Section 9: Environmental and cultural control

- Before the advent of practical insecticides, agriculturalists developed many practices to make environments unsuitable for pests, or to destroy them.
- These practices remain important to reduce the biotic potential of pests, especially in less developed countries, or where low crop value precludes the use of more expensive tactics, or where chemical use is not desirable.

Why environmental and cultural controls?

- Sometimes environmental and cultural methods are completely adequate alone.
- Also, they can be used in combination with insecticides, either as a primary or secondary pest management tactic.
- However, need to ascertain that as the environment is modified to address one problem, you are not creating another.

- Cultural practices can create problems or cure them. Storage of corn (above) or bags of onions (below) under dry conditions in the field can alleviate problems with fungi. What happens if these fields receive a great deal of rain? Do stored product pests gain entry readily under such conditions? Cultural practices often are implemented without regard to pest issues.

Some environmental and cultural controls

- Mechanical disturbance of environment
- Irrigation
- Fertilizers and other soil additives
- Sanitation
- Diversionary hosts
- Multiple cropping
- Separation in time/space
- Crop geometry

Conservation tillage in corn

Mechanical disturbance

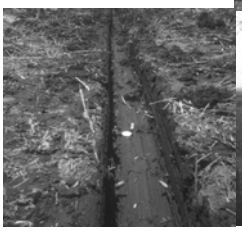
- Cultivation/plowing destroys some insects directly, and brings others to the surface where birds predate them or they desiccate.
  - Birds often seen following tractors, feeding on white grubs, wireworms, and cutworms
  - Corn root aphid affected by disturbance of ant colonies that tend them
  - Minimum tillage exacerbates western corn rootworm problems (overwintering eggs not disturbed), and better habitat for slugs

Tillage (left) can help eliminate some insects. Close-up of disks used to prepare soil for planting; as they slice through soil they kill many insects (photos USDA, ARS).

More mechanical disturbance

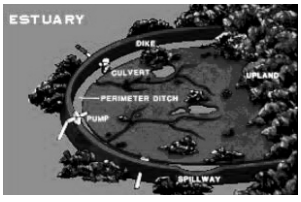
- Clearing of brush and trees disrupts biology
  - removes favorable resting habitat for tsetse flies
  - removes overwintering sites (e.g., poplars) for beet root aphid (and other aphids, depending on trees and bushes removed)
- Water management
  - drainage has been of major importance in reducing mosquito breeding by eliminating larval habitat (both fresh and salt water)

Salt marshes often are flooded monthly as a result of unusually high tides associated with the full moon. These temporary floods can produce serious mosquito problems, which sometimes are alleviated by enhancing the drainage from, and entry of mosquito-eating fish into, salt marsh water impoundments.



Here you see a photograph of an coastal impoundment, and a diagram showing important elements that allow water level regulation and relief from production of mosquitoes following periodic high tides.

Note that water can be pumped in, maintaining water (and oxygen) for fish, but water can also escape following heavy rainfall.



Temporary impoundments lack fish and other mosquito predators. Though permanent water produces some mosquitoes, temporary flooding or emergent vegetation exacerbates problems. Deepening the impoundment, removing vegetation, and creating steeper sides assists in mosquito management.

Grazing by livestock provides physical disturbance, and also competition for the food resource. The compaction caused by animal hooves may also be a factor in insect survival. Though grazing is sometimes said to cause insect population increases, it is over-grazing and disruption of floral communities that causes problems. Generally, moderate grazing reduces availability of plant material to insects, thereby suppressing insect abundance.

A grazed pasture (left portion of image) and ungrazed pasture (right portion of image). Grasshopper abundance is much greater in the ungrazed pasture.

Mowing the ground cover can also affect insects. It has the some of same impact as grazing, though the mower blades add a lethal element to insects if they don't move out of the way. Ground cover management can sometimes also be used to force predatory mites or small insects up into trees to consume pests.

Mowing the grass in and around citrus groves in Florida to make the vegetation less suitable to grasshoppers.

Irrigation

- Small insects such as aphids, thrips, and newly hatched caterpillars drown or are washed from vegetation by overhead irrigation.
- Where cropland can be submerged, flooding can kill soil-dwelling pests
  - Summer flooding for symphylans in California
  - Winter flooding for wireworms in Florida
- Alternating periods of rice flooding with dry periods can kill mosquito larvae.
- Incorrect irrigation often produces excess water (tailwater) that results in mosquito breeding.

The whorl of corn plants holds water, drowning young corn borers.

Getting irrigation water to its destination and then removing excess water requires an extensive network of canals and ditches. In many cases, water is left behind to breed mosquitoes.

Fertilizers and other soil additives

- Healthy plants tolerate damage better, and recover quickly. Also, thin stands favor some insects (e.g., chinch bugs).
- High nitrogen application favors growth and reproduction of many sucking insects (aphids, whiteflies, mites, chinch bugs, thrips) whereas phosphorous and potassium are more suppressive.

Mulching

- Mulching favors plants through maintenance of even soil moisture.
- May favor survival of insect pathogens, especially fungi, which affect insects pupating or sheltering at ground level. (Effect on plant fungi?)
- Mulch favors survival of ground-dwelling predators such as ground beetles and spiders by providing harborage, but also favors some pests (e.g., slugs, cutworms).

Mulching (below left) like reduced tillage (also known as minimum tillage, conservation tillage, etc.; below right) results in shelter for arthropods, and the higher moisture levels favored by slugs.

Plastic mulch, especially the silver-colored reflective mulch shown here, creates an entirely different environment than produced by organic mulches. Not only does reflective mulch repel some insects, but also denies ready shelter for ground-dwelling species.

Sanitation

- Very important for both plant-feeding and animal-feeding pests; important to understand biology.
- Crop residues often harbor pests, so deep plowing buries them.
- Volunteer plants can harbor pests and the diseases they vector, especially early in the growing season.
- Abandoned crops can produce insects that then disperse to neighboring fields or to later-planted crops; mandatory plow-downs sometimes are legislated.

More sanitation

- Fallen fruits can be an important source of pests (e.g., codling moth, pepper weevil)
- Weeds, especially those related to the crop, can be a source of insects and plant diseases.

Fallen pepper fruit infested with weevils

Weeds within crop fields or adjacent to fields (roadsides, irrigation ditches) can be a significant source of future insect and plant disease problems.

Field border showing balsam apple (left; photo, W. Adlerz), a weed host of papaya ringspot virus, and a deformed squash plant (below; photo, G. Simone) infected by this aphid-transmitted virus.

Burning has long been a cultural practice used in agriculture. Burning commonly is occurs in association with weed and brush management to keep irrigation ditches open, to remove undesired understory vegetation in forests, to destroy plant disease, or to remove excessive dry vegetative matter. If flames can be applied long enough to burn green foliage, the insects found there will also be killed. Below-ground insects are largely immune. The increased cost of fossil fuels, the increased awareness of the value of organic matter, and higher air quality standards have reduced the use of burning in agriculture.

More sanitation

- Breeding sites for container-breeding mosquitoes can often be eliminated by careful management of old tires, cans and buckets, bird baths, boats, and unused swimming pools.
- Fecal materials from livestock operations needs to be dried quickly or treated, or parasitoids introduced, to keep flies from breeding.
- Food waste and animal carcasses should be bagged or buried to help manage nuisance flies.

Anything that holds water is a potential site for mosquito breeding, and trash or other debris is notorious for its ability to capture water and to produce mosquitoes.

Is sanitation always desirable?

Army cutworm is known as wheat pest, but if nocturnal larvae are observed at night, it can be seen that tansymustard is preferred host. Wheat farmers typically spray herbicide about time cutworms are abundant.

Army cutworm on tansymustard

Careful examination in the morning shows that tansymustard, not wheat, is consumed. Should we leave weeds? What about conflicting value of weed control for water conservation?

Tansymustard stubble between rows of damage-free wheat.

Bromeliads capture and hold water, allowing mosquitoes to breed. In some areas they are part of our native flora, and many have great ornamental value. Though sanitation - elimination of the bromeliads - might seem attractive to some, there are conficting values to be resolved.

Diversionary hosts

- Usually called trap crops, which are more attractive than main crop, planted earlier, or situated on edge of field where they intercept dispersing insects.
- Trap plants can be treated with insecticide or destroyed to kill insects.
- Examples:
  - pollinating corn more attractive to western corn rootworm adults
  - collards more attractive than cabbage to diamondback moth
  - sorghum planted around watermelon intercepts dispersing aphids
  - petunias in greenhouse attract flower thrips
  - mosquitoes prefer livestock over people

In a Florida study, rows of tomato bordered by squash had fewer silverleaf whiteflies and lower incidence of tomato yellow leafcurl virus than squash-free plots because whiteflies feed preferentially on squash. This may be useful in small-scale production (photo D. Schuster)

Multiple cropping and intercropping

- Evolved for various reasons in addition to insect management. For example, in bean-corn-squash,
  - bean provides nutrition from nitrogen fixing bacteria
  - corn supports upward growth of beans
  - squash provides good weed suppression

Mayans in Guatemala practice traditional intercropping agriculture (photo, H. Smith).

Ecological theory behind plant diversification

- Diversification may provide benefits due to:
  - Physical obstruction
  - Visual camouflage
  - Masking of host plant odors
  - Presence of repellent chemicals
  - Chemical profiles of host plants altered
  - Resource concentration
  - Abundance of natural enemies
  - Frequency of appropriate landings

Most popular hypotheses

- Resource concentration - more diverse flora interferes with host location; movement arrested by pure stands
- Natural enemies - predators and parasites are more effective in diverse stands
- Frequency of appropriate landings - insect make repeated flights and landings before deciding that host is suitable

(third provides mechanism for first; second, though appealing, has little data to support it)

Separation in time or space

- Crop rotation may leave specialized insects behind where they cannot survive
  - Corn-soybean rotation for corn rootworms
- Even short moves leave behind weak fliers
  - Colorado potato beetle, pea midge, carrot rust fly
- Isolation of growing areas
  - San Luis Valley of Colorado for seed potatoes
- Time planting or harvesting around period is susceptibility
  - Fly-free period for Hessian fly in wheat: delayed planting until emergence and flight is complete
  - Early planting and harvesting of cucurbits in Florida allows escape from pickleworm and aphid-transmitted viruses

Hessian fly is a frail, short-lived insect in the adult stage, so if crop planting is timed to avoid peak adult occurrence the wheat crop escapes infestation.

More benefits: time and space

– Removing cattle from pastures for protracted periods causes some ticks (Amblyomma, Boophilis spp.) to starve

– Harvesting alfalfa before alfalfa weevil matures disrupts life cycle

- Strip harvesting of alfalfa provides refugia for natural enemies of alfalfa weevils

Crop geometry

Small fields like those shown here in Guatemala have a high level of "edge," allowing easy dispersal throughout a crop planting (photo, H. Smith)

- Size of plantings, and plant density, can influence pests.
- Many pests invade from edges, stopping to feed at first suitable host plants, then slowly dispersing in crop.
- Planting larger blocks means less edge, and less area affected.

Is there value in treating the edge selectively with insecticides in such cases?

Edges can favor damage: for example, grasshoppers move from wheat stubble (at far left) to young wheat, which is destroyed (center).

More on size and density

- Alighting insects often orient to soil. We can take advantage of this optomotor landing response by reducing the amount of soil with dense planting of crops, or by vegetating the between row areas with a cover crop.
- Increase in plant density decreases the relative number of pests, so high seeding rates sometimes recommended. Need to balance this with optimal spacing for water, light, and nutrients, however.

Questions

- How do environmental and cultural management practices affect insects?
- Can you list 6 types of environmental or cultural practices useful for insect pest management?
- Describe how water management affects insects, and provide examples.
- Mulching is often recommended for water conservation; is mulching always beneficial?
- How do weeds affect insect pests of crops?
- Why is plant diversification promoted with respect to insect pests?

Questions from supplementary reading

- Reading 4, host plant selection
  - Can you list and explain the 8 hypotheses to explain why plant diversity interferes with host location/acceptance by insects?
  - Which do you think is more important in host location/acceptance, chemical perception or vision? What proof can you offer to defend your position?
  - How does the organic gardening practice of “companion planting” fit into the appropriate/inappropriate landing hypothesis?

Video

Please watch the following videos found on the Video section of the Lecture CD:

Crop Rotation
Other Methods