Something Wicked This Way Comes:
California's Perennial Problem with Invasive Arthropods

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California's Invasive Species Problem

- **California has a lot of exotic arthropods**
  - 1,686 species as of 2010
- **Impacts?**
  - About 20% (314 spp.) are pests
- **Where do they come from?**
  - Origin suspected for 992 (~60%) exotic species
    - Invasion bridgeheads (& transcontinental invaders) in USA and Canada (44%)
      - Originated from populations established elsewhere in the USA
    - Direct invaders (56%)
      - Europe = 25%
      - Mexico (2%), Central, and South America (7%) = 9%
      - Asia = 10%
      - Africa = 4%
      - Australia = 5%
      - South Pacific = 3%

Dowell et al. 2016. Proc. Cal. Acad. Sci. 63: 63-157

Invader Identities

- Top orders accounting for ~85% of non-native species are:
  - Hemiptera (32%)
    - Aphididae, Diaspididae, Pseudococcidae, Cicadellidae, Coccidae, & Psyllidae
  - Coleoptera (19%)
    - Curculionidae, Staphylinidae, & Chrysomelidae
  - Lepidoptera (10%)
    - Pyralidae & Tortricidae
  - Acari (8%)
    - Eriophyidae & Tetranychidae
  - Diptera (7%)
    - Cecidomyiidae
  - Hymenoptera (6%)
    - Formicidae
  - Thysanoptera (4%)
    - Thripidae

Sandy Liebhold et al. 2012 – live plant imports are major conduits for introductions of insects and pathogens that attack plants (69% of established pests)

Sap feeders most common group introduced

Front. Ecol. Environ. 10: 135-143

Dowell et al. 2016. Proc. Cal. Acad. Sci. 63: 63-157

Are Invasions into California Accelerating?

Prior to 1989 CA acquired ~ 6 exotics/yr, one every ~ 60 days

1989-2010 CA acquired ~ 9.7 exotics/yr, one every ~ 40 days

Rate of acquisition has increased by ~62% per year

Dowell et al. 2016. Proc. Cal. Acad. Sci. 63: 63-157

Seebens et al. (2017) analyses indicate that so far there is no observable saturation in the accumulation of non-native species globally, rates of introduction/establishment are not slowing down

This trend is consistent for mainland and islands

Trade is the major driver of introductions of non-native species and is coupled with increasing cultivation of plants in agriculture, botanic, and private gardens

Nature Communications 8: Article No. 14435

Classical Biological Control: The Premise and Practice

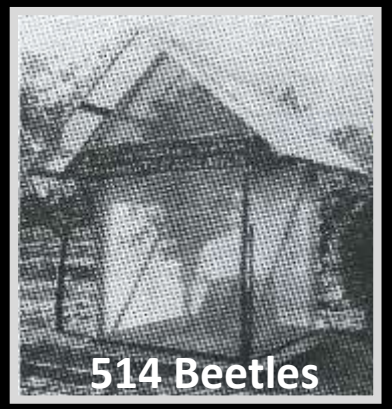
- **Why do some new introductions become pests?**
  - Enemy release
- **The counter attack?**
  - Classical or introduction biological control
- **What are natural enemies?**
  - Predators
  - Parasites
  - Parasitoids
  - Pathogens
  - Herbivores

Co-evolved host specific natural enemies from the native range of the target pest

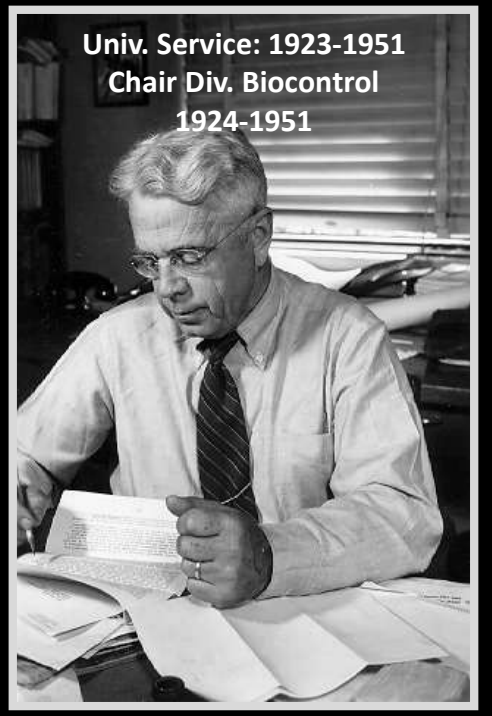
- **Foreign exploration**

The Response to the First Invasive Arthropod & The Aftermath

Nov. 1888 – March 1889 4 ocean going shipments to SF

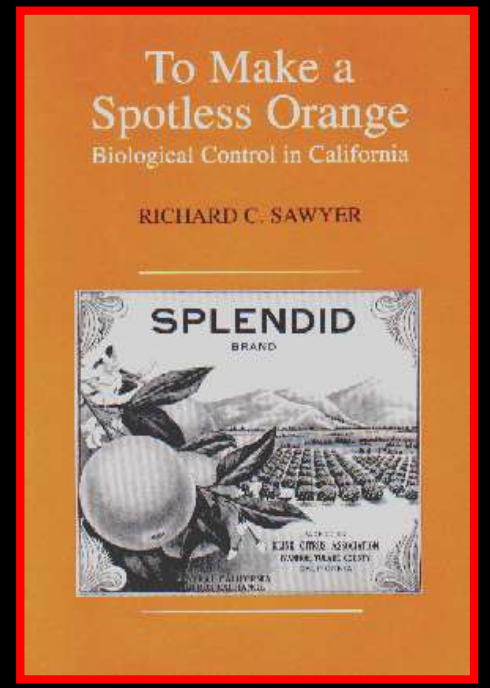


514 Beetles



Univ. Service: 1923-1951
Chair Div. Biocontrol
1924-1951

The phrase "Biological Control" was first used Prof. Harry Scott Smith in August 1919 at the meeting of Pacific Slope Branch of the American Association of Economic Entomologists at the Mission Inn



The First Classical Biocontrol Program in the Galapagos Islands




Icerya **introduced in 1982. By 1996 15/18 islands infested. 80 native/endemic species attacked, 10 were threatened species. Native Lepidoptera and birds threatened. 23% of the Galapagos insect fauna is non-native**



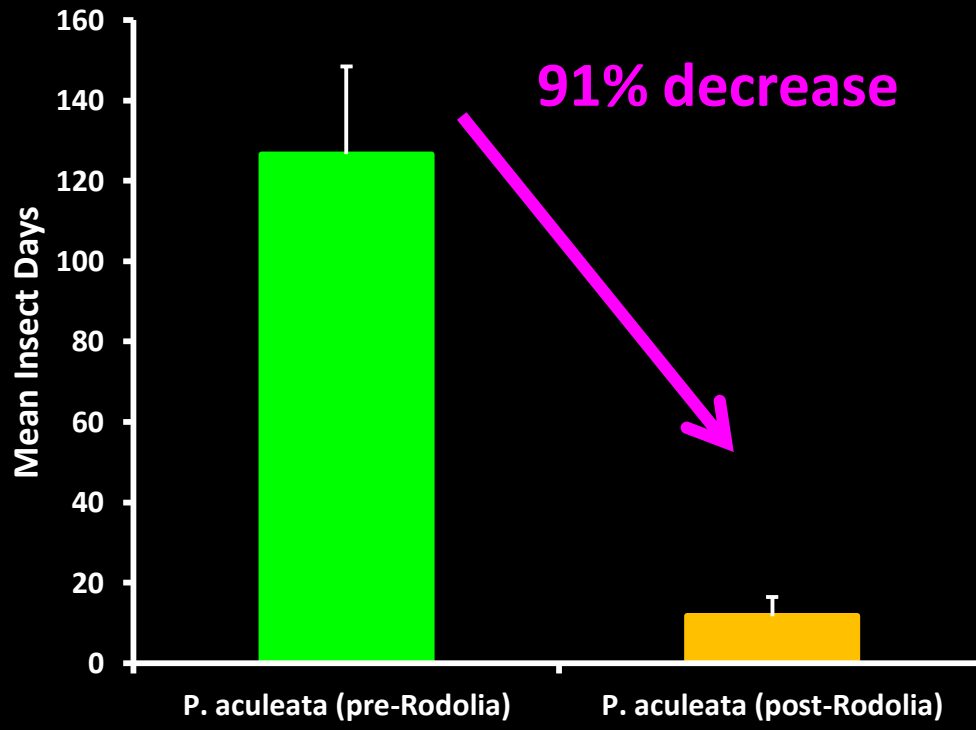
2002-2005 2,206 ***Rodolia*** **released on 10 islands. Immediate establishment rapid population declines on most infested species**

26 month follow up study indicated major and permanent declines in *Icerya* densities across all islands and major infested habitats

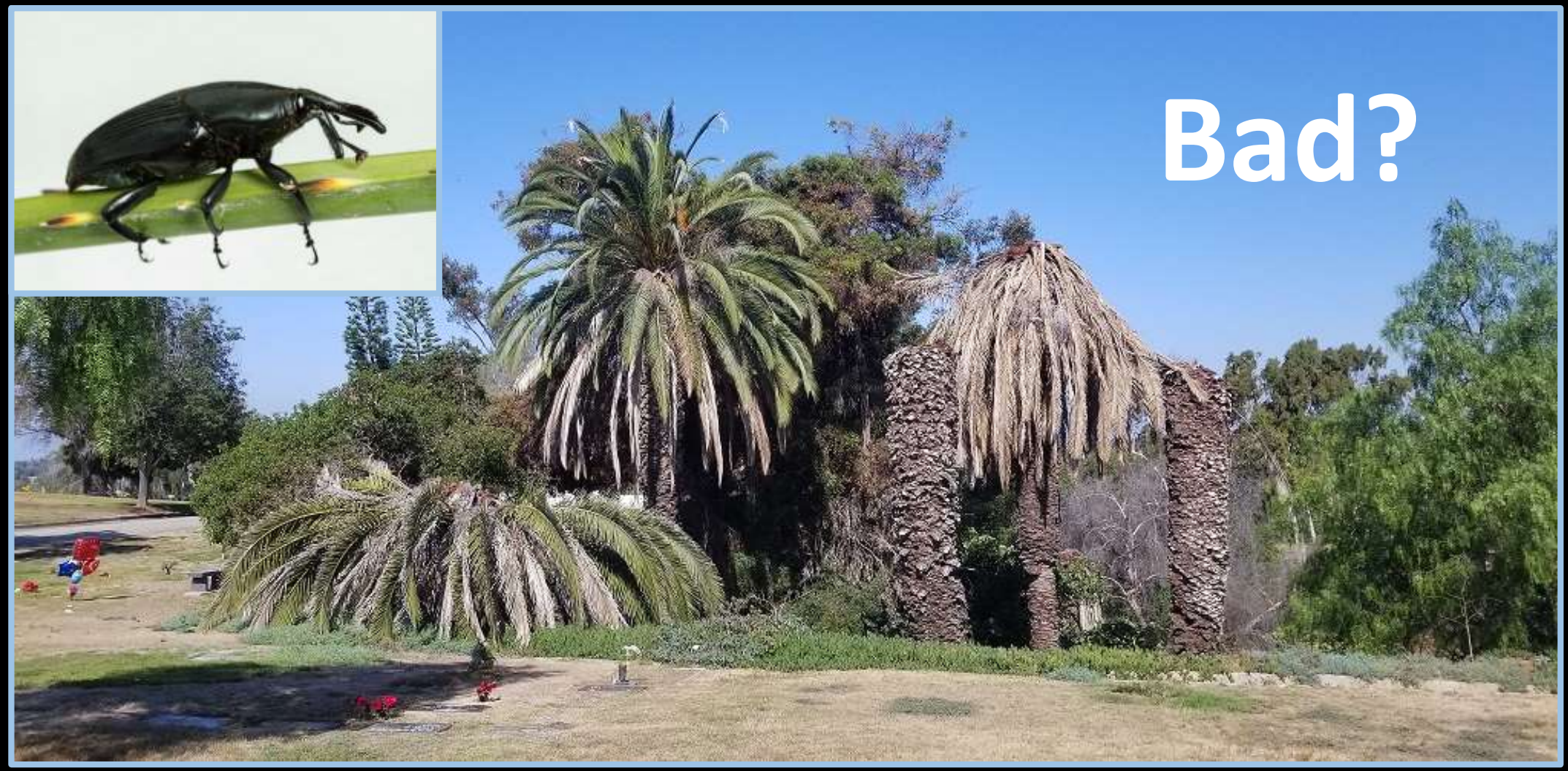
Zero evidence for non-target impacts

Robust recovery of native & endemic plants infested by *Icerya*, almost complete elimination on some species

Biocontrol extremely successful – blackberry and bird parasitic flies being considered for control



Good or Bad?: A Question of Perspective?



Good or Bad?: A Question of Perspective?

Good or Bad?: A Question of Perspective?

Bad for Hawaii!!

Established in HI in 2010. Significant impacts on naio, *M. sandwicense*, high ecological and cultural importance

Leaning In: Proactive Biocontrol

OUTLOOK

Proactive biological control: A cost-effective management option for invasive pests

Proactive biocontrol could accelerate responses to invasive pests in urban areas — where pesticide use may be unpopular — before they spread to agricultural areas.

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Invasive pests regularly threaten California agriculture as well as the state's diverse urban and wildland areas. Approximately nine nonnative species of invertebrates (i.e., insects, mites, spiders, etc.) establish in the state each year, of which about three become pests (Dowell et al. 2016). These invasive species move globally through trade and tourism. Biological control programs are typically implemented as part of an integrated pest management (IPM) approach for some invasive species infestations in California. However, a proactive approach would be to screen a pest's natural enemies and approve them for release ahead of time, before the pest establishes in California. Such a project is just getting underway.

California's agricultural enterprises are vast (valued at $46 billion in 2015), and the state is a world leader in the development of science-based pest management solutions. Biological control and IPM originated here. IPM is a comprehensive approach to managing pests and combines plant and pest management practices, of which biological control is one, to reduce pest pressures, crop damage and pesticide use. Biological control is the intentional use of a pest's natural enemies for suppressing population densities to less damaging levels. When a new native species is introduced into a new area, its population may grow and spread rapidly because predators, parasitoids or pathogens that limited population growth in the native area are not present. Classical biological control programs import, screen for safety and establish safe natural enemy species from the invader's native area for pest control.

Biological control programs in California began 125 years ago, with numerous achievements over the years in agricultural crops (e.g., citrus, olives, grapes, alfalfa) and urban areas (e.g., ash and eucalyptus). In several cases, imported natural enemies have suppressed invasive pest populations so that they no longer require management, and in many instances they have contributed significantly to IPM programs by reducing the need to spray pesticides. When a new invasive pest becomes established, IPM programs that carefully manage insecticide use may be disrupted as spraying increases in response to pressure from the new pest. In urban areas, which can be hot spots for invasive species that threaten agriculture, pesticide use to eradicate or control an invasive pest can cause public resistance, which sometimes results in legal actions and the termination of pest control programs.

Asian citrus psyllid is arguably the most serious threat California citrus growers face, because it vectors a citrus-killing bacterium.

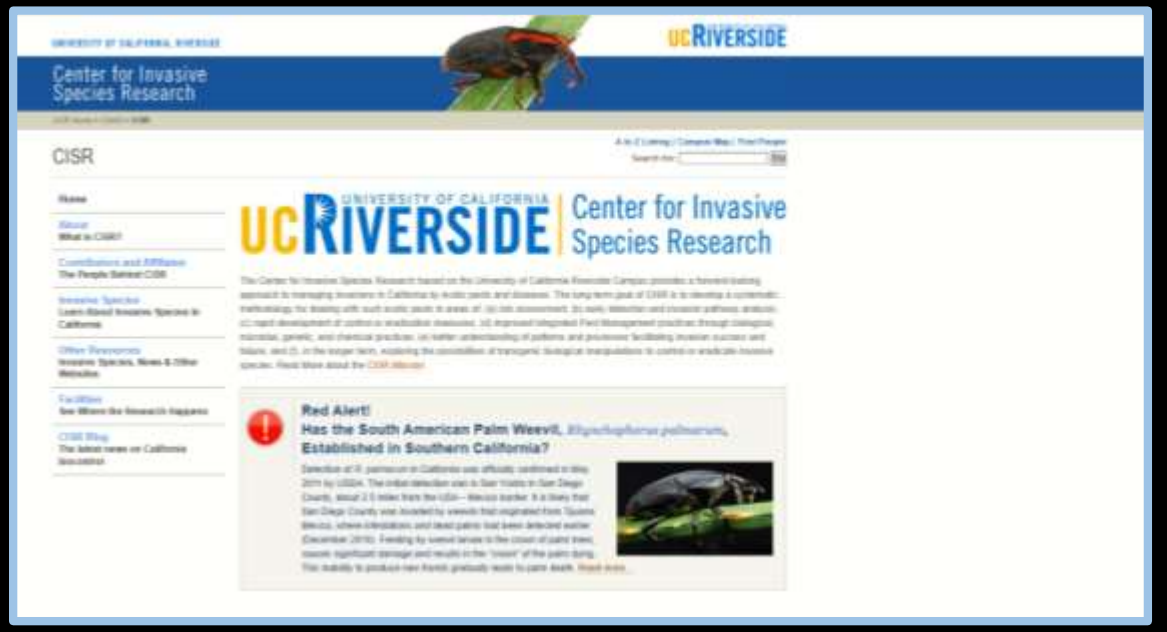
Hoddle et al. (2018) Cal. Ag.
https://doi.org/10.3733/ca.2018a0027

Conclusions

- **Incursion and establishment of invasive pests will continue unabated**
  - **Accelerate?**
  - **New unexpected threats due to climate change? Drought? Fire?**
    - **All habitats under siege**
      - **Aquatic (freshwater and marine)**
      - **Rangelands**
      - **Natural areas**
      - **Agriculture**
      - **Urban**
- **Classical biocontrol**
  - **Very effective and safe – when done properly and when it works – not a panacea!**
  - **Not all pest targets are amenable – some pest groups highly susceptible**
  - **Theory and practice, especially with respect to host range and host specificity of arthropod natural enemies is continuing to improve**
  - **Non-traditional targets need consideration?**

Want More?

www.biocontrol.ucr.edu



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Questions?