Classical Biological Control (Importation of the Biological Enemies)

That means to release an exotic natural enemy into a new environment so that it will become established and will regulate a pest population over the long term without further intervention. Classical biological control has been used extensively and some programs have been extremely successful.

Introducing the Vedalia beetle against cottony cushion scale

In California in 1868, the cottony cushion scale was a new pest attacking citrus, pear, and acacia in southern California. By 1880, it had spread all over California in 1888, Albert Koebele was sent to search for natural enemies throughout Australia for this project.
The most promising natural enemies Koebele found were a parasitic fly *Cryptochaetum iceryae* and a lady beetle (Coccinellidae), *Rodolia cardinalis*

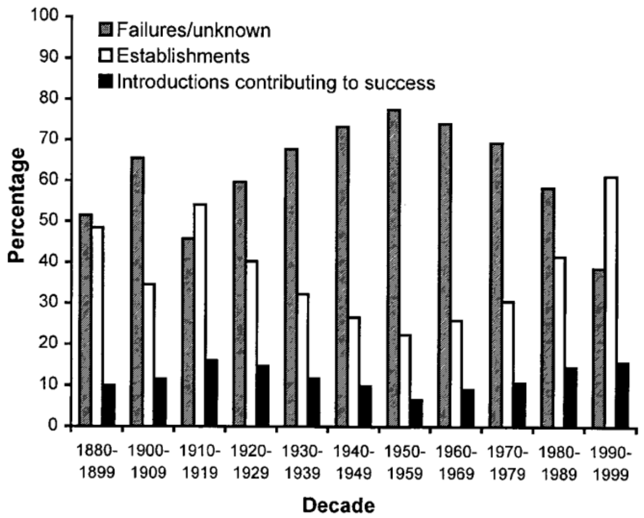
Koebele collected and sent both the flies and beetles in five shipments, during which both scales and natural enemies had to be kept alive throughout the 3-week boat trip from Australia to California. By 1889, a total of 514 individuals of *R. cardinalis* had arrived in California. These beetles were released, and 4 months after the first release, adult Vedalia beetles were swarming over a 3,200 tree orchard that had previously been heavily infested with scale. To hasten spread of the beetles, branches covered with scale-feeding beetles were transported to uninfested orchards. By 1890, all infestations of the cottony cushion scale were completely destroyed. the citrus industry was saved, and the total control program had cost less than $5,000, including salaries.

What makes *R. cardinalis* very successful is that very specific, feeding only on scale insects
And its host range is restricted. Most predators are not as specific as the Vedalia beetle. In addition, this beetle had the ability to become established when only a few females were introduced. For example, only four females of this beetle were introduced to Peru to control this same pest and the beetle became established.

Success of Classical Biological Control

The principal types of natural enemies used for classical biological control have been insect parasitoids and predators for controlling insect pests and phytophagous insects for controlling weeds. Natural enemies generally considered appropriate for classical biological control are host specific to some extent so that natural enemy populations would increase when hosts increase and decrease when hosts decrease in a density-dependent relationship.

The goal of classical biological control is to establish natural enemies permanently in a new environment where they will persist thus this strategy has been applied more successfully to more permanent ecosystems, such as forests, natural areas, orchards, and perennial crops. This strategy has been used less frequently in short-term agricultural crops. Classical biological control has often been used against pests introduced to relatively isolated areas, such as Australia and islands such as Hawaii or the Californian agricultural area that is isolated by mountains and desert from other North American agricultural areas. For islands in particular, it has been hypothesized that since the fauna on islands is known to be less complex, introduced agents would have better chances of successful colonization.



Statistics on the results of classical biological control introductions of predators and parasites to control insect pests. Percentages of introductions contributing to success (black), establishments (white) and failures or unknown (gray) by decade.

Many different types of pests have been targeted by classical biological control programs but there are certain groups that seem to be controlled more successfully. Arthropod pests that are exposed and not hidden and are less mobile have been more successfully controlled because natural enemies have easier access to the pest. For this reason, use of parasitoids and predators against phloem-feeding insects such as aphids, scale insects, mealybugs has been very successful, in part because these hosts are fairly sessile and feed externally on plants. A narrow host range is desirable so that non-targets will not be affected and host mortality will be density dependent, resulting in regulation of the pest population.

In classical biological control the natural enemy is often released in small quantities, to result in self-perpetuating permanent control. Historically, such programs have been quite inexpensive to conduct that can result in huge savings. Governmental or international funding nearly always supports classical biological programs because control is permanent and without cost to individuals, this type of strategy has been considered extremely appropriate for pests affecting resource poor farmers without the resources to pay for pest control.

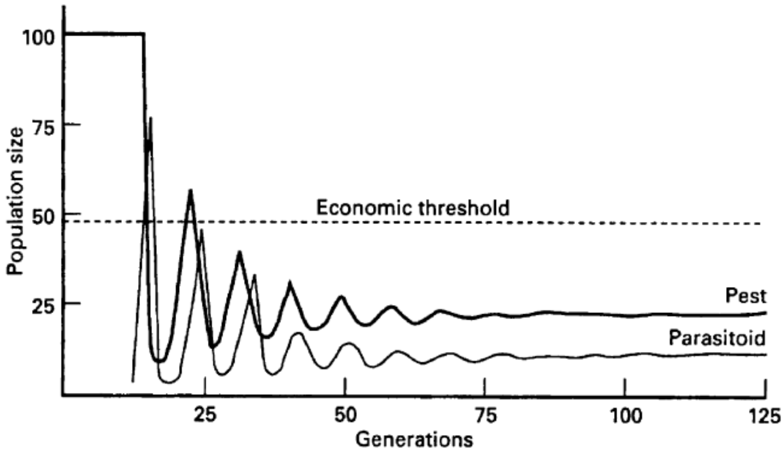


Figure 7.1 Hypothetical example of successful control of a pest population by an introduced parasitoid or predator. In this case, the pest population in the first generation is at an outbreak level (100), well above the economic threshold. The parasitoid or predator is introduced after 10 generations. As its numbers increase, pest numbers decrease. Initial oscillations in both populations decrease with time, and a stable equilibrium is attained at which the pest population remains suppressed to well below the economic threshold. Source: Greathead and Waage (1983), reproduced by permission of The World Bank.

To evaluate success of classical biological control, a set of terms with specific meanings, such as establishment, substantial control, and complete control are used.

Establishment: Permanent occurrence of an imported natural enemy in a new environment.

Complete control: When no other control method is required or used, at least where the agent is established.

Substantial control: Other control methods are needed but the efforts required have been reduced due to the activity of the natural enemy.

Partial control: While the natural enemy has some effect, other means of control are still necessary (also called “negligible” control).

All of the interactions in the environment that could affect the success of a natural enemy cannot always be known before a release and even exhaustive laboratory studies of agents to be released do not always help us to predict the outcome of releases once the natural enemies are confronted with the pest under field conditions.

The first step is establishing the natural enemy in the release area. For parasitoids, one study demonstrated that establishment is improved if the climatic adaptations of the host and natural enemy are similar. If a species of natural enemy did not become established after the first release, there was a greater chance of successful establishment if a different species altogether was released next instead of releasing further strains of the first species. Once that agent becomes established, it rarely goes extinct as long as habitat and hosts are present.

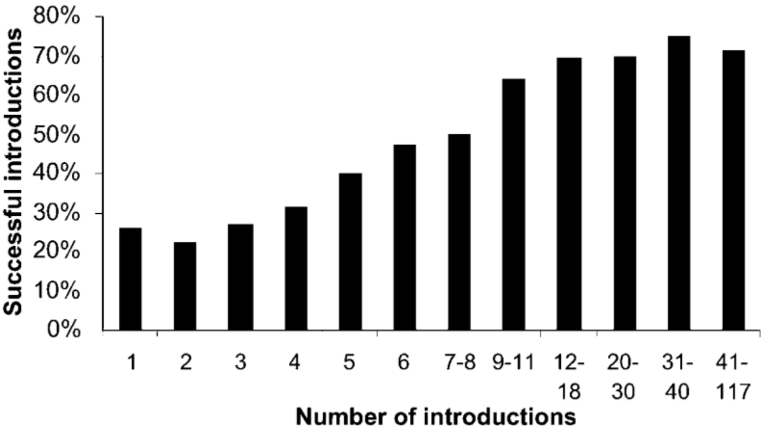
Biological control with parasitoids and predators pests. Success is also greater when pests live in exposed locations, such as external feeders on plant leaves versus stem borers.

In addition, for parasitoids presence of alternate hosts or food have been associated with success. For releases against introduced pests, first the origin of the pest must be determined. This sounds easy but has proven difficult in many situations, often because the pest is extremely widespread or the pest is not an outbreak species in its area of origin and therefore is not well known

The major knowledge of the host range of the natural enemies should be known so that non-target effects are minimized. For natural enemies like parasitoids, when adults are being released, it is also important to release them in areas where there are nectar sources, so that they will be able to feed. They are released under proper weather conditions to promote establishment. For example, adults of tiny parasitic wasps might be released in shady locations at mid-day on a day with little wind. Insect pathogenic fungi could also be released in the shade and in the evening so that when dew occurs overnight, the fungus can take advantage of the higher humidity.

Only one or many natural enemies should be introduced; the worry was whether natural enemies might compete with each other and thereby decrease the overall control if numerous species were introduced. It is normal practice for numerous species of natural enemies to be released against an arthropod pest or weed due to the unpredictability in results after release.

A more recent analysis agrees that as more natural enemies are introduced the probability for success increases. Also multiple releases attitude on the basis that utilising a range of enemy species promote for each other which enriches the community stability when they operate additively with each other to suppress herbivorous densities and tend to attack different life stage of the host, although at least against insect pests this relationship seems to reach a plateau when approximately 9-14 natural enemy species have been released against one pest.



Methods for practicing classical biological control

1. Choose a target pest for which classical biological control would be appropriate and identify its origin. Increasing numbers of countries require that permission for foreign exploration be formally requested.

2. Acquire natural enemies, often through foreign exploration. The natural enemies must be sent to quarantine to make certain they are without their own parasites or contaminants and for further evaluation.

3. Natural enemies for release will be chosen based on efficacy and safety testing in quarantine. Governmental approval for releases should be sought.

4. The natural enemy will be released in suitable habitats, using best estimates for how many individuals to release and how best to release them.

5. After establishment, distribution of the natural enemy throughout the distribution of the pest is frequently required, especially when the natural enemy does not spread quickly on its own.

6. Evaluation of the activity of the natural enemy. This step can sometimes take numerous years because establishment not always immediate.

Quarantine

In the quarantine, the natural enemies must be maintained and increased in number. This usually means that quarantine personnel must also grow the pest to propagate the natural enemy. During rearing, any diseases or parasites of the natural enemies should be eliminated such as when a parasitoid attacking another parasitoid. To maintain the most effective natural enemies, time in the quarantine should be minimized so that the genetic variability in the natural enemy population is maintained.

Augmentation: inundative and inoculative biological control

Involve releasing biological control agents without the goal of permanent establishment. Augmentation is used to control pests when natural enemies are absent, when the control due to natural enemies would naturally occur too late to prevent damage, or when natural enemies occur naturally in numbers too low to provide effective control.

Inundative biological control

The use of living organisms to control pests when control is achieved exclusively by the organisms themselves that have been released. This strategy is directed toward rapid control of pests over the short term. In all cases, no reproduction by the natural enemy is expected. Because control is only due to the released individuals, inundative releases would have to be repeated if pest populations increase again after natural enemies are released. In practice, releases are often repeated if pest populations were not all present in a susceptible stage during the previous application, if new pests disperse into the crop, or if the crop is long lived, increasing the length of time it could become infested. The released agents must contact and kill a sufficiently high proportion of the pest population, or by other means reduce the damage level, to provide control. Of course, to achieve sufficient control rapidly, it is important to release a large number of organisms to inundate the pest population.

Inoculative biological control

The intentional release of a living organism as a biological control agent with the expectation that it will multiply and control the pest for an extended period, but not that it will do so permanently.

For this strategy, control is due not only to the released organisms themselves but also to their progeny. This strategy provides more long-term and self-sustained control than inundative releases. It is used in systems where a natural enemy can respond to and control a pest population, often in a density-dependent manner. If an inoculative release is intended for predators, parasitoids, or pathogens sufficient pest numbers (or other means for growth of the biocontrol agent) must be present following the initial release to support a second or third generation of the released agent, and conditions that allow multiplication of the natural enemy must occur.

Although fewer natural enemies need to be released than with the inundative approach, these programs still usually require some aspect of mass-production to supply enough agents at appropriate times for release.

The distinction between inoculative and inundative releases is not always so precise. An important feature of inundative augmentation is that although the biological control agent is applied without the expectation that it will reproduce, it is a living organism capable of reproduction. In practice, inundative biological control is probably often followed by residual effects if hosts are present and the released organisms can multiply. Conversely, with inoculative release, the majority of control can be caused by the released organisms and the effects from progeny can be minimal, if reproduction is limited.

Whether a natural enemy species is considered for inoculative or inundative biological control is determined in part by the difficulty and cost of producing adequate quantities of that agent for release. For example, while large volumes of the insect-pathogenic bacterium *B. thuringiensis* can be mass-produced in fermenters at a reasonable cost, producing large numbers of parasitic wasps for release is vastly more difficult and costly.

The ability of those organisms being applied to reproduce after application and for their offspring subsequently to attack hosts influences which augmentative strategy is appropriate. For example, when the insect-pathogenic bacterium *Bacillus thuringiensis* is sprayed, although more bacterial cells are produced in infected insects after they die, any subsequent bacterial generations virtually never go on to infect more hosts. Therefore, use of *B. thuringiensis* is never considered an inoculative application. Conversely, parasitoids are adapt at searching for hosts and the progeny of initially introduced parasitoids can have a significant impact on host populations. Therefore, whether parasitoids are intended for inundative or inoculative release, their progeny frequently continue to parasitize hosts, providing the benefits of an inoculative release.

Production of natural enemies by industry

Use of an inundative release strategy, in particular, requires an industry to produce and distribute natural enemies. In general, companies producing natural enemies specialize in either macroorganisms or microorganisms due to the different types of equipment, methodology, and expertise needed.

It is more difficult to develop natural enemies as a product than chemical pesticides because natural enemies often cannot be stored for very long when they are not needed.

Steps necessary for developing a natural enemy for augmentative release

Biological control agents range in complexity from viruses to higher eukaryotes, and methods for mass production, storage, and transport are equally divergent

1. Identification of a market searching for a pest-control solution
2. Identification of an efficacious strain of a natural enemy for mass-production, both effective against the target and cost effective to produce
3. Development of a method for mass-production
4. Development of storage methods
5. Development of methods for transport
6. Registration of the natural enemy can be required
7. Development of methods for release and quantities needed for release in different situations.

Mass- production

One way to make mass-production more cost-effective would be to produce the natural enemies on artificial diets. However, in practice, this technology is used only for producing egg parasitoids in China.

Artificial diets are not used more extensively for producing macro beneficials because methods that have been developed are often not as successful as use of live hosts. There is also concern that natural enemies reared in association with artificial diets will not learn the cues needed to locate hosts or host plants. It is critical not to alter the behaviors of the beneficial that make that species effective for control.

The best advice is to rear the natural enemy on the target pest on the type of plant or substrate that will be encountered in the field and under normal climate conditions, at least when beginning mass production.

To monitor quality over time, population attributes followed include emergence rates, sex ratio, length of the lifespan, fecundity, adult size, and predation/ parasitism rate. In addition, a committee of the Association of Natural Bio-Control Producers has developed standards for the quality of natural enemies.

Care must be taken with these living organisms to make sure that they arrive at the release site in excellent condition and are not crushed, asphyxiated, overheated, frozen. It is also often important to maintain humidity within packing containers so that natural enemies do not die of desiccation.

When transit requires several days, food can be packed along with the agents (e.g., honey for parasitoids and pollen or prey for predators). Because predators are often generalists they can be cannibalistic when hungry and at high densities will eat each other with the result that fewer individuals arrive at their destination than were packed initially.

Microorganisms

Augmentative release is the major strategy used for controlling insects, weeds and plant pathogens with microbial natural enemies. In contrast with macroorganisms, commercial microorganisms are easier to mass produce, store and apply. For industries in many developed countries to sell microbes for augmentation, the microbe must be registered with governmental agencies.

With microbes, virulence can vary so much from strain to strain that major emphasis is placed on comparing pathogenicity of multiple strains within a species. While virulence studies are always done in the laboratory, plant pathologists strongly suggest that such strain comparisons should also be conducted under field conditions.

Microorganisms to be used for biological control have been in exploration of manipulations to enhance activity. Many microorganisms have much smaller and simpler genomes than macroorganisms and thus have been targets for use of genetic engineering techniques. Genes have been inserted into viruses, bacteria, and fungi used for biological control to (1) enhance virulence, (2) confer resistance to pesticides, and (3) alter host range. Field trials have been conducted by releasing genetically engineered microbial agents in limited areas.

Bacterial pathogen *Bacillus thuringiensis*, require simple media and are relatively cheap to mass-produce in larger fermenters. For other species, it has been important to spend time optimizing nutrients for instance carbon sources, carbon to nitrogen ratios and the fermentation environment such as temperature, pH & aeration. While viruses and some obligate pathogens, can only be grown in living hosts. The need for living hosts can seriously influence the extent to which microbial natural enemies are mass-produced. Among the fungi and bacteria, products are dominated by species and strains that are easy to grow in culture without live hosts.

Mass-produced microbes include (1) assurance that cultures have not become contaminated, especially by microbes pathogenic to humans, (2) assurance that cultures are still virulent to target species, and (3) assurance that active unit numbers, such as fungal spores, are indicated for the product.

Storage and transport

Some microbes can be stored for months or years at room temperature, for example, *B. thuringiensis* spores are thought to survive decades, if not longer. For these species, storage, shelf life, and shipping are similar to synthetic chemical pesticides. This is an important advantage because it allows year-round production and easy storage until the product is needed. Some fungi are more fragile and can be stored only for several months, often with refrigeration. The entomopathogenic fungus *Verticillium lecanii*, sold to control aphids in greenhouses, is viable for a few months when kept cold.

Another advantage of microbes is that they can often be applied with pre-existing equipment used for synthetic chemical pesticides. For materials that can be produced in large quantities and that need to be applied over extensive areas such as large fields, forests, or rangeland, application is possible from the air in contrast with the macro-natural enemies, microbes must be deposited closer to the correct location of the pest because they have less ability to disperse and locate the pest, compared with mobile parasitoids and predators.

Microbes are almost always mixed with other materials to facilitate application; this is called formulation. Microbes are sensitive to desiccation and solar radiation and cannot protect themselves after application. Therefore, formulations can include aids for extending the lives of microbes, such as protectants against ultraviolet radiation. Formulations can also include materials added for delivery to the target pest, such as materials that help the microbe stick to a plant leaf instead of directly washing off. Formulations can help improve the activity of a microbe; for example fungal spores that require free water for germination can be formulated in vegetable oils that retain water.

The most widespread application of macro-beneficials in the field worldwide may be the use of the hymenopteran egg parasitoid *Trichogramma*. These egg parasitoids are mass-produced around the world to control caterpillars in a variety of ecosystems while in micro-organisms, the most important is *Bacillus thuringiensis*, accounting for the majority of the US$75 million per year in sales of natural enemies.

Conservation and enhancement of natural enemies

This strategy for biological control differs from classical biological control and augmentation because natural enemies are not released. Instead, the resident populations of natural enemies are conserved or enhanced.

So it is modification of the environment or existing practices to protect and enhance specific natural enemies or other organisms to reduce the effect of pests.

A fundamental requirement for using conservation and enhancement is that the biology, behavior, and ecology of the pest and natural enemies must be understood to some extent. To develop effective conservation and enhancement of natural enemies we need to understand what factors inhibiting their ability to control pest so can be manipulated to enhance population levels of natural enemies.

Diversity in methods used for preserving and increasing natural enemy numbers and activity

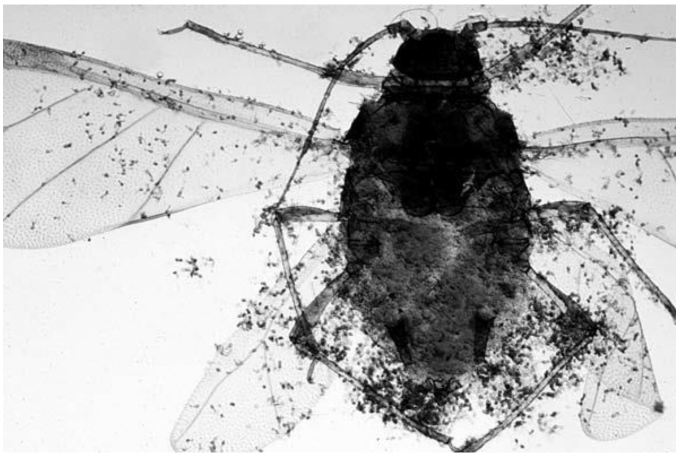
Conservation through altering pesticide use

Enhancement through Providing food, often nectar and pollen sources, Providing permanent habitats, shelter and favorable microclimate, Providing alternate prey or hosts (often present naturally in more diverse habitats).

Use of agricultural chemicals directly kills natural enemies of the target pest or, by killing natural enemies of other organisms in the environment, secondary pests are created. Chemical pesticides also often reduce pest numbers to such low levels that natural enemies cannot persist. Because pests are often great dispersers and faster colonizers than natural enemies, the pests recolonize areas more quickly, leading to habitats lacking of predators and parasitoids. Synthetic chemical pesticides do not always kill natural enemies but can decrease their

longevity and fecundity, thereby decreasing their effect on pests.

Cotton aphids were not considered major pests in the USA until population outbreaks after insecticide applications began for control of boll weevil (*Anthonomus grandis*) in the 1940s. Cotton aphid outbreaks at that time were attributed to elimination of their natural enemies by insecticides. After a pause, cotton aphids again became problematic in the 1980s due to development of resistance to pesticides at the same time that broad spectrum pesticides suppressed natural enemies. Aphid populations can increase rapidly and the honeydew produced by their feeding can make cotton black, dirty, and sticky, decreasing its values.



Dead cotton aphid, *Aphis gossypii*, on a microscope slide. Growth of the fungal pathogen *Neozygites fresenii* is indicated by fungal spores on the aphid's wings and fungal cells growing throughout the body.

Not every natural enemy is killed by each agricultural chemical especially if it was selective pesticides. Also granular formulations that are applied to the soil would not affect natural enemies on the foliage. Systemic pesticides taken up by plants would not affect natural enemies that do not feed on the plant. However, as a warning regarding systemic pesticides, if the pests that are feeding on the plant are not affected by the systemic pesticide and it accumulates in their bodies, natural enemies that are sensitive and then attack pests can be affected.

Pesticides could be applied when natural enemies are not present during the season or when they are in a protected stage such as during pupation. For example, models were used to predict development of a parasitoid and its host, the cereal leaf beetle, *Oulema melanopus*, so that pesticides were applied in the spring before parasitoids had emerged.

Enhancing natural enemy populations

Habitats must provide resources needed by natural enemies, such as food, hosts or prey, shelter, and acceptable abiotic conditions. Often crop habitats fail to provide these resources or they are not provided where or when natural enemies occur. To enhance natural enemy populations, we must learn what resources are limiting the natural enemies and devise methods to provide these limiting resources at the correct time and place. Therefore, understanding the biology and ecology of organisms in a system is critical. Due to the variability among species occurring in different systems.

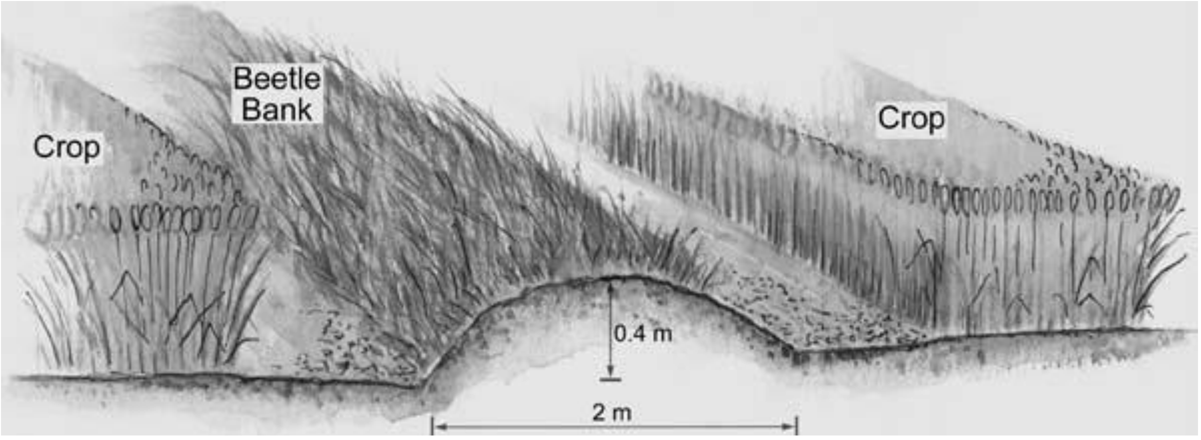
Enhancing habitat for natural enemies and providing refuges: within a crop

Many crops are grown today in simple monocultures which, without change, may not provide the resources required by natural enemies. Food and shelter especially can be minimal after harvest and before a field is replanted. This situation can be altered in various ways, from providing microclimate and shelter to providing alternate food, including nectar, pollen, and alternate hosts or prey and several totally different types of crop plants can be planted within the same field. Natural enemies require carbohydrates for energy and protein for growth and reproduction and these nutrients can be limiting in simplified monocultures.

This practice of polyculture, also called intercropping, is used in over 2.3 million ha in northern China to reduce damage in cotton from cotton aphids. Cotton and wheat are interplanted and natural enemies are thereby maintained in wheat fields. Wheat grows first and natural enemies feed on prey in wheat but as cotton grows, the natural enemies then move into cotton when preys are present. Without wheat as an alternate habitat, once cotton begins to grow, predators will eventually arrive but usually they arrive too late to control aphid populations adequately.

Construction of natural areas that occupy limited areas within fields provides an excellent example of very successful control that has been accepted by growers. One of the most successful applications of conservation biological control is the establishment of permanent strips of natural vegetation within cereal fields, so-called ‘‘beetle banks,” to provide a long-term home for natural enemies.

Beetle bank is constructed by creating a ridge or bank of earth about 0.5 m high and 1.5–2 m wide, extending for most of the length of a field, using two-directional plowing.



In greenhouses where pests are managed using natural enemies, pollen and nectar-bearing flowering plants maintained among the vegetables or ornamentals provide alternate food for the predators and parasitoids that are released.

Cover crops

A dense plant canopy can also improve natural enemy populations by providing a sheltered microhabitat within the crop. Cover crops in citrus orchards in Queensland, Australia, are important for control of phytophagous mites. Between 80% and 95% of growers in the major citrus-growing districts encourage the flowering of Rhodes grass (*Chloris gayana*) during the fruit-bearing season because the grass pollen produced is used as alternate food by predaceous mites. To do this, alternate inter-rows between citrus trees are mowed every 3 weeks to allow time for production of pollen from grass growing

between rows while still maintaining a neat orchard. In addition, 30--50% of growers plant *Eucalyptus* trees with hairy leaves in wind breaks so that pollen is caught on leaves and predators can build up long-term populations in these refuges.

As a caveat, cover crops are not the answer for all systems because in some cases, these plants can compete with the crop plants and decrease yield & cover crops can also provide resources for pests.

Plant characteristics

If monocultures are grown, care can be taken to use cultivars of plants that enhance natural enemies. Extensive studies in greenhouses showed that the whitefly parasitoid *Encarsia formosa* is very effective on numerous vegetable crops, but it consistently did poorly against whiteflies on cucumbers. The main factors for poor activity were that cucumbers are a good host plant for greenhouse whitefly so the pest grows very fast. However, of equal importance, the cultivar of cucumber that was regularly planted had large leaf hairs that reduced the walking speed of the parasitoid. The hairs also caught the sticky honeydew from the whiteflies (the sugar-rich liquid excreta produced from whiteflies, aphids, scale insects, and mealybugs) and if the parasitoids contacted the honeydew, they would become stuck to it. This situation was solved by plant

breeding to develop a cultivar with half of the leaf hairs that were present on the commercial cultivar.

The waxiness of plant leaves can vary by plant cultivar and has been shown to affect natural enemies of herbivores. Predatory insects were released on cabbage cultivars with reduced amounts of wax covering leaves. Adult lady beetles and larval lacewings ate more diamondback moth (*Plutella xylostella*) larvae when hunting on low-wax cabbage leaves. These predators required much more time walking on waxy leaves because wax particles attached to their feet and they spent time either scrambling for attachment or grooming. More recently noticed that more pea aphids (*Acyrthosiphon pisum*) became infected with the fungal pathogen *Pandora neoaphidis* on low wax pea leaves; this due to mechanism by which fewer of the spores of this entomopathogenic fungus adhered to waxy leaves so there was less inoculum to infect aphids on waxy-leaved plants.

The physical environment strongly influences the activity of natural enemies. Application of water has been used to improve the microclimate within crops and enhance pathogens of insect pests. In greenhouses, activity of the fungus *Verticillium lecanii* can be enhanced by watering and providing night-time temperatures that yield the high humidities necessary for infection. Altering plant density also can be used to increase humidity in the microclimate occupied by pest and pathogen. Infections by the fungus *Nomuraea rileyi* in three species of caterpillars were greatest when soybeans were planted early, in narrow rows with high seeding rates so that the plant canopy closed early, thus increasing the relative humidity in the microhabitat occupied by both host and pathogen.

Enhancing habitat for natural enemies: using the area around the field

One of the best-known strategies for conserving and enhancing natural enemies is to provide ‘‘wild insectary” areas at the edges of fields of cultivated plants. These areas of ‘‘companion plants” can serve to provide food and shelter when there is no crop in the field or if the crop does not provide the resources needed by the natural enemy. These areas are much more effective if they are present over the long term so that natural enemy populations can build in them. One well-known example is the use of flowering plants along the edges of agricultural fields to provide nectar for parasitoids and pollen for predators.

Several species in the plant genus *Euphorbia* naturally grew as weeds around sugarcane fields in Hawaii. These plants provided nectar and mating sites for adults of a tachinid fly (*Lixophaga sphenophori*) that parasitized the sugarcane weevil, *Rhabdoscelis obscurus*.

Larvae of hoverflies, or syrphids, can be important predators of aphids. Adults need nectar for energy and pollen for sexual maturation. A flower from dry areas in the North American southwest, *Phacelia tanacetifolia*, was planted alongside winter wheat fields in the United Kingdom and syrphid populations were monitored. More syrphid eggs were laid and fewer aphids were found in wheat field surrounded by flowers. However, precautions have to be taken that the pollen and nectar that are provided do not lead to increases in pest populations.