

ECONOMIC ISSUES TO CONSIDER FOR GENE DRIVES

Paul D. Mitchell, Ag & Applied Economics, UW-Madison

Neil McRoberts, Plant Pathology, UC-Davis

Zachary Brown, Ag & Resource Economics, NC State



NC STATE UNIVERSITY

Roadmap to Gene Drives

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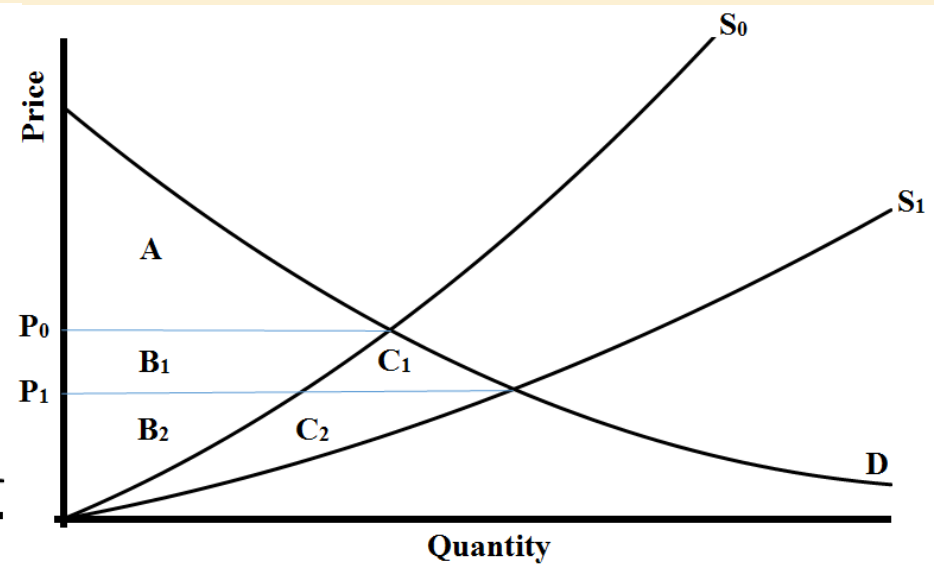
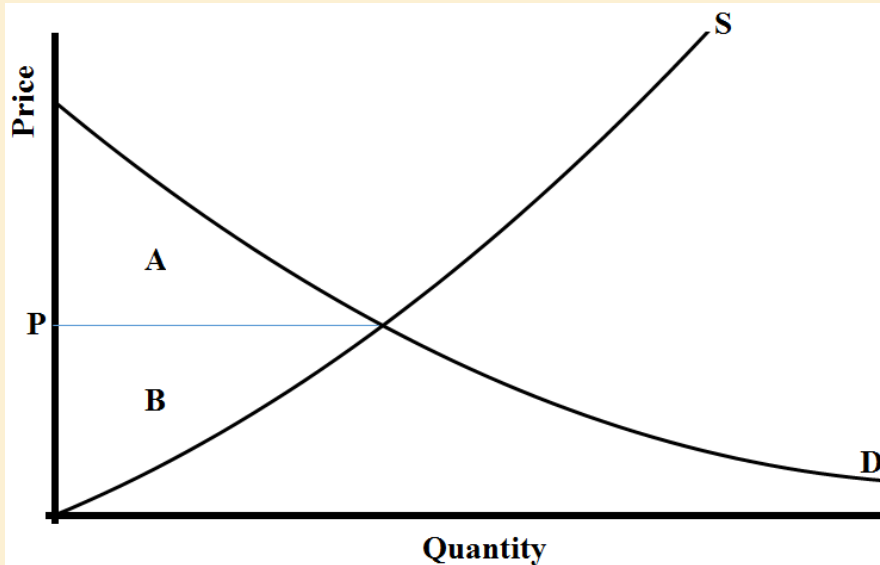


Overview

- Intellectual contribution of economics to issues of this type
 - Surplus, Tradeoffs and Unintended Consequences
- General economic considerations regarding gene drives
 - Role of public perceptions
 - Model of gene drive deployment and nonlinearities arising from perceptions and initial deployments
 - Make system governance difficult
- Reflect on case studies
- Keep an eye on research needs

Intellectual Contribution of Economics: Surplus as Measure of Social Welfare

- Surplus is the fundamental monetary measure of the social benefits of market goods, allows cross-good comparisons
- New technology or policy shifts supply and/or demand, and so can measure the net change in social benefits
- Non-market valuation for non-market goods (e.g., public goods)



Intellectual Contributions of Economics: Tradeoffs and Unintended Consequences

- Tradeoffs: There is no such thing as a free lunch!
- The benefits can outweigh the costs, but there are always costs and someone eventually has to pay them
- Focus on externalities and regulation
- Regulation of gene drives has more than just direct costs
- Unintended Consequences: People respond to incentives to offset the direct effects of policies and technologies
- Jevons' Paradox (Rebound Effect): more energy efficient technology can lead to greater overall energy use
 - A partial offset of the main effect: Slippage or Leakage

Public Perceptions of Gene Drives

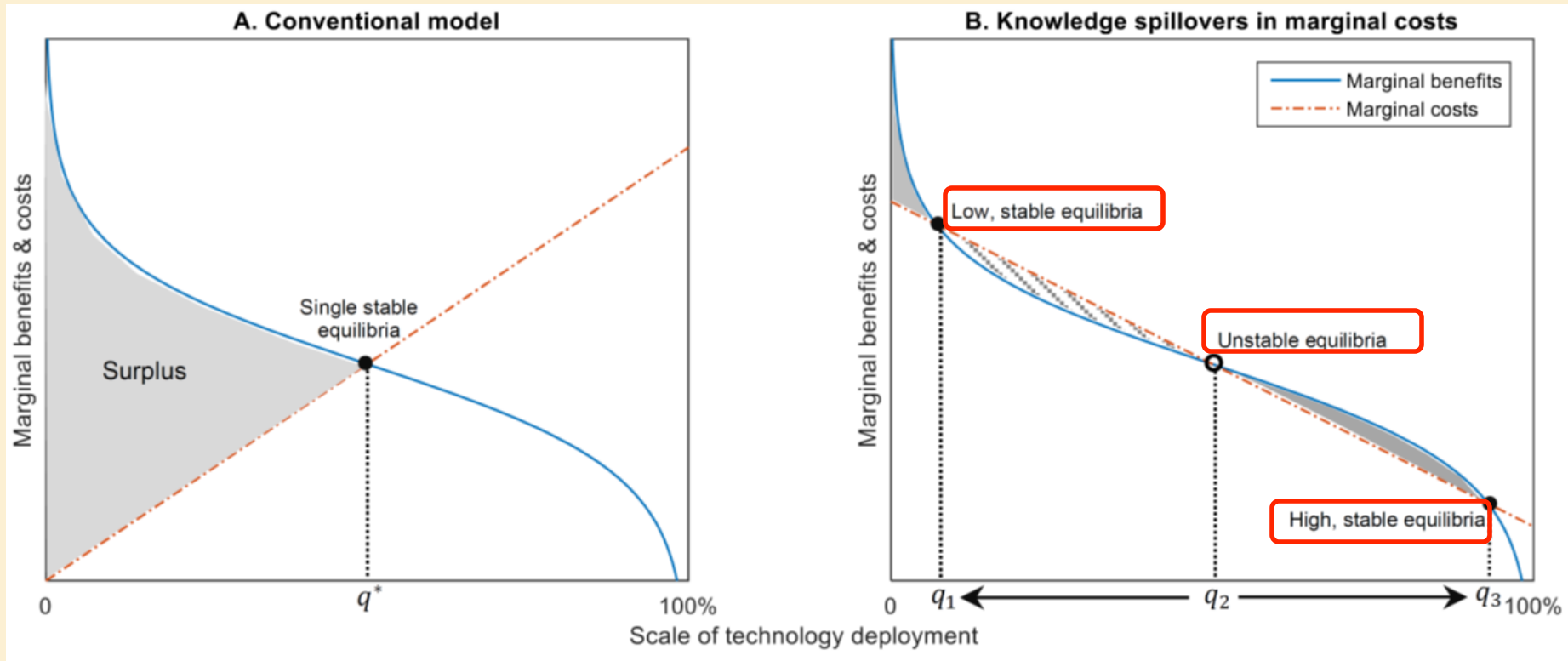
- Tremendously important for gene drive successes
- It's more than just science – good science does not always win: Consider biotech crops and climate change
 - Humans have an instinct for Herd Behavior
 - Fads, investment bubbles, Ebola scare, ...
 - Not rational or science-based behavior
 - More than just an “Information Deficit” problem
- **Need research on public perceptions of gene drives and how they can be molded and managed**
 - Marketing research: Perceptions are reality in marketing
 - Benefit-to-Risk Ratio, Trust & Attitudes (Amin & Hashim 2015)

Public Perceptions of Gene Drives

- **Regulation, Governance and Financing of gene drive deployments will affect public perceptions**
- Regulation necessary, but affects the type of organization that can deploy gene drives and the cost of deployment
- Ag biotech: 12-15 years to register, regulatory costs \$20-\$30 million – major pests, large corporations, large crops
- Gene Drives: lots of regulation to ensure safety may mean only large corporations & big government agencies
- What about non-profits? What about allying with respected non-profits like Doctors without Borders?
- Financing: corporations, charity, governments, UN
- Who should pay for public health? Ag pest management?

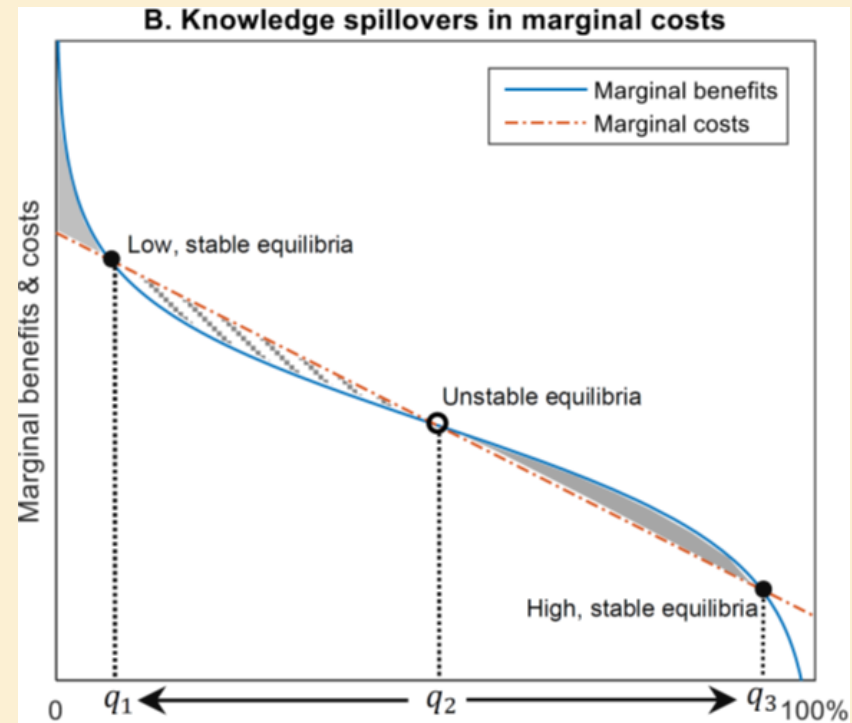
Model of Gene Drive Deployment

- Conventional model has standard single equilibrium
- Knowledge spillover model has multiple equilibria
- Low and High stable equilibria and a middle Unstable one



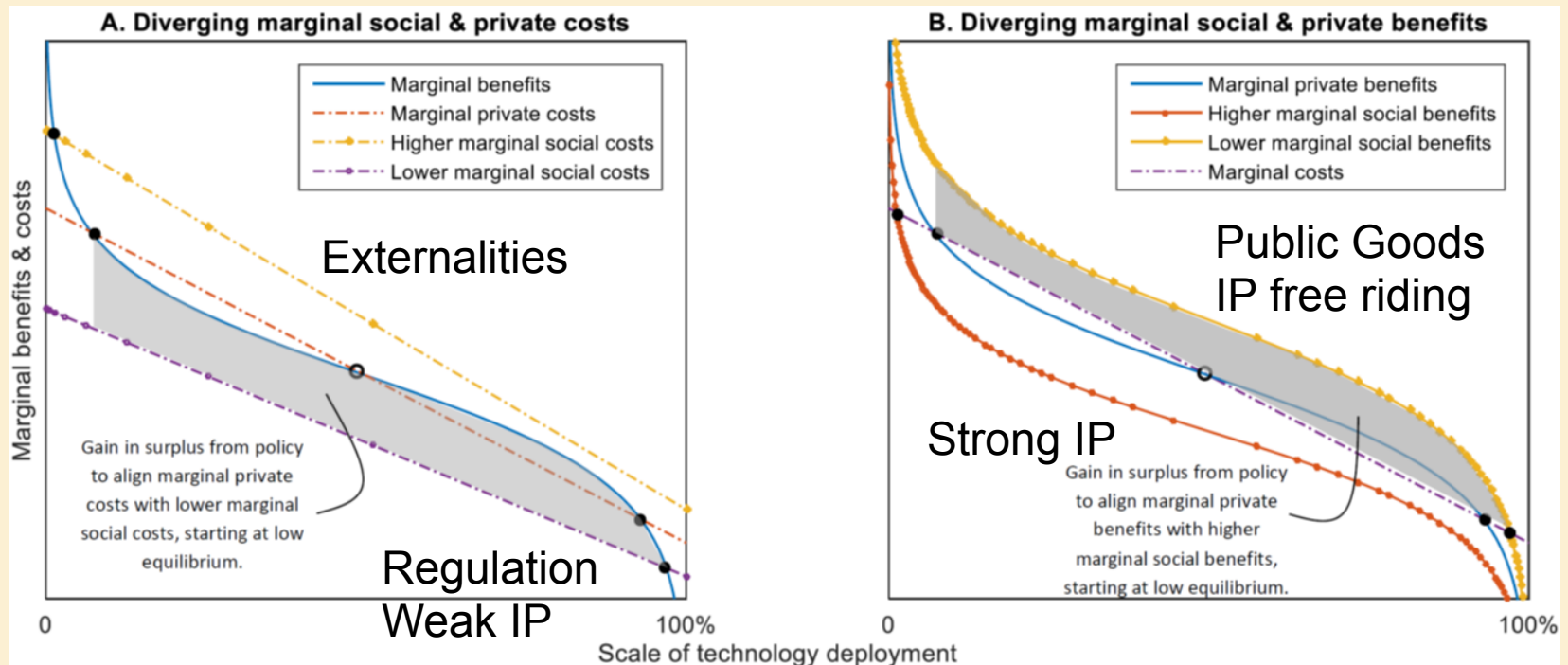
Initial Conditions Matter: Path Dependency

- **Low stable equilibrium???**
Skeptical public, small projects:
ag & islands, not public health,
lots of regulation for safety
- **High stable equilibrium???**
Collaborative projects, public
engagement, big splash human
health projects pull ag and
islands along, reasonable level
of regulation
- Have to get over the q_2 “hump”



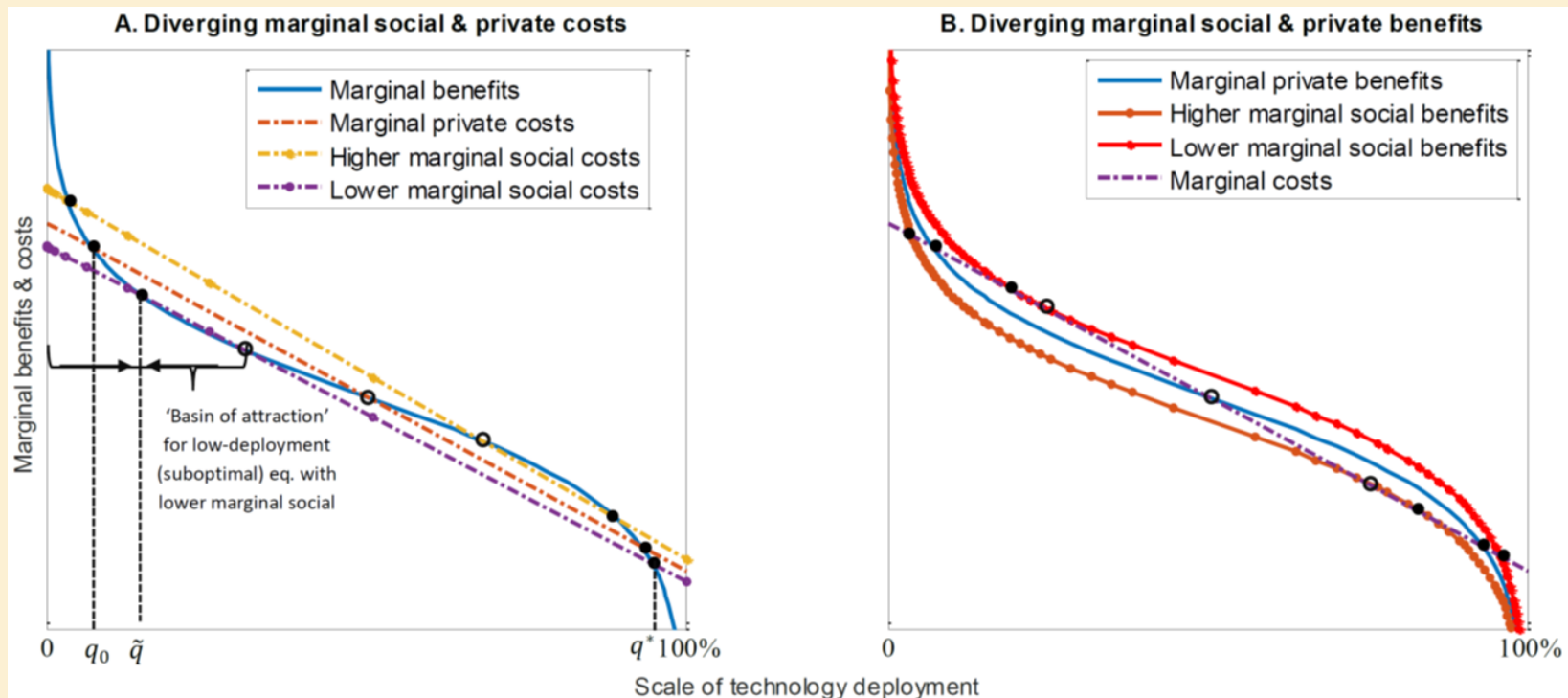
Large divergence of private & public costs/benefits

- Divergence splits supply & demand into private & public curves, policies to align incentives give high equilibrium
- Externalities and public goods from gene drives
- Excessive regulation, IP protection too strong or too weak



Small divergence of private & public costs/benefits

- With small divergence, aligning public and private incentives keeps low equilibrium as a basin of attraction
- Need additional policy instruments to reach high equilibrium



Implications: Policies to Move from Low to High Equilibria

- Use policy tools to move firms to the public costs/benefits curves and so reach the high deployment equilibrium
- Policies can cause “flips” from low to high equilibria and nonlinear “jumps” in social surplus
- Main point: need to be careful with standard policy tools, may not work as expected
 - Large divergences, yes. Small divergences, no
- **Research: Need to understand the potential market (supply and demand) for gene drives**
- Develop data to estimate the supply and demand for gene drive applications and divergences between public and private incentives due to IP, externalities & regulation

Case Study: Mosquito-Vectored Disease

- Tremendous benefit eradicating/reducing these diseases
- Tradeoff/Unintended Consequence: What to do with all the people? Population increase: need food, education, jobs, ...

Norman Borlaug: humanitarian hero
or menace to society? **theguardian**

- *"Aside from Kissinger, probably the biggest killer of all to have got the peace prize was Norman Borlaug, whose 'green revolution' wheat strains led to the death of peasants by the million."* (Alexander Cockburn 2007)
- Disease eradication can be destabilizing, needs to be part of a coordinated development program
- **Research needs: theoretical and applied development**

Surplus a Limited Measure of Social Welfare

- Hirsch's critique (The Social Limits of Growth)
- Dual economy is both material and non-material
- Economic development or growth focuses on the material economy [surplus], but misses the non-material
- Eventually reach diminishing marginal utility from material goods – more “growth” does not make us better off
- In some cases, expansion of material economy actually makes us worse off – have lots of stuff but not happier
- Non-material goods are often status goods or positional goods that the elites keep rare and hard to get
- **Main point: there's more to life than surplus (money)**

Financing and Governance

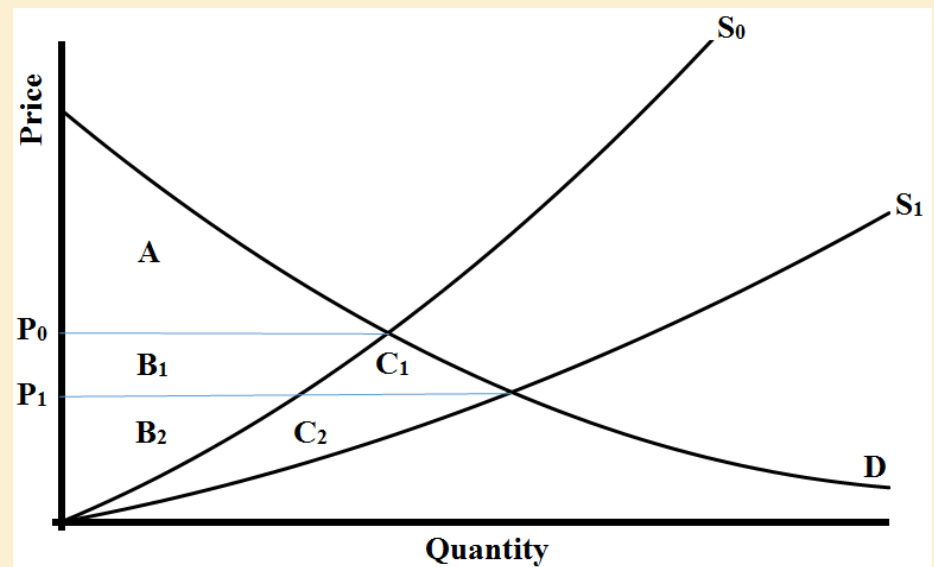
- Public health a public good, no market
- How do you fund public goods? Nations can free ride
 - Private companies with public funding – Oxitec
- Positive and negative externalities from gene drives
- Should a nation release gene drive mosquitoes that cross borders? Transboundary pollution or benefits
- Governance issues: Do we need unanimous consensus?
- What about weak or illegitimate govts? Rogue nations?
- **Research needs: Theoretical and applied research on public health economics and political science**

Case Study: Invasive Rodents on Islands

- Seems like a great place for a field study, proof of concept
- Invasive species eradication can be destabilizing
 - Ecosystem partially adapted to the invasive, so removing it may not move system back to original equilibrium
 - Unexpected or bad outcome could create bad publicity
- Risk of locking world into a low equilibrium
 - Don't do too many little projects, or public expectations for gene drives may become small, erode support
- **Research need: public perceptions of these (early) gene drive applications to conservation**
 - Do they allay fears and facilitate public health applications or confirm fears and galvanize opposition?

Case Study: Agricultural Insect Pests

- Economic surplus model works well for estimating the benefits of ag applications – shifts in supply
- Cochrane's Treadmill: New technologies increase supply, which reduces prices so much that farm income falls and farms exit the industry
- Farmers on a treadmill running faster and faster to adopt new technologies and to stay ahead of falling prices



Case Study: Agricultural Insect Pests

- Multiple options for Financing and Governance
 - Self-funded (farmer cooperative) or public/private partnership
 - Boll weevil eradication or screwworm SIT
 - Citrus growers and USDA for Asiatic citrus psyllid and huanglongbing (citrus greening)
 - Corporate-funded unintended consequence: European corn borer areawide suppression with Bt corn
- “Safer” applications than human health
- Public already used to agriculture using genetic biotech
- Agriculture will likely be supportive of gene drive use

Research Needs: Agricultural Insect Pests

- **Good case to see how/if governance matters for public perceptions of gene drive applications**
 - Grower cooperative, public-private partnership, big or small corporation, non-profit, govt. agency, ...
 - Does the crop or insect matter?
- **Good case to estimate costs & benefits of regulation**
 - How regulation affects incentives to deploy technology
 - Value or impact of IP/patents

Research Needs

- Need research on public perceptions of gene drives and how they can be molded and managed
 - How does Regulation, Governance and Financing affect perceptions fo gene drives?
 - What does public want for Regulation, Governance and Financing of gene drives? How do these differ globally?
- Need to understand the potential market (supply and demand) and value for different gene drives applications
 - Public health, conservation, ag pests
- Need research expertise from specialists in development, public health and political science

Thanks for Your Attention!

Questions?

Paul D. Mitchell

Agricultural and Applied Economics
University of Wisconsin, Madison, WI
pdmitchell@wisc.edu 608-265-6514