Economic decision levels for pest populations

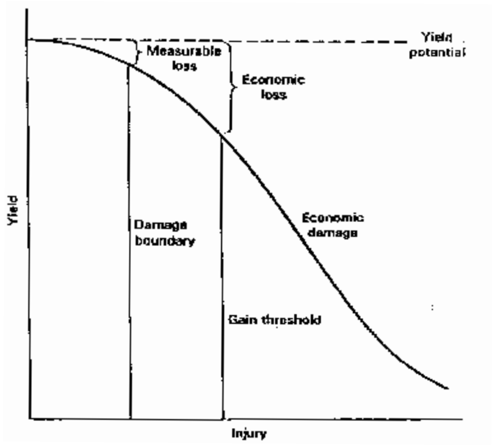
Introduction

- **Economic decision level** -- expressed as the no. insects per area, plant, or animal unit, or sampling procedures.
- **Economic damage (ED)** --- the amount of injury which will justify the cost of artificial control measures.
- **Injury** -- effect of pest activities on host physiology that is usually deleterious.
- **Damage** -- measurable loss of host utility, mostly include yield quantity, quality and aesthetics.

Introduction

- **Gain threshold** -- unit of measure of marketable product per a specific land area. eg. If management cost for insecticide application for 1 ha is NT$1000, and the harvested mango is marketed at NT$10/kg, thus the gain threshold is 100 kg/ha.
- In other words, an insecticide application would need to save at least 100 kg per ha for the activity to be profitable.
- **Damage boundary (DB)** -- the lowest level of injury where damage could be measured (***where yield loss is detectable***)
- This level is reached before economic damage (ED) occurs, and no injury level below DB merits control.

Relationship between the damage boundary and the gain threshold



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Economic injury level (EIL)

- **EIL** -- lowest no. insects that will cause economic damage, or the minimum no. insects that will reduce yield.
- In general, when insects can be suppressed and the loss can be avoided completely, the following formula would apply: EIL = C / (V x I x D) where C = cost of management per area (eg. NT$/ha), V = market value per unit of produce (eg. NT$/kg), I = injury units per insect per production unit (eg. % defoliation/insect/ha), D = damage per unit injury (eg. kg lost/ha/% defoliation).
- However, in more complex situation where other aspects are involved such as loss of yield due to reduction in photosynthesis, more complicated formula would be required. Please refer to Pedigo & Rice (2009) - page 258 - 259 for more details.

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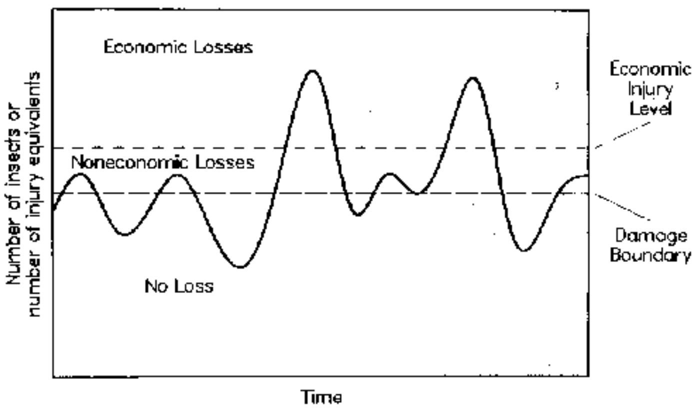
Relationship between a hypothetical population with the damage boundary and the economic-injury level



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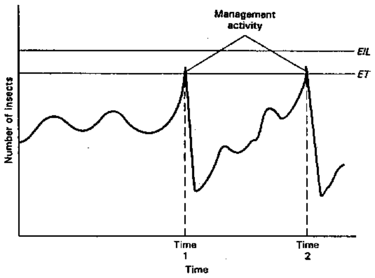
Economic threshold (1)

- **Economic threshold (ET)** -- number of insects that will trigger management action.
- Sometimes known as *action threshold.*
- The relationship between the EIL and ET demonstrate that action taken when a population level exceeds the ET forces down the population before it can reach the EIL. No action is taken at levels below the ET.



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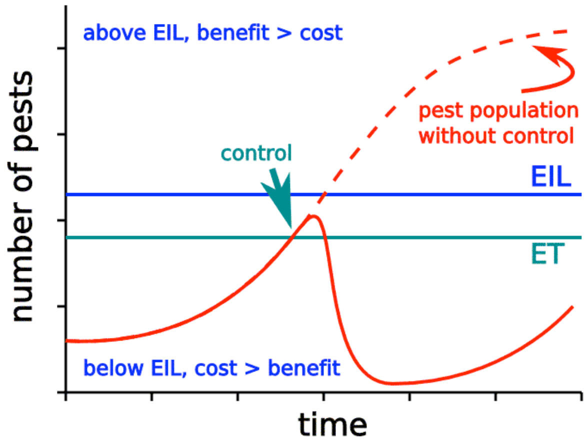

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Economic threshold (2)

- The ET is a complex value that depends on estimating and predicting several difficult parameters.
- The most significant of these include 1) the EIL variables (this is because the ET is based on the EIL), 2) pest and host phenology, 3) population growth and injury rates, and 4) time delays associated with the IPM tactics utilized.
- Because of the uncertainties involved, particularly in pest population growth rates, most ETs are relatively crude; they do not carry the same quantitative resolution as do EILs.

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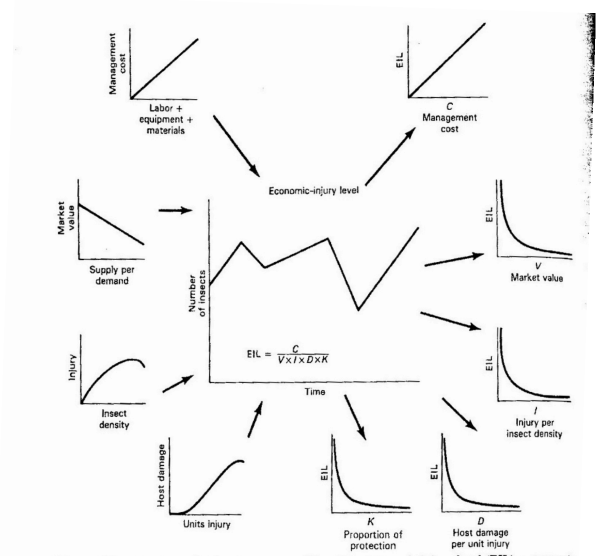

Figure 7.7 Stylized graphs showing relationships of the economic-injury level (EIL) components and their variables. Primary components (graphs to left) are affected by secondary variables like insect density and labor costs. These variables cause fluctuations in the EIL with time (center graph). Resulting responses of the EIL to changes in primary components are shown in graphs at right.

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(Revision)

- The **damage boundary** is the number of a pest insect that must be present before their injury can be measured as yield loss. There is no reason to spend money and effort to control insects that are present in numbers fewer than the damage boundary because there will not be any observable return in protected yield and there can be detrimental effects on the natural enemies.
- The **economic injury level (EIL)** is the number of insects that need to be present for the value of the lost yield to equal the costs of control.
- The **economic threshold (ET)** is a decision point. It is the number of pest insects that need to be present for a control to be applied and keep the increasing pest population from reaching the EIL.

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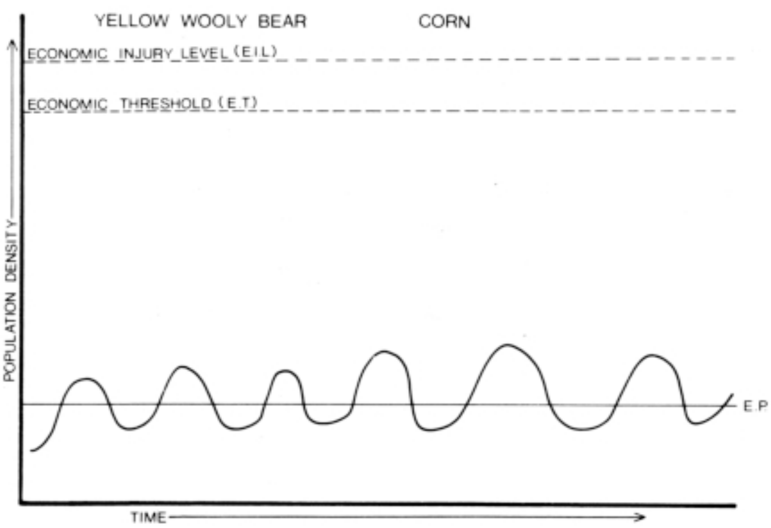

FIGURE 3-5. Equilibrium level is well below economic injury level. Such an insect is never a pest; control action is never needed (after Luckmann and Metcalf, 1975).

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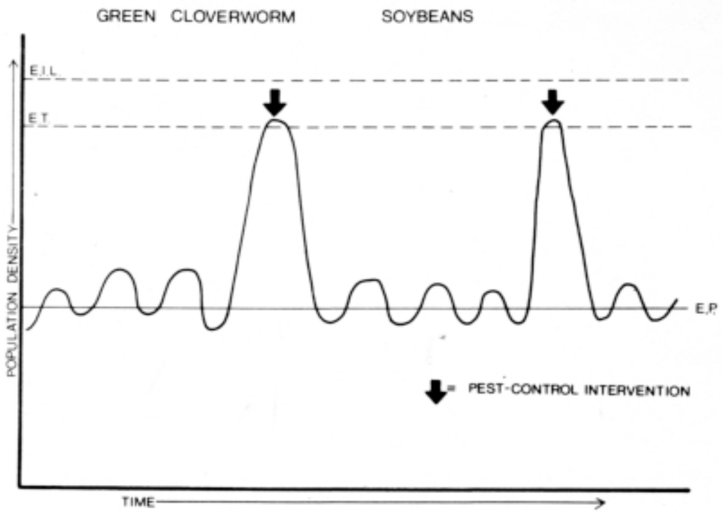

FIGURE 3-6. Equilibrium level is well below economic injury level, but for various reasons the population density sometimes reaches the economic injury level. This is an occasional pest; occasional control action is needed (after Luckmann and Metcalf, 1975).

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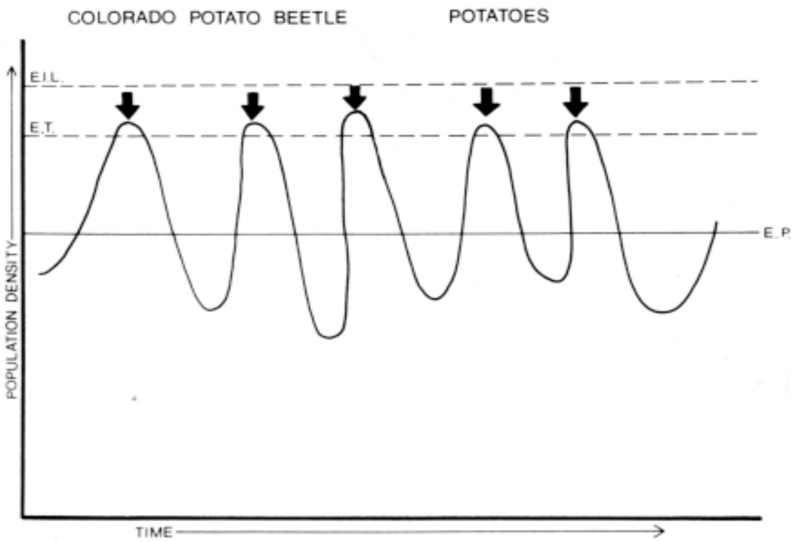

FIGURE 3-7. Equilibrium position close to economic injury level; this is a frequent pest requiring regular pest control action (after Luckmann and Metcalf, 1975).

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How to calculate EIL

- The calculation of EIL -- continuing process because input variables are constantly changing.
- Market value, management costs, plant susceptibility, etc.
- Several EILs may be required even for a single season because crop development and susceptibility may change.
- General steps for calculating EIL: (1) estimate loss per insect, (2) determine the gain threshold, (3) determine loss that can be avoided if applying management tactics. (4) EIL = gain threshold/(loss per insect x amount of loss avoided).

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EIL, however may differ with time and space

- Example -- the importance of subterranean termite infestation differs with locations where they are found.
- EIL for rain forest = low.
- EIL for park = moderate.
- EIL for factories = high.
- EIL for expensive residential property = very high.

Example - EIL of potato leafhopper (*Empoasca fabae*) on soybean

- To estimate damage per insect, small soybean plots were caged and infested with various leafhopper numbers at 3 plant growth stages (seedling, beginning flowering, and beginning pod-filling) -- value obtained based on 1 insect/plant: 1.55 kg/ha, 0.17 kg/ha, 0.08 kg/ha respectively.
- To calculate the gain threshold, the cost of applying 1 kg (active ingredient) of malathion by aircraft is $9.50/ha. It was predicted that the harvested grain can be sold for $4.15/kg. Thus the gain threshold = 9.50/4.15 = 2.29 kg/ha.
- Thus, EIL (seedling stage) = 2.29/(1.55 x 1) = 1.48 leafhopper/plant. EIL (beginning flowering) = 2.29/(0.17 x 1) = 13.47 leafhopper/plant. EIL (beginning pod-filling) = 2.29/(0.08 x 1) = 28.63 leafhopper/plant.

Categories of plant pests

- **Stand reducer** -- reduce standing plants, produce an immediate loss in plant biomass and decrease photosynthesis.
- **Leaf-mass consumers** -- leaf consumption by insects reduces photosynthesis of the remaining plants.
- **Assimilate sappers** -- piercing-sucking and rasping insects that remove plant carbohydrates and nutrients.
- **Turgor reducers** -- soil insects and stem feeders that influence plant water, and nutrient balance at root and stem sites. Normally they reduce rooting depth and density, and also girdle the stems.
- **Fruit feeders** -- injure fruit, causing direct damage to harvestable produce.
- **Architecture modifiers** -- change plant morphology to reduce yield.

Stand reducers

Black cutworm (*Agrotis ipsilon*) (Lepidoptera) on corn/cotton

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Leaf-mass consumers

Diamond-back moth, *Plutella xylostella*

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Assimilate sappers

Tarnished plant bug, *Lygus lineolaris* on peach tree

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Turgor reducers

Corn rootworm (*Diabrotica*) (left); Threecornered alfalfa hopper (*Spissistilus festinus*) (right)

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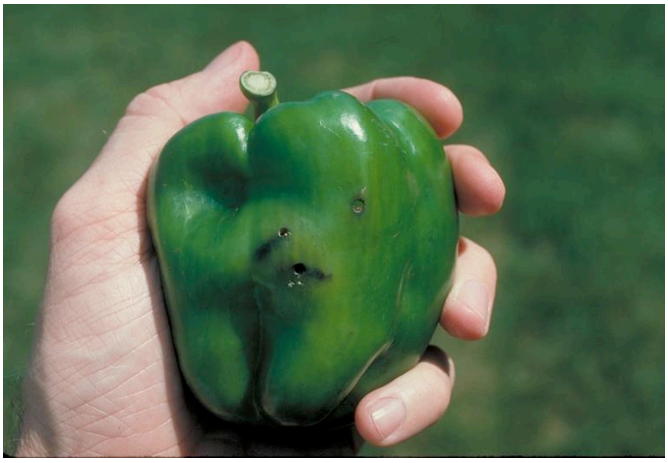
Fruit feeders

European corn borer (*Ostrinia nubilalis*) on bell pepper



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Architecture modifiers

Seedcorn maggot *Delia platura* consumes plumules of soybean seedlings and cause Y-plants.

Normal soybean seedling

Affected soybean Y-seedling

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Factors affecting crop injury

- **Time of injury** -- Seedlings are the most susceptible stage, while older plants are more able to withstand injury. However, when yield-producing organs are forming, they become susceptible again.
- **Part of plant injured** -- Where the injured part will also affect the plant's response to injury. Those injury on the yield-forming organs (direct injury) will affect EILs, while those on nonyield-forming organs are less important.
- **Injury types** -- the nature of the injury would affect how a plant responds to different intensities.
- **Intensity of injury** -- the degree of injury would affect the EILs.
- **Environmental effects** -- Environmental factors affects how plants respond to injury. In different seasons, plant susceptibility to insect attacks may differ.

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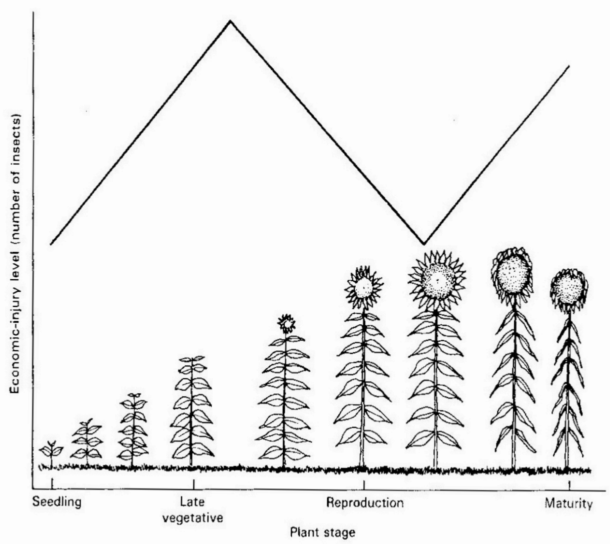

Figure 7.13 Graph showing typical changes in the economic-injury level with changes in plant stage. Many plants are particularly vulnerable during reproductive stages.

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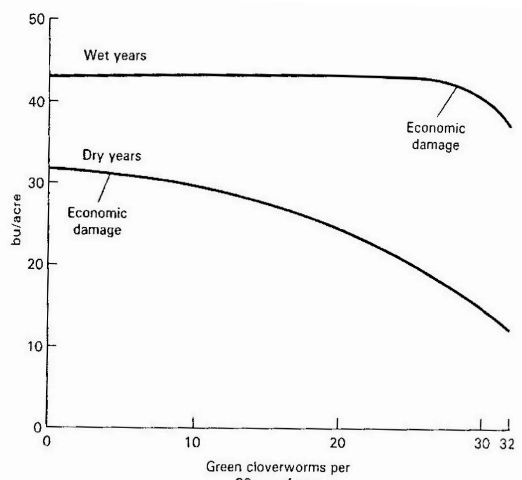

Figure 7.15 Stylized soybean-yield response curves to defoliation of the green cloverworm, *Hypena scabra,* in years of normal rainfall (wet) and those with below normal rainfall (dry). Note the differences in number of insects required to cause economic damage between the two types of years.

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Environmental EILs

- The desire to decrease pesticide usage while maintaining agricultural production and profitability is challenging.
- Further decreases in pesticide inputs in these situations can and should be attempted by developing environmentally based EILs and their concomitant ETs.
- An *Environmental EIL* is an EIL that focuses on environmental issues and attempts to incorporate environmentally conscience actions in its makeup, i.e., a purposeful manipulation of the EIL variables.
- Activities to support greater environmental responsiveness in the EIL include accounting for environmental costs in the *C* variable, reducing damage per injury by increasing plant tolerance in the *D* variable, and developing an effective, yet environmentally responsible, *K* variable by reducing pesticide application rates.

Limitation of EIL concept

- Many factors have limited both the design of new economic thresholds and the development of existing ones. Some of the major limitations are: (1) Lack of a thorough mathematical definition of the ET, (2) Lack of valid EILs, (3) Inability to make cost effective and accurate population estimates, (4) Inability to predict critical ET variables such as market values and population trends, (5) Lack of a simple means to incorporate externalities, especially environmental costs into EILs
- To advance, the limitations should be addressed across all areas, including theoretical work, research, and implementation. In particular, research is needed to achieve improved thresholds.
- The knowledge of pest population dynamics and a better capability to predict pest population trends is needed.
- More research should be directed toward improving knowledge of pest injury and host responses to injury; an understanding of this important area is still quite inadequate.