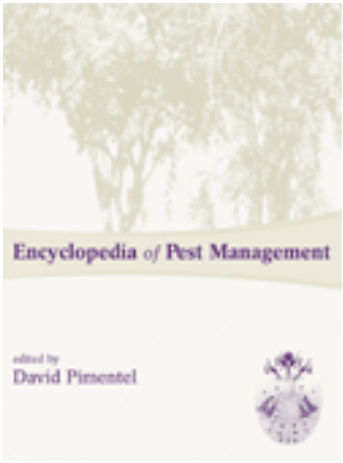


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# Habitat Manipulation for the Conservation of Natural Enemies

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# Habitat Manipulation for the Conservation of Natural Enemies

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**Abstract**
Habitat manipulation for the conservation of natural enemies involves providing and protecting vegetation in and around agricultural areas so that beneficial arthropods can use this vegetation for food, shelter, or overwintering sites. The goal of habitat manipulation is to ensure that natural enemies are present in sufficient numbers when pests become established so that pests are suppressed below economically damaging densities. Hedgerows and beetle banks are examples of long-term provisioned habitat. Beetle banks provide overwintering and dispersal sites for epigeal predators such as carabid beetles, staphylinid beetles, and spiders. Insectary plants are flowering plants grown in association with a crop to offer floral resources to beneficial insects. Nectar and pollen are the primary floral resources provided by insectary plants. Nectar and pollen are important food sources for some parasitic wasps, syrphid fly adults, and predators. In addition, provisioned habitat can offer alternate victims for parasitoids and predators. Many studies have demonstrated increased abundance of natural enemies associated with provisioned habitat. Studies demonstrating a reduction in pest pressure in agricultural crops by natural enemies because of habitat manipulation are less common.



## INTRODUCTION

Habitat manipulation involves providing or protecting vegetation in an agricultural area so that natural enemies can benefit from food and shelter offered by this vegetation. The goal of habitat manipulation is to ensure that natural enemies are present in sufficient numbers when pests become established so that pests are suppressed below economically damaging densities. Habitat manipulation is one component of conservation biological control, which also focuses on limiting the impact of insecticides on natural enemies. It can be used on its own or as one strategy within an integrated pest management program to reduce pest densities.

Hedgerows, grassy banks, and riparian environments that border fields are examples of habitat that can provide overwintering sites and long-term resources for beneficial arthropods.[1] Short -term habitat manipulation often involves incorporating flowering plants into the cropped area early in the crop cycle to provide floral resources to beneficial arthropods and so enhance their activity throughout crop development. Provisioned habitat may also help establish and sustain populations of natural enemies by offering alternative prey and hosts. Habitat manipulation tends to focus on enhancing the activity of endemic natural enemies rather than introduced or augmentatively released natural enemies. Many studies have demonstrated increased abundance of natural enemies in association with insectary plants, beetle banks, and other provisioned habitat. Studies demonstrating reductions in pest pressure in agricultural crops by natural enemies due to habitat manipulation are less common.

## HEDGEROWS, BEETLE BANKS, AND FIELD MARGINS

Hedgerows can be significant sources of arthropod diversity and natural enemies,[2] and are important overwintering sites for generalist epigeal predators such as carabid beetles, staphylinid beetles, and spiders.[3] Hedgerows typically consist of a line of closely planted perennial, woody vegetation. Hedgerows can vary according to species mix, successional stage and understory vegetation, as well as in the quality of floral resources offered. The loss of hedgerows from British and European landscapes in recent decades led to the development of beetle banks as provisioned habitat for epigeal predators. Beetle banks are ridges planted with the perennial, herbaceous vegetation typical of hedgerow understories. Tussocky grasses such as *Dactylis glomerata* L. and *Holcus lanatus* L. seem to provide the best overwintering habitat for epigeal predators such as carabid beetles, staphylinid beetles, and spiders. Beetle banks were originally designed to run through the middle of large fields and so reduce the distance that predators must disperse to colonize aphid-infested cereal crops. Collins et al.[4]

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demonstrated that beetle banks can enhance aphid suppression in wheat.

Unmanaged field margins and woodlands can also provide habitat to many types of predators, including carabid, staphylinid, and coccinelid beetles, Dermaptera, syrphid flies, and Anthocoridae, as well as harvestmen and spiders.[5] Within predator groups, species demonstrate differential preferences for habits, and distinct tendencies to move between habitats. Pollard[6] found that certain syrphid species were only collected in woodland, and others were primarily collected in open habitat. Bedford and Usher[7] report similar findings for ground beetles and spiders. Kajak and Lukasiewicz[8] found in a study in Poland that small staphylinid beetles were the most common predator patrolling between cropland and patches of forest, while spiders and ground beetles were the most common predators moving between crop fields and grasslands.



## FLORAL RESOURCES

Nectar and pollen are the primary floral resources offered to natural enemies through habitat manipulation. Nectar is a sugar-rich liquid produced by flowers and in the extra-floral nectaries of some plants. In addition to sugars, floral nectar contains proteins, amino acids, lipids, and other substances.[9] Faba beans (*Vicia faba* L.), various members of the Malvaceae, and other plant families contain extrafloral nectaries. Sugar sources have been demonstrated in a number of studies to improve longevity, fecundity, and searching ability in parasitoids.[10] Pollen is necessary for gametogenesis in syrphid adults. Pollen is also consumed by parasitic wasps, ladybird beetles, green lacewings, and other natural enemies. In addition, honeydew produced by various sucking insects in provided habitat can serve as an indirect food source to beneficial insects, including Coccinelidae, Chrysopidae, and Tachinidae. Vegetation can also offer seeds and sap as a food source to beneficial insects.[11]

Insectary plants are often annual flowering plants that are grown in association with crops in order to enhance the activity of parasitoids and predators, although some of the most useful insectary plants such as sweet alyssum [(*Lobularia maritima*) L. (Desv.)] are perennials. Commonly used insectary plants include phacelia (*Phacelia tanecetifolia* Benth.), buckwheat (*Fagopyrum escuelentum* Moench), sweet alyssum, various Apiaceae (common and dhani-ya coriander [*Coriandrum sativum* L.]; dill [*Anethum graveolens* L.]), mustards, and clovers. Commercially available ''good bug blends'' contain mixtures of flowering plants, grasses, and forbs. In Switzerland, the government encourages the use of sown wildflower strips on field margins in part to serve as insectaries.[10] Weeds can also provide floral resources and alternate victims to beneficial arthropods, and so serve as insectary plants.

Insectary plants can be intercropped or undersown with the main crop, or planted on the field margin. Insectary plants must integrate easily into target cropping systems and not create new problems. They should establish easily, not become weedy, and not serve as a significant host of pathogens or insect pests. Flower architecture must be compatible with the morphology of desired beneficial arthropods so that nectar and pollen are accessible.[9,12] Insectary plants may vary in the quality of nectar, pollen, and alternate victims that they offer beneficial arthropods. The usefulness of the insectary planting is also influenced by the timing, duration, and abundance of flower production.

## SOME EXAMPLES

Several studies have evaluated the impact of insectary plantings on parasitism and predation of pests of cole crops with variable results. For example, Zhao et al.[13] found that intercropping broccoli with nectar-producing plants increased densities of diamondback moth (*Plutella xylostella* [L.]) and imported cabbageworm larvae (*Artogeia rapae* L.) when compared to with broccoli grown in monoculture. However, cabbage aphid (*Brevicoryne brassicae* L.) and green peach aphid (*Myzus persicae* [Sulzer]) were suppressed in cabbage planted with phacelia, presumably by syrphid larvae.[14] Predation of Colorado potato beetle egg masses was greater on eggplant interplanted with coriander and dill than on eggplant alone in experiments carried out in New Jersey.[15] In Australia, alfalfa (*Medicago sativa* L., also called lucerne) has been evaluated as a means to increase generalist predators and suppress *Helicoverpa* sp. [16]

Habitat manipulation in vineyards has included the use of buckwheat and sunflower (*Helianthus annuus* L.) cover crops to enhance natural enemies of the western grape leafhopper, *Erythroneura elegantula* (Osborn) and western flower thrips, *Frankliniella occidentalis* (Pergande).[17] Prune trees (*Prunus domestica* L.) have been evaluated as refuge plants in California vineyards for *Anagrus epos* Girault, an egg parasitoid of *E. elegantula*. Prune trees support the prune leafhopper, *Edwardsiana prunicola* (Edwards) an alternate host for *A. epos*, and have been associated with enhanced levels of egg parasitism of the grape leafhopper.[18]

## CONCLUSION

The perceived advantages and risks associated with habitat manipulation for conservation of natural enemies vary in different parts of the world, and according to the cropping system in question. Hedgerows and other provisioned environments are also valued because they can help address problems related to soil erosion and water quality on farms. In addition, they provide habitat for birds and other animals, and this has led to the development of food safety concerns. Current priorities in habitat manipulation include determining the optimal spatial arrangement of habitat in order to enhance colonization of cropped areas by beneficial arthropods, and ongoing evaluation of plant species as resources for natural enemies. The economic impact of taking land out of production in order to provide habitat requires ongoing analysis.



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