What is a pest?

- Pest - an organism that reduces the availability, quality, or value of some human resources.
- The resource can be plant, animal grown for food, fiber, pleasure (eg. pets, plants in the house), health, and even peace of mind.
- Pests - defined by human needs and values and may change with time and space.

Termites and glass buildings

- If one day, man only live in glass or stainless steel buildings with stainless steel foundation, plastic furniture, bed and glass bathroom with zero usage of ligno-cellulosic material, termites may cease as a pest.

Cockroaches as food

- If one day, man decide to only eat cockroaches as their sole protein source, cockroaches will cease as a pest and will enjoy the same status as fish, chicken, swine and cow.

Cockroach as pet – anyone?

What about gecko/ house lizard?



Geckos are good luck animals in Indonesia, Thailand, Japan which are sometimes used as charm, yet we despise them in Malaysia and Singapore!

Dutch sambal

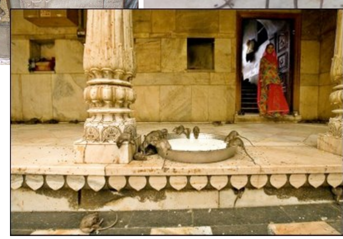
Pest status changes with location (eg. pigeon)

- Pigeons are normally reared as great meat birds in rural areas of Malaysia, Indonesia and Thailand, while they are considered as pests in urban cities.



Visit Karni Mata Rat Temple in Deshnoke, India





History of Pest Control

Prehistoric times to the Renaissance (1)

- Insects disturbed pre-historic man's nomadic hunting-gathering life-style must have been few.
- As humans during this period grew no crops and had no permanent homes and few possessions, we can imagine that pest problems would have been limited to lice, fleas, flies and mosquitoes that caused them physically discomfort.
- Pre-historic control of these insects are likely to be picking, slapping and squashing.

Prehistoric times to the Renaissance (2)

- The development of agriculture, establishment of permanent settlement and introduction of a life-style started about 10,000 years ago.
- These required the storage of greater/ lesser quantities of food and other food items that a concerted effort to control a variety of organisms became necessary.
- Early pest control practices were based on mysticism or superstition, often offering to a god or the performance of a ritual dance.
- Gradually over the millennia and through trials and errors, a few useful methods became known.

Prehistoric times to the Renaissance (3)

- Before 2500 BC, the Sumerians were using sulphur compounds to control insects.
- Around 1200 BC, the Chinese were using plant-derived insecticides for seed treatment and fumigation uses.
- The Chinese also used chalk and wood ash for prevention and control of both indoor and stored product pests. Mercury and arsenic compounds were employed to control body lice and other pests.
- The Chinese also used natural enemies and adjusting crop planting times to avoid pest outbreaks a few hundred years before Christ (AD).

Prehistoric times to the Renaissance (4)

- Similar techniques were common among the Greek and Roman comtemporaries.
- In 950 BC, Homer noted the value of burning for locust control.
- Herodotus (450 BC) mentions the use of mosquito net and the practice of building high sleeping towers to avoid mosquitoes.
- Roman Cato reported the use of oil sprays, oil and bitumen sticky bands, oil and ash, and sulphur bitumen ointments for pest control.
- A pest proof granary by Roman architect Marcus Pollio in 13 BC shows a clear understanding of the benefits of habitat modification in preventing pest problems.

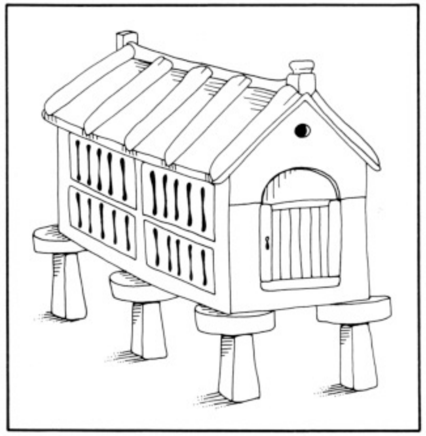


FIGURE 4-2. Galician "horreo" or granary. The design is unchanged from the time of the Celtic Invasion of Spain (ca. 500 B.C.). Made of granite slabs and wood, the horreo is fire- and vermin-proof. It rests on columns topped by circular stone rat guards. Rats are unable to climb upside-down around the stone guards and cannot get to the grain stored above. This practical protection from granary rat pests may have been the forerunner of the classical capital!

Prehistoric times to the Renaissance (5)

- However, not all pest control practices in Roman Empire were founded biologically.
- There were those who turn to religion and superstition for help with their pest problems.
- Eg. a Roman agricultural text (50 AD) named *De re Rustica* suggests "a woman with flying hair must run barefoot around the garden, or a crayfish must be nailed up in different places around the garden."
- In China, the evolution of pest control technology continued during the first 1000 years after Christ.

Prehistoric times to the Renaissance (6)

- This was made possible through knowledge and intense interest in insects (with the cultivation of silkworm in 4700 BC) and good understanding of food webs, feedback mechanisms and other natural population control.
- A Chinese text written around 300 AD said:

  "A factor which will increases the abundance of a certain bird will indirectly benefit a population of aphids because of the thinning effect which it will have on a lady bug beetle which eat aphids, but are themselves eaten by the bird"
- Because of an appreciation of the functioning of ecosystems, the Chinese were responsible for the earliest application of biological control.

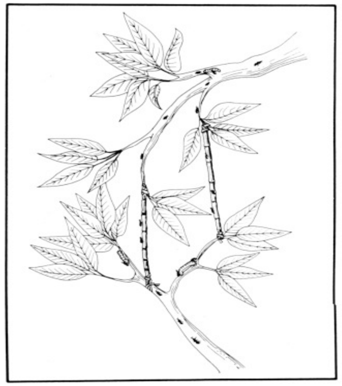


FIGURE 4-3. The earliest recorded use of natural enemies to control pest insects was the use of predatory ants in citrus orchards to control caterpillar and beetle pests in China. Nests were established in the orchards by Chinese growers, and bamboo bridges were placed between branches to facilitate the ants' movements from tree to tree.

Prehistoric times to the Renaissance (6)

- Other pest control methods employed in early China with remarkable sophistication in technique.
- Ge Hong 葛洪, a great alchemist (4th century), recommended a root application of white arsenic when transplanting rice to protect against insect pests.
- While the China was advancing in pest control approaches, the European methods (after the fall of Roman empire) relied increasingly on religious faith, superstition and less on biological knowledge.

Renaissance (1450 - 1600) and Agricultural Revolution (1)

- In Europe, Renaissance brought a rebirth of the search for scientific knowledge and an increase understanding of organisms that became pests.
- Using microscope, van Leeuwenhoek discovered bacteria in 1675.
- Other scientific advances in 17th century included Redi's proof that insects do not arise spontaneously from decaying material, but from eggs laid there, Valisneri's demonstration of the nature of insect parasitism, etc.
- In the first half of 18th century, Linnaeus laid the foundation of true systematics with his development of bionomial nomenclature.

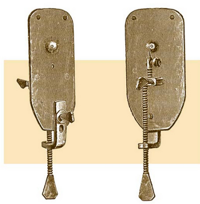


FIGURE 4-4. An eighteenth-century flea trap to be worn around the neck. Fleas entered the outer perforations (bottom left) and were caught on a sticky tube inside (top left). No record of the effectiveness of this trap remains. However, we do know that fleas were a constant harassment to people of all classes during this period in Europe.

Renaissance (1450 - 1600) and Agricultural Revolution (2)

- Reamur (1683 - 1756) discussed the significance of host-parasite relationship in pest outbreaks and suggested the use of entomophagous insects (eg. lacewings) to predate on aphids.
- In the late 17th and early 18th centuries, the European discovered botanical insecticides (pyrethrum, quassia, tobacco leaf infusion).
- 1754 - France prohibited the use of arsenic and mercury for seed treatment.
- 1750 - 1880 - Agricultural revolution - Farming became more of a commercial enterprise.
- Increase in yield due to changes in land distribution and agricultural practices.

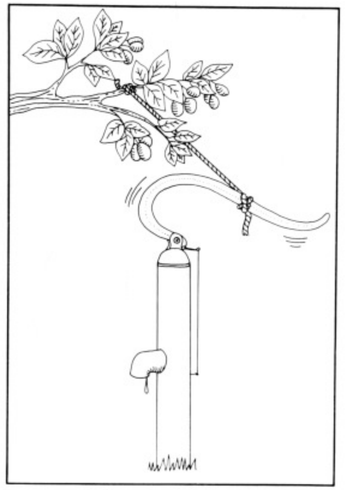


FIGURE 4-5. An ingenious method of control for curculios (a type of weevil with boring larvae) injuring plum and apricot trees, devised by Colonel T. Forest of Germantown, Pennsylvania, in the early 1800s. "Having a fine plum tree near his pump [he] tied a rope from the tree to his pump handle, so that the tree was greatly agitated every time there was occasion to pump water. The consequence was that the fruit on his tree was preserved in the greatest perfection" (from Dethier, 1976).

Renaissance (1450 - 1600) and Agricultural Revolution (3)

- During mid 1700s, farmers began to grow crops in rows, thus permitting weed removal with horse-pulling hoe.
- The greatest cause of large-scale crop disaster was not pests, but weather. Weather-induced damaged may be direct (eg. drought, flood, tornado), or indirect (eg.diseases which are favoured by high humidity and other conducive environments).
- Some of the worst agricultural disasters were: potato blight in late 1840s in Ireland, England and Belgium, powdery mildew in 1850s in grape-growing are of Europe, fungus leaf spot disease of coffee which caused Ceylon (Sri Lanka) to switch from coffee production to tea cultivation, and invasion of American grape phylloxera which nearly put an end to the wine industry in France (1848 - 1878).

Renaissance (1450 - 1600) and Agricultural Revolution (4)

- The solution to powdery mildew fungus problem came by accident.
- A farmer, in an attempt to stop stealing of his grapes by passersby, applied a poisonous-looking mixture of copper and lime to his roadside plants.
- Afterwards, he discovered that these roadside plants have escaped infection by fungus.
- This led to the development of two fungicides that dominate plant pathogen control, I.e. Bordeaux mixture (hydrated lime + copper sulphate) and Paris green (copper acetoarsenite).

Renaissance (1450 - 1600) and Agricultural Revolution (5)

- Both were also found later to show insecticidal properties, and Paris Green became the most commonly used insecticides in the late 19th century.
- It was also in late 19th century that the importation and establishment of natural enemies for biological control was shown.
- The cottony cushion scale was accidentally introduced into California in late 1860s and spread throughout the citrus growing areas in California and nearly wipe out the industry.
- Albert Koebele, an entomologist, went to Australia (the scale's native land) and came back with the vedelia beetle (*Rodolia cardinalis*) and managed to salvage the situation.
- In fact, the control by the beetle was so successful that the cottony cushion scale has never risen to pest status again.

Vedalia beetle feeding on cottony cushion scale

Renaissance (1450 - 1600) and Agricultural Revolution (6)

- In 1890s, an incredible breakthroughs in medical entomology happened.
- 1893: Smith & Kilborne found Texas cattle fever (a protozoan disease of cattle) was caused by tick.
- 1896: Bruce found African sleeping sickness was carried by Tsetse flies.
- 1897: Rat flea was identified as the vector for plague.
- 1897: Anopheles mosquito was identified as the malarial vectors.
- 1898: Flies were found as mechanical vectors for typhoid fever.
- 1900: Mosquitoes were positively identified as carriers of yellow fever virus.

Renaissance (1450 - 1600) and Agricultural Revolution (6)

- The control of disease vectors grew into a new area of pest management.
- The building of Panama canal (completed in 1915) represented the first large-scale success in controlling an important medical vector. The failure of the French in their attempt to build the canal in the last quarter of 19th century was partly due to their ability to control malaria and yellow fever due to ignorance to the role of mosquitoes.
- Mosquito control in 1900s focused on destruction of larval habitat, filling, impounding and periodic flushing and use of larvicide (eg. kerosene).

Renaissance (1450 - 1600) and Agricultural Revolution (6)

By the turn of 19th century, 5 major approaches of insect control were established and in common use:

1. Biological control.
2. Mechanical and physical control.
3. Cultural control.
4. Chemical control.
5. Use of resistant varieties.

The sixth approach, legal control, was first established in the USA in 1912 by the Plant Quarantine Act 1912.

The Early 20th Century

- By early 1900s, the number of people actively employed as economic entomologists was sustantial.
- Textbooks at that period show that these sciences were well developed.
- E.Dwight Sanderson's *Insect Pests of Farm, Garden and Orchard (1915)* stressed the importance of correct identification of pests, and the need for a solid understanding of pest biology, especially in the timing of application of control measures.
- Sanderson's book suggested many important control methods such as crop rotation, arrangement of planting times to avoid pest outbreaks, trap crops, etc.
- Physical and mechanical control devices were also used in insect control such as screening of houses, mosquito nets, use of sticky bands on tree trunks to keep climbing insects. Mechanical devices - fly traps, moth traps…

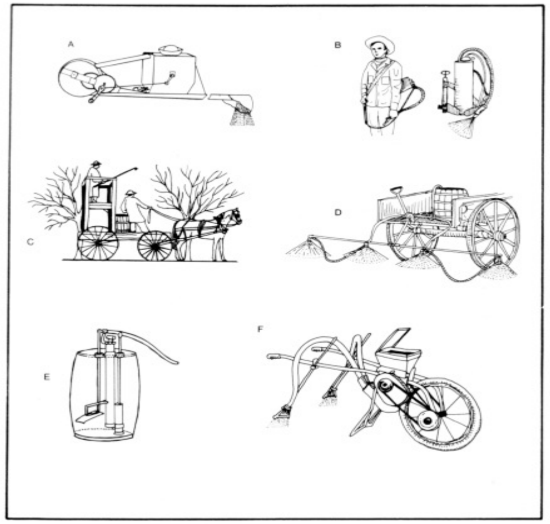


FIGURE 4-7. Early pesticide application equipment, ca. 1915. (A) A powder-gun for applying insecticides in dust form. (B) Compressed-air sprayer, individually held. (C) Spraying orchard trees from a rough tower bolted to a one-horse wagon. (D) Row-spraying attachment for use with barrel pump, adjustable for various widths of rows. (E) Barrel pump. (F) Wheelbarrow applicator for dusts.

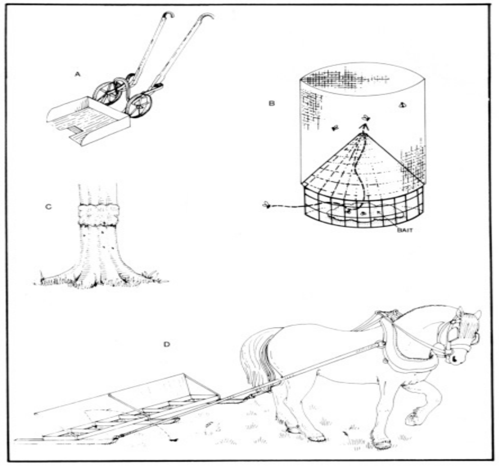


FIGURE 4-8. Physical and mechanical control devices of the early twentieth century. (A) A hopperette, designed for catching leafhoppers. Immediately after weedy areas, grass, or forage crops are cut, a hopperette can be pushed through the infested area; thousands of leafhoppers will fly into the machine and adhere to the sticky substance on its sides and bottom. (B) A fly trap. Flies are attracted to bait in the bottom of the trap, then fly up into the cone and cannot get out. With an attractive bait and a correctly sized trap, buckets of flies can be caught in a short period of time. (C) Sticky band or ''tangle foot'' around the trunk of a tree. Insects migrating up into the leafy portions of the tree get stuck in the band. (D) A hopperdozer. This is similar to the hopperette described in (A), but it is larger and designed particularly for catching grasshoppers. Oil or kerosene is placed in the trough of the hopperdozer to kill the pests once caught.

After WWII - DDT and other synthetic organic insecticides

- WW1 had been primarily fought in Europe, and pest problems that affected the troops were the usual uncomfortable problems of lice, fleas, bed bugs. However much of WW2 happened in the tropics and insect-vectored diseases had the potential of becoming a truly devastating situation to the entire war effort.
- Thus, both sides realised that research on more effective insecticides was the top priority.
- DDT was discovered by a Swiss chemist (Paul Mueller) and was virtually lethal to every test insect. The wartime benefits conferred by DDT through diminution of various diseases should not be underestimated.
- At the same time, the German came up with an equally toxic group (organophosphates).
- A third group (carbamates) was also discovered in 1940s by Swiss, but they were not popular until 1950s.

After WWII - DDT and other synthetic organic insecticides (2)

- The first use of these insecticides was for the control of human disease vectors.
- After the war, they found a ready market in peacetime agricultural enterprise. Their success was immediate because they were cheap, effective in small quantities, easy to apply and widely toxic.
- Thus the pesticide industry boomed!
- The effects of these new pesticides was revolutionary. Previously, farmers only talked about controlling the pests, but they were then talking about eradicating them.
- Subsequently, many researchers became concerned with the effectiveness of the chemicals produced.
- The trend of this area of study was clearly reflected in the number of papers published in this subject matter in *Journal of Economic Entomology* (between 1940 - 1960s)

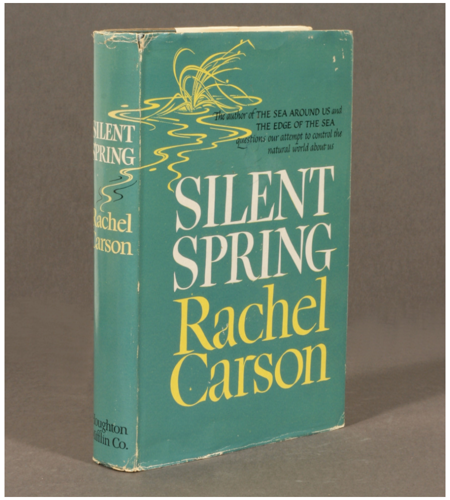
After WWII - DDT and other synthetic organic insecticides (3)

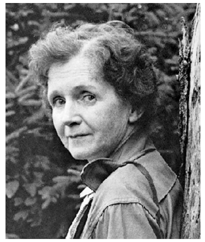
- Then, came the problem of <u>insecticide resistance.</u>
- The first case was DDT resistance in house flies in Sweden in 1946.
- In less than 20 years after the first case, some 225 species of insects and acarines had been recorded to be resistant to one or more groups of insecticides.
- Another problem that occurred was <u>target pest resurgence.</u>
- This is a situation where after spraying with insecicide, the pest population will drop drastically, and then suddenly surge to higher levels than before. This is due to the killing of natural enemies and the pests. Any surviving natural enermies will die of starvation or they were forced to emigrate to other fields.
- The pest population then comes back with no or limited natural enemies to affect it.

After WWII - DDT and other synthetic organic insecticides (4)

- The third problem was <u>induced secondary pest outbreak.</u>
- This occurs when a plant-feeding species, previously not a pest, suddenly erupts to damaging levels.
- This eruption is usually the results of the pesticides' destruction of natural enemies.
- The final problem is <u>environmental contamination</u> which began to be a concern with the publication of Silent Spring in 1962.

Silent Spring -- Rachel Carson






'Silent Spring' Is Now Noisy Summer

Pesticides Industry Up in Arms Over a New Book

By JOHN M. LEE

The $300,000,000 pesticides industry has been highly irritated by a quiet woman author whose previous works on science have been praised for the beauty and precision of the writing.

The author is Rachel Carson, whose "The Sea Around Us" and "The Edge of the Sea" were best sellers in 1951 and 1955. Miss Carson, trained as a marine biologist, wrote gracefully of sea and shore life.

In her latest work, however, Miss Carson is not so gentle.

Rachel Carson Stirs Conflict—Producers Are Crying 'Foul'

fending the use of their products. Meetings have been held in Washington and New York. Statements are being drafted and counter-attacks plotted.

A drowsy midsummer has suddenly been enlivened by the greatest uproar in the pesticides industry since the cranberry scare of 1959.

Miss Carson's new book is entitled "Silent Spring." The title is derived from an idealized situation in which Miss Carson envisions an imaginary town where chemical pollution has silenced "the voices of spring."

Emergence of Pest Management

- The concept started from the discontentment of insecticidal approach to pest control in the 1950s.
- The concept of integrated control was developed, emphasizing on selective use of insecticides so that natural enemies were conserved in the agroecosystem.
- In 1961, 2 Australian entomologists Clark & Geier outlined the principles of pest management.
- Pest management differed from previous pest technologies because of its holistic viewpoint, synthesis of ideas and inclusion of basic population theory.
- ***Control*** refers to having power over something; however, ***management*** refers to judicious use of means to accomplish a specific goal.
- The main objective of pest control is *to kill the pests*, while pest management stresses on *reducing or modifying pest impact, and reducing injury to tolerable levels.*

The concept of pest management

- Definition: *a comprehensive pest technology that uses combined means to reduce the pest status to tolerable levels while maintaining a quality environment.*
- The main objective --- reduce pest status. *Killing the pests is not the objective, but preventing economic loss is.*
- Complete elimination is not feasible, or even desirable.
- The second objective -- maintenance of a quality environment.
- Because pest status is determined by both insects and the crop, the following management strategies could be adopted based on the economics and pest characteristics: (1) Do nothing, (2) Reduce pest population numbers, (3) Reduce crop susceptibility to pest injury, (4) Combine reduced population numbers with reduced crop susceptibility.

The Do-nothing strategy

- It is possible that the insect injury does not cause a loss to the yield as the crop tolerates the injury.
- If pest density is below threshold level, there is really no need to treat.
- At other times, insects may cause indirect injury to the crop, but it does not affect the yield.

Western Corn Rootworm scraping leaf of corn.

Reduce-numbers strategy

- Probably the most widely used strategy in pest management.
- If the pest's long-term GEP (general equilibrium position) is low compared to the economic threshold, the strategy is to reduce the pest peaks.
- However, if the GEP lies very close (or above) to the economic threshold, we can either (1) reduce the environmental carrying capacity, or (2) reduce the survival potentials of the population, so that it can be kept below economic threshold.
- Eg. (1) make the habitat less suitable. (2) reduce the insects innate ability to reproduce (eg. sterile insect technique).

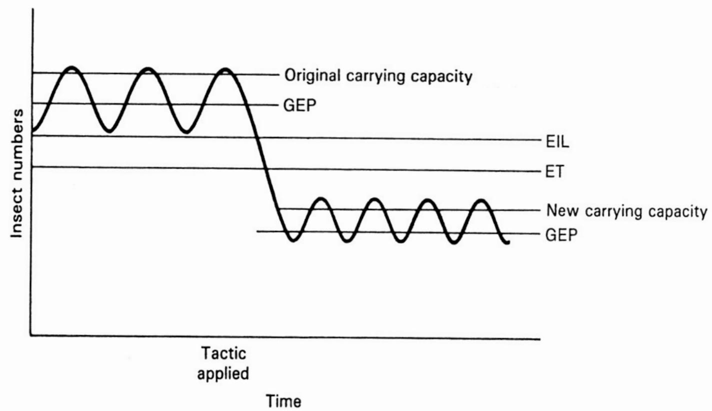


Figure 8.8 Graph showing the management strategy of lowering the carrying capacity of a pest. EIL, economic-injury level; ET, economic threshold; and GEP, general equilibrium position.

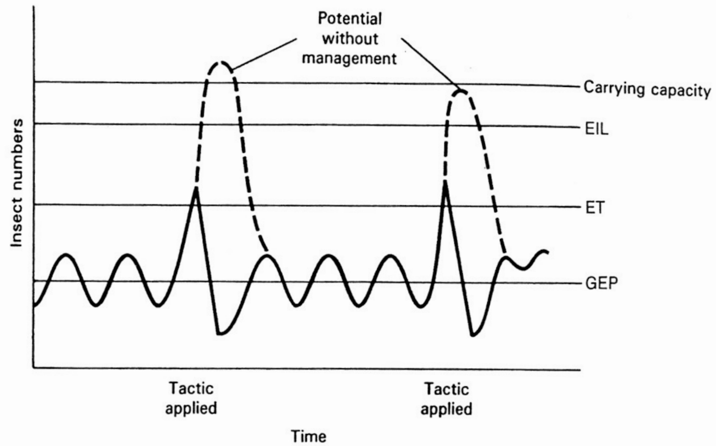


Figure 8.7 Graph showing the management strategy of dampening peaks. EIL, economic-injury level; ET, economic threshold; and GEP, general equilibrium position.

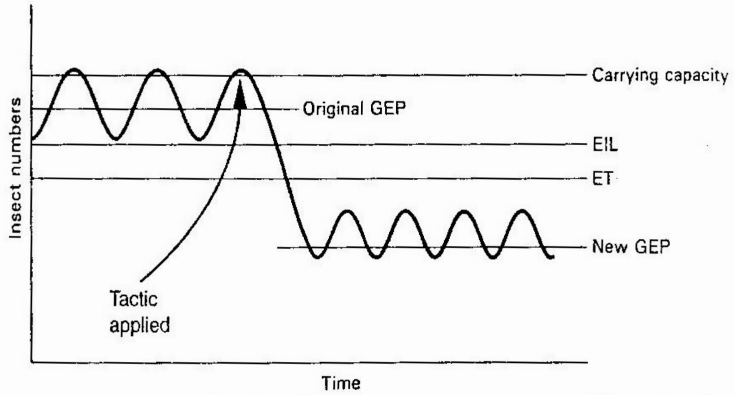


Figure 8.9 Graph showing the management strategy of lowering the general equilibrium position (GEP) but not the carrying capacity. EIL, economic-injury level, and ET, economic threshold.

Reduce crop susceptibility strategy & Combined strategy

- For this strategy, insect population is not managed at all.
- Involved using resistant variety of crop that are tolerant to insect attack.
- Some other strategies in ecological management improve plant vitality through fertilization, and changing planting dates to un-synchronize pest cycle and a susceptible plant stage.
- ***Combined strategy*** combines the objectives of all the mentioned strategies to produce a pest management program with several tactics.

Kinds of pests and strategies

- **Subeconomic pests** -- GEP of this pest is far below the EIL, and the highest pest population does not reach EIL.
- **Occassional pests** -- GEP of this pest is substantially below the EIL, but the highest pest population occasionally exceed EIL.
- **Perennial and severe pests** -- also known as key pests -- cause serious and difficult problems in crop production. Usually because of high market value of crop, or very dense population -- For *perennial pest*: GEP is below EIL, but close to economic damages. For *severe pest*: GEP is above EIL, thus the insects are a consistent problem.

Development of a pest management program

- There are a number of important building blocks before a program can be developed.
- Biological information such as pest habitat, life cycle, seasonal cycle, relationship to crop biology, population dynamics.
- Correct species identification.
- Rearing and culture techniques.
- Sampling technique.
- Bioeconomics -- relationship between pest number and losses of yield.
- Management tactics.
- By putting all the information together, an integrated pest management program can be developed.

Major components of an insect pest management program