Black Swans, Dragons and the Phoenix: Rebuilding Citrus after HLB

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5th International Research Conference on HLB

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RENK AGRIBUSINESS INSTITUTE
College of Agricultural & Life Sciences

NPM
Nutrient and Pest Management Program

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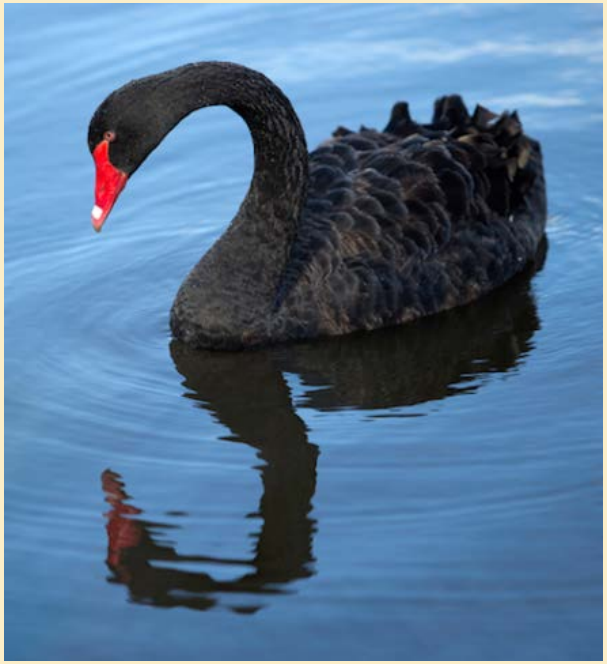
Overview

- What do mythological symbols like Black Swans, Dragons and the Phoenix have to do with HLB?
- An economic perspective on HLB: How bad is it?
- Reflections on the role of research for rebuilding citrus after HLB
  - Lessons from my research and experience in pest economics and agricultural biotechnology

Black Swan

- An old phrase meaning something “impossible”
- A perfect wife is *rara avis in terris nigroque simillima cygno*
- Roman poet Juvenal late 1st early 2nd century
- Popular usage for centuries, then in 1590’s, the Dutch found real black swans in western Australia!
- Usage changed to become something thought impossible that is later proven possible



Thanks Wikipedia!

Black Swan

- Nassim Taleb, *The Black Swan* (2007) (risk management)
  - The event is a surprise (to the observer)
  - The event has a major effect
  - After the event, it is rationalized by hindsight
- World War I, fall of the Soviet Union, the personal computer, the Internet, and the September 2001 attacks
- Can’t be predicted using standard or usual statistical models, rather we need to make society more “black swan robust” (resilient)

Thanks Wikipedia!

Effects of a Black Swan Event

- The path you are following permanently shifts, you cannot go back, but you have embarked on a new trajectory
- New attitudes, new ways of thinking, new institutions
- A paradigm shift, a revolution, …

The world has changed.
I see it in the water.
I feel it in the Earth.
I smell it in the air.
Much that once was is lost,
For none now live who remember it.

J. R. R. Tolkien

British scholar & fantasy novelist (1892 - 1973)

http://www.quotationspage.com/quote/31877.html

- **The Great Recession**

Source: https://fred.stlouisfed.org/series/A939RX0Q048SBEA

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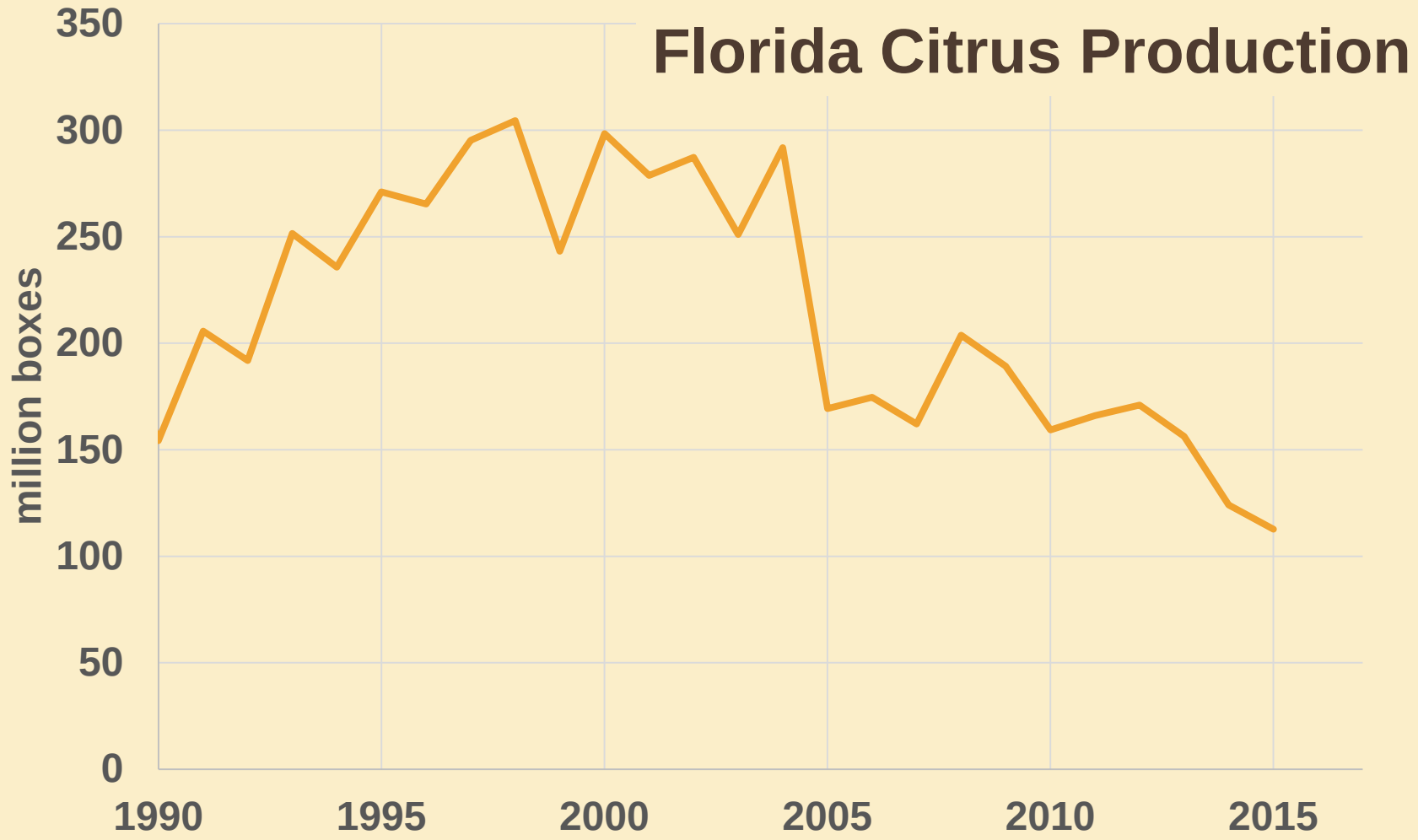
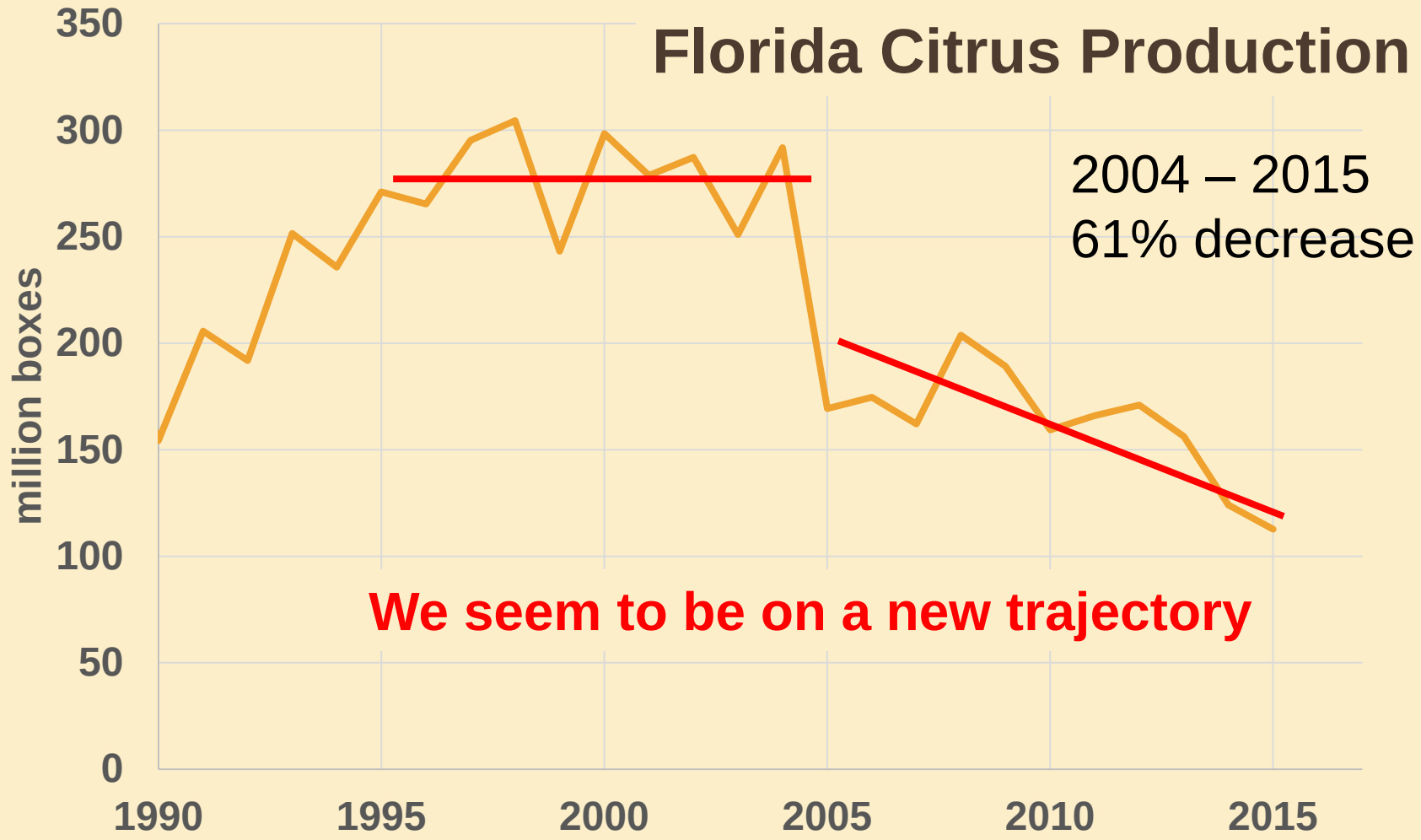
Huanglongbing is a Black Swan



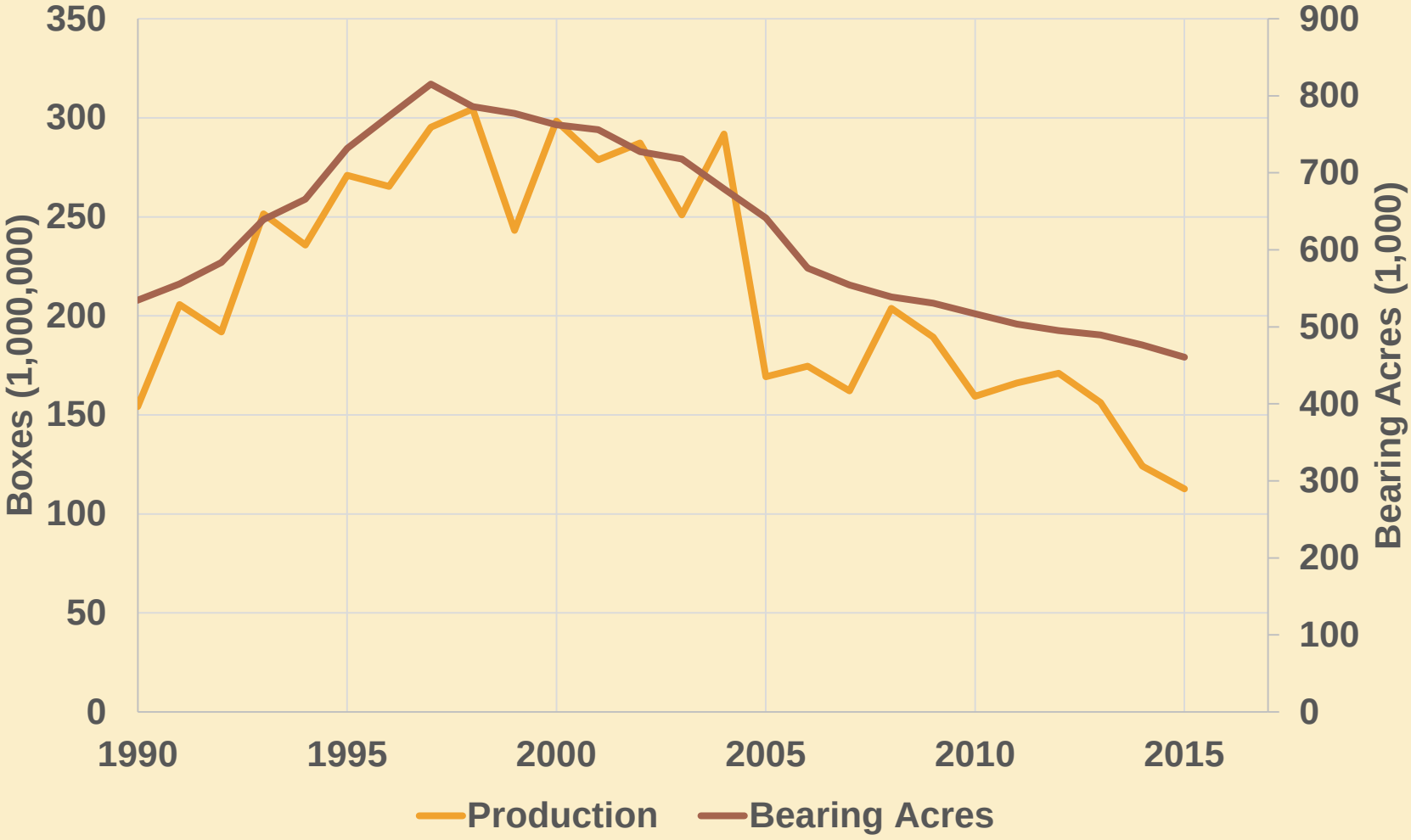
Source: USDA-NASS

Huanglongbing is a Black Swan



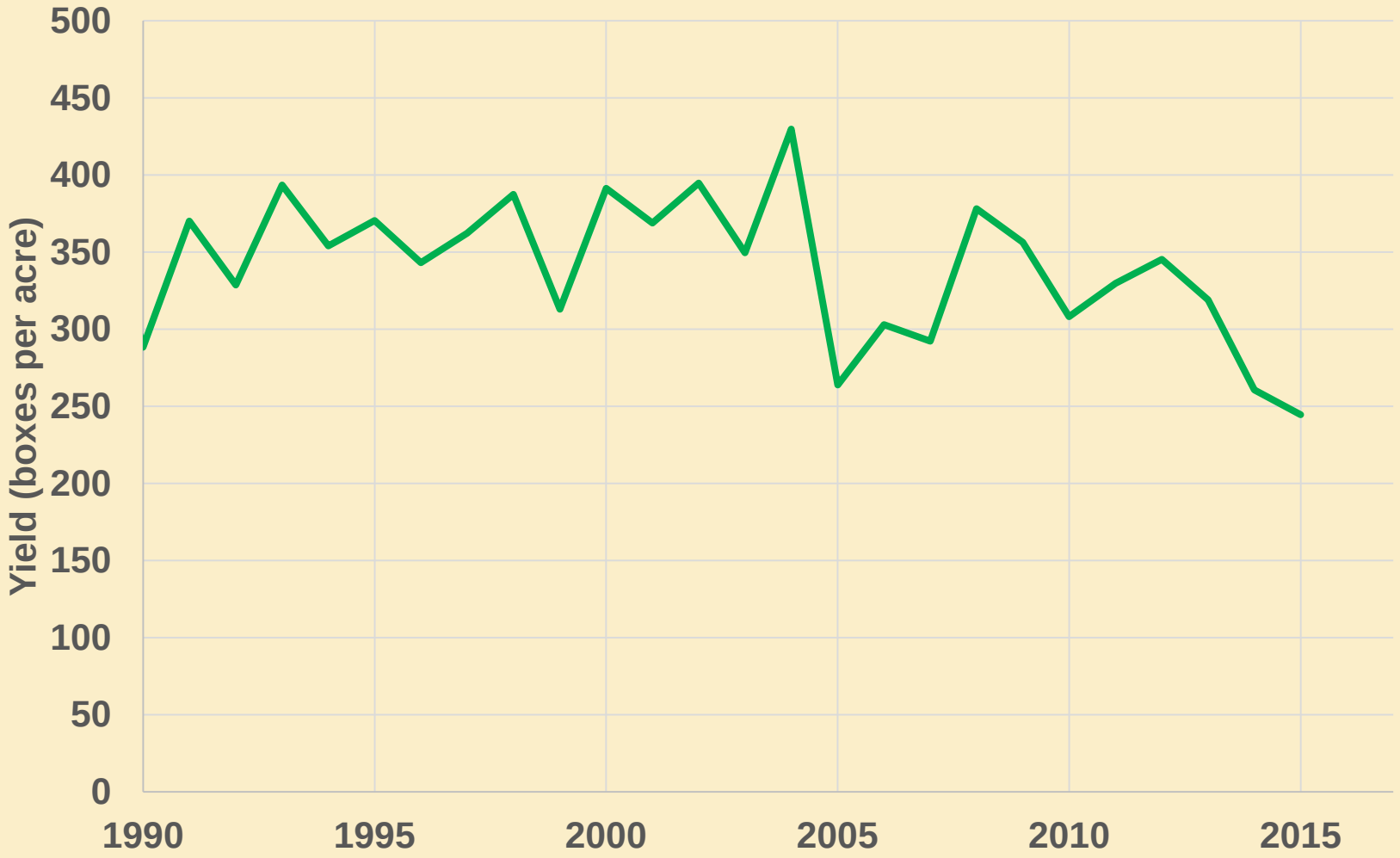
Source: USDA-NASS

Florida production held steady as citrus bearing acres declined, until HLB



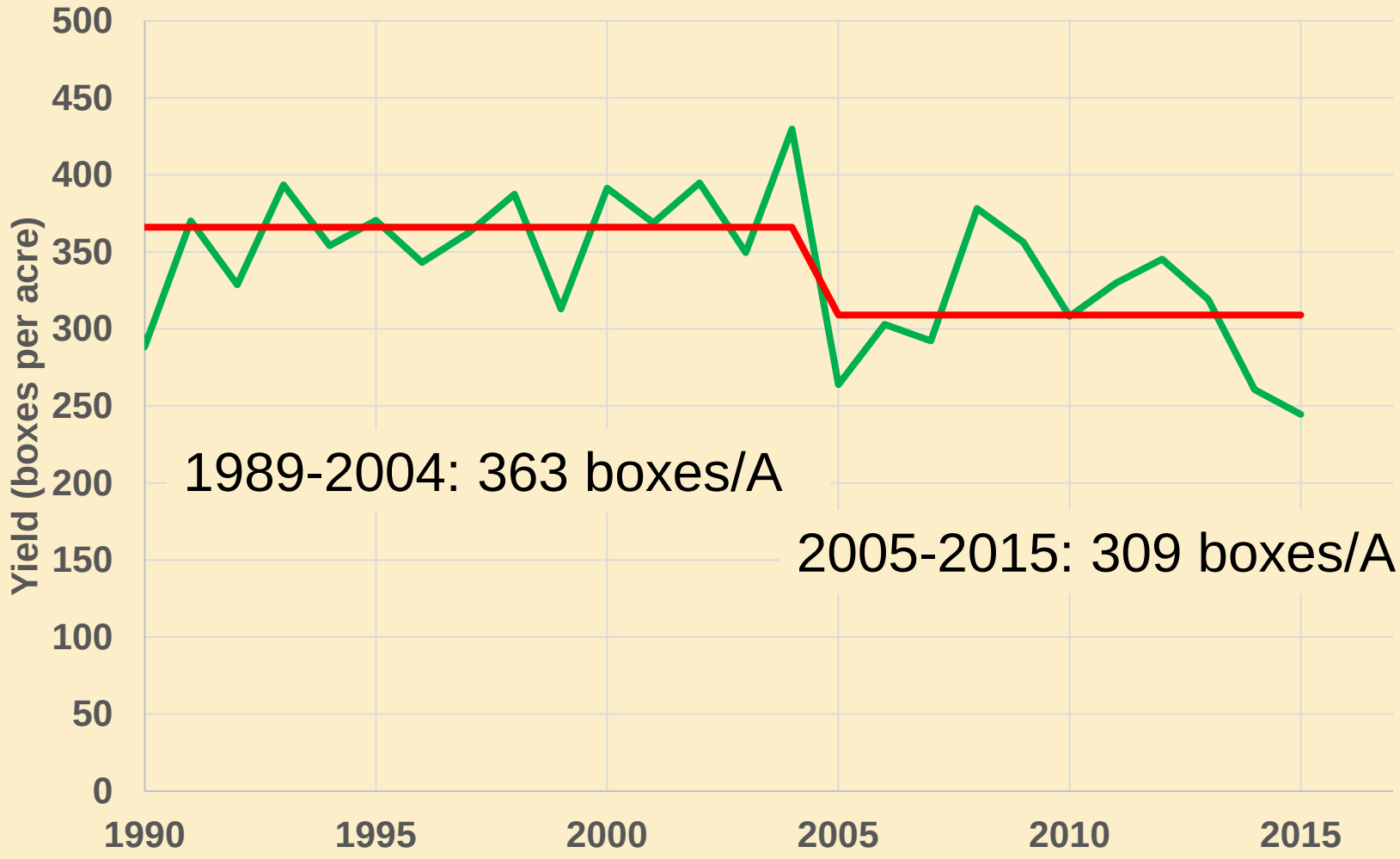
Source: USDA-NASS

Florida yield/A held steady, until HLB



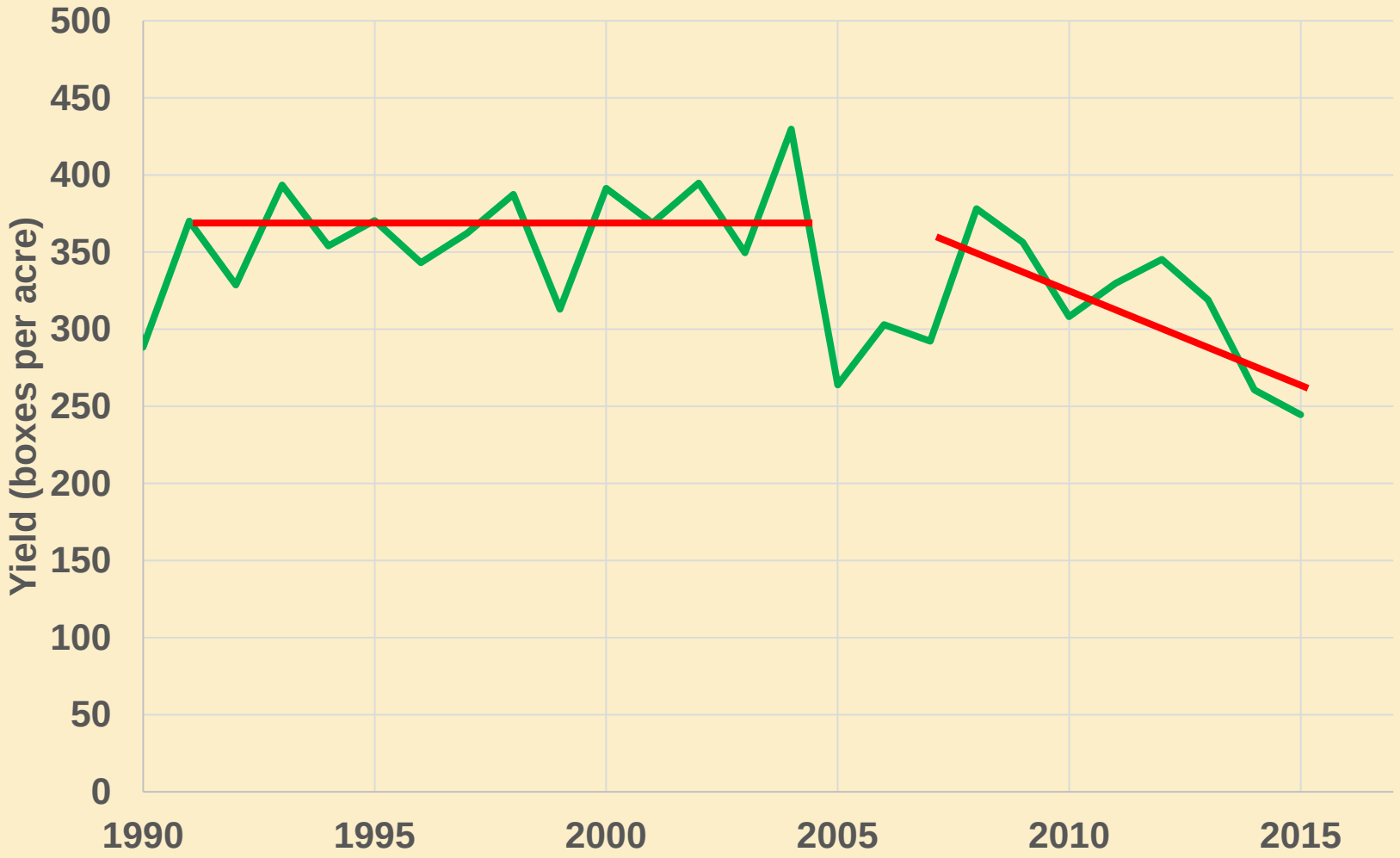
Source: USDA-NASS

Florida yield/A held steady, until HLB



Source: USDA-NASS

Florida yield/A held steady, until HLB

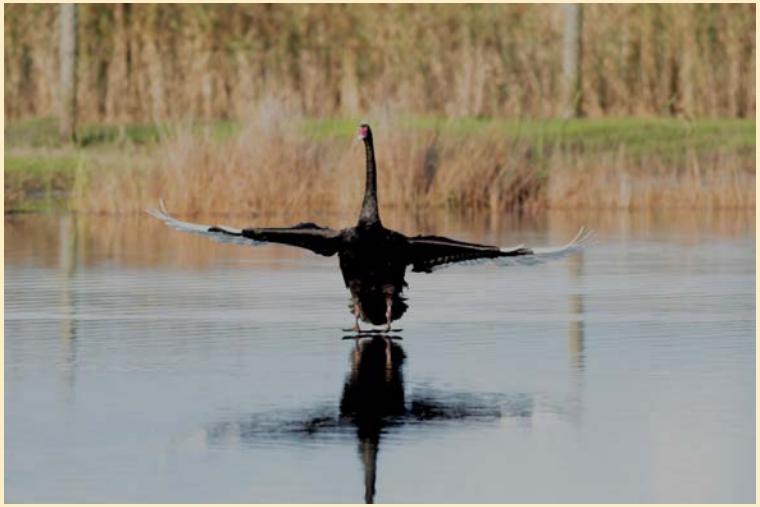


Source: USDA-NASS

What Fundamentally Transforms Nations?

- HLB is fundamentally changing US citrus production
- Walter Scheidel (Stanford history professor) new book on what stops socio-economic inequality "*The Great Leveler*"
  - Government Collapse
  - Revolutions
  - Pandemics
  - Total War
- See the book reviews in the New York Times (Dec 12, 2016) or the Atlantic Monthly (Feb 2017)
- https://www.nytimes.com/2016/12/06/business/economy/a-dilemma-for-humanity-stark-inequality-or-total-war.html
- https://www.theatlantic.com/business/archive/2017/02/scheidel-great-leveler-inequality-violence/517164/

What happens when a Black Swan lands?



People do stupid things!

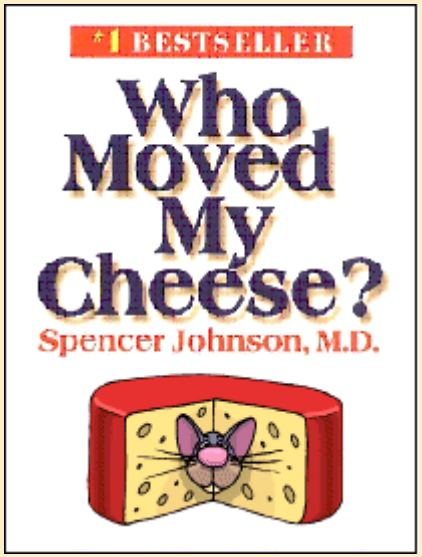
Panic, Fear, Anger,

Denial, Disbelief, …

http://wampy1.blogspot.com/2011/04/black-swan-landing.html

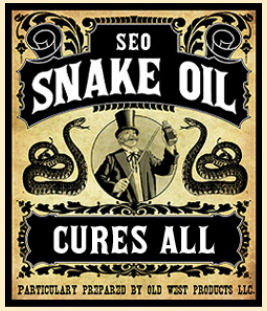
How do people respond to a crisis?

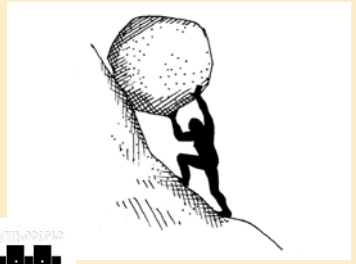
- Initial Responses
  - Panic: The sky is falling!
  - Blame Game: Who moved my cheese!
  - Denial: Stick your head into the sand

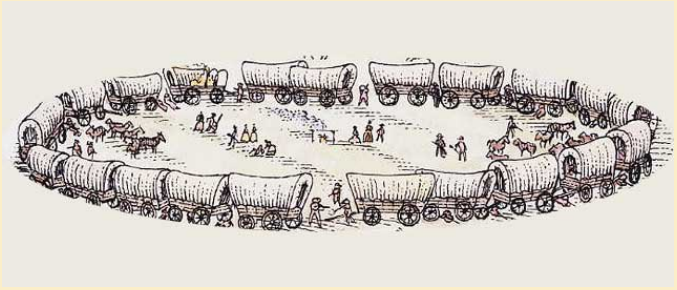


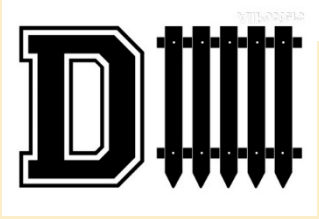
How do people respond to a crisis?

- False Hope: Grasp at Straws
- Depression
  - Passive: Dazed & confused, listless, withdrawn, wander
  - Active: Keep Calm & Carry On, Go thru the motions, Sisyphus
- Fight: Circle the Wagons, Defense
- Quit: Abandon ship, lose hope









Opportunity

- Dragon = Power, grandeur, a primal force
- Political power often uses dragon iconography
  - East: Lucky, wise, benevolent (Mushu in Mulan)
  - West: Malice, trickery (Smaug in The Hobbit)
  - HLB is both types of dragons
- Chinese word for crisis = danger + opportunity
  - Not true, but we want it to be!
- The space between black swans and dragons is where opportunity exists
- Yellow Dragon Disease or Yellow Shoot Disease?

Huanlongbing

- The HLB crisis is on-going, but we are in the middle of building a new path
  - Not everyone will make it
- Hard work, science and innovation, and luck needed to rebuild the citrus industry after HLB
- The Phoenix is the symbol of rebirth, with one generation born from the ashes of the previous
- Citrus will see new leaders, new intuitions, new ways of doing things
- Return to glory? Collapse? Smaller & leaner?

Why all the Myth and Symbolism?

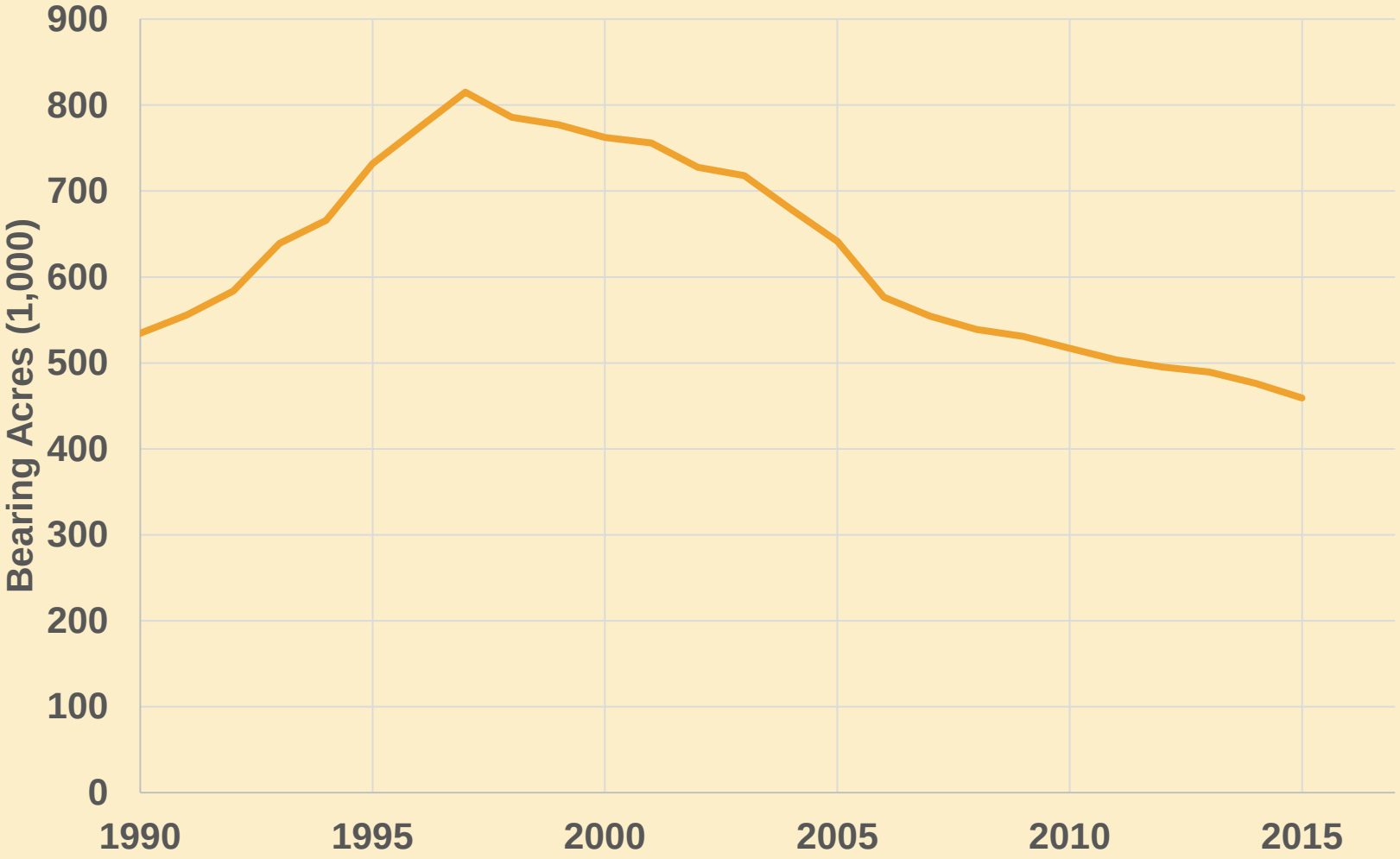
- Humans have used myths and stories, symbols and imagery to motivate and inspire for thousands of years
- Humans are social and spiritual beings and we all need inspiration and motivation, even scientists
- We should remind ourselves that improving the science about HLB to help rebuild citrus globally is an useful and honorable activity worth our time and effort
- Scientists need inspiration too: "*the day-to-day work of science is intensely boring*" (Stephen J. Gould, Sci Am 1995)

Economic Research: How bad is HLB?

- Joint research led by Dr. Fengxia Dong at UW

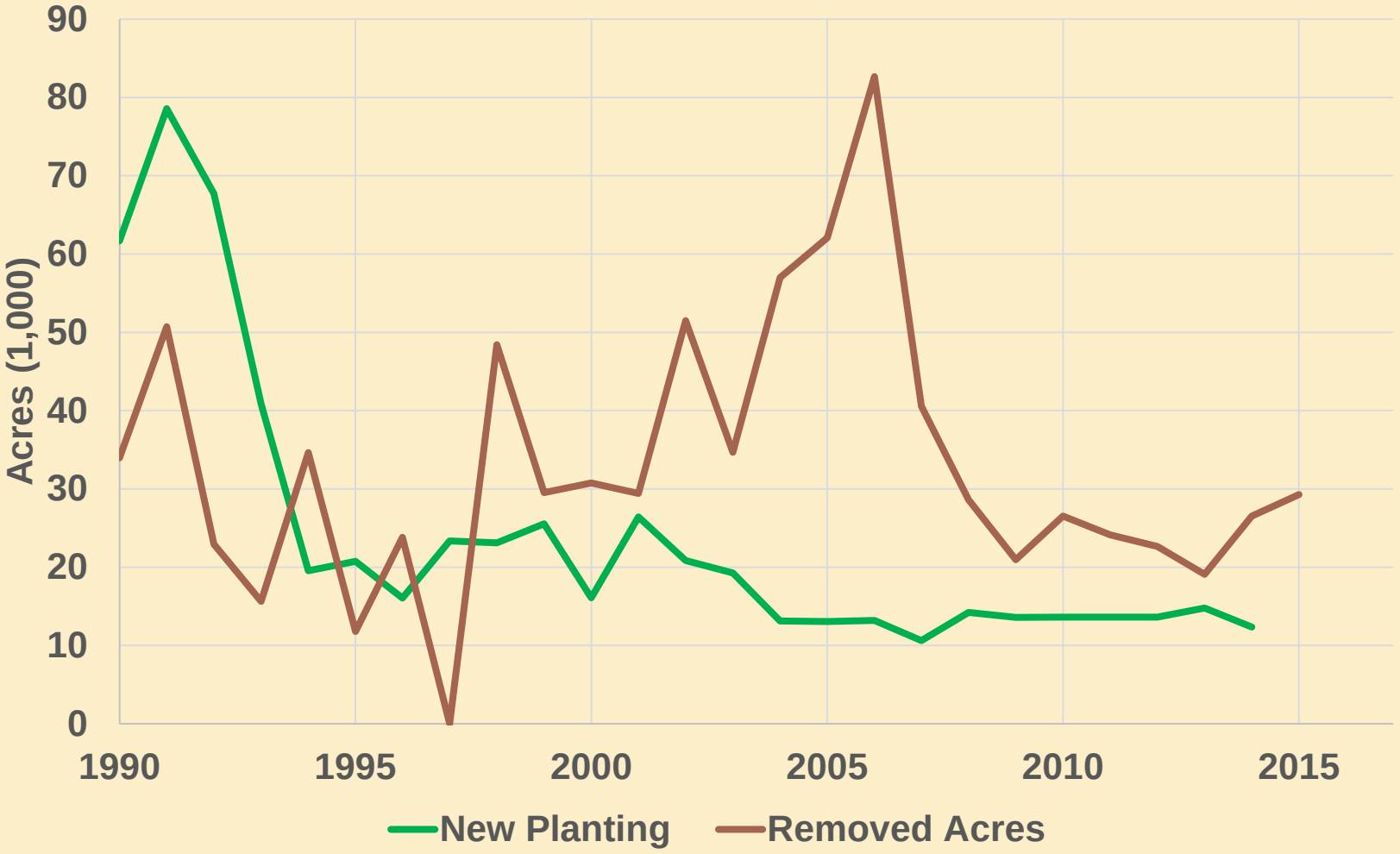
- What is the economic impact of HLB in Florida?
- In what way and how much has HLB contributed to the decline in citrus bearing acres?
- Analyze newly planted citrus acres and removal of citrus acres and yields

Florida Citrus Bearing Acres: Declining since 1997



Source: USDA-NASS

Florida Citrus New Plantings and Removed Acres 1990-2015



Source: USDA-NASS

New Citrus Planting (w/ Dr. Fengxia Dong)

Variable	Coefficient	P Value
Bearing Acres: 5-Yr Average	0.051*	0.065
Expected Long Run Profit	32.4**	0.041
HLB	-5.29*	0.096
New Acres as % of Bearing Acres	12.6	0.554
Expected Long Run Yield	0.002	0.969

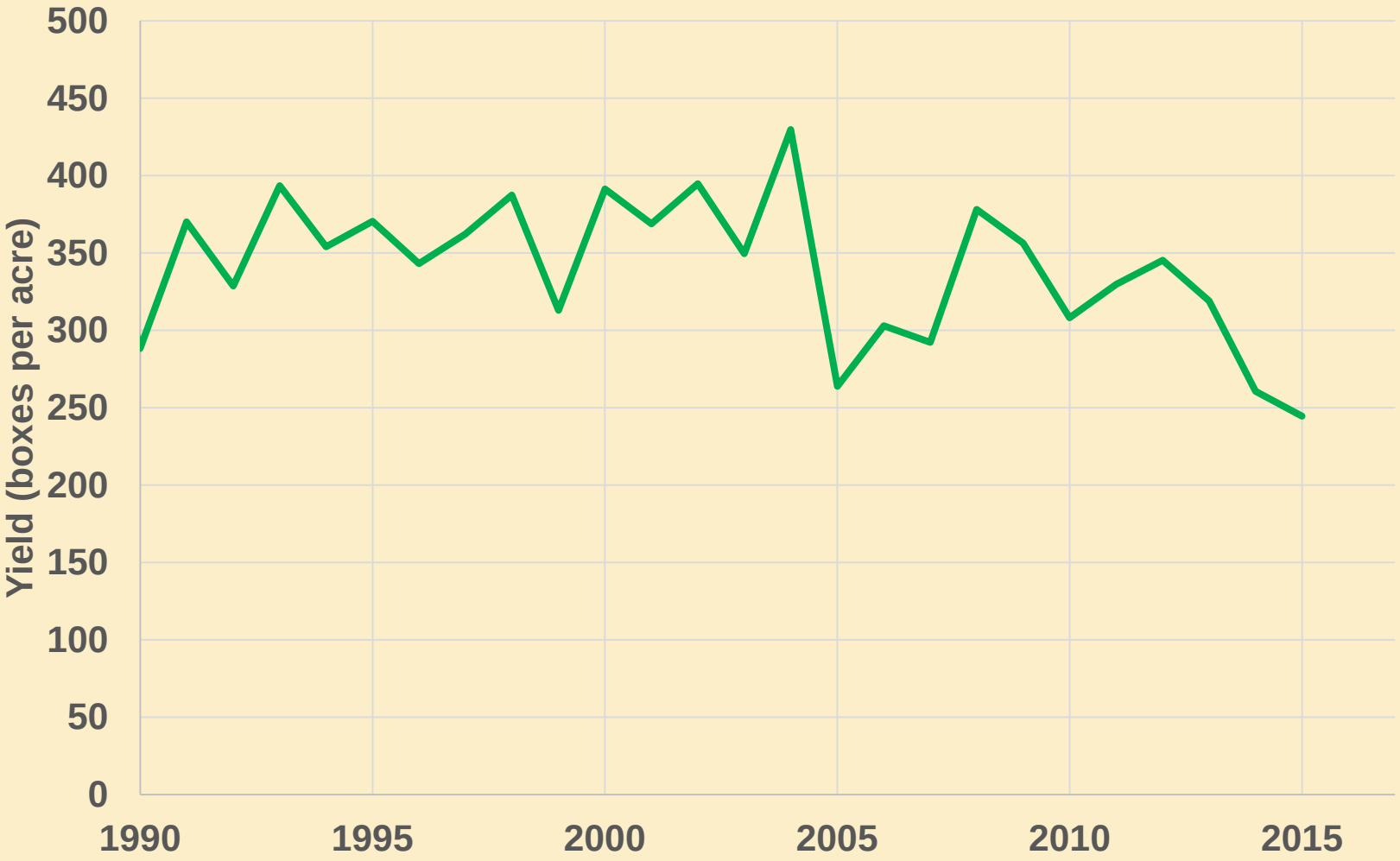
- As expected long run citrus profit increases, new citrus planting increases
- When HLB arises, new citrus planting decreases
- As the long-run average bearing acres decrease, new citrus planting decreases

Citrus Removal (w/ Dr. Fengxia Dong)

Variable	Coefficient	P Value
Bearing Acres: 5-Yr Average	-0.026	0.649
Expected Short Run Profit	-40.4*	0.053
HLB	-17.2	0.251
Hurricane	3.16	0.765
Housing Price Index	0.178***	0.009

- As expected short run citrus profit increases, citrus removal decreases
- When the price for houses increases, citrus removal increases
- HLB does not significant effect on aggregate removal

Florida Citrus Yield per Acre 1990-2015



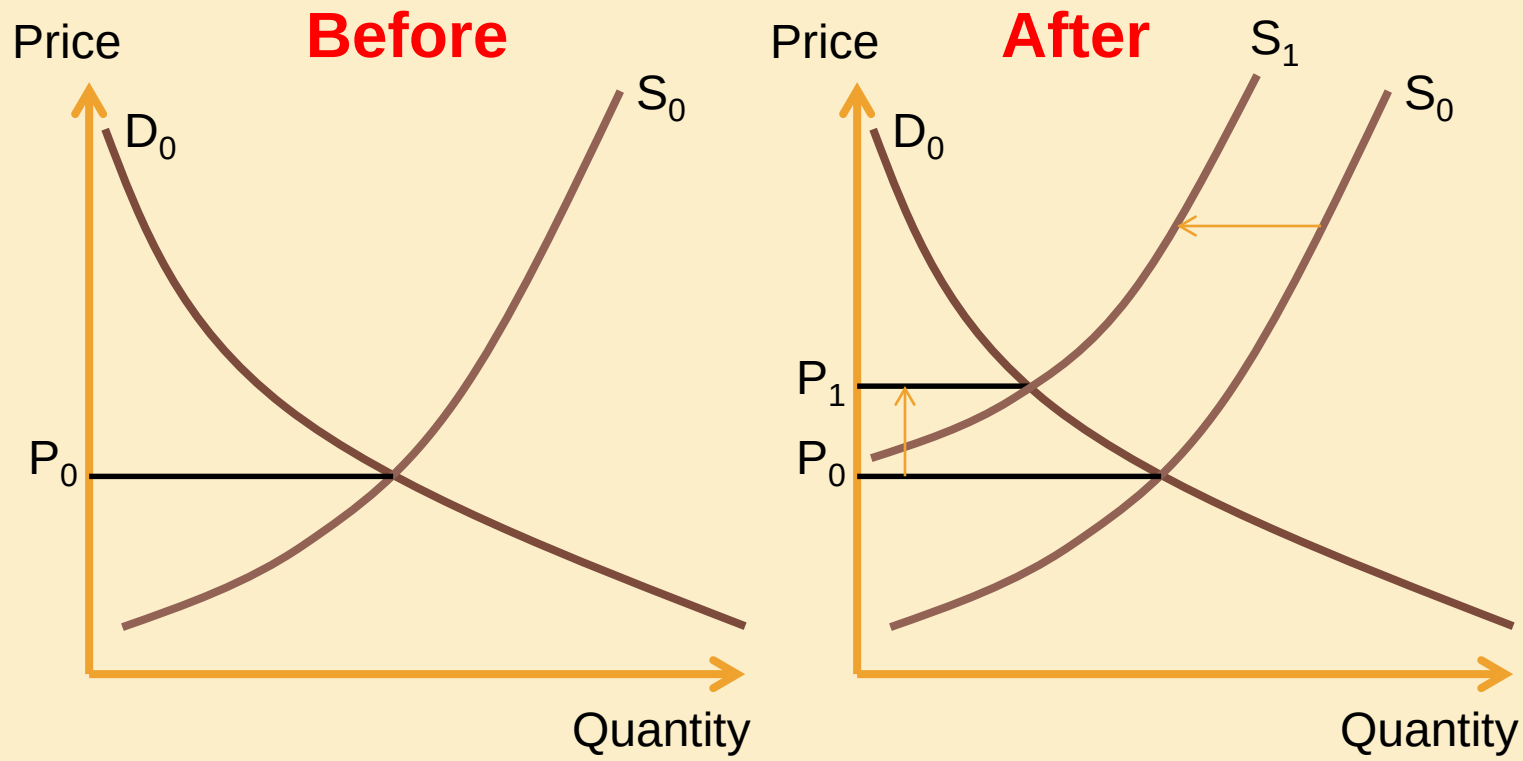
Source: USDA-NASS

Citrus Yield: Boxes per Bearing Acre (w/ Dr. Fengxia Dong)

Variable	Coefficient	P Value
Bearing Acres Decrease	-0.130	0.283
Expected Short Run Profit	122.5***	0.010
HLB	-106.5***	0.001
Hurricane	25.8	0.319
Trend	1.49	0.512

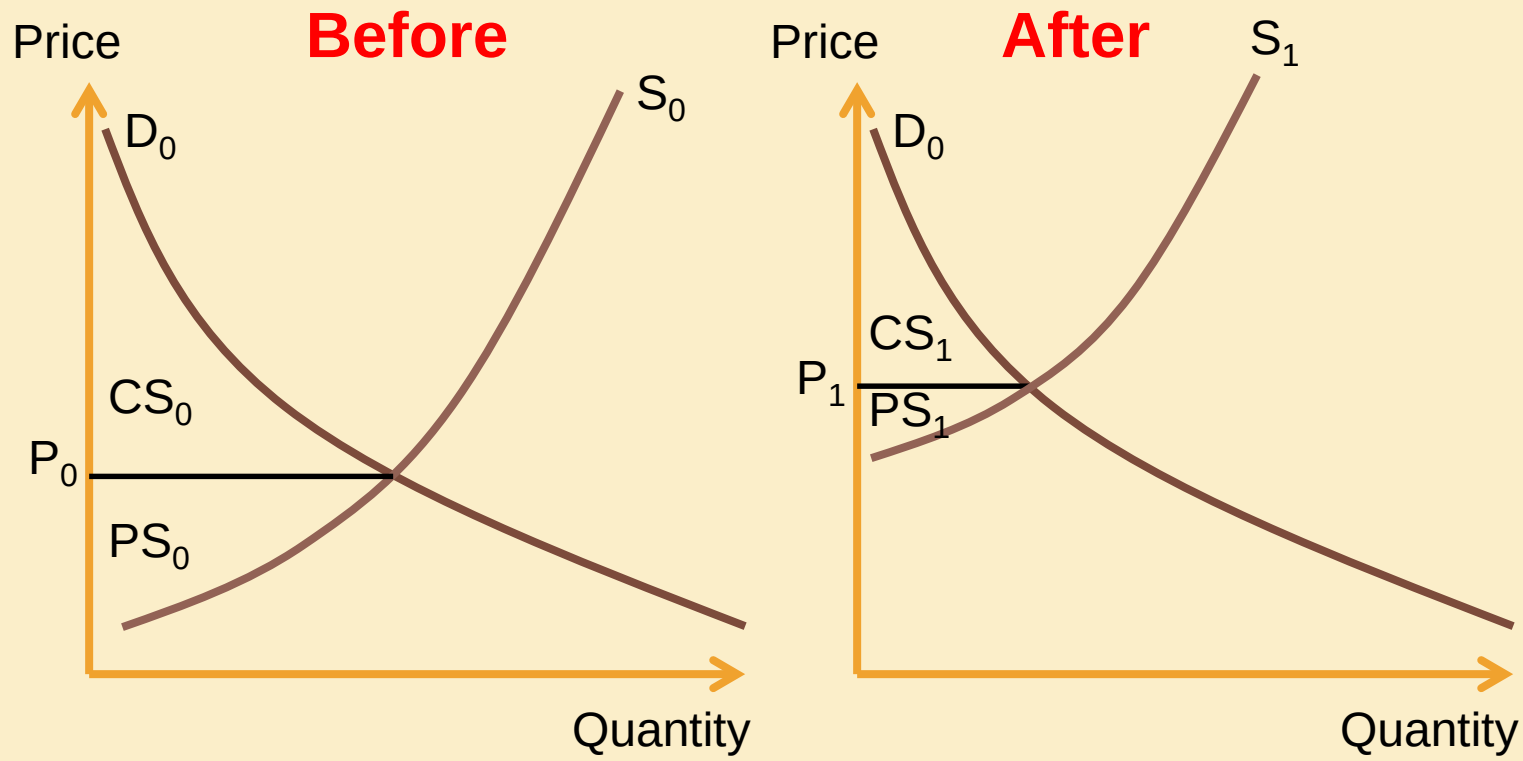
- As expected short run citrus profit increases, citrus yield increases
- When HLB arises, citrus yield decreases

Citrus Market Before and After HLB



Impact of HLB on Social Surplus

$ Value Economists use to Measure Impact



Surplus Before = $CS_0 + PS_0$ Surplus After = $CS_1 + PS_1$

HLB Impact = $(CS_1 + PS_1) – (CS_0 + PS_0)$

Impact of HLB on Social Surplus (w/ Dr. Fengxia Dong)

- Estimated yield loss due to HLB = 29.3%
  - Singerman and Useche (2016) = 33% for Southwest Florida based on grower survey
- Cost impact of HLB = 27.5% increase based on Muraro (2012) average for 2007-2010 across regions
- HLB causes $466 million per year in Losses (Preliminary)
  - $125 million in Consumer Losses
  - $341 million in Producer Income Losses
- Does not include the multiplier effects
- Average farm value of Florida Citrus over the last 10 years (2006-2015) = $1.237 billion

Implications of $466 Million Loss

- $341 million annual producer income loss means less money for growers to do and to fund research and to invest in mitigation and management alternatives
  - Singerman and Useche (2016) report larger losses for other Florida regions
- Can estimate how large the social losses could be for California or other regions (Mediterranean)
- Cost-benefit analysis would justify lots of spending for
  - Prevention, monitoring, eradication, delay, containment
  - Research for solutions, mitigation and management alternatives and outreach education and training

Rebuilding Citrus after HLB

- What will the new citrus industry be?
  - A return to the glory days?
  - A smaller and leaner citrus?
  - Collapse?
- Innovation and Research will be the foundation
- Different types of innovation and research needed and best done by different agents with different funding and incentives and rewards
  - University and government
  - Private industry: multi-nationals and businesses
  - Farmers and crop consultants

http://eskipaper.com/orange-tree-wallpaper-1.html#gal_post_84149_orange-tree-wallpaper-1.jpg

Rebuilding Citrus after HLB

- “Traditional” research and innovation
  - Temporary/short-term management of the problem?
  - Help industry survive until better alternatives found?
  - As good as it gets? The new reality of citrus production?
  - Research and innovation roles for everyone
  - Risks and economics better understood
- Biotechnology
  - Lots of possibilities
  - Mostly by government, university, multi-nationals
  - Risks and economics less understood

Insect Vector Management

- Insecticides/Biocides to manage the vector or pathogen
  - Usually only multi-nationals can afford to discover, register and distribute a new AI and earn ROI
  - Adding new pest/crop to an existing label cheaper
- Biological Control
  - Often only public sector, difficult to make commercially viable ROI
  - Practical application needs farmers and consultants
- Insect and Pathogen Biology
  - Governments, universities or multi-nationals
  - Helps improve chemical and biological control
  - Local/practical knowledge from farmers and consultants

http://californiacitrusthreat.org/pest-disease

Insect Vector Management

- Areawide management likely needed to coordinate actions, to reduce inoculum, to clean up abandoned acres
- Requires developing and implementing new institutions or processes to facilitate cooperation
- Social innovation and research: behavioral economics: need both theoretical and practical knowledge
  - Universities/government research, with key outreach and extension roles
  - How do you pay for these institutions and activities?
- Citrus will not be the same, the social fabric of the industry will change

http://californiacitrusthreat.org/pest-disease

Resistance Management

- Pests and pathogens will become resistant to control methods eventually, can only slow/delay the inevitable
- Biological issues differ by species and control methods
  - Multiple methods/modes, rotate modes, full dose, …
- Social aspect important: How do you get farmers and industry to follow resistance management?
- Common issue underlying many problems: Current costs with future benefits or Current benefits with future costs
- Social innovation and research, behavioral economics, both theoretical and practical knowledge
- Research at all levels: university, government, extension, large corporations, farmers and agricultural professionals

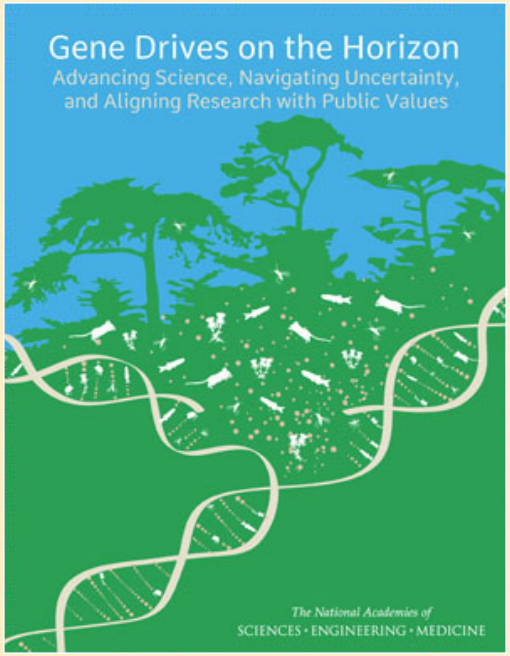
Citrus Under Protective Screen (CUPS)

- Cultural control, more than just HLB, other pests/pathogens, sunburn, wind scaring, humidity, food safety, …
- Used globally for different crops
- Highly managed system: pests, water, nutrients, …
  - Trend towards data-driven adaptive management, tree-specific monitoring and management
- Economics: Cost? Productivity gain? Efficacy? ROI? Life expectancy? Hurricanes and wind?
- Research and innovation: universities/government to estimate efficacy, productivity gain, & cost
- The real innovation will be by farmers and private companies to make it commercially viable

http://www.growingproduce.com/citrus/planting-citrus-under-protective-screen-goes-commercial/

Biotechnology

- Transgenic/Cisgenic Crops: move genes between or within species
  - Roundup Ready and Bt crops
- RNAi: Species-Specific AIs
  - Foliar sprays field testing
  - PIPS in corn for corn rootworm commercialized soon
- Gene Editing: CRISPR/Cas9, TALENS, ZFNs, …
- Gene Drives: Introgress desirable genes into populations



Potential HLB Applications

- Trees that are immune, resistant or tolerant to HLB
  - Transgenic Trees: Spinach defensins (SoD2) in process
- Rootstocks that convey immunity, resistance or tolerance to HLB in the whole (grafted) tree
- Species-specific RNAi sprays or PIPS for HLB vectors
- Transgenic/Cisgenic/Gene Edited insects that no longer transmit the HLB pathogen, then add a gene drive to make them the dominate population type
- Gene edited insects plus a gene drive to eradicate HLB insect vectors
- More ideas and inventions will come and will be needed

Lessons to Learn from Biotech Crops

- Roll out of Roundup Ready® and Bt crops did not go well!

Failure to explain, educate public about GM a mistake: Monsanto

Jan 12, 2017

THE WESTERN PRODUCER

- Recent food crops
  - Arctic Apples: Fuji, Granny Smith, Golden Delicious
  - Simplot's Innate® White Russet Potatoes

http://www.arcticapples.com

http://www.innatepotatoes.com

White Russet Lessons

http://www.innatepotatoes.com

- Names carefully chosen: Innate, white russet
  - Cisgenic, no antibiotic or herbicide markers
- Consumer traits the initial focus
  - Gen 1: Bruise resistant/anti-browning, low acrylamide
    - Sold in 2015 ~2,000 acres, 2016 ~5,000 acres
  - Gen 2: Late blight resistance, reduced sugar-end defect
    - Approved for sale in 2017, planted this spring
- Careful supply chain control, segregation, contracting
- Focus on institutional, pre-processed uses (diced), chips
  - Currently not accepted by McDonalds or Frito-Lay
- Built industry/stakeholder and consumer awareness early

Specialty Crops Regulatory Assistance (SCRA) Workshop Sep 2016

Tuesday, 20 September 9:00am - 5:00pm

9:00am	Case Study 1 - Citrus Tree Defensin Protein, Moderator: Beth Hood
	Overview and Introduction by developer: Mike Irey, Southern Gardens Citrus
9:45am	Presentations by agency representatives
	APHIS (30min) Margaret Jones, USDA-APHIS BRS
	EPA (30min) Milutin Djurickovic and Shannon Borges, EPA
10:45am	Break
11:00am	Presentations by agency representatives continued
	FDA (30min) Bob Merker, FDA
11:30am	Case Study 1 Discussion
12:30pm	Networking Boxed Lunch
1:30pm	Case Study 2 - Simplot W-8 Potato, Moderator: John Cordts, Cordts Consulting
	Overview and Introduction by developer: Susan Collinge, J.R. Simplot
2:15pm	Presentations by agency representatives
	APHIS (30min): Kate Rappaport, USDA-APHIS BRS
	EPA (30min): Milutin Djurickovic and Shannon Borges, EPA
3:15pm	Break
3:30pm	Presentations by agency representatives continued
	FDA (30min): Bob Merker, FDA
4:00pm	Case Study 2 Discussion

http://www.specialtycropassistance.org/

- Citrus Tree Defensin Protein
- Simplot's Innate Potato

http://www.specialtycropassistance.org/content.cfm?m=247&id=247&startRow=1&mm=0

Citrus vs Potato Biotech

- Meeting regulatory hurdles takes a long time: Years
  - Corn/Soy: new active ingredient or biotech event costs $250-$280 million and takes 10-15 years
  - $20-$30 million in regulatory costs (McElroy 2003)
- Both agreed that regulators are there to help, but you have to follow their process
- Lessons potato mentioned that citrus did not
  - Inform industry stakeholders of commercial intentions and timelines: communicate early
  - Think about trait stewardship and trait durability for commercial business, how to extend trait
    - How will you determine if field failures are trait failures, resistance or due to some other cause?

What will Consumers Think?

- Perceptions are reality in marketing
- Deployment process will matter: keep building awareness of the HLB problem and efforts to find solutions
  - Most Midwesterners do not know about HLB
- Perceptions of biotech citrus will partly depend on who owns it and makes money from it
  - Ringspot virus resistant papaya vs Roundup Ready® soybean: GM opposition as anti-corporate
- Google GM citrus: New York Times, Mother Jones (2013) National Geographic (2014), Huffington Post (2015)
  - Supportive or at least not automatically against GM
  - How do you manage to keep this positive image going?

Biotech Citrus

- Inform industry of commercial intentions and timelines
- They can develop and recommend marketing and deployment strategies
- Marketing is actually quite expensive, let them help!

A Dose of Reality

- Biotech solutions will take time to be developed, registered and commercially used – years
  - Traditional insect vector management, foliar-tree feeding, CUPS, etc. will be needed, likely for years
  - They will be part of resistance management for traits
  - They may be the only solutions we ever have
- We never “solve” pest problems, just manage them
  - Species are under tremendous pressure to evolve resistance to any management: insecticide, cultural control, RNAi, gene drive, …
  - If eradicate one pest, another one will take its place!
- Sustainable pest management means using multiple methods: biotech is not a silver bullet, just one tool

Summary

- HLB is a Black Swan event
  - Large losses and big changes, but also opportunities
  - Careers will be made, new leaders and new institutions will emerge, citrus will change
  - Future still uncertain, collapse could occur
  - Need good science and innovation, motivation matters
- HLB is bad: preliminary estimate is $466 million/year loss
  - Justifies a lot of spending for research on solutions and on prevention and containment
  - As losses continue, lose infrastructure and capital, citrus erodes in consumer consciousness
  - Now is not the time for complacency

Summary

- Biotech solutions for HLB
  - Transgenic citrus in process: Spinach defensins (SoD2)
  - Lots more options possible: other transgenic and cisgenic, RNAi, gene editing, gene drives, …
  - Commercialization takes years after the Eureka!
  - Communicate with stakeholders early and often
  - Consumer preferences seem to be changing, pay for savvy marketing and watch potatoes and apples
  - Technology stewardship is important: the insect vector and/or pathogen will develop resistance
    - Have a stewardship plan & a process for field failures

Summary

- Traditional management practices will be needed for some time
  - Insecticides, biocontrol, cultural control, agronomics, …
  - Survive until biotech or better alternatives emerge
  - May be the only management options we have
  - Part of resistance management for biotech solutions
  - Some consumers will reject biotech citrus: niche market
- Innovation does not only happen in labs or field plots
  - Social science: New institutions and coordination, extension, organizations, private sector
  - Business: Good ideas still need to acquire capital, coordinate efforts, create cash flow and generate ROI

Questions? Comments?

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