research Service $1M area-wide study on managing herbicide resistance, likely extending 4 more years for $5M total.

$1M conservation innovation proposal by U.S. Sugar Beet Foundation with academic scientists to test community based pilot projects

Herbicide Resistance Action Committee – industry efforts to foster integrated weed mgmt
CPR programs are complex with different influencing factors.

Agrawal (2003) – meta review of studies

- Factors affecting formation do not have unequivocal effects, e.g., size of group.
- Higher group heterogeneity is not always a disadvantage.
- Need to account for resource, social/political contexts and community/personal values.