What is a pest? Why do we have pests? Where do we find pests? Who uses pesticides?
History of pesticide use DDT, *Silent Spring*, Rachel Carson (1962)
How do pesticides work?
Problems with insecticides?
Affects of human health? Acute vs. chronic effects
How do pesticides foster pest outbreaks? 1. Development of resistance 2. Disruption of natural enemies with chemical controls. 3. Secondary pest outbreaks

What is Biological Control? A type of ecosystem management.

> The decline in pest damage that results from the reduction in the abundance or activity of a pest through the action of living natural enemies

Ecological basis for biological control 1) the idea of discrete populations or communities 2) the balance of nature 3) the natural control of numbers

Goal of Biological Control 1) Reduction 2) Stability

Types of Biological Control
- Importation – import and establish specialized natural enemies from the region of origin of the exotic pest
- Augmentative- seasonal or generational release of mass reared natural enemies
- Conservation – enhancing the action of natural enemies by manipulating their environment and resources

Cottony cushion scale
Gypsy moth
Tansy ragwort
Klammath weed

Risks
Indian mongoose => West Indies, Hawaiian Islands, Fiji => control rats => nontarget native birds
Florida / Central America predatory snail => Hawaii Tahiti => African snail => native snails
Fresh water fish => altered vegetation => altered composition of fish communities
Cactoblastus => control *Opuntia* => Carribbean islands => threatens native *Opuntia* in Florida
Generalist parasitoid fly => introduced New England 1906-1986 against 13 species => examined instars of two native Saturniid moths
England => rabbit => virus => ant => butterfly

TERMS
Bad actor pesticides – acute poisons, known or probable carcinogens, neurotoxins, reproductive or developmental toxicants, found in ground water
Secondary pest outbreaks
Bioaccumulation / biomagnification
Trophic interaction
Parasitism vs predators
Specialist / generalist
Parasite / Parasitoid
Herbivore / Insectivore
Endoparasitoid / Ectoparasitoid
Hyperparasitism / Superparasitism

Common name	Scientific name	Origin	Pest of	Control agents	Type	Origin
			Forest			
Gypsy moth	*Lymantria dispar*	Europe	US northeastern hardwoods	none		
			Weeds			
Tansy ragwort	*Senecia jabobaea*	Eurasia	Cut over forests, pasteurs	*Tyria jacobaeae* *Longitarsus jacobaeae*	cinabar moth Tansy flee beetle	
Klamath weed (St. Johns wort)	*Hypericum perforatum*	Europe, Asia, Africa	Rangelands			
Prickly pear	*Opuntia spp.*		Rangeland / forest Australai	*Cactoblastus cactorum*	Moth / herbivore	Brazil
Aquatic fern	*Salvinia molesta*	Brazil	Waterways Australia, Papua New Guinea	*Cryptobagous salviniae*	Weevil / herbivore	
			Agriculture			
Brown planthopper	*Nilaparvata lugens*	Asia	Rice	*Lycosa*	spider	Asia
Cottony cushion scale	*Icerya purchasi*	Australia	Citrus	*Rodolia sp.* *Cryptochetum sp.*	Vedalia beetle / predator Fly / parasitoid	Australia

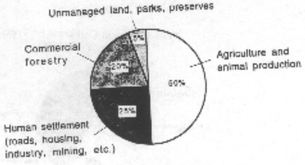


FIGURE 19.6
Use of the world's land area.
Data from Pimentel et al. (1992).

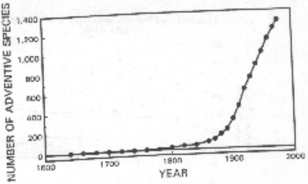


Figure 1.2 Total number of adventive insect species in the United States from 1640 to 1977 (after Sailer 1978).

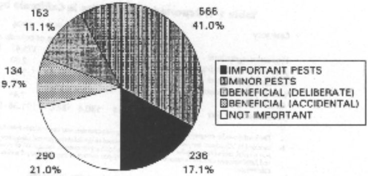
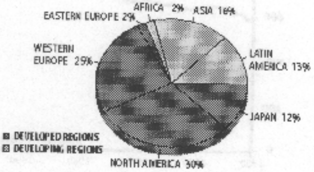


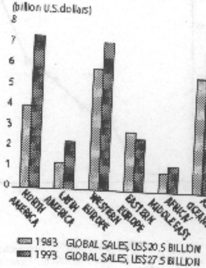
Figure 1.3 Numbers of adventive insect species in the United States in various categories in 1977 (after Sailer 1978).

Percentage of Global Pesticide Sales, by Region, 1994



Source: "Upturn in World Agrochemical Sales in 1994," *AGRO: World Crop Protection News*, No. 238 (August 1995), p. 20.

Pesticide Sales by Region, 1984-93



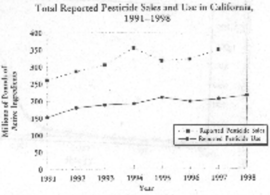


Figure 1-2. Total reported pesticide use in California increased an average of 7.2 million pounds of active ingredients per year between 1991 and 1998. Pesticide sales generally paralleled use, increasing on average about 12.4 million pounds per year.

Source: DPR PUR data, 1991–1998.

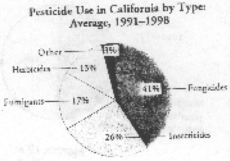


Figure 1-1. Fungicides account for the highest percentage of pesticide use, followed by insecticides and fumigants.

Source: DPR PUR data, 1991–1998.

Table 1-1: Reported Pesticide Use in California by General Category

Category	1991[a]	1992[a]	1993	1994	1995	1996	1997	1998
	(in millions of pounds of active ingredients)							
Production agriculture	—	—	172.49	175.41	187.58	182.38	189.80	199.30
Post-harvest commodity treatment	—	—	1.70	2.00	3.77	1.85	1.61	1.65
Structural pest control	—	—	4.69	5.19	4.84	4.74	5.18	5.88
Landscape maintenance	—	—	1.32	1.32	1.38	1.26	1.23	1.40
All others[b]	—	—	7.81	7.43	7.56	7.61	6.96	6.80
Total Reported Use	**153.14**	**180.4**	**188.01**	**191.36**	**205.13**	**197.82**	**204.78**	**215.02**

a. The breakdown by category for 1991 and 1992 using corrected data was not available from DPR; only totals are reported.
b. Included in "All others" are pesticide applications reported in the following general categories: pest control on rights-of-way; public health pest control, including [illegible]; vertebrate pest control; fumigation of nonfood and nonfeed materials, such as lumber and furniture; pesticide use in research; and regulatory pest control to ongoing control and/or eradication of pest infestations (e.g., medfly infestations).

Source: California Department of Pesticide Regulation Pesticide Use Reports, 1996, 1997 and 1998.

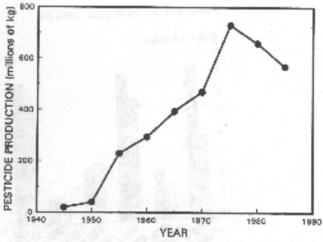
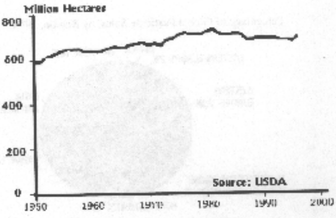


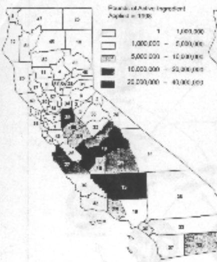
Figure 1.4 Pesticide production in the United States (after Pimentel 1991).



World Grain Harvested Area 1950-1996

4

Map 1: Total Pounds of Pesticide Use Reported in 1998 by County



Map 2: Pounds of CA Bad Actor Pesticide Use Reported in 1998 by County

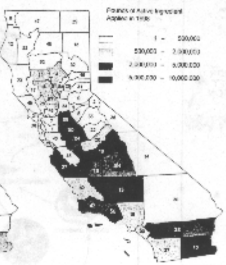


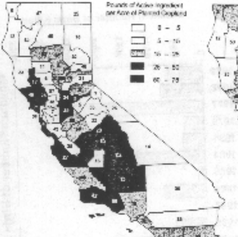
Table 2-4: Changes in Planted Acreage, Pesticide Use on Cropland, and Intensity of Pesticide Use in California, 1991–1998

Year	Total Pesticide Use on Cropland[a] (millions of pounds)	Planted Acreage[2] (millions of acres)	Average Intensity of Total Pesticide Use (pounds per acre planted)	Average Intensity of CA Bad Actor Pesticide Use (pounds per acre planted)
1991	128.96	8.98	14.36	4.10
1992	152.80	8.80	17.37	5.15
1993	168.84	8.30	20.33	5.32
1994	171.60	8.33	20.60	6.04
1995	180.70	8.13	22.24	6.97
1996	181.08	8.91	20.32	6.50
1997	185.52	8.53	21.75	6.62
1998	194.74	8.46	23.02	6.30

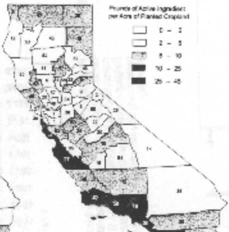
a. Cropland includes all land used for fruits and nuts, vegetables and melons, field crops and spices and herbs, as well as land fallowed or uncultivated agricultural areas and land with preplant soil applications. Nurseries and greenhouses are not included in this total.

2. See Appendix 1 for comments about determination of acres planted.

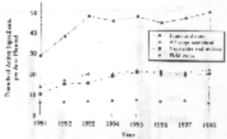
Map 3: Intensity of All Pesticide Use on Planted Cropland in 1998 by County



Map 4: Intensity of CA Bad Actor Pesticide Use on Planted Cropland in 1998 by County



Average Intensity of Total Pesticide Use in California by Crop Category, 1991–1998

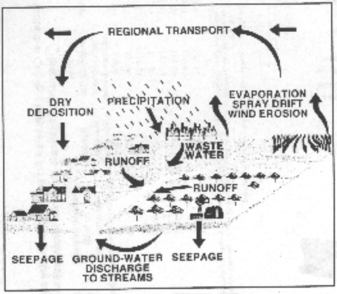


Average Intensity of CA Bad Actor Pesticide Use in California by Crop Category, 1991–1998

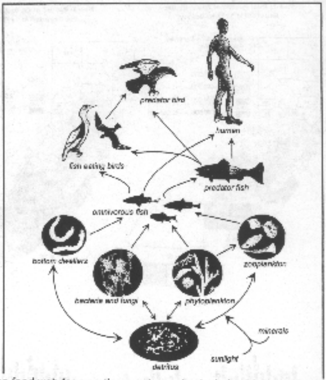
Figure 2-1. The average intensity of total pesticide use on different types of crops rose most substantially for fruit and nut crops between 1991 and 1998.* CA Bad Actor intensity rose sharply for vegetables and melons between 1993 and 1995.

* Average intensity was calculated for each category by dividing the total pounds of pesticides used in a given year by the total cropland acres planted for that year.

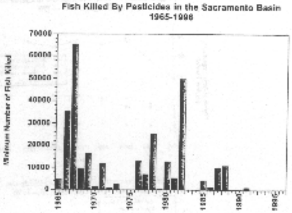
Source: DPR PUR data, 1991–1998.

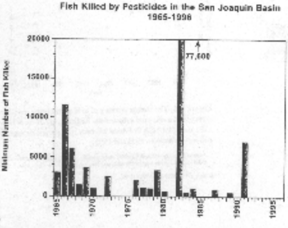


Pesticides don't always remain where they are applied and are transported through air and water. As they volatilize, they are transported by winds and precipitate out with rainfall. Runoff from agricultural and urban areas into surface waters contributes significant pollution to groundwater and surface waters (reproduced with permission of the U.S. Geological Survey).[36]



: The food web for aquatic organisms also includes birds and humans, which eat the fish that eat the lower organisms. This interconnected web is disrupted by pesticides, which reduce the populations of the organisms forming the basis for the food web—the phytoplankton and zooplankton.





Reported fish mortality due to pesticides for the Sacramento and San Joaquin basins.[23] These numbers reflect only the minimum number of fish killed, since many kills are not noticed or reported.

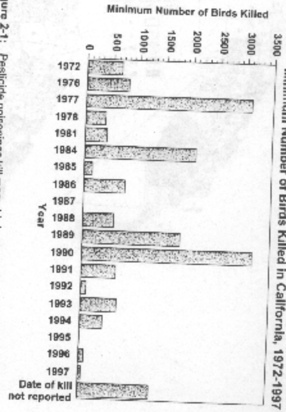


Figure 2-1: Pesticide poisonings kill many birds every year. The plot represents the documented number of birds killed in California due directly to pesticide poisonings, as reported to the U.S. Environmental Protection Agency.[4] Because most dead birds are neither found nor counted, the reports represent only the *minimum* number of birds killed and vastly underestimate mortality.

6

Mortality of Fathead Minnows Exposed to Sacramento River Water

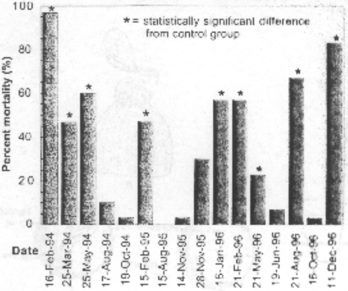


Figure 3-4: Sacramento River water is toxic to fathead minnows during winter and spring. The spring toxicity is thought to be due to the fungicide ziram.

Trends in the Use of Different Categories of CA Bad Actor Pesticides, 1991–1998

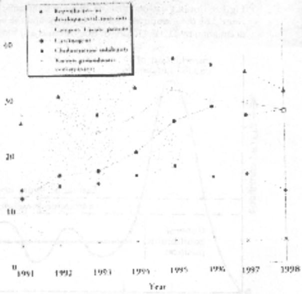
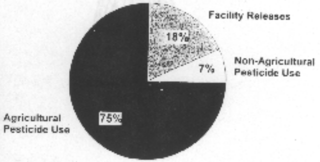


Figure B. Overall use of CA Bad Actor pesticides increased significantly from 1991 to 1995, but declined steadily after 1995. Use of carcinogens and groundwater-contaminating pesticides continued to increase between 1995 and 1998; other categories of CA Bad Actor pesticides remained stable or showed a slight decrease.

Comparison of Sources of Reproductive and Developmental Toxicants Released Into the Environment



: Pesticide use is the single largest source of reported toxic emissions in California, dwarfing reported industrial emissions. The chart reports 1995 releases for 78 chemicals that are known reproductive and developmental toxins.[5]

Chronological Increase in Unique Cases of Herbicide-Resistant Weeds Worldwide

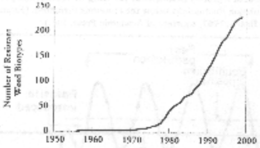


Figure 5-1. The number of herbicide-resistant weeds increased 850% between 1979 and 1995.

Source: I. Heap, International Survey of Herbicide Resistant Weeds, Weedscience, http://www.weedscience.com.

Average Intensity of CA Bad Actor Pesticide Use in California by Crop Category, 1991–1998

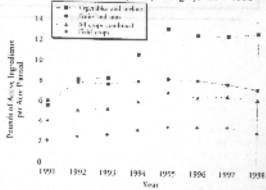


Figure C. Pesticide intensity on all crops increased between 1991 and 1995 with vegetables and melons posting the most dramatic increases. The increase in intensity observed for vegetables and melons was primarily due to increased use of soil fumigants on carrots, tomatoes, onions and melons.

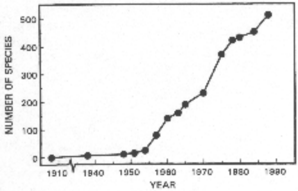
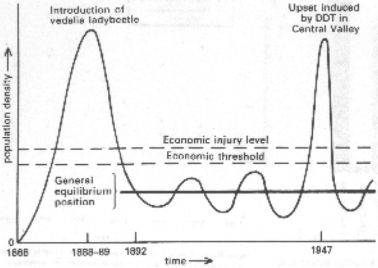


Figure 7.5. Cumulative number of cases of resistance to pesticides in arthropods (after Georghiou and Lagunes-Tejeda 1991).

Fig.1.8. Cottony cushion scale on citrus in California: effective biological control by the introduced vedalia ladybeetle and the upset due to its decimation by DDT. (Redrawn from Stern et al., 1959.)



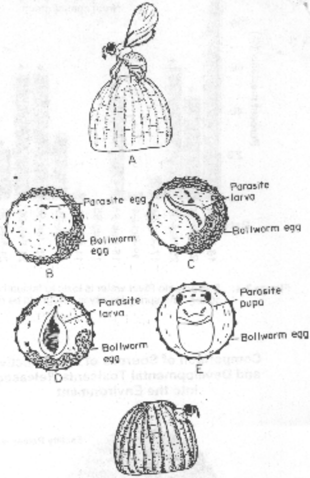


Fig.3.1. The introduction of an exotic natural enemy, or any manipulation increasing the efficacy of an existing enemy, may result in complete biological control of a pest by permanently lowering its equilibrium position and population fluctuations below the economic threshold. (From Smith & van den Bosch, 1967; courtesy of Academic Press, Inc.)