Farmscaping to Enhance Biological Control

by Rex Dufour
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December 2000

Abstract: This publication contains information about increasing and managing biodiversity on a farm to favor beneficial organisms, with emphasis on beneficial insects. The types of information farmscapers need to consider is outlined and emphasized. Appendices have information about various types and examples of successful “farmscaping” (manipulations of the agricultural ecosystem), plants that attract beneficials, pests and their predators, seed blends to attract beneficial insects, examples of farmscaping, hedgerow establishment and maintenance budgets, and a sample flowering period table.

Hedgerow of insectary plants at Fong Farms Ltd. in Woodland, CA.

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Thank You for your valuable feedback!
“Farmscaping” is a whole-farm, ecological approach to pest management. It can be defined as the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, bats, and birds of prey.

In some respects, beneficial organisms should be considered—and managed as—mini-livestock. The larger varieties of livestock are healthier and reproduce more readily when provided an adequate and nutritious diet. Likewise, “mini-livestock” require adequate supplies of nectar, pollen, and herbivorous insects and mites as food to sustain and increase their populations. The best source of these foods is flowering plants.

Farming, like other components of sustainable agriculture, requires more knowledge and management skill on the part of the grower than conventional pest management. The investment in knowledge and management may yield such benefits as:

♦ A reduction in pesticide use
♦ Savings in pesticide costs
♦ Reduced risk of chemical residues on farm products
♦ A safer farm environment and more on-farm wildlife.

However, farmscaping is not a magical cure for pest problems. It is simply an ecological approach to pest management that can be an integral component of a biointensive integrated pest management (IPM) program.

The use of farmscaping to increase beneficial organism habitat must be understood and practiced within the context of overall farm management goals. For example, when considering planting a perennial hedgerow the producer should evaluate the various costs and benefits likely to be associated with a hedgerow. Growers with farmscaping experience will likely be the best source for this kind of information.

There are probably as many approaches to farmscaping as there are farmers. Some growers, after observing a cover crop harboring beneficial insects, plant strips of it in or around their crop fields. The advantages of this kind of approach are:

♦ It is simple to implement
♦ It is often very effective

Benefits should be viewed as mini-livestock. They will be healthier, reproduce more readily, and be more effective biocontrols when provided habitat with an adequate and easily available diet of nectar, pollen, and herbivorous insects and mites.

Feedback

1. What information do you think is missing from this publication?

2. Do you know someone implementing farmscaping techniques on their farm? Can you pass on their address and phone number?

3. Do you know of farmscaping-related research that would improve this publication?

4. Do you know of a good farmscaping-related website not listed in this publication?
In other instances the beneficials may not exist in numbers sufficient to control pest populations during the time when pest populations generally increase. Predator/prey population balances are influenced by the timing of availability of nectar, pollen and alternate prey/hosts for the beneficials. Therefore, there is a strong argument to be made for having year-round beneficial organism habitat and food sources. The “beneficial habitat season” may be extended by adding plants that bloom sequentially throughout the growing season or the whole year.

When contemplating farmscaping, consideration should be given to the cost of developing beneficial habitat and maintenance of the habitat as well as the cost of any land that might be taken out of production. In any case, a more systematic, research-oriented approach to farmscaping can often help the grower avoid mistakes and develop desirable habitats that match the needs of the beneficial organisms as well as the pest management needs of the farm.

The following are key considerations in crafting a farmscaping plan:

1. Ecology of Pests and Beneficials
   - What are the most important (economic) pests that require management?
   - What are the most important predators and parasites of the pest?

2. Timing
   - When do pest populations generally first appear and when do these populations become economically damaging?
   - When do the most important predators and parasites of the pest appear?
   - When do food sources (nectar, pollen, alternate hosts, and prey) for beneficials first appear? How long do they last?
   - What native annuals and perennials can provide habitat?

3. Identification of Strategies
   - Reduction of pest habitat (i.e., reduce/alter overwintering pest sites, or reduce/alter locations from which pest invades.)
   - Augmentation of beneficial habitat (insectary establishment; consider both perennial options—permanent plantings such as hedgerows—and annual options.)
   - Trap Crops—planted specifically to be more attractive to the pest than is the crop to be harvested. This is due to the timing of the appearance of the trap crop or the fact that it is physiologically more attractive to the insect. (Please see appendices D and G for descriptions of planting systems that can be used in farmscaping.)
4. Insectary Establishment

- Seed and plant sources
- Cost of ground preparation, planting and maintenance (irrigation, weeding, etc.) for:
  - at least one year following establishment of perennials
  - needed number of plantings per season of beneficial habitat (remember that many annuals provide pollen or nectar for only a few weeks during the cropping season, so that either relay plantings or plant species mixes may be needed for beneficial habitat.)
- Equipment needs (Cost estimates for installation and first-year maintenance of a typical hedgerow in California are given in Appendix E.)

Other Considerations

Weather

Weather variations from year to year may cause a particular management practice to be beneficial one year and problematic the next. A flexible approach is needed in order to adjust beneficial habitat according to weather variations. An observant eye is the grower’s most valuable tool in this respect.

Perennial vs. Annual

The type of cropping system, perennial vs. annual, is an important factor in farmscaping. Perennial systems such as orchards possess an inherent ecological stability derived from the variety of tree-based habitats, which are not harvested or destroyed as in annual systems. Adding a cover crop to an orchard can increase and complement the biodiversity of the system.

Ideally, cover crops (CCs) in orchard systems should be selected and managed for the following attributes (1):

- CCs should not harbor important orchard pests
- CCs should have some ability to divert generalist pests from the orchard crop
- CCs should confuse specialist pests visually or olfactorily (by smell) and thus reduce their colonization of orchard trees
- CCs should be capable of altering host-plant nutrition (without negatively impacting the crop) and thereby reduce pest success
- CCs should reduce dust and thereby reduce spider mite outbreaks
- CCs should change the microclimate and thereby reduce pest success
- CCs should increase natural enemy abundance or efficiency, thereby increasing biological control of arthropod pests.

Studies of commercial pecan orchards in Oklahoma (2) and almond plantations in California (3) have demonstrated the efficacy

Resources

For information about crop pests, their parasites and predators, and the ecological requirements of both, contact your local county extension service (under county listings in the phone book) or state Cooperative Extension Service (CES):


Biological Control: A Guide to Natural Enemies of North America:

http://www.nysaes.cornell.edu/ent/biocontrol/

To receive a free copy of Suppliers of Beneficial Organisms of North America, call the California EPA’s Department of Pesticide Regulation:

(916) 324-4100 or download from:

http://www.cdpr.ca.gov/docs/dpr/docs/goodbug/benefic.htm

Appendix G

Farmscaping Practices Defined

The practices described below can be integrated with an array of cultivation schemes. Each farm can take advantage of the variety of farmscaping tools available to create a cropping system especially suited to its unique environment.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companion planting</td>
<td>A mix of species of plants within a row or bed–was rated difficult to manage by farmers in one study (G1) due to varying cultural needs such as planting time, irrigation needs, and harvesting.</td>
</tr>
<tr>
<td>Strip planting, strip cropping</td>
<td>The practice of growing two or more crops in different strips across a field wide enough for independent cultivation, (e.g., alternating six-row blocks of soybeans and corn, or alternating strips of alfalfa with cotton) was rated as most easily adapted to vegetable production systems (G1). Like intercropping, strip cropping increases the diversity of a cropping area, which in turn may help ‘disguise’ the crops from pests. Another advantage is that one of the crops may act as a reservoir and/or food source for beneficial organisms. However, much more research is needed to study the complex interactions between different crops and their pest and predator complexes.</td>
</tr>
<tr>
<td>Multiple cropping</td>
<td>The production of more than one crop on the same land in one year. Depending on the type of cropping sequence used, multiple cropping can be useful as a weed control measure, particularly when the second crop is interplanted into the first.</td>
</tr>
<tr>
<td>Interplanting</td>
<td>The seeding or planting of a crop into a growing stand, such as oversowing a cover crop into a grain stand.</td>
</tr>
<tr>
<td>Intercropping</td>
<td>The practice of growing two or more crops in the same, alternate, or paired rows in the same area. This technique is particularly appropriate in vegetable production. The advantage of intercropping is that the increased diversity helps “disguise” crops from insect pests, and if done well, may allow for more efficient utilization of limited soil and water resources.</td>
</tr>
<tr>
<td>Cover crops</td>
<td>Cover crops and green manures can be integrated into both perennial and annual cropping systems. Cover crops, often a legume or grass species, prevent soil erosion and suppress weeds. A cover crop can also be used as a green manure.</td>
</tr>
<tr>
<td>Green manures</td>
<td>Generally incorporated into the soil to provide nitrogen and organic matter for subsequent crops. When incorporated, some cover crops in the Brassica family (such as rapeseed, broccoli and radish) have the ability to suppress nematode pests (G2). Left in the field as residues, rye, wheat, and some other grasses will provide greater than 90 percent weed suppression (G3,G4).</td>
</tr>
<tr>
<td>Windbreaks, Shelterbelts and Hedgerows</td>
<td>These are linear barriers of trees, shrubs, perennial forbs and grasses that are planted along field edges or other unused areas. When done correctly, they reduce windspeed and, as a result, modify the microclimate in the protected area. Aside from providing a microclimate favorable to beneficial organisms, shelterbelts also protect against wind erosion of soil, decrease the dessicating effect of winds on crops, help enhance snow distribution and provide wildlife habitat.</td>
</tr>
<tr>
<td>Permanent border</td>
<td>A strip of permanent vegetation bordering a field. A border such as this can be modified to attract beneficial insects throughout the cropping season if the proper plants are used and sufficient water is made available.</td>
</tr>
</tbody>
</table>

Sources:

Appendix F

Flowering Periods of California Native Insectary Plants

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Genus/ sp.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willow</td>
<td>Salix sp.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>California lilac</td>
<td>Ceanothus spp.</td>
<td></td>
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<td>X</td>
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<td></td>
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<tr>
<td>Mule fat</td>
<td>Baccharis cinerea</td>
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<tr>
<td>Coffeeberry</td>
<td>Rhamnus californica</td>
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<td></td>
<td></td>
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<tr>
<td>Hollyleaf cherry</td>
<td>Prunus ilicifolia</td>
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<td></td>
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<tr>
<td>Yarrow*</td>
<td>Achillea millefolium</td>
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<tr>
<td>Silverleaf vine</td>
<td>Pygopus askewii</td>
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<td></td>
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<tr>
<td>Toyon</td>
<td>Hetomoeoeis arbustifolia</td>
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<td></td>
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<tr>
<td>Golden sticky monkeyflower</td>
<td>Menites guttulus</td>
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<td></td>
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<tr>
<td>Elderberry</td>
<td>Sambucus mexicana</td>
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<tr>
<td>California buckwheat*</td>
<td>Eriogonum fasciculatum</td>
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<tr>
<td>Deergrass</td>
<td>Muhlenbergia rigens</td>
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<tr>
<td>Creeping boobilal</td>
<td>Murraya pareifolia</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>California fuchsia</td>
<td>Zauschneria californica</td>
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<td></td>
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<tr>
<td>Narrowleaf milkweed</td>
<td>Lactuca fasicularis</td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>St. Catherine’s lace</td>
<td>Zauschneria gigantea</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Coyote bush</td>
<td>Baccharis pilularis</td>
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</tr>
</tbody>
</table>

*Insects prefer common yarrow over the ornamental (salmon-colored) yarrows. Yarrow reseeds itself well.

**California buckwheat is very attractive to beneficials, but also very sensitive to overwatering.

Source:

Microplitis croceipes, a parasitoid of the corn earworm in cotton (7). Important findings included:

- Retention of the wasp and parasitization rates were highest in cotton plots in which wasps were able to feed on extraloral nectar.
- Retention of the wasp and parasitization in patches with honeydew was comparable to patches without food—probably due to the rapid increase in quality of honeydew as it dries, combined with low quantity per site and general low detectability of this food by the parasitoid. Honeydew is scattered about randomly within a field and on a plant.
- Extrafloral or floral nectaries, on the other hand, are always found at the same location on a particular plant, making it easier for beneficials to locate this food source.
- Important characteristics of an ideal food source in the field are high quality, high quantity per site, high detectability, and high predictability of the food location. Nectar sources possess all these qualities.

To summarize this research, some species of parasitic wasps will stay in an area with nectar and host locations is too great or when the wasp can spend more time hunting for food. Many parasitoids will disperse from target areas in hungry parasitoids. As a consequence, parasitoids will disperse from target areas in search for food. After feeding, parasitoids will move up to 250 feet into the adjacent crop and ecosystem so that parasites spend most of their time controlling pests (as opposed to searching for food) and producers know how much land insectaries will require and where they are most effectively placed.

The appearance of beneficials should be timed to coincide with peak need for biological control of pests associated with the main crop. Another way of looking at this is that an insectary should grow and bloom at a time that best meets the needs of beneficials for pollen, nectar, or alternate hosts. Strategies to prolong bloom include planting cover crops in strips on successive planting dates. Planting a mix of plants, particularly perennials, that bloom in succession and that meet the habitat needs of desired beneficials is another farmscaping option. It may be helpful to develop a diagram, such as the one below (from Appendix F), when planning habitat that will have something in flower year-round.

**Appendix E**

**Hedgerow Installation and Maintenance Cost Estimates**

For one hedgerow 1400 feet long x 15 feet wide (~.5 acre) planted with a strip of native grasses next to a line of shrubs. Labor costs are estimated at $10/hr.

<table>
<thead>
<tr>
<th>Task</th>
<th>Date of Cost Estimate</th>
<th>Labor</th>
<th>Material</th>
<th>Equipment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hedgerow Installation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedgerow design</td>
<td>Nov. 96</td>
<td>$260.00</td>
<td>Survey flags: $8.00</td>
<td></td>
<td>$268.00</td>
</tr>
<tr>
<td>Roundup: summer weed control</td>
<td>Aug. 96</td>
<td>$20.00</td>
<td>Roundup: $30.00</td>
<td>ATV+sprayer: $8.08</td>
<td>$58.08</td>
</tr>
<tr>
<td>Disk: pre-plant weed control</td>
<td>Oct. 96</td>
<td>$10.00</td>
<td></td>
<td>Tractor+disc: $18.08</td>
<td>$28.08</td>
</tr>
<tr>
<td>Fertilize/proplant (tables)</td>
<td>Nov. 96</td>
<td>$4.00</td>
<td>Fertilizer: $43.50</td>
<td></td>
<td>$47.50</td>
</tr>
<tr>
<td>Plant trees, shrubs, and forbs</td>
<td>Nov. 96</td>
<td>$120.00</td>
<td>Oracite: $50.00</td>
<td></td>
<td>$170.00</td>
</tr>
<tr>
<td>Install 2 tubes tree tube</td>
<td>Nov. 96</td>
<td>$20.00</td>
<td>Tubes: $172.00</td>
<td></td>
<td>$192.00</td>
</tr>
<tr>
<td>Plant grasses (broadcast)</td>
<td>Nov. 96</td>
<td>$30.00</td>
<td>Seed: $257.00</td>
<td></td>
<td>$287.00</td>
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<tr>
<td>Harvest to cover grass seed</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td></td>
<td></td>
<td>$10.00</td>
</tr>
<tr>
<td>Roundup: annual weed control</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td>Roundup: $15.00</td>
<td></td>
<td>$25.00</td>
</tr>
<tr>
<td>Ronstar-G: apply in plant row</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td>Ronstar-G: $75.00</td>
<td></td>
<td>$85.00</td>
</tr>
<tr>
<td>Install drip irrigation system</td>
<td>Mar. 97</td>
<td>$100.00</td>
<td>Drip supplies: $200.00</td>
<td></td>
<td>$300.00</td>
</tr>
<tr>
<td><strong>Total Installation</strong></td>
<td></td>
<td>$640.00</td>
<td>$1,319.00</td>
<td>$44.54</td>
<td>$2,003.54</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Task</th>
<th>Date of Cost Estimate</th>
<th>Labor</th>
<th>Material</th>
<th>Equipment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hedgerow Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2.4 D: Broadleaf weed control</td>
<td>Mar. 97</td>
<td>$10.00</td>
<td>2.4 D: $20.00</td>
<td>ATV+sprayer: $4.04</td>
<td>$34.04</td>
</tr>
<tr>
<td>New hedge plant row*</td>
<td>Mar.-Sept. 97</td>
<td>$20.00</td>
<td></td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Irrigate twice/no.</td>
<td>Mar.-Aug. 97</td>
<td>$225.00</td>
<td>Emitters/plugs: $8.25</td>
<td></td>
<td>$233.25</td>
</tr>
<tr>
<td>Mow grasses: annual weed control</td>
<td>Apr. 97</td>
<td>$10.00</td>
<td></td>
<td>Tractor+mower: $10.19</td>
<td>$20.19</td>
</tr>
<tr>
<td>Remove Tubes</td>
<td>Apr.-May 97</td>
<td>$20.00</td>
<td></td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Roundup: spot-spray</td>
<td>May-Jun 97</td>
<td>$20.00</td>
<td>Roundup: $15</td>
<td></td>
<td>$35.00</td>
</tr>
<tr>
<td>Fertilize: proplant (tables)</td>
<td>Sep. 97</td>
<td>$10.00</td>
<td>Fertilizer: $87.70</td>
<td></td>
<td>$97.70</td>
</tr>
<tr>
<td>Replant trees, shrubs &amp; forbs</td>
<td>Sep. 97</td>
<td>$80.00</td>
<td>Plants: $100.00</td>
<td></td>
<td>$180.00</td>
</tr>
<tr>
<td>2.4 D: spot-spray in grasses</td>
<td>Sep. 97</td>
<td>$10.00</td>
<td>2.4 D: $10.00</td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Flame: annual grass weed control</td>
<td>Oct. 97</td>
<td>$10.00</td>
<td>Flamin: $15.00</td>
<td>ATV: $15</td>
<td>$40.00</td>
</tr>
<tr>
<td>Ronstar-G: entire hedgerow</td>
<td>Oct. 97</td>
<td>$20.00</td>
<td>Ronstar-G: $225.00</td>
<td></td>
<td>$245.00</td>
</tr>
<tr>
<td>Mow grasses: twice weed control</td>
<td>May-Mar. 98</td>
<td>$20.00</td>
<td></td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Hoe hedge plant row</td>
<td>Jun-Jul 98</td>
<td>$120.00</td>
<td></td>
<td></td>
<td>$120.00</td>
</tr>
<tr>
<td>Irrigate twice/no.</td>
<td>Apr-Sep 98</td>
<td>$200.00</td>
<td></td>
<td></td>
<td>$200.00</td>
</tr>
<tr>
<td>Hoe hedge plant row</td>
<td>Jun-Jul 98</td>
<td>$120.00</td>
<td></td>
<td></td>
<td>$120.00</td>
</tr>
<tr>
<td>Harvest: 2,4 D (in grasses)</td>
<td>Aug. 98</td>
<td>$100.00</td>
<td>2,4 D: $10.00</td>
<td></td>
<td>$110.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td>$1,160.00</td>
<td>$411.95</td>
<td>$38.65</td>
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<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td>$1,800.00</td>
<td>$780.95</td>
<td>$180.65</td>
<td>$3,761.60</td>
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</tbody>
</table>

Source: Kimball and Lamb, 1999. (See p. 36)
Appendix D

Examples of Farmscaping continued

<table>
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<tr>
<td>Phylloxera on Grapes</td>
<td>California: A recent 2-year field study (D8) by UC Davis researchers found that soil management practices can significantly influence the amount of root damage resulting from phylloxera-induced fungal infections. The researchers found that per root unit root populations of phylloxera did not significantly differ between organically managed vineyards (OMV) and conventionally managed vineyards (CMV), when both were infested with phylloxera. However, root samples from OMVs displayed significantly less root necrosis (9%) caused by fungal pathogens than did samples from CMVs (31%). Organic vineyard management is characterized by use of cover crops and composts and no synthetic fertilizers or pesticides. This study sampled four OMVs in Sonoma, Napa and Mendocino Counties. Eight CMVs were initially sampled in these counties and San Joaquin County. This was later reduced to five CMVs for practical reasons. All vines except for those in San Joaquin (own-rooted) were on AXR#1 rootstock. No significant differences between OMVs and CMVs were found for single year comparisons of percent organic matter, total nitrogen, nitrate and percent sand/silt/clay. The pooled data for the two years tell a slightly different story: OMVs soil had a significantly higher (by 5%) percent organic matter (%OM) than CMVs soil and over all vineyards and all years there was a weak but significant inverse correlation between root necrosis and soil %OM. Cultures of the necrotic root tissue also revealed some interesting differences: significantly higher levels of the beneficial fungus Trichoderma were found in CMVs in 1997 (but not in 1998) and significantly higher levels of pathogens Fusarium oxysporum and Cylindrocarpon spp. were found in CMVs in 1998 (but not in 1997).</td>
<td>Dr. Jeffrey Granett 380B Briggs Hall (530) 752-1537 FAX: (530) 752-1237 <a href="mailto:grannett@ucdavis.edu">grannett@ucdavis.edu</a></td>
</tr>
</tbody>
</table>

Sources:


The migration of certain species of beneficials from the cover crop(s) to the main crop is sometimes associated with senescence (or post-bloom period) of the cover crop. In these instances, moving the cover crops in alternate strips may facilitate their movement while the remaining strips continue to provide refuge for other beneficial species. Sickle-bar mowers are less disruptive to be beneficials than flail mowers and rotary mowers.

Mulches

Although this publication generally focuses on living habitat, clearly some beneficial organisms, such as spiders and ground beetles, benefit from mulches (or a habitat that mimics some of the effects of mulches, such as that found in “no-till” fields). Much of the benefit lies in the fact that mulches provide overwintering habitat for these organisms in a moderated microclimate (9).

Trap Crops

A related strategy in farmscaping is the selection of plants that attract pests. These “trap crops” can then be plowed down or managed in some fashion that takes advantage of a vulnerable stage in the crop pest life cycle. See Appendix D for examples of farmers using trap crops.

Birds and bats are important insect predators, particularly during the spring when they are raising young. Their activities complement each other. Birds are generally active during the day and feed on caterpillars and other insects, while bats feed during dusk and into the night on mosquitoes, moths, and other nocturnal insects.

Birds and bats are both amenable to living in artificial shelters—free-standing or attached to a building. This could be a slightly modified structural component of a building, such as nest shelves along eaves for barn swallows (10) or a spaced board attached to a beam for bat habitat. Bats, frequently found in man-made structures, prefer places that are warm, dry, and protected from disturbance (11).

Both birds and bats will benefit from having a small pond or body of water on the property or nearby. Bats require a watering area ideally 10 feet in diameter, and protected from disturbance (11). Bats not only eat insects that are a nuisance to humans (a small brown bat can devour up to 600 mosquitoes in an hour), but can provide significant agricultural pest control services. In one season, a typical colony of about 150 big brown bats in the Midwest eats 50,000 leafhoppers, 38,000 cucumber beetles, 16,000 June bugs, and 19,000 stink bugs (11) — not to mention thousands of moths such as adult corn borers, earworms, and cutworms.

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Bat Housing

The easiest way to construct bat housing is to simply add a sheet of plywood to a barn or house wall with ¾” spacers between the sheet and wall. Placing the long axis of the plywood vertically will allow for greater temperature variation in the bat space. (See pages 13–14 for contacts who know about bat habitat and housing.)

Other construction considerations include (11):

- Use exterior-grade plywood with exterior-grade staples and bolts.
- Minimum bat house dimensions are 32” tall, 14” wide, with 3-6” landing pads.
- Provide 1-4 roosting chambers, spaced at ¾”. Landing pad and roosting chamber should be roughened or have a durable textured surface for the bats to grasp—no sharp points to tear bat wings!
- Front and side venting should be appropriate for local climate.
- All seams should be caulked to avoid leaks.
- Treating bat houses with diluted bat guano or allowing some weathering of a new bat house may help attract new “renters”.

Considerations when locating a bat house (11):

- Any place that already has bats is best, particularly agricultural areas (vs. urban areas) due to insect abundance and habitat variety.
- Place the bat house near water—within a quarter mile is ideal.
- Place it near some sort of protective cover like a grove of trees—don’t place houses in a grove of trees, but 20–25 ft. away due to predator concerns, and at least 10 ft. above the ground.
- Don’t place bat houses near barn owl boxes—the barn owl is a bat predator. Place the two types of boxes a fair distance from each other facing in opposite directions.
- Do not mount bat houses on metal buildings (too hot for bats) or in locations exposed to bright lights.
- In California, bat houses in barns and on the north and west sides of buildings have had the greatest rate of occupancy. This may not be true for locations in other parts of the country.
- Paint the exterior with three coats of outdoor paint. Available observations suggest that the color should be black where average high temperatures in July are 80–85°F, dark colors (such as dark brown or gray) where they are 85–95°F, medium or light colors where they are 95–100°F, and white where they exceed 100°F. Much depends upon amount of sun exposure; adjust to darker colors for less sun. (14)

Bat Conservation International
P.O. Box 162603, Austin, TX 78716
(512) 327-9721
http://www.batcon.org/

or contact,
Rachael Freeman Long
Yolo County Farm Advisor
UC Cooperative Extension
(530) 666-8143

For further information about bats and bat houses, contact:

Bat Conservation International
P.O. Box 162603, Austin, TX 78716
(530) 666-8143
http://www.batcon.org/

or contact,
Rachael Freeman Long
Yolo County Farm Advisor
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(530) 666-8143

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| Leaffoppers and spider mites in vineyards | California: If properly managed, winter annual, legume/grass (oat/vetch) cover crops can reduce the reliance of grape growers on insecticides and miticides used to control leaffoppers and spider mites. Two systems: 1) the cover crop as dry mulch by cutting the cover crop biomass and placing it on row berm for weed suppression to reduce herbicide use, 2) cover crop was cut and left in row middles. If sulfur dust (used for disease control) was used sparingly in late Spring and early Summer, the presence of these cover crops increased early season activity of predatory mites, resulting in reduced spider mite infestations. Similarly, where leaffopper numbers were not very low and cover crops were properly maintained through early July, the presence of cover crops resulted in reduced infestations of leaffoppers. These reductions were attributed to enhanced activity of certain groups of spiders, which consistently attained higher densities in the presence of cover crops compared to the clean-cultivated systems. Leaffoppers were also utilizing the cover crops as non-host crops, which may have resulted in less time spent on vines. | Frank G. Zalom
Extension Entomologist
Department of Entomology
University of California Davis, CA 95616
(916) 752-8350
FAX: (916) 752-6004
E-Mail: fgzalom@ucdavis.edu |
| Aphids in Cereals (D3) | England: Recent research in England indicates that by planting border strips of Phacelia tanacetifolia Bentham (a North American annual that is a good source of pollen for syrphids—syrphid larvae feed on aphids) among cereal fields, significant reductions of aphid populations can be obtained. Increased populations of syrphid flies extended up to 180 meters (395 yards) from the border strips. The researcher notes that in seasons of early crop maturity, syrphid fly larvae may not be able to decrease aphid populations due to lack of attractiveness of the “older” wheat to ovipositing syrphids. | Janice M. Hickman
Department of Biology,
School of Biological Sciences,
Biomedical Sciences Building
The University,
Southampton, SO16 7PX
UK |
| Pest in Vegetables | North Carolina: Organic vegetable grower plants an insectary strip every 36 feet or so (i.e., if growing canteloupes on 6 foot rows, the 7th row will be an insectary strip, or if growing peppers on 3 foot rows, every 13th row will be planted in an insectary strip). Rye/vetch mixtures are planted in the fall and will flower early in the spring and are plowed down and sequentially replaced with buckwheat prior to the rye/vetch going to seed. For example, one week a third of the rye/vetch rows may be plowed down and replaced with buckwheat. A few weeks later, another third will be plowed down, etc. This way, there is habitat as well as continual pollen and nectar sources for beneficial insects throughout most of the year. During the summer, the buckwheat is also replaced sequentially as it senesces. The farmer states that this system has been very successful. | Kenny Haines
Looking Back Farms
St. B, 1292 New Bridge Rd
Tyner NC, 27980
(252) 426-2218
FAX: (252) 426-9661 |
| Pests in Cotton (D6) | Texas: This study examined the predator flux between adjacent planted cotton and grain sorghum fields. It was found that there was a general influx of generalist predators (Orius spp.—minute pirate bug, and Hippodamia convergens—convergent lady beetle) from sorghum to cotton, although dispersion of predators works in both directions and may be dependent on both crop phenology and associated food resources (i.e., lack of or abundance of herbivorous prey). | Jarrahd R. Prasifka
Biological Control Lab
Department of Entomology
Texas A&M University
College Station, TX 77843-2475
(409) 862-3407
email: jrp7200@labs.tamu.edu |
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</thead>
<tbody>
<tr>
<td>Cabbage aphid in broccoli</td>
<td>Oregon: In an on-farm research trial exploring the use of beneficial insectary flowers to increase the abundance of predatory insects, experimental plots using the insectary plant <em>Alyssum maritime</em> showed a significant increase in predacious syrphid flies caught in traps and in number of syrphid eggs laid on broccoli leaves. Parasitism of the cabbage aphid was doubled in the alyssum plots. Bugg and Ellis (D4) observed that flowers of canola attracted adults of the following species of hoverflies (Syrphidae): <em>Allograpta oliva</em> (Gy), <em>Sphaerophoria spp.</em>, <em>Syrphus spp.</em>, and <em>Toxomerus spp.</em> Larvae of all of these species are predators of aphids.</td>
<td>John Luna Oregon State University Dept. of Horticulture Corvallis, OR 97331 (541) 737-5430</td>
</tr>
<tr>
<td>Diamondback moth on crucifers</td>
<td>Florida: Trap crops of highly fertilized collards planted in a border around cabbage fields are more attractive to egglaying adult female diamond back moths (dbms). This resulted in minimal damage from dbm to cabbages. In commercial cabbage fields, two rows of collards were planted around perimeters with seven collar plants planted on the ends of each cabbage row. Cabbage fields with collards required 75-100% fewer chemical applications than those without collards. Marketability from both collar and non-collar fields was the same.</td>
<td>Everett Mitchell USDA-ARS 1600 S.W. 23rd Dr. Gainesville, FL 32604 (352) 374-5710</td>
</tr>
<tr>
<td>Black Flea beetles on crucifers</td>
<td>Eastern Colorado: Radish cultivar, “Japanese Daikon” as trap crop interplanted at 2’ intervals within broccoli rows, which were planted 16” apart. This technique reduced the numbers of black flea beetles colonizing broccoli compared to plots without interplanted radishes or with interplanted radishes at lower densities (D7).</td>
<td>Mohammed Al-Doghbairi 1700 W. Plum St. #379 Ft. Collins, CO 80521 (970) 491-3055 or 3261</td>
</tr>
<tr>
<td>Azelea lace bug on Landscape/ornamentals</td>
<td>New Jersey: The presence of flowering plants—shasta daisy plugs (<em>Little Princess Chrysanthemum maximum</em> and <em>Marconi chrysanthemum superbum</em>) and coriander (<em>Coriandrum sativum</em>)—reduced lacebug numbers because of the buildup of syrphids, lady beetles and other unidentified predators. There appears to be a seasonal impact of flower species on the duration of predator species and abundance. Coriander flowered earlier but more briefly than the two daisy species, and appeared to harbor less diversity than the daisy. However, there were more species of syrphids in the coriander. The azaleas were small, and researchers believe that many released lacewings left the plots. The flowers and azaleas established well, so prospects for clear results are high in 1999.</td>
<td>Paula M. Shrewsbury Rutgers University Dept. of Entomology, 13th Smith Hall, P.O. Box 231 New Brunswick NJ 08903 (908) 932-9324</td>
</tr>
<tr>
<td>Leafhoppers and flower thrips in vineyards</td>
<td>California: This study suggests that the creation of corridors of sequentially flowering native plant species can serve as a key strategy to allow natural enemies emerging from riparian forests to disperse over large areas of otherwise monoculture systems. This study examined distributions and abundance of western grape leafhopper, <em>Erythroneura elegantula</em>, its parasitoid, <em>Anagrus spp.</em>, western flower thrips, <em>Frankliniella occidentalis</em>, and generalist predators (D6).</td>
<td>Miguel Altieri Center for Biological Control University of California Berkeley, CA 94720 (510) 642-9802 <a href="mailto:agroecc3@nature.berkeley.edu">agroecc3@nature.berkeley.edu</a></td>
</tr>
</tbody>
</table>

A Recap: Steps to Farmscaping

Habitat enhancement for beneficial organisms can provide the foundation for a biologically integrated Integrated Pest Management (IPM) program. The steps presented below may help when attempting to increase the “directed diversity” of an agricultural ecosystem:

1. Keep good records of where, when, and what pests occur on the farm.
2. Obtain as much information as you can about both the pest’s and the beneficial organism’s life cycle and habitat requirements. Where are eggs laid and when do they hatch? Where does the pest/beneficial feed and how long does it need to develop into an adult? Where does the pest/beneficial overwinter and in what form? This information will not only aid in farmscaping, but will also aid pest management.
3. Make a list of tools that are available to create a friendlier habitat for the beneficiaries (or a more unfriendly habitat for pests). This may include various combinations of: insectary plants, crop rotations, hedge rows, intercropping schemes, planting or harvesting time and methods, etc. Beware of aggressive insectary or hedgerow plants.
4. Select those tools listed in #3 that best fit into your cropping system, rotation, equipment, and labor availability. Remember, permanent plantings will require maintenance during the first few years after planting. (See Appendix E for a general cost table.)
5. Experiment, observe the results, fine tune the system, and experiment again. Try something new—a variation on something that’s already being done.
6. Start simple and small, then develop the farmscaping as experience and observations dictate.

Federal Cost Share Programs for Habitat Development

USDA/NRCS Conservation Reserve Program (CRP)

http://www.fsa.usda.gov/dapf/cepd/12crplogo/tableof.htm

Under the “new” CRP, erosion control remains a top priority, but now water quality and wildlife habitat improvement are also emphasized. Continuous sign-up is available to farmers implementing special projects such as filter strips, riparian buffer strips, windbreaks, and wildlife habitat plantings (hedgerows could be included in these categories). Participating farmers must sign up for a minimum of 10 years (with an option to renew for an additional 5 years) and develop a conservation plan that takes certain acres out of production. In return, the farmer receives annual rental payments on the land from the government, up to $50,000 per person per year. Participating farmers can also apply for 50% cost share on implementation of conservation practices agreed to in the conservation plan. For more information, contact your local Natural Resources Conservation Service (NRCS) office.
Environmental Quality Incentive Program (EQIP)
http://www.nrcs.usda.gov/NRCSProg.html#Anchor-Environmental

This program supports implementation of conservation plans that include structural, vegetative, and land management practices on eligible land. Five- to ten-year contracts are made with eligible producers. Cost-share payments (up to 75%, $10,000 maximum/year, $50,000 maximum/contract), may be made to implement one or more eligible structural or vegetative practices, such as animal waste management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. These plans are developed in cooperation with NRCS and approved by the Farm Service Administration County committee. Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management. For more information, contact your local Natural Resources Conservation Service (NRCS) office.

Wildlife Habitat Incentive Program (WHIP)

Similar in many ways to the EQIP program, WHIP is a voluntary program for people who want to develop and improve wildlife habitat primarily on private lands. NRCS offers both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat. The cost-share agreement generally lasts from 5 to 10 years from the date the agreement is signed. NRCS will pay up to 75 percent of the cost of installing the wildlife habitat practices as long as NRCS or its agent has access to monitor the effectiveness of the practices. NRCS helps participants prepare a wildlife habitat development plan in consultation with the local conservation district. The plan describes the landowner’s goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement. This plan may or may not be part of a larger conservation plan that addresses other resource needs such as water quality and soil erosion.

Wetlands Reserve Program
http://www.wl.flnet.org/

For additional information about the Wetlands Reserve Program, which may have some applicability to farmscaping, please visit the website or call your local NRCS office.

US Fish and Wildlife Service (USFWS)

Partners for Wildlife
http://partners.fws.gov/index.htm

The Partners for Fish and Wildlife Program (formerly named the Partners for Wildlife program) is a proactive, voluntary program of the U.S. Fish and Wildlife Service that provides technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. The program emphasizes the reestablishment of native vegetation and ecological communities for the benefit of fish and wildlife in concert with the needs and desires of private landowners. The Service also enlists the assistance of a wide variety of other partners to help restore wildlife habitat on private lands. The partners include other federal agencies, tribes, state and local governments, conservation organizations, academic institutions, businesses and industries, school groups, and private individuals.

The USFWS provides financial and technical assistance to private landowners through voluntary cooperative agreements. Landowners agree to maintain restoration projects as specified in the agreement, but retain full control of the land. Depending on the project, landowners can apply for cost share on up to 50% of the expense of implementing the plan. Landowners and national, state, and local organizations can serve as partners with the USFWS in carrying out restoration work on private lands.

Appendix D

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| Integrated sour cherry orchard design effects on pest management |
| Michigan: The orchard systems include an integrated system of Alternative Insect Management (AIM); and a PLM System (PER). A third system, Integrated Pest Management (IPM) which is currently used by progressive growers is included for comparison. AIM is based on fundamental changes in the orchard ecosystem, including mixed species hedgerow barriers to reduce pest immigration and enhance beneficial arthropod abundance; insect phenome mating disruption; endohytic grasses to inhibit pest abundance; mass trapping; tree mulches and alternative groundcovers to reduce weed competition and enhance biological diversity. |
| Charles Edison IPM Program, Center for Integrated Plant Systems, Michigan State Univ. R18 Food Safety and Toxicology Blvd East Lansing, MI 48824 (517) 353-5134 |

| Strip-planting clover-afla endophytes mix with vegetables for insect pest control |
| California: Pest break strips (D1) have been effective for enhancing biological control in potatoes and several other row crops. Pest break strips have a dual role: 1) as trap crops, they divert pests away from market crops; and 2) as insectary crops, they grow beneficial insects helping to provide biological control of pests in adjacent rows of vegetable crops. This report noted that control was “Good to excellent. Insect predators and parasites keep aphids and caterpillars under control; leafhopper and leaf miner prefer alfalfa in pest break strips to other hosts.” The large-scale trials occurred on a farm in central California. Managers made pest break strips five to seven beds wide (80-inch bed width) at intervals of 350 feet across the farm. Several mixes of grasses, legumes and wildflower were tested for effectiveness in supporting beneficial insects. The most effective mix was found to be predominantly alfalfa (60%) mixed with Dutch white clover, strawberry clavens, benseem clover and crimson clover (30% each). |
| Nature Farming Foundation 6495 Santa Rosa Road Lompoc, CA 93436 (805) 737-1536 FAX: (805) 736-9599 |

| Green peach aphid on lettuce |
| California: W.E. Chaney of the UC Cooperative Extension in Salinas, CA, has done field trials interplanting insectary plants (which provide beneficial insects pollen and nectar) with vegetables for biological control of the green peach aphid. He used sweet alyssum interplanted every twenty rows in a field of lettuce. Alyssum was chosen because it can be seeded instead of using transplants, and will flower in about 30 days. It does not attract either aphids or tarnished plant bugs, is not aggressive, and provides a good food source for parasitic wasps. By adding sweet alyssum and other pollen and nectar plants to monoculture vegetables, natural enemies such as the green peach aphid parasite, Diaretiella rapae, will have a chance to play a greater role in vegetable pest control. Under ideal conditions, Diaretiella rapae paralyzed 90-95 percent of available host aphids (D2). Cheney’s trial in lettuce provided sufficient reduction of aphids to do without other controls. However, 5 percent of the production area was lost to alyssum. It should be noted that during the course of this research, changes in the lettuce pest complex led to a situation in which the pea aphid, Lopa correctly, was increasing in importance relative to the green peach aphid. As a result, local growers did not adopt this system. |
| W.E. Chaney U.C. Cooperative Extension 5432 Abbot St Salinas, CA 93901 (408) 759-7350 |
### Appendix D

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<td><strong>Stink bugs in Pecans</strong></td>
<td><strong>Texas:</strong> Trap crop of black-eyed peas for stink bugs. When the growers compared the average dollar losses from stink bugs between the trap-cropped sites and the non-trap-cropped sites they found that the non-trap-cropped sites sustained $29.29 more stink bug associated losses than did the trap-cropped orchards. It cost the growers approximately $2,112.50 (about $211.25/acre of peas) to establish and maintain the trap-cropped peas. When spread over the 650 acres of the pecan farm being affected by the presence of the trap crops, the growers spent $3.25/acre (of pecans) to establish and maintain the trap crops. The growers determined for every dollar they spent establishing and maintaining the trap-crops, they prevented $9.01 in kernel damage from stink bugs. See also: <a href="http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe?id=689">http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe?id=689</a></td>
<td>Kyle Brocksieker Box 216 Van Horn, TX 79855 (915) 283-2506</td>
</tr>
<tr>
<td><strong>Thrips on pepper plants</strong></td>
<td><strong>Florida:</strong> Cover crops and weeds as beneficial insect habitat for thrips control. During the summer of 1994 the participants tried Alyce clover and Aeschynomene, both legumes, as cover crops. Rank growth of the latter resulted in these being mowed soon after peppers were planted. The participants also monitored insect populations in a native weed species, Wedelia frutescens, found growing abundantly on the ditch banks. This particular weed harbored large numbers of a non-destructive species of thrips, as well as predatory insects, and will be examined further in the future. Future testing of such nursery areas will include a more critical selection of cover crops. The researchers will be seeking plants with a prostrate growth habit that does not interfere with farming operations and that will continue to flower through Florida’s winter season. The research found that cover crops are helpful in providing refuges for predatory insects, but more covers with prostrate growth and a winter flowering period need to be identified. USDA entomologists predict that the range of the melon thrips, <strong><a href="http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe?id=687">http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe?id=687</a></strong></td>
<td>Ted &amp; Trudy Winsberg Green Cay Farms Rt. 1 Box 3318 Boynton Beach, FL 33437 (407) 499-5345</td>
</tr>
<tr>
<td><strong>Establishing Hedgerows as Beneficial Insect Habitat</strong></td>
<td><strong>California:</strong> perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops.</td>
<td>Mary Kimberly 221 W. Court St., Ste. 1 Woodland, CA 95695 (530) 662-2037 ext. 3</td>
</tr>
<tr>
<td><strong>Lygus bug on strawberries</strong></td>
<td><strong>California:</strong> Annual trap-crop of one dormant and one semi-dormant alfalfa variety, two radish varieties (Daikon and the edible variety Cherry Belle) and sweet alyssum (Carpet of Snow variety). Preliminary indications are that lygus moving in from surrounding fields settle on the annual trap crop mix. The trap crop can then be treated by chemicals or vacuumed, thereby avoiding any chemical applications to the strawberries.</td>
<td>Sean Sweeney / Polly Goldman U.C. Santa Cruz Santa Cruz, CA (831) 755-2889</td>
</tr>
</tbody>
</table>
The goal of farmscaping is to prevent pest populations from becoming economically damaging. This is accomplished primarily by providing habitat to beneficial organisms that increase ecological pressures against pest populations. Farmscaping requires a greater investment in knowledge, observation, and management skill than conventional pest management tactics, while returning multiple benefits to a farm’s ecology and economy. However, farmscaping alone may not provide adequate pest control. It is important to monitor pest and beneficial populations so that quick action can be taken if beneficials are not able to keep pest populations in check. Measures such as maintaining healthy soils and rotating crops are complementary to farmscaping and should be integrated with farmscaping efforts. Biointensive Integrated Pest Management (IPM) measures, such as the release of commercially-reared beneficials (applied biological control) and the application of “soft” pesticides (soaps, oils, botanicals) can be used to augment farmscaping efforts.

### Appendix C

#### Seed Blends, Plants and Sprays to Attract Beneficial Insects (C1, C2)

<table>
<thead>
<tr>
<th>Blend</th>
<th>Planting information (from manufacturers/suppliers)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>No specific blends</td>
<td>Specializes in native grasses, including: Bentgrass, Tufted Hairgrass, Slender Hairgrass, Squirrel Tail, Slender Wheatgrass, Blue Wild Rye, Idaho Fescue, Calif. Fescue, Meadow Barley, Calif. Barley, Junegrass, Creeping Wild Rye, Calif. Onion Grass, Hartford’s melic, Deergrass, Nodding Needlegrass, Foothill Needlegrass, Purple Needlegrass, One sided Bluegrass.</td>
<td>Hedgrow Farms 21740 County Rd. 88 Winters, CA 95694 (916) 662-4570</td>
</tr>
<tr>
<td>Forbs: Yarrow, Narrow-leaf Milkweed, Purple Aster, Calif. Poppy, Gum Plant.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legumes: Small-flowered Lupine, Arroyo Lupine, Yellow Lupine, Bull Clover, and Toncat clover.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Beneficial Blend</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Cereal rye, barley, subclover, common vetch, yellow clover, white clover, crimson clover, LM 331 alfalfa, mustard, Queen Anne's lace, coriander, baby's breath, buckwheat, baby-blue-eyes, bishop's weed, fennel, celery, yarrow, sweet alyssum.</td>
<td>Lohse Mill, Inc P.O. Box 168 Artois, CA 95913 (916) 934-2157 <a href="http://www.forages.css.orst.edu/Resources/Vendors/Seed/Lohse/index.html">http://www.forages.css.orst.edu/Resources/Vendors/Seed/Lohse/index.html</a></td>
</tr>
<tr>
<td><strong>Beneficial Insect Food</strong> (spray/paste)</td>
<td>Ready to use, just add water. Beneficial Insect Food supplies the pollen and nectar sources that beneficials (Ladybugs, Lacewings) need, to go with the protein they get from eating other insects. Helps attract beneficials, aids in increased reproduction, and keeps them in your garden and greenhouse. May also be made into a paste.</td>
<td>Garden City Seeds 778 Hwy 93 North Hamilton, MT 59840 (406) 961-4837</td>
</tr>
<tr>
<td>no specific blends</td>
<td>West Coast natives including California lilac, grasses, perennial buckwheat and wildflowers.</td>
<td>Cornflower Farms P.O. Box 896 Elk Grove CA 95759 (916) 689-1015</td>
</tr>
<tr>
<td>no specific blends</td>
<td>Herbs, mints, vetch, Queen Anne's lace, yarrow and other wildflowers.</td>
<td>Richter's 357 Hwy 47 Goodwood, ON L0C 1A0 Canada (905) 640-6677</td>
</tr>
</tbody>
</table>

#### Sources:


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**Help us to better help farmers.**

If you have suggestions for improvements in this publication, areas about which you’d like more information or detail, ideas, case studies, or sources of good farmscaping information (articles or websites), please call Rex Dufour at 1-800-346-9140, or email at rexd@ncat.org. Please fill out the feedback form on the back page of this publication. Thank you!
Appendix C

<table>
<thead>
<tr>
<th>Blend</th>
<th>Planting information (from manufacturers/suppliers)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier Patrol&lt;sup&gt;TM&lt;/sup&gt; (made by Lohse-Mill)</td>
<td>Beneficial insect attractant flowers. Formulated by Clyde Robin wildflower company, this is a mix of flower seeds specially chosen to attract beneficial insects and provide homes for them. One can covers 350 square feet, and it's recommended for use as a border around the garden or between beds. Works best if it's planted a few weeks before the rest of the garden; first blossoms will appear in 45–90 days. Many of the flowers are perennials which will bloom year after year; the mix includes evening primrose, wild buckwheat, baby blue eyes, black-eyed susan, straw flowers, nasturtiums, bishop's flowers, angelica, and yarrow.</td>
<td>Bountiful Gardens 18001 Shaffer Ranch Road Wills, CA 95490 (707) 459-6410</td>
</tr>
<tr>
<td>Haven&lt;sup&gt;TM&lt;/sup&gt; Flowering Herbs</td>
<td>Haven is a blend of popular culinary herbs (dill, fennel). These herb varieties have small flowers (tiny predators can't reach the nectar of large blossoms), with abundant nectar and a long flowering period. The flowers attract a wide variety of the most desirable beneficial insects. Sow the seeds after danger of spring frost.</td>
<td>Gardens Alive! 5100 Schenley Place Lawrenceburg, IN 47025 (812) 537-8650 <a href="http://www.gardens-alive.com/">http://www.gardens-alive.com/</a></td>
</tr>
<tr>
<td>Haven&lt;sup&gt;TM&lt;/sup&gt; Cover Crop</td>
<td>Blend of leguminous cover crops provides a habitat for beneficial insects. Sow in spring on soil that is to lie fallow for the season. When tilled under, the plants add nitrogen to the soil and reduce the need for additional fertilizing. Includes ladino, red clover, white clover, hairy vetch, alfalfa, mustard, Barley, cereal rye, subclover, berseem clover, crimson clover, white clover, yellow clover, allafa, mustard, coriander, sweet alyssum, yarrow, buckwheat. Use ½ lb./1500 sq. ft. or 10–12 lb./acre.</td>
<td>Gardens Alive! (see above)</td>
</tr>
<tr>
<td>Bug Pro&lt;sup&gt;TM&lt;/sup&gt; (spray)</td>
<td>BugPro provides the protein beneficial insects need to induce egg-laying, when a natural insect diet is not available. BugPro is a water based spray of live lacewings to your garden. 5 lbs. makes 10 gallons, covers 10,000 sq. ft. Spray or drop on foliage where you want to attract beneficials.</td>
<td>Gardens Alive! (see above)</td>
</tr>
<tr>
<td>no specific blends</td>
<td>Nursery that sells plants at three different sizes, including many ornamental and useful plants from around the world. California lilac, willows, shrubs, wildflowers, grasses.</td>
<td>Forestfarm 980 Tetherow Road Williams, OR 97544 (541) 846-7269 <a href="http://www.forestfarm.com/search/plant.asp">http://www.forestfarm.com/search/plant.asp</a></td>
</tr>
<tr>
<td>no specific blends</td>
<td>Niche Gardens is a mail-order and retail nursery. They specialize in nursery-propagated wildflowers and natives, perennials, ornamental grasses and unusual trees and shrubs.</td>
<td>Niche Gardens 111 Dawson Road Chapel Hill, NC 27516 (919) 967-0078</td>
</tr>
</tbody>
</table>

References:

Useful Contacts for Farmscaping Information

Central Coast Wilds specializes in farmscape planning, installation, and management. They provide information and native plants in order to meet several farm system goals:

- beneficial insect habitat
- wind break
- erosion control
- riparian stabilization
- non-point source water pollution reduction

http://www.centralcoastwilds.com/farmscape.html

Dr. Robert Bugg
Cover Crops/Restoration Ecology
UC-Sustainable Agriculture Research & Education Program (SAREP)
Davis, CA 95616
(530) 754-8549
rbugg@ucdavis.edu

Dr. Robert Bugg works with the Biologically Integrated Orchard Systems (BIOS) project and is knowledgeable about beneficial insects associated with various cover crops.

W.E. Chaney
Farm Advisor, Entomology/vegetable crops
UC-Cooperative Extension
1432 Abbott St.
Salinas, CA 93901
(831) 759-7359
wchaney@ucdavis.edu

Bill Chaney has done work on enhancing biological control of aphids through the use of insectary plants grown in fields of vegetables.

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University of Georgia
Coastal Plain Experiment Station
P.O. Box 748
Tifton, GA 31793
(912) 386-3901
phatak@cpes.peachnet.edu

Dr. Sharad Phatak
University of Georgia
Coastal Plain Experiment Station
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Tifton, GA 31793
(912) 386-3901
phatak@cpes.peachnet.edu

Both Dr. Phatak and Dr. Dutcher have done extensive research into biological control, and the Coastal Plain Experiment Station is a center of innovative research in this area.

Diane Mathews Gehringer
2774 Silver Creek Rd.
Kutztown, PA 19530
(610) 285-4317

Ms. Gehringer, formerly with the Rodale Institute, is knowledgeable about biological control.

Bat Habitat

Rachael Long
Farm Advisor
UC-Cooperative Extension
70 Cottonwood St.
Woodland, CA 95695
(530) 666-8143

Jim Kennedy
Bat Conservation International
P.O. Box 162603
Austin, TX 78716
(512) 327-9721

Dr. Steve Cross
Southern Oregon State College
1250 Siskiyou Blvd.
Ashland, OR 97520-5071
(541) 552-6749

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Appendix C

Seed Blends, Plants and Sprays to Attract Beneficial Insects (C1, C2)

<table>
<thead>
<tr>
<th>Blend</th>
<th>Planting information (from manufacturers/suppliers)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Bug Blend®</td>
<td>Since the mix blooms nearly year-round, Good Bug Blend should be planted in areas that can go a little wild, such as field borders, ditchbanks, fence rows, etc. Generally, you need to plant only 1–5% of your land with this mix for good results. Crimson, rose and sweet clovers, subclovers, alfalfas, gypsophila, Eriogonum fascifolium, white alyssum, nasturtium, yarrow, carrot, dill, daikon, celery, radish, fennel, caraway, chervil, coriander, and more. Drill or broadcast seed at 10–15 lb./acre (1 lb./1,000 sq. ft.) in any but the coldest months of the year. Large-scale growers: if you are planting in fall, add vetch at 5 lb./acre. If you are planting in spring, add 10 lb. of buckwheat and 10 lb. of cowpeas/acre.</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>Low Growing Good Bug Blend</td>
<td>A mix of annuals and perennials under 2 feet tall, for use below trees, cane berries, vines or along border areas with height limitations. This mix performs best with regular drip, sprinkler or furrow irrigation during dry periods. It blooms 6–10 months/year and contains: carrot, chervil, coriander, clovers (crimson, white, rose), subclovers, nasturtium, parley, alyssum and yarrow. Drill or broadcast at 10–15 lb./planted acre (1 lb./1,000 sq. ft.).</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>Border Patrol®</td>
<td>For best results sow this mix 4–6 weeks prior to planting your garden. Border Patrol has more color, but is less effective than Good Bug Blend. Species include white evening primrose, wild buckwheat, baby blue eyes, candytuf, bishop’s flower, black-eyed susan, strawflower, nasturtium, angelica and yarrow.</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>Good Bug Food (Spray)</td>
<td>This product is a food source for beneficial insects. In their adult stage, these insects need pollen and sugars, which are often not present in sufficient quantities. Beneficial insects especially need additional food during their adult stage, these insects need pollen and sugars, which are often not present in sufficient quantities. Derived from Brewer’s Yeast and powdered milk, Good Bug Food can attract and increase beneficial populations as much as tenfold. Mix one part food with an equal part of honey or sugar. Paint this mixture onto cardboard or wooden stakes and place in your garden or greenhouse.</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>All Purpose Insectary Plant Blend® (Pacific Seed)</td>
<td>Plant swaths through crop areas. White clover, yellow clover, yarrow, crimson, fennel, caraway, fennel, parsley, sweet alyssum, tidy tips, baby’s breath, cosmos. Use ½ lb./1500 sq. ft. or 10–12 lb./acre.</td>
<td>Harmony Farm Supply (see above)</td>
</tr>
</tbody>
</table>

Supplier Information

- Peaceful Valley Farm Supply
  P.O. Box 2209
  Grass Valley, CA 95945
  (916) 272-4769
  http://www.groworganic.com/

- Harmony Farm Supply
  P.O. Box 460
  Graton, CA 95444
  (707) 823-9125
  http://www.harmonyfarm.com/
Appendix B

<table>
<thead>
<tr>
<th>Pest</th>
<th>Beneficial that attacks it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leafminer</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Looper</td>
<td>Big-eyed bug, parasitic wasps</td>
</tr>
<tr>
<td>Lygus bugs</td>
<td>Big-eyed bug, braconid wasp, Anaphes iole</td>
</tr>
<tr>
<td>May beetle</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>Ladybug, big-eyed bug, mealybug destroyer, lacewing</td>
</tr>
<tr>
<td>Mexican bean beetle</td>
<td>Spined soldier bug</td>
</tr>
<tr>
<td>Mites</td>
<td>Ladybug, big-eyed bug, Lacewing, minute pirate bug</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Rove beetle</td>
</tr>
<tr>
<td>Oriental fruit moth</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Peach twig borer</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Psyllids</td>
<td>Big-eyed bug</td>
</tr>
<tr>
<td>Sawfly</td>
<td>Spined soldier bug, tachinid fly</td>
</tr>
<tr>
<td>Scales</td>
<td>Lacewing, predatory thrips</td>
</tr>
<tr>
<td>Slugs</td>
<td>Ground beetle, parasitic nematodes</td>
</tr>
<tr>
<td>Snails</td>
<td>Ground beetle</td>
</tr>
<tr>
<td>Soft scales</td>
<td>Ladybug</td>
</tr>
<tr>
<td>Sowbug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Spider mite</td>
<td>Ladybug, minute pirate bug, predatory thrips, spider mite destroyer, western predatory mite</td>
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<tr>
<td>Springtails</td>
<td>Rove beetle</td>
</tr>
<tr>
<td>Spruce budworm</td>
<td>Trichogramma wasp</td>
</tr>
<tr>
<td>Squash bug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Tent caterpillar</td>
<td>Ground beetle, tachinid fly</td>
</tr>
<tr>
<td>Thrips</td>
<td>Ladybug, minute pirate bug, big-eyed bug, damsel bug, lacewing</td>
</tr>
<tr>
<td>Tomato hornworm</td>
<td>Big-eyed bug, assassin bug, Trichogramma wasp</td>
</tr>
<tr>
<td>Treehoppers</td>
<td>Damselfly</td>
</tr>
<tr>
<td>Whiteflies</td>
<td>Lacewing, predatory thrips, whitefly parasitic wasp (Encarsia spp.)</td>
</tr>
</tbody>
</table>

**Bat Houses**

Natural Insect Control
R.R. #2
Stevensville, Ontario
Canada LOS ISO
(905) 382-2904
FAX: (905) 382-4418

Peaceful Valley Farm Supply
P.O. Box 2209 #P
Grass Valley, CA 95945
(530) 272-4769
http://www.groworganic.com

The Green Spot
Dept. of Bio-Ingenuity
93 Priest Rd.
Nottingham, NH 03290
(603) 942-8925
FAX: (603) 942-8932

Danny Smith
P. O. Box 703
La Porte, TX. 77572-0703
genes96597@aol.com
FAX: (281) 471-6477
http://home.earthlink.net/~riverdan2/ wildlife.htm

**Seed Suppliers**

See Appendix C

**Windbreaks, Shelterbelts and Hedgerows**

Mary Kimble
Yolo County Resource Conservation District
221 W. Court St., Ste. 1
Woodland, CA 95695
(530) 662-2037 ext. 3

The Yolo County Conservation District is doing some excellent ongoing work concerning hedgerow establishment, plant selection, types of beneficials attracted, and budgets for hedgerow installation and maintenance.

Bruce Wight
National Windbreak Forester
USDA Natural Resources Conservation Service (NRCS)
Federal Building
100 Centennial Mall North
Lincoln, NE 68508-3866
(402) 437-5178 ext. 36
bwight@telspec.itc.nrcs.usda.gov
http://www.unl.edu/nac/

The folks at USDA’s National Agroforestry Center have technical information about the benefits, planting, maintenance, and impact on wildlife of windbreaks, hedgerows, snowfences.

**Useful Websites**

Biological Control: A Guide to Natural Enemies of North America
http://www.nysaes.cornell.edu/ent/biocontrol/

This site, Biological Control: A Guide to Natural Enemies of North America provides photographs and descriptions of over 100 biological control (or biocontrol) agents of insect, disease, and weed pests in North America. It is also a tutorial on the concept and practice of biological control and integrated pest management (IPM). Excellent photos and lifecycle descriptions supplemented with diagrams.

Insect Parasitic Nematodes
http://www.oardc.ohio-state.edu/nematodes/

This site has much useful information about the use of insect parasitic nematodes: the biology and ecology of nematodes, how to use nematodes, a list of suppliers, and more! An extremely useful section provides full citation for research papers according to author, title, or abstract. Research papers can also be searched for according to Order and Family of target insect. To get to this section, click on: Search Publications ⇒ Keyword Search Page (just underneath the “author, title, abstract” search engine)=insects. Then you may choose the Order and Family of your choice.
Additional Reading

Articles:


Appendix B

Pests and Associated Beneficial Insects

<table>
<thead>
<tr>
<th>Pest</th>
<th>Beneficial that attacks it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa weevil</td>
<td>Predatory thrips, Bathyplectes wasps, Tetrastichus incertus (wasp parasite)</td>
</tr>
<tr>
<td>Aphid</td>
<td>Aphid midge, aphid parasites, syrphid fly, ladybug, parasitic wasp, big-eyed bug, damsel bug, mealybug destroyer, soldier beetle, lacewing, braconid wasp, predatory thrips, rove beetle, syrphid fly</td>
</tr>
<tr>
<td>Armyworm</td>
<td>Big-eyed bug, braconid wasp, spined soldier bug, tachinid fly</td>
</tr>
<tr>
<td>Beetles</td>
<td>Braconid wasp</td>
</tr>
<tr>
<td>Bud moth</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Cabbage looper</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Cabbage-root maggots</td>
<td>Ground beetle, rove beetle</td>
</tr>
<tr>
<td>Cabbageworm</td>
<td>Braconid wasp</td>
</tr>
<tr>
<td>Caterpillars in general</td>
<td>Assassin bug, lacewing, Trichogramma wasp, braconid wasp, damsel bug, minute pirate bug</td>
</tr>
<tr>
<td>Codling moth</td>
<td>Braconid wasp, predatory thrips, Trichogramma wasp</td>
</tr>
<tr>
<td>Colorado potato beetle</td>
<td>Ground beetle, spined soldier bug</td>
</tr>
<tr>
<td>Corn earworm</td>
<td>Big-eyed bug, minute pirate bug, Trichogramma wasp, lacewing</td>
</tr>
<tr>
<td>Cotton bollworm</td>
<td>Trichogramma wasp</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Ground beetle, tachinid fly</td>
</tr>
<tr>
<td>European corn borer</td>
<td>Braconid wasp, Trichogramma wasp</td>
</tr>
<tr>
<td>Flea beetles</td>
<td>Big-eyed bug</td>
</tr>
<tr>
<td>Flies</td>
<td>Braconid wasp</td>
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<tr>
<td>Green stink bug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Gypsy moth</td>
<td>Braconid wasp, ground beetle, tachinid fly</td>
</tr>
<tr>
<td>Japanese beetle</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Leafhopper</td>
<td>Big-eyed bug, damsel bug, minute pirate bug</td>
</tr>
</tbody>
</table>
Appendix A

Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalcid wasps (many families, including</td>
<td>Spruce budworm, cotton bellworm, tomato</td>
<td>Maintain a diversity of plants, including dill,</td>
</tr>
<tr>
<td>Trichogrammatidae)</td>
<td>hornworm, corn earworm, corn borer,</td>
<td>anise, caraway, hairy vetch, spearmint, Queen</td>
</tr>
<tr>
<td></td>
<td>coding moth, other moths</td>
<td>Anne’s lace, buckwheat, common knotweed, yarrow,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>white clover, taro, cowpea, fennel, cosmos,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>chervl. For orchards, provide a mix of clover</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and flowering weeds (A2, A3, A6).</td>
</tr>
<tr>
<td>Whitley parasitic wasp (Encarsia formosa)</td>
<td>Greenhouse whitefly, sweet potato whitefly</td>
<td>Carrot family (Queen Anne’s lace, dill, fennel,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>taro), sunflower family (yarrow, sunflower,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cosmos, coreopsis) (A2).</td>
</tr>
</tbody>
</table>

Sources:


Additional Reading continued


Farmscaping Books:


This book provides detailed technical insights into habitat manipulation for biological control. Each chapter is written by an expert about a particular aspect of habitat management (i.e., The Role of Spiders and Their Conservation in the Agroecosystem, or, Within-field and Border Refugia for the Enhancement of Natural Enemies). This volume is a must for researchers in this field as well as a useful reference for farmscaping practitioners.

For ordering information:

Univ. of California Press, CPFS, 1095 Essex St. Richmond, CA 94801 (609) 883-1759 FAX: (609) 883-7413


This is a great resource for farmers and land managers, though a fair amount of the information is specific to the Lower Sacramento Valley. Contains much useful information about establishing habitat for wildlife—from hedgerows and native perennial grass stands to riparian enhancement and tailwater ponds. Also includes information on how to attract beneficial insects, birds and bats, planting techniques and weed control, and cost share programs (Federal, State (CA) and local) for habitat enhancement.

To order: Send $18/copy (includes postage and handling) with check payable to “Yolo County RCD” to:

Yolo County RCD
221 West Court St., Ste. 1
Woodland, CA 95695

This is a great resource for farmers and land managers, though a fair amount of the information is specific to the Lower Sacramento Valley. Contains much useful information about establishing habitat for wildlife—from hedgerows and native perennial grass stands to riparian enhancement and tailwater ponds. Also includes information on how to attract beneficial insects, birds and bats, planting techniques and weed control, and cost share programs (Federal, State (CA) and local) for habitat enhancement.

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Yolo County RCD
221 West Court St., Ste. 1
Woodland, CA 95695
Additional Reading continued


This bulletin from the Sustainable Agriculture Network (SAN) outlines how to use ecological principles to control pests on your farm. Contains successful strategies and a resource listing.

Ordering information:
Sustainable Agriculture Network
(301) 405-3186
http://www.sare.org/san/htdocs/pubs/

Biocontrol/IPM Books:


“Orchard Pest Management is an outstanding resource book for growers, consultants, orchard managers, and those interested in the latest findings on integrated pest management tactics, not only in the Pacific Northwest, but throughout the United States. It explains in detail the philosophy of IPM, and the tools and tactics needed to implement this management approach. All the information is presented in an easily readable style both the neophyte and expert can follow. The book is comprehensive, well written and organized, and amply illustrated with colorful photographs and excellent line drawings and graphics....” - Dr. Larry A. Hull, Professor of Entomology, Penn. State University. We agree.

Ordering information:
Washington State Fruit Commission
105 Tieton Drive
Yakima, WA 98902
(509) 575-2315
FAX: (509) 453-4880


The chapters of this well-formatted book are organized according to vegetable crop and written by experts on that crop. The focus is on IPM and the charts, diagrams, drawings, and pictures all contribute to an exceptionally well-designed book that is easily readable but dense with useful information. An excellent resource for midwestern vegetable growers and IPM practitioners.

To Order: Unfortunately, Vegetable Insect Management is sold out.

Contact:
Meister Publishing Company
37733 Euclid Avenue
Willoughby, OH 44094
(800) 572-7740
FAX: (440) 942-0662
e-mail: meisterpro_sales@meisternet.com

Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spider</td>
<td>Many insects</td>
<td>Caraway, dill, fennel, cosmos, marigold, snapseed (A2, A6).</td>
</tr>
<tr>
<td>Spider mite destroyer</td>
<td>Spider mite</td>
<td>Carrot family (dill, fennel, etc.), mustard family (sweet alyssum, candalynf, etc.).</td>
</tr>
<tr>
<td>Spined soldier bug</td>
<td>Fall armyworm, sawfly, Colorado potato beetle, Mexican bean beetle</td>
<td>Sunflower family (goldenrod, yarrow), bishop’s weed; Maintain permanent plantings (A7).</td>
</tr>
<tr>
<td>Syrphid fly (Hover flies)</td>
<td>Aphid</td>
<td>Carrot family (Queen Anne’s lace, dill, fennel, caraway, tansy, parsley, coriander, bishop’s weed), the sunflower family (coreopsis, Gloriosa daisy, yarrow, cosmos, sunflower, marigolds), candalynf, sweet alyssum, ceanothus, holly-leaved cherry (Prunus ilicifolia), buckwheat, scabiosa, spearmint, coyote brush (Baccharis pilularis), knotweed (Polygonum aviculare), California lilacs (Ceanthus spp.), soapbark tree, meadow foam (Limnanthes douglasii), baby-blue-eyes (Nemophila); (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Tachinid fly (Tachinidae family)</td>
<td>Cutworm, armyworm, tent caterpillar, cabbage looper, gypsy moth; some attack sawfly, Japanese beetle, May beetle, squash bug, green stink bug, sowbug</td>
<td>Carrot family (caraway, bishop’s weed, coriander, dill, parsley, Queen Anne’s lace, fennel), goldenrod, sweet clover, Phacelia spp., sweet alyssum, buckwheat, amaranth, buckthorn, Heteromeles arbutifolia (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Tiger beetle (Cicindelidae family)</td>
<td>Many insects</td>
<td>Maintain permanent plantings and some exposed dirt or sand areas.</td>
</tr>
</tbody>
</table>
Appendix A

<table>
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<tr>
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<td>Minute Pirate Bug</td>
<td>Thrips, spider mite, leafhopper, corn earworm, small caterpillars, many other insects</td>
<td>Effective predators of corn earworm eggs. Carrot family (Queen Anne’s lace, tansy, coreiander, bishop’s weed, chervil), sunflower family (cosmos, tidy tips (Ligat), goldenrod, daisies, yarrow), baby-blue-eyes (Nemophila), hairy vetch, alfalfa, corn, crimson clover, buckwheat, blue elderberry (Sambucus canadensis) willow, shrubs. Maintain permanent plantings or hedgerows (A2, A4, A6, A7, A9).</td>
<td></td>
</tr>
<tr>
<td>Parasitic nematodes</td>
<td>Nematodes</td>
<td>Marigolds, chrysanthemum, gaillardia, helenium, Eriophyllum lanatum, horseweed (Conyza canadensis), hairy indigo, castor bean, Cretilaria spp., Dipsedius spp., seshania, mexicantea (Chrysopius ambrosiodes), shattencane (Sorghum bicolor), lupines, Plantago strumpurpurata (A10).</td>
<td></td>
</tr>
<tr>
<td>Praying mantis</td>
<td>Any insect (including beneficials)</td>
<td>Cosmos, brambles. Protect native species by avoiding pesticides (A3).</td>
<td></td>
</tr>
<tr>
<td>Predatory mite</td>
<td>Spider mite</td>
<td>There are many species of predatory mites with ecological requirements—especially with respect to humidity and temperature—particular to the species. Avoid use of insecticides. Provide beneficial refugia for non-crop habitat of non-crop mite prey.</td>
<td></td>
</tr>
<tr>
<td>Predatory thrips</td>
<td>Spider mite, aphid, other thrips, Oriental fruit moth, codling moth, bud moth, peach twig borer, alfalfa weevil, whitely, leafminer, scale</td>
<td>There are several species of predatory thrips. Predatory thrips populations may be conserved/maintained by having non-crop populations of plant-feeding mites (e.g., European red mite, two-spotted spider mite), scales, aphids, moth eggs, leafhoppers, and other thrips.</td>
<td></td>
</tr>
<tr>
<td>Rove beetle</td>
<td>Aphid, springtail, nematode, fly; some are parasitic on cabbage-root maggot</td>
<td>Permanent plantings; interplant strips of rye, grains, and cover crops; mulch beds; make stone or plant walkways in garden to provide refuges.</td>
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</tr>
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### Additional Reading continued


This book focuses on the life cycle of natural enemies of insect pests. It includes a general discussion about each family of natural enemies, within which details are provided about some species, including appearance and life cycle, pests attacked and relative effectiveness. With its diagrams and pictures, this book is a good reference for agricultural field workers.

Ordering information:
Resource Center
7 Business/Technology Park
Cornell University
Ithaca, NY 14850
(607) 255-2080
FAX: (607) 255-9946
e-mail: DIST_Center@CCE.Cornell.EDU
Order code: 139NVP
$14.95 postage included


This book provides a good introduction to biological control of insects and mites with a geographic focus on the north central U.S. A brief review of insect biology, types of pests, and crop damage is followed by sections on natural and artificial types of insect pest control. A third of the book, accompanied by good photos and diagrams, focuses on the families of natural enemies that provide biological control of insects and mites. The remaining text gives an overview of biological control techniques, with a focus on periodic release of natural enemies. Information on conservation of natural enemies is a bit thin, but overall a very good reference and overview of the subject.

To order:
Send $13.50/copy ($11 + $2.50 for shipping) with check payable to “Extension Publications” to:
University of Wisconsin Cooperative Extension Publications
45 N. Charter St.
Madison, WI 53715


This book provides information on the use of natural enemies for control of greenhouse pests. It includes a comparison of the advantages and disadvantages of different methods of pest control and detailed information on the use of predatory insects. The book is a valuable reference for anyone involved in greenhouse production.

Ordering information:
Resource Center
7 Business/Technology Park
Cornell University
Ithaca, NY 14850
(607) 255-2080
FAX: (607) 255-9946
e-mail: DIST_Center@CCE.Cornell.EDU
Order code: 161NVP
$12.25 postage included

### Additional Reading

- **Predatory thrips**
- **Parasitic nematodes**
- **Praying mantis**
- **Predatory mite**
- **Predatory thrips**
- **Rove beetle**

### Pest and Disease Suppression

- **Crop Rotations**
- **Reduce Pest Habitat**
- **Beneficial Organism Habitat**
- **Above-Ground Diversity to Favor Beneficials**
- **Mineral Use of Chemical Pesticides**
- **Minimal Tillage**
- **Regular Additions of Organic Matter**
- **Healthy Soil Healthy Soil Healthy Soil Healthy Soil Healthy Soil**

### Beneficial Organism Habitat

- **Hedgerows for insects and wildlife**
- **Beneficial bird and bat habitat**
- **Cover crops as insectaries**

### Beneficial Organism Habitat

- **Plants that Attract Beneficials (A1)**
- **Additional Reading**
- **Ordering information**
Plants that Attract Beneficials (A1)

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphid midge <em>(Aphiodoletes aphidimyza)</em> (Larvae are aphid predators)</td>
<td>Aphid</td>
<td>Dill, mustard, thyme, sweet clover; Shelter garden from strong winds; Provide water in a pan filled with gravel (A2).</td>
</tr>
<tr>
<td>Aphid parasites <em>(Aphidius nitricarvae and others)</em></td>
<td>Aphid</td>
<td>Nectar-rich plants with small flowers (anise, caraway, dill, parsley, mustard family, white clover, Queen Anne's lace, yarrow). Don't use yellow sticky traps (A2).</td>
</tr>
<tr>
<td>Assassin bug <em>(Reduviidae family)</em></td>
<td>Many insects, including flies, tomato hornworm, large caterpillars</td>
<td>Permanent plantings for shelter (e.g., hedgerows)</td>
</tr>
<tr>
<td>Bigeyed Bugs <em>(Geocoris spp. of Lygaeid Family)</em></td>
<td>Many insects, including other bugs, flea beetles, spider mites, insect eggs and small caterpillars. Will also eat seeds (A12).</td>
<td>Can build up in cool-season cover crops such as borage clover (Trifolium alexandrium) and subterranean clovers (Trifolium subterraneum). Can be found on common knotweed (Polygonum aviculare) as well (A11).</td>
</tr>
<tr>
<td>Braconid wasp <em>(Braconidae family)</em></td>
<td>Armyworm, cabbageworm, codling moth, gypsy moth, European corn borer, beetle larvae, flies, aphid, caterpillars, other insects</td>
<td>Nectar plants with small flowers (caraway, dill, parsley, Queen Anne's lace, fennel, mustard, white clover, tansy, yarrow), sunflower, hairy vetch, buckwheat, cowpea, common knotweed, crocuses, spearmint (A2, A3, A4, A6).</td>
</tr>
<tr>
<td>Damselfly <em>(Nabidae family)</em></td>
<td>Aphid, thrips, leafhopper, treehopper, small caterpillars</td>
<td>Anything in the sunflower family as well as goldenrod, yarrow, alfalfa.</td>
</tr>
<tr>
<td>Ground beetle <em>(Carabidae family)</em></td>
<td>Slug, snail, cutworm, cabbage-root maggot; some prey on Colorado potato beetle, gypsy moth and tent caterpillar</td>
<td>Permanent plantings, amaranth, white clover in orchards, mulching.</td>
</tr>
</tbody>
</table>

Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Lacewing, Neuroptera Family <em>(Chrysoperla and Chrysopa spp.)</em></td>
<td>Soft-bodied insects including aphid, thrips, mealybug, scale, caterpillars, mite</td>
<td>Carrot family (caraway, Queen Anne's lace, tansy, dill, angelica), sunflower family (coreopsis, cosmos, sunflowers, dandelion, goldenrod), buckwheat, corn, holly leaf cherry (Prunus ilicifolia), flowering bottle tree (Brachychiton populneum), soapbark tree (Quillaja saponaria). Provide water during dry spells (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Ladybird beetle or ladybug <em>(Hippodamia spp. and others)</em></td>
<td>Aphid, mealybug, spider mite, soft scales</td>
<td>Once aphids leave a crop, lady beetles will also. To retain active lady beetles, maintain cover crops or other hosts of aphids or alternate prey (A11). Carrot family (fennel, angelica, dill, tansy, bishop's weed (Anthemis), Queen Anne's lace), sunflower family (goldenrod, coreopsis, cosmos, golden marguerite (Anthemis), dandelion, sunflower, yarrow), crimson clover, hairy vetch, grains and native grasses, butterfly weed (Asclepias), black locust, buckwheat, euonymus, rye, hemp sesbania (Sesbania crinita), soapbark tree, buckthorn (Rhamnus), saltbush (Atriplex spp.), black locust (Robinia pseudacacia) (A2, A3, A4, A6, A7, A8).</td>
</tr>
<tr>
<td>Mealybug destroyer <em>(Cryptolaemus montrouzieri)</em></td>
<td>Mealybug</td>
<td>Carrot family (fennel, dill, angelica, tansy), sunflower family (goldenrod, coreopsis, sunflower, yarrow) (A2).</td>
</tr>
</tbody>
</table>
### Plants that Attract Beneficials (A1)

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<td>Aphid midge (Aphidoletes aphidimyza) (Larvae are aphid predators)</td>
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<td>Dill, mustard, thyme, sweet clover; Shelter garden from strong winds; Provide water in a pan filled with gravel (A2).</td>
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<td>Aphid parasites (Aphidius nutricarue and others)</td>
<td>Aphid</td>
<td>Nectar-rich plants with small flowers (anise, caraway, dill, parsley, mustard family, white clover, Queen Anne's lace, yarrow). Don't use yellow sticky traps (A2).</td>
</tr>
<tr>
<td>Assassin bug (Reduviidae family)</td>
<td>Many insects, including flies, tomato hornworm, large caterpillars</td>
<td>Permanent plantings for shelter (e.g., hedgerows)</td>
</tr>
<tr>
<td>Bigeyed Bugs (Geocoris spp. of Lygaeid Family)</td>
<td>Many insects, including other bugs, flea beetles, spider mites, insect eggs and small caterpillars. Will also eat seeds (A12).</td>
<td>Can build up in cool-season cover crops such as borage, sweet clover, Trifolium alexandrium and subterranean clover, Trifolium subterraneum. Can be found on common knotweed, Polygnum arnicale as well (A11).</td>
</tr>
<tr>
<td>Braconid wasp (Braconidae family)</td>
<td>Armyworm, cabbageworm, codling moth, gypsy moth, European corn borer, beetle larvae, flies, aphid, caterpillars, other insects</td>
<td>Nectar plants with small flowers (caraway, dill, parsley, Queen Anne's lace, fennel, mustard, white clover, tansy, yarrow), sunflower, hairy vetch, buckwheat, cowpea, common knotweed, crotuses, spearmint (A2, A3, A4, A6).</td>
</tr>
<tr>
<td>Damsel bug (Nabidae family)</td>
<td>Aphid, thrips, leafhopper, treehopper, small caterpillars</td>
<td>Anything in the sunflower family as well as goldenrod, yarrow, alfalfa.</td>
</tr>
<tr>
<td>Ground beetle (Carabidae family)</td>
<td>Slug, snail, cutworm, cabbage-root maggot; some prey on Colorado potato beetle, gypsy moth and tent caterpillar</td>
<td>Permanent plantings, amaranth, white clover in orchards, mulching.</td>
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<td>Soft-bodied insects including aphid, thrips, mealybug, scale, caterpillars, mite</td>
<td>Carrot family (caraway, Queen Anne's lace, tansy, dill, angelica), sunflower family (coreopsis, cosmos, sunflowers, dandelion, goldenrod), buckwheat, corn, holly leaf cherry (Prunus ilicifolia), flowering bottle tree (Brachychiton populneum), soapbark tree (Quillaja saponaria). Provide water during dry spells (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Ladybird beetle or ladybug (Hippodamia spp. and others)</td>
<td>Aphid, mealybug, spider mite, soft scales</td>
<td>Once aphids leave a crop, lady beetles will also. To retain active lady beetles, maintain cover crops or other hosts of aphids or alternate prey (A11). Carrot family (fennel, angelica, dill, tansy, bishop's weed (Anemone), Queen Anne's lace), sunflower family (goldenrod, coreopsis, cosmos, golden marigold (Aster), dandelion, sunflower, yarrow), crimson clover, hairy vetch, grains and native grass, butterfly weed (Asclepias), black locust, buckwheat, euonymus, rye, hemp sesbania (Sesbania crassiflora), soapbark tree, buckthorn (Rhamnus), saltbush (Atriplex spp.), black locust (Robinia pseudoacacia) (A2, A3, A4, A6, A7, A8).</td>
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<td>Mealybug destroyer (Cryptolaemus montrouzieri)</td>
<td>Mealybug</td>
<td>Carrot family (fennel, dill, angelica, tansy), sunflower family (goldenrod, coreopsis, sunflower, yarrow) (A2).</td>
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### Plants that Attract Beneficials (A1) **continued**

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<tbody>
<tr>
<td>Minute Pirate Bug (Anthocorid Family, Orius spp.)</td>
<td>Thrips, spider mite, leafhopper, corn earworm, small caterpillars, many other insects</td>
<td>Effective predators of corn earworm eggs. Carrot family (Queen Anne's lace, tansy, coriander, bishop's weed, chervil), sunflower family (cosmos, tidy tips (Liatris), goldenrod, daisies, yarrow), baby-blue-eyes (Nemophila), hairy vetch, alfalfa, corn, crimson clover, buckwheat, blue elderberry (Sambucus canadensis) willows, shrubs. Maintain permanent plantings or hedgerows (A2, A4, A6, A7, A9).</td>
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<tr>
<td>Parasitic nematodes</td>
<td>Nematodes</td>
<td>Marigolds, chrysanthemum, gaillardia, heliopsis, Eriophyulus lanatus, horsetail (Conyza canadensis), hairy indigo, castor bean, Crepis spp., Dendroctonus spp., sesbania, mexicantea (Chenopodium ambrosioides), shattacane (Sorghum bicolor), lupines, Phlomis strigosae (A10).</td>
</tr>
<tr>
<td>Praying mantis (Mantis spp.)</td>
<td>Any insect (including beneficials)</td>
<td>Cosmos, brambles. Protect native species by avoiding pesticides (A3).</td>
</tr>
<tr>
<td>Predatory mite (Tiphidae family)</td>
<td>Spider mite</td>
<td>There are many species of predatory mites with ecological requirements—especially with respect to humidity and temperature—particular to the species. Avoid use of insecticides. Provide beneficial refugia for non-crop habitat of non-crop mite prey.</td>
</tr>
<tr>
<td>Predatory thrips (Thripidae family)</td>
<td>Spider mite, aphid, other thrips, Oriental fruit moth, coding moth, bud moth, peach twig borer, alfalfa weevil, whitefly, leafminer, scale</td>
<td>There are several species of predatory thrips. Predatory thrips populations may be conserved/maintained by having non-crop populations of plant-feeding mites (e.g., European red mite, two-spotted spider mite), scales, aphids, moth eggs, leafhoppers, and other thrips.</td>
</tr>
<tr>
<td>Rove beetle (Staphylinidae family)</td>
<td>Aphid, springtail, nematode, fleas; some are parasitic on cabbage-root maggot</td>
<td>Permanent plantings; interplant strips of rye, grains, and cover crops; mulch beds; make stone or plant walkways in garden to provide refuges.</td>
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### Additional Reading **continued**


This book focuses on the life cycle of natural enemies of insect pests. It includes a general discussion about each family of natural enemies, within which details are provided about some species, including appearance and life cycle, pests attacked and relative effectiveness. With its diagrams and pictures, this book is a good reference for agricultural field workers.

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Madison, WI 53715
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(301) 405-3186
http://www.sare.org/san/htdocs/pubs/

Biocontrol/IPM Books:

“Orchard Pest Management is an outstanding resource book for growers, consultants, orchard managers, and those interested in the latest findings on integrated pest management tactics, not only in the Pacific Northwest, but throughout the United States. It explains in detail the philosophy of IPM, and the tools and tactics needed to implement this management approach. All the information is presented in an easily readable style both the neophyte and expert can follow. The book is comprehensive, well written and organized, and amply illustrated with colorful photographs and excellent line drawings and graphics...” - Dr. Larry A. Hull, Professor of Entomology, Penn. State University. We agree.

Ordering information:
Washington State Fruit Commission
1005 Tieton Drive
Yakima, WA 98902
(509) 575-2315
FAX: (509) 453-4880


The chapters of this well-formatted book are organized according to vegetable crop and written by experts on that crop. The focus is on IPM and the charts, diagrams, drawings, and pictures all contribute to an exceptionally well-designed book that is easily readable but dense with useful information. An excellent resource for midwestern vegetable growers and IPM practitioners.

To Order: Unfortunately, Vegetable Insect Management is sold out.
Contact:
Meister Publishing Company
3773 Euclid Avenue
Willoughby, OH 44094
(800) 572-7740
FAX: (440) 942-0662
email: meisterpro_sales@meisternet.com


This book is an illustrated guide to the identification and biology of beneficial organisms including natural enemies of plant pathogens, nematodes, weeds, and arthropods. Many excellent photos and informative diagrams and tables make this book a good reference for farmers, farm managers and students. This book does not cover farmscaping.

Ordering information:
Meister Publishing Company
3773 Euclid Avenue
Willoughby, OH 44094
(800) 572-7740
FAX: (440) 942-0662
email: meisterpro_sales@meisternet.com

Appendix A

Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spider</td>
<td>Many insects</td>
<td>Caraway, dill, fennel, cosmos, marigold, spearmint (A2, A6).</td>
</tr>
<tr>
<td>Spider mite destroyer</td>
<td>Spider mite</td>
<td>Carrot family (dill, fennel, etc.), mustard family (sweet alyssum, candytuft, etc.).</td>
</tr>
<tr>
<td>Spined soldier bug (Fadus maculiventris)</td>
<td>Fall armyworm, sawfly, Colorado potato beetle, Mexican bean beetle</td>
<td>Sunflower family (goldenrod, yarrow), bishop’s weed; Maintain permanent plantings (A7).</td>
</tr>
<tr>
<td>Syrphid fly (Flower flies) (Syrphidae family)</td>
<td>Aphid</td>
<td>Carrot family (Queen Anne’s lace, dill, fennel, caraway, tansy, parsley, coriander, bishop’s weed), the sunflower family (coreopsis, Gloriosa daisy, yarrow, cosmos, sunflower, marigolds), candytuft, sweet alyssum, ceanothus, holly-leaved cherry (Prunus ilicifolia), buckwheat, scabiosa, spearmint, coyote brush (Baccharis pilularis), knotweed (Polygonum aviculare), California lilacs (Ceanothus spp.), soapbark tree, meadow foam (Limnanthes douglasi), baby-blue-eyes (Nemophila), (A2, A3, A4, A5, A6, A7).</td>
</tr>
<tr>
<td>Tachinid fly (Tachinidae family)</td>
<td>Cutworm, armyworm, tent caterpillar, cabbage looper, gypsy moth; some attack sawfly, Japanese beetle, May beetle, squash bug, green stink bug, sowbug</td>
<td>Carrot family (caraway, bishop’s weed, coriander, dill, parsley, Queen Anne’s lace, fennel), goldenrod, sweet clover, Phacelia spp., sweet alyssum, buckwheat, amaranth, buckthorn, Heteromeles arbutifolia (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Tiger beetle (Cicindelidae family)</td>
<td>Many insects</td>
<td>Maintain permanent plantings and some exposed dirt or sand areas.</td>
</tr>
</tbody>
</table>

Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphid</td>
<td>Carrot family (Queen Anne’s lace, dill, fennel, caraway, tansy, parsley, coriander, bishop’s weed), the sunflower family (coreopsis, Gloriosa daisy, yarrow, cosmos, sunflower, marigolds), candytuft, sweet alyssum, ceanothus, holly-leaved cherry (Prunus ilicifolia), buckwheat, scabiosa, spearmint, coyote brush (Baccharis pilularis), knotweed (Polygonum aviculare), California lilacs (Ceanothus spp.), soapbark tree, meadow foam (Limnanthes douglasi), baby-blue-eyes (Nemophila), (A2, A3, A4, A5, A6, A7).</td>
<td></td>
</tr>
<tr>
<td>Tachinid fly (Tachinidae family)</td>
<td>Cutworm, armyworm, tent caterpillar, cabbage looper, gypsy moth; some attack sawfly, Japanese beetle, May beetle, squash bug, green stink bug, sowbug</td>
<td>Carrot family (caraway, bishop’s weed, coriander, dill, parsley, Queen Anne’s lace, fennel), goldenrod, sweet clover, Phacelia spp., sweet alyssum, buckwheat, amaranth, buckthorn, Heteromeles arbutifolia (A2, A3, A4, A6, A7).</td>
</tr>
<tr>
<td>Tiger beetle (Cicindelidae family)</td>
<td>Many insects</td>
<td>Maintain permanent plantings and some exposed dirt or sand areas.</td>
</tr>
</tbody>
</table>
### Appendix A

#### Plants that Attract Beneficials (A1) continued

<table>
<thead>
<tr>
<th>Beneficial</th>
<th>Pests</th>
<th>How to attract/conserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalcid wasps (many families, including Trichogrammatidae)</td>
<td>Spruce budworm, cotton bollworm, tomato hornworm, corn earworm, corn borer, coding moth, other moths</td>
<td>Maintain a diversity of plants, including dill, anise, caraway, hairy vetch, sparsamint, Queen Anne's lace, buckwheat, common knotweed, yarrow, white clover, taro, cowpea, fennel, cosmos, chervil. For orchards, provide a mix of clover and flowering weeds (A2, A3, A6).</td>
</tr>
<tr>
<td>Whitely parasitic wasp (Encarsia formosa)</td>
<td>Greenhouse whitefly, sweet potato whitefly</td>
<td>Carrot family (Queen Anne's lace, dill, fennel, taro), sunflower family (yarrow, sunflower, cosmos, coreopsis) (A2).</td>
</tr>
</tbody>
</table>

**Sources:**


### Additional Reading


**Farmscaping Books:**


This book provides detailed technical insights into habitat manipulation for biological control. Each chapter is written by an expert about a particular aspect of habitat management (i.e., The Role of Spiders and Their Conservation in the Agroecosystem, or, Within-field and Border Refugia for the Enhancement of Natural Enemies). This volume is a must for researchers in this field as well as a useful reference for farmscaping practitioners.

**For ordering information:**

Univ. of California Press, CPFS, 1095 Essex St. Richmond, CA 94801 (609) 883-1759 FAX: (609) 883-7413


This is a great resource for farmers and land managers, though a fair amount of the information is specific to the Lower Sacramento Valley. Contains much useful information about establishing habitat for wildlife—from hedgerows and native perennial grass stands to riparian enhancement and tailwater ponds. Also includes information nuggets on how to attract beneficial insects, birds and bats, planting techniques and weed control, and cost share programs (Federal, State (CA) and local) for habitat enhancement.

**To order:** Send $18/copy (includes postage and handling) with check payable to “Yolo County RCD” to: Yolo County RCD 221 West Court St., Ste. 1 Woodland, CA 95695
ATTRA’s Phenology Resource List
http://www.attra.org/attra-pub/phenology.html
This website has descriptions of dozens of websites that contain information about plant phenology. Some sites are state or region-specific; other sites have information about specific groups of plants and when they flower at a particular location.

SELECTV (selective) D-base on pesticide effects on non-target arthropods
http://www.ent3.orst.edu/Phosure/data-base/selctv/selctv.htm
The SELCTV (pronounced as “selective”) database was created in 1986/87 by Karen M. Theiling, then a research student working towards a Master’s thesis, under the supervision of Professor Brian Croft in the Department of Entomology at Oregon State University, Corvallis. The database represents a relatively comprehensive compilation of the worldwide published literature describing pesticide effects on non-target arthropods (Theiling & Croft, 1988) during the period from 1921 to 1985, with a small number of entries from publications dated between 1986 and 1994. The principal database table contains approximately 12,500 data records, 99.7% of which originate from the pre-1986 literature. Each record in the principal table represents one screening of a pesticide on one natural enemy taxon under conditions described in the source publication.

Additional Reading

Articles:

Useful Websites continued

Appendix B

Pests and Associated Beneficial Insects

<table>
<thead>
<tr>
<th>Pest</th>
<th>Beneficial that attacks it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa weevil</td>
<td>Predatory thrips, <em>Bathyplectes</em> wasps, <em>Tetrastichus incertus</em> (wasp parasite)</td>
</tr>
<tr>
<td>Aphid</td>
<td>Aphid midge, aphid parasites, syrphid fly, ladybug, parasitic wasp, big-eyed bug, damsel bug, mealybug destroyer, soldier beetle, lacewing, braconid wasp, predatory thrips, rove beetle, syrphid fly</td>
</tr>
<tr>
<td>Armyworm</td>
<td>Big-eyed bug, braconid wasp, spined soldier bug, tachinid fly</td>
</tr>
<tr>
<td>Beetles</td>
<td>Braconid wasp</td>
</tr>
<tr>
<td>Bud moth</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Cabbage looper</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Cabbage-root maggots</td>
<td>Ground beetle, rove beetle</td>
</tr>
<tr>
<td>Cabbageworm</td>
<td>Braconid wasp</td>
</tr>
<tr>
<td>Caterpillars in general</td>
<td>Assassin bug, lacewing, <em>Trichogramma</em> wasp, braconid wasp, damsel bug, minute pirate bug</td>
</tr>
<tr>
<td>Codling moth</td>
<td>Braconid wasp, predatory thrips, <em>Trichogramma</em> wasp</td>
</tr>
<tr>
<td>Colorado potato beetle</td>
<td>Ground beetle, spined soldier bug</td>
</tr>
<tr>
<td>Corn earworm</td>
<td>Big-eyed bug, minute pirate bug, <em>Trichogramma</em> wasp, lacewing</td>
</tr>
<tr>
<td>Cotton bollworm</td>
<td><em>Trichogramma</em> wasp</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Ground beetle, tachinid fly</td>
</tr>
<tr>
<td>European corn borer</td>
<td>Braconid wasp, <em>Trichogramma</em> wasp</td>
</tr>
<tr>
<td>Flea beetles</td>
<td>Big-eyed bug</td>
</tr>
<tr>
<td>Flies</td>
<td>Braconid wasp</td>
</tr>
<tr>
<td>Green stink bug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Gypsy moth</td>
<td>Braconid wasp, ground beetle, tachinid fly</td>
</tr>
<tr>
<td>Japanese beetle</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Leafhopper</td>
<td>Big-eyed bug, damsel bug, minute pirate bug</td>
</tr>
</tbody>
</table>
Appendix B

### Pests and Associated Beneficial Insects continued

<table>
<thead>
<tr>
<th>Pest</th>
<th>Beneficial that attacks it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leafminer</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Looper</td>
<td>Big-eyed bug, parasitic wasps</td>
</tr>
<tr>
<td>Lygus bugs</td>
<td>Big-eyed bug, braconid wasp, Anaphes iole</td>
</tr>
<tr>
<td>May beetle</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>Ladybug, big-eyed bug, mealybug destroyer, lacewing</td>
</tr>
<tr>
<td>Mexican bean beetle</td>
<td>Spined soldier bug</td>
</tr>
<tr>
<td>Mites</td>
<td>Ladybug, big-eyed bug, Lacewing, minute pirate bug</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Rove beetle</td>
</tr>
<tr>
<td>Oriental fruit moth</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Peach twig borer</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Psyllids</td>
<td>Big-eyed bug</td>
</tr>
<tr>
<td>Sawfly</td>
<td>Spined soldier bug, tachinid fly</td>
</tr>
<tr>
<td>Scales</td>
<td>Lacewing, predatory thrips</td>
</tr>
<tr>
<td>Slugs</td>
<td>Ground beetle, parasitic nematodes</td>
</tr>
<tr>
<td>Snails</td>
<td>Ground beetle</td>
</tr>
<tr>
<td>Soft scales</td>
<td>Ladybug</td>
</tr>
<tr>
<td>Sowbug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Spider mite</td>
<td>Ladybug, minute pirate bug, predatory mite, predatory thrips, spider mite destroyer, western predatory mite</td>
</tr>
<tr>
<td>Springtails</td>
<td>Rove beetle</td>
</tr>
<tr>
<td>Spruce budworm</td>
<td>Trichogramma wasp</td>
</tr>
<tr>
<td>Squash bug</td>
<td>Tachinid fly</td>
</tr>
<tr>
<td>Tent caterpillar</td>
<td>Ground beetle, tachinid fly</td>
</tr>
<tr>
<td>Thrips</td>
<td>Ladybug, minute pirate bug, big-eyed bug, damsel bug, lacewing</td>
</tr>
<tr>
<td>Tomato hornworm</td>
<td>Big-eyed bug, assassin bug, Trichogramma wasp</td>
</tr>
<tr>
<td>Treehoppers</td>
<td>Damselfly</td>
</tr>
<tr>
<td>Whiteflies</td>
<td>Lacewing, predatory thrips, whitefly parasitic wasp (Encarsia spp.)</td>
</tr>
</tbody>
</table>

### Bat Houses

Natural Insect Control
R.R. #2
Stevensville, Ontario
Canada LOS ISO
(905) 382-2904
FAX: (905) 382-4418
Peaceful Valley Farm Supply
P.O. Box 2209 #P
Grass Valley, CA 95945
(530) 272-4769
http://www.groworganic.com
The Green Spot
Dept. of Bio-Ingenuity
93 Priest Rd.
Nottingham, NH 03290
(603) 942-8925
FAX: (603) 942-8932
Danny Smith
P. O. Box 703
La Porte, TX 77572-0703
genes96597@aol.com
http://home.earthlink.net/~riverdan2/wildlife.htm

### Seed Suppliers

See Appendix C

### Windbreaks, Shelterbelts and Hedgerows

Mary Kimble
Yolo County Resource Conservation District
221 W. Court St., Ste. 1
Woodland, CA 95695
(530) 662-2037 ext. 3

The Yolo County Conservation District is doing some excellent ongoing work concerning hedgerow establishment, plant selection, types of beneficials attracted, and budgets for hedgerow installation and maintenance.

### Useful Websites

**Biological Control: A Guide to Natural Enemies of North America**
http://www.nysaes.cornell.edu/ent/biocontrol/

This site, Biological Control: A Guide to Natural Enemies of North America provides photographs and descriptions of over 100 biological control (or biocontrol) agents of insect, disease, and weed pests in North America. It is also a tutorial on the concept and practice of biological control and integrated pest management (IPM). Excellent photos and lifecycle descriptions supplemented with diagrams.

**Insect Parasitic Nematodes**
http://www.oardc.ohio-state.edu/nematodes/

This site has much useful information about the use of insect parasitic nematodes: the biology and ecology of nematodes, how to use nematodes, a list of suppliers, and more! An extremely useful section provides full citation for research papers according to author, title, or abstract. Research papers can also be searched for according to Order and Family of target insect. To get to this section, click on: Search Publications ⇒ Keyword Search Page (just underneath the “author, title, abstract” search engine)=Insects. Then you may choose the Order and Family of your choice.

The folks at USDA’s National Agroforestry Center have technical information about the benefits, planting, maintenance, and impact on wildlife of windbreaks, hedgerows, snowfences.

**ATTRA**
http://www.oardc.ohio-state.edu/nematodes/

This site has much useful information about the use of insect parasitic nematodes: the biology and ecology of nematodes, how to use nematodes, a list of suppliers, and more! An extremely useful section provides full citation for research papers according to author, title, or abstract. Research papers can also be searched for according to Order and Family of target insect. To get to this section, click on: Search Publications⇒Keyword Search Page (just underneath the “author, title, abstract” search engine)=Insects. Then you may choose the Order and Family of your choice.

Bruce Wight
National Windbreak Forester
USDA Natural Resources Conservation Service (NRCS)
Federal Building
100 Centennial Mall North
Lincoln, NE 68508-3866
(402) 437-5178 ext. 36
bwight@telspec.itc.nrcs.usda.gov
http://www.unl.edu/nac/
Central Coast Wilds specializes in farmscape planning, installation, and management. They provide information and native plants in order to meet several farm system goals:
- beneficial insect habitat
- wind break
- erosion control
- riparian stabilization
- non-point source water pollution reduction

http://www.centralcoastwilds.com/farmscape.html

Dr. Robert Bugg
Cover Crops/Restoration Ecology
UC-Sustainable Agriculture Research & Education Program (SAREP)
Davis, CA 95616
(530) 754-8549
rbugg@ucdavis.edu

Dr. Sharad Phatak
University of Georgia
Coastal Plain Experiment Station
P.O. Box 748
Tifton, GA 31793
(912) 386-3901
phatak@cpes.peachnet.edu

Both Dr. Phatak and Dr. Dutcher have done extensive research into biological control, and the Coastal Plain Experiment Station is a center of innovative research in this area.

Diane Mathews Gehringer
2774 Silver Creek Rd.
Kutztown, PA 19530
(610) 285-4317

Ms. Gehringer, formerly with the Rodale Institute, is knowledgeable about biological control.

Bat Habitat

Rachael Long
Farm Advisor
UC-Cooperative Extension
70 Cottonwood St.
Woodland, CA 95695
(530) 666-8143

Jim Kennedy
Bat Conservation International
P.O. Box 162603
Austin, TX 78716
(512) 327-9721

Dr. Steve Cross
Southern Oregon State College
1250 Siskiyou Blvd.
Ashland, OR 97520-5071
(541) 552-6749

Dr. James Dutcher
University of Georgia
Coastal Plain Experiment Station
P.O. Box 748
Tifton, GA 31793
(912) 386-3374

Appendix C

<table>
<thead>
<tr>
<th>Seed Blends, Plants and Sprays to Attract Beneficial Insects (C1, C2)</th>
<th>Blend</th>
<th>Planting information (from manufacturers/suppliers)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Bug Blend™</td>
<td>Since the mix blooms nearly year-round, Good Bug Blend should be planted in areas that can go a little wild, such as field borders, ditchbanks, fence rows, etc.Generally, you need to plant only 1-5% of your land with this mix for good results. Crimson, rose and sweet clovers, subclovers, alfalfa, gypsophila, Eringyum foeniculatum, white alyssum, nasturtium, yarrow, carrot, dill, daikon, celery, radish, fennel, caraway, chervil, coriander, and more. Drill or broadcast seed at 10-15 lb./acre (1 lb./1,000 sq. ft.) in any but the coldest months of the year. Large-scale growers: if you are planting in fall, add vetch at 5 lb./acre. If you are planting in spring, add 10 lb. of buckwheat and 10 lb. of cowpeas/acre.</td>
<td>Good Bug Blend™</td>
<td>Peaceful Valley Farm Supply P.O. Box 2289 Grass Valley, CA 95945 (916) 272-4769 <a href="http://www.groworganic.com/">http://www.groworganic.com/</a></td>
</tr>
<tr>
<td>Low Growing Good Bug Blend</td>
<td>A mix of annuals and perennials under 2 feet tall, for use below trees, cane berries, vines or along border areas with height limitations. This mix performs best with regular drip, sprinkler or furrow irrigation during dry periods. It blooms 6-10 months/year and contains: carrott, chervil, coriander, clovers (cinnamon, white, rose), subclovers, nasturtium, parley, alyssum and yarrow. Drill or broadcast at 10-15 lb./planted acre (1 lb./1,000 sq. ft.).</td>
<td>Low Growing Good Bug Blend</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>Border Patrol™</td>
<td>For best results sow this mix 4-6 weeks prior to planting your garden. Border Patrol has more color, but is less effective than Good Bug Blend. Species include white evening primrose, wild buckwheat, baby blue eyes, candytuff, bishop's flower, black-eyed susan, strawflower, nasturtium, angelica and yarrow.</td>
<td>Border Patrol™</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>Good Bug Food (Spray)</td>
<td>This product is a food source for beneficial insects. In their adult stage, these insects need pollen and sugars, which are often not present in sufficient quantities. Beneficial insects especially need additional food during dry periods. Derived from Brewer's Yeast and powdered milk, Good Bug Food can attract and increase beneficial populations as much as tenfold. Mix one part food with an equal part of honey or sugar. Paint this mixture onto cardboard or wooden stakes and place in your garden or greenhouse.</td>
<td>Good Bug Food (Spray)</td>
<td>Peaceful Valley Farm Supply (see above)</td>
</tr>
<tr>
<td>All Purpose Insectary Plant Blend™ (Pacific Seed)</td>
<td>Plant swaths through crop areas. White clover, yellow clover, yarrow, cilantro, caraway, fennel, parsley, sweet alyssum, fiddly tips, baby's breath, cosmos. Use ½ lb./1500 sq. ft. or 10-12 lb./acre.</td>
<td>All Purpose Insectary Plant Blend™ (Pacific Seed)</td>
<td>Harmony Farm Supply P.O. Box 460 Graton, CA 95444 (707) 833-9125 <a href="http://www.harmonyfarm.com/">http://www.harmonyfarm.com/</a></td>
</tr>
</tbody>
</table>
### Appendix C

#### Seed Blends, Plants and Sprays to Attract Beneficial Insects (C1, C2) continued

<table>
<thead>
<tr>
<th>Blend</th>
<th>Planting information (from manufacturers/suppliers)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beneficial Blend™</strong> (made by Lohse-Mill)</td>
<td>Barley, cereal rye, subclover, berseem clover, crimson clover, white clover, yellow clover, alfalfa, mustard, coriander, sweet alyssum, yarrow, buckwheat. Use ½ lb./1500 sq. ft. or 10–12 lb./acre.</td>
<td>Harmony Farm Supply (see above)</td>
</tr>
<tr>
<td><strong>Border Patrol™</strong></td>
<td>Beneficial insect attractant flowers. Formulated by Clyde Robin wildflower company, this is a mix of flower seeds specially chosen to attract beneficial insects and provide homes for them. One can covers 350 square feet and it's recommended for use as a border around the garden or between beds. Works best if it's planted a few weeks before the rest of the garden; first blossoms will appear in 45–90 days. Many of the flowers are perennials which will bloom year after year, the mix includes evening primrose, wild buckwheat, baby blue eyes, black-eyed susan, straw flowers, nasturtiums, bishop's flowers, angelica, and yarrow.</td>
<td>Bountiful Gardens 18001 Shafer Ranch Road Willits, CA 95490 (707) 459-6410</td>
</tr>
<tr>
<td><strong>Haven™ Flowering Herbs</strong></td>
<td>Haven is a blend of popular culinary herbs (dill, fennel). These herb varieties have small flowers (tiny predators can’t reach the nectar of large blossoms), with abundant nectar and a long flowering period. The flowers attract a wide variety of the most desirable beneficial insects. Sow the seeds after danger of spring frost.</td>
<td>Gardens Alive! 5100 Schenley Place Lawrenceburg, IN 47025 (812) 537-8650 <a href="http://www.gardens-alive.com/">http://www.gardens-alive.com/</a></td>
</tr>
<tr>
<td><strong>Haven™ Cover Crop</strong></td>
<td>Blend of leguminous cover crops provides a habitat for beneficial insects. Sow in spring on soil that is to lie fallow for the season. When tilled under, the plants add nitrogen to the soil and reduce the need for additional fertilizing. Includes ladino, red clover, white clover, hairy vetch.</td>
<td>Gardens Alive! (see above)</td>
</tr>
<tr>
<td><strong>Bug Pro™ (spray)</strong></td>
<td>BugPro provides the protein beneficial insects need to induce egg-laying, when a natural insect diet is not available. BugPro effectively attracts lady beetles and lacewings to your garden. 5 lbs. makes 10 gallons, covers 10,000 sq. ft. Spray or drop on foliage where you want to attract beneficials.</td>
<td>Gardens Alive! (see above)</td>
</tr>
<tr>
<td>no specific blends</td>
<td>Nursery that sells plants at three different sizes, including many ornamental and useful plants from around the world. California lilac, willows, shrubs, wildflowers, grasses.</td>
<td>Forestfarm 980 Tetherow Road Williams, OR 97544 (541) 846-7269 <a href="http://www.forestfarm.com/search/plant.asp">http://www.forestfarm.com/search/plant.asp</a></td>
</tr>
<tr>
<td>no specific blends</td>
<td>Niche Gardens is a mail-order and retail nursery. They specialize in nursery-propagated wildflowers and natives, perennials, ornamental grasses and unusual trees and shrubs.</td>
<td>Niche Gardens 1111 Dawson Road Chapel Hill, NC 27516 (919) 967-0078</td>
</tr>
</tbody>
</table>

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### References:

Summary

The goal of farmscaping is to prevent pest populations from becoming economically damaging. This is accomplished primarily by providing habitat to beneficial organisms that increase ecological pressures against pest populations. Farmscaping requires a greater investment in knowledge, observation, and management skill than conventional pest management tactics, while returning multiple benefits to a farm’s ecology and economy. However, farmscaping alone may not provide adequate pest control. It is important to monitor pest and beneficial populations so that quick action can be taken if beneficials are not able to keep pest populations in check. Measures such as maintaining healthy soils and rotating crops are complementary to farmscaping and should be integrated with farmscaping efforts. Biointensive Integrated Pest Management (IPM) measures, such as the release of commercially-reared beneficials (applied biological control) and the application of “soft” pesticides (soaps, oils, botanicals) can be used to augment farmscaping efforts.

Appendix C

| Seed Blends, Plants and Sprays to Attract Beneficial Insects (C1, C2) |
|-----------------------------|-----------------------------|-----------------------------|
| Blend | Planting information (from manufacturers/suppliers) | Supplier |
| No specific blends | Specializes in native grasses, including: Bentgrass, Tufted Hairgrass, Slender Hairgrass, Squirrel Tail, Slender Wheatgrass, Blue Wild Rye, Idaho Fescue, Calif. Fescue, Meadow Barley, Calif. Barley, Junegrass, Creeping Wild Rye, Calif. Onion Grass, Hartford’s melic, Deergrass, Nodding Needlegrass, Foothill Needlegrass, Purple Needlegrass, One sided Bluegrass. | Hedgewood Farms 21740 County Rd. 88 Winters, CA 95694 (916) 662-4570 |
| Forbs: | Yarrow, Narrow-leaf Milkweed, Purple Aster, Calif. Poppy, Gum Plant. | Garden City Seeds 778 Hwy 93 North Hamilton, MT 59840 (406) 961-4837 |
| Legumes: | Small-flowered Lupine, Arroyo Lupine, Yellow Lupine, Bull Clover, and Toncat clover. | Cornflower Farms P.O. Box 896 Elk Grove CA 95759 (916) 689-1015 |
| | | Richter’s 357 Hwy 47 Goodwood, ON L0C 1A0 Canada (905) 648-6677 |

Sources:


Help us to better help farmers.

If you have suggestions for improvements in this publication, areas about which you’d like more information or detail, ideas, case studies, or sources of good farmscaping information (articles or websites), please call Rex Dufour at 1-800-346-9140, or email at rdxr@ncat.org.

Please fill out the feedback form on the back page of this publication. Thank you!
## Appendix D

### Examples of Farmscaping

<table>
<thead>
<tr>
<th>Cropping System &amp; Problem</th>
<th>Location; Strategy (e.g. beneficial habitat, trap crop) and Details</th>
<th>Researcher and Contact Information</th>
</tr>
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<tbody>
<tr>
<td>Stink bugs in Pecans</td>
<td>Texas: Trap crop of black-eyed peas for stink bugs. When the growers compared the average dollar losses from stink bugs between the trap-cropped sites and the non-trap-cropped sites they found that the non-trap-cropped sites sustained $29.29 more stink bug associated losses than did the trap-cropped orchards. It cost the growers approximately $211.50 (about $211.25/acre of peaches) to establish and maintain the trap-cropped peaches. When spread over the 650 acres of the pecan farm being affected by the presence of the trap crops, the growers spent $3.25/acre (of pecans) to establish and maintain the trap crops. The growers determined for every dollar they spent establishing and maintaining the trap crops, they prevented $9.01 in kernel damage from stink bugs. See also: <a href="http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe/id=689">http://www.sarep.ucdavis.edu/cgi-win/sare/sare.exe/id=689</a></td>
<td>Kyle Broeksieker, Box 216 Van Horn, TX 79855 (915) 283-2506</td>
</tr>
<tr>
<td>Thrips on pepper plants</td>
<td>Florida: Cover crops and weeds as beneficial insect habitat for thrips control. During the summer of 1994 the participants tried Alyce clover and Aeschynomene, both legumes, as cover crops. Rank growth of the latter resulted in these being mowed soon after peppers were planted. The participants also monitored insect populations in a native weed species, Wedelia triloba, found growing abundantly on the ditch banks. This particular weed harbored large numbers of a non-destructive species of thrips, as well as predatory insects, and will be examined further in the future. Future testing of such nursery areas will include a more critical selection of cover crops. The researchers will be seeking plants with a prostrate growth habit that does not interfere with farming operations and that will continue to flower through Florida’s winter season. The research found that cover crops are helpful in providing refuges for predatory insects, but more covers with prostrate growth and a winter flowering period need to be identified. USDA entomologists predict that the range of the melon thrips, Thrips palmi, will extend north into Georgia, and west to the Pacific Ocean. Accordingly, nearly all of the nation’s winter pepper production will be seeking plants with a prostrate growth habit that does not interfere with farming operations and that will continue to flower through Florida’s winter season. The research found that cover crops are helpful in providing refuges for predatory insects, but more covers with prostrate growth and a winter flowering period need to be identified. USDA entomologists predict that the range of the melon thrips, Thrips palmi, will extend north into Georgia, and west to the Pacific Ocean.</td>
<td>Ted &amp; Trudy Winsberg Green Cay Farms Rt. 1 Box 331B Boynton Beach, FL 33437 (407) 499-5345</td>
</tr>
<tr>
<td>Establishing Hedgerows as Beneficial Insect Habitat</td>
<td>California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops. California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops. California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops. California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops. California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops. California: perennial plants and native grasses as hedgerows for beneficial insect habitat for various row crops.</td>
<td>Mary Kimble 221 W. Court St., Ste. 1 Woodland, CA 95695 (530) 662-2007 ext. 3</td>
</tr>
<tr>
<td>Lygus bug on strawberries</td>
<td>California: Annual trap-crop of one dormant and one semi-dormant alfalfa variety, two radish varieties (Daikon and the edible variety Cherry Belle) and sweet alfalfa (Carpet of Snow variety). Preliminary indications are that lygus moving in from surrounding fields settle on the annual trap crop mix. The trap crop can then be treated by chemicals or vacuumed, thereby avoiding any chemical applications to the strawberries.</td>
<td>Sean Sweezy / Polly Goldman U.C. Santa Cruz Santa Cruz, CA (831) 755-2889</td>
</tr>
</tbody>
</table>

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### This pending draft legislation, being considered for passage in 2001, may have significant opportunities for farms to implement sustainable practices in the future. Due to the nature of this legislation, we felt it important to include draft language of the legislation in this document to provide sustainable agriculture practitioners with information about a possible future resource.

### Conservation Security Act 2000

**Summary:** The Conservation Security Act (CSA) of 2000 provides financial assistance to help farmers and ranchers find viable solutions to agricultural, environmental, and economic problems. The CSA rewards producers for good stewardship in appreciation of the many nonmarket environmental and social benefits that these practices provide society. The Act balances federal funding for conservation on working lands with existing funding for land retirement, providing farmers access to payments for whole-farm resource planning.

**Conservation Purposes:** The Conservation Security Program (CSP) created by the CSA addresses the full range of conservation concerns related to agriculture, including:
- conservation of soil, water, energy, and other related resources
- soil, water, and air quality protection and improvement
- on-farm conservation and regeneration of plant germplasm
- wetland and wildlife habitat restoration, conservation, and enhancement
- greenhouse gas emissions reduction and carbon sequestration
- and other similar conservation goals

**Participation:** Participation in the program stipulates that land practices must achieve resource and environmental benefits, but does not require the removal of land from production. Practices do not need to be newly introduced to the farm/ranch; producers can be rewarded for good stewardship practices implemented prior to enrollment in the CSP. Participants are responsible for developing conservation security plans that identify targeted resources, practices, and implementation schedules. Participants are granted maximum flexibility for choosing land management, vegetative, and structural practices suitable for individual farms. In certain instances, the plan may include an on-farm research or demonstration component.

**Tiers:** Participants have the choice of enrolling in one of three tiers:
- Tier I participants address priority resource concerns on all or part of their farms/ranches. Practices may include soil and residue management, nutrient management, pest management, irrigation management, grazing management, wildlife habitat management, contour farming, strip cropping, cover cropping, and related practices.
- Tier II participants address priority resource concerns on the whole farm/ranch and meet applicable resource management system criteria. Tier II practices entail adoption of land use adjustment practices such as resource-conserving crop rotations, rotational grazing, conversion to soil-conserving practices, installing conservation buffer practices, restoration of wildlife habitats, prairies, and/or wetlands, and other related practices.
- Tier III participants satisfy the requirements of tiers I and II, while integrating land use practices into a whole-farm, total-resource approach that fosters long-term sustainability of the resource base.

**Payment and Eligibility:** Payments are based on the natural resource and environmental benefits expected from plan implementation, the number and timing of management practices established, income foregone due to land use adjustments, costs related to on-farm research, and several other factors. Bonuses are also offered to beginning farmers, joint participation by operators within a small watershed, and plans that optimize carbon sequestration and minimizes greenhouse gas emissions. Payments may not exceed $20,000, $35,000, and $50,000 for Tier I, II, and III contracts, respectively.

**Funding:** The program is funded out of the Commodity Credit Corporation and all eligible producers will receive contract payments for the requisite number of years. CCC funding is also provided for technical assistance, education and outreach, and monitoring and evaluation.
NRCS helps participants prepare a plan for installing wildlife habitat development practices on eligible land. Five- to ten-year contracts are made with eligible producers. Cost-share payments (up to 75%, $10,000 maximum/year, $50,000 maximum/contract), may be made to implement one or more eligible structural or vegetative practices, such as animal management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. These plans are developed in cooperation with NRCS and a appointed Conservation District Administration County committee. Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management. For more information, contact your local Natural Resources Conservation Service (NRCS) office.

**Wildlife Habitat Incentive Program (WHIP)**


In similar ways to the EQIP program, WHIP is a voluntary program for people who want to develop and improve wildlife habitat primarily on private lands. NRCS offers both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat. The cost-share agreement generally lasts from 5 to 10 years from the date the agreement is signed. NRCS will pay up to 75 percent of the cost of installing the wildlife habitat practices as long as NRCS or its agent has access to monitor the effectiveness of the practices. NRCS helps participants prepare a wildlife habitat development plan in consultation with the local conservation district. The plan describes the landowner’s goals for improving wildlife habitat, includes a list of practices and a schedule for implementing the plan, and describes the steps necessary to maintain the habitat for the life of the agreement. This plan may or may not be part of a larger conservation plan that addresses other resource needs such as water quality and soil erosion.

**Wetlands Reserve Program**

http://www.wlfb.net.org/

For additional information about the Wetlands Reserve Program, which may have some applicability to farmscaping, please visit the website or call your local NRCS office.

**US Fish and Wildlife Service (USFWS)**

**Partners for Wildlife**

http://partners.fws.gov/index.htm

The Partners for Fish and Wildlife Program (formerly named the Partners for Wildlife program) is a proactive, voluntary program of the U.S. Fish and Wildlife Service that provides technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. The program emphasizes the reestablishment of native vegetation and ecological communities for the benefit of fish and wildlife in concert with the needs and desires of private landowners. The Service also enlists the assistance of a wide variety of other partners to help restore wildlife habitat on private lands. These partners include other federal agencies, tribes, state and local governments, conservation organizations, academic institutions, businesses and industries, school groups, and private individuals.

The USFWS provides financial and technical assistance to private landowners through voluntary cooperative agreements. Landowners agree to maintain restoration projects as specified in the agreement, but retain full control of the land. Depending on the project, landowners can apply for cost share on up to 50% of the expense of implementing the plan. Landowners and national, state, and local organizations can serve as partners with the USFWS in carrying out restoration work on private lands.

**Appendix D**

### Examples of Farmscaping continued

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<tr>
<td>Integrated sour cherry orchard</td>
<td>Michigan: The orchard systems include an integrated system of Alternative Insect Management (AIM); and a Permaculture System (PER). A third system, Integrated Pest Management (IPM) which is currently used by progressive growers is included for comparison. AIM is based on fundamental changes in the orchard ecosystem, including mixed species hedgerow barriers to reduce pest immigration and enhance beneficial arthropod abundance; insect pheromone mating disruption; endophytic grasses to inhibit pest abundance; mass trapping; tree mulches and alternative groundcovers to reduce weed competition and enhance biological diversity.</td>
<td>Charles Edson IIPM Program, Center for Integrated Plant Systems, Michigan State Univ. R18 Food Safety and Toxicology Bldg. East Lansing, MI 48824 (517) 353-5134</td>
</tr>
<tr>
<td>Strips of grass, clover-alfalfa mix with vegetables for insect pest control</td>
<td>California: Pest break strips (D1) have been effective for enhancing biological control in potatoes and several other row crops. Pest break strips have a dual role: 1) as trap crops, they divert pests away from market crops; and 2) as insectary crops, they grow beneficial insects helping to provide biological control of pests in adjacent rows of vegetable crops. This report noted that control was “Good to excellent. Insect predators and parasites keep aphids and caterpillars under control; leafhopper and leaf miner prefer alfalfa in pest break strips to other hosts.” The large-scale trials occurred on a farm in central California. Managers made pest break strips five to seven beds wide (80-inch bed width) at intervals of 350 feet across the farm. Several mixes of grasses, legumes and wildflower were tested for effectiveness in supporting beneficial insects. The most effective mix was found to be predominantly alfalfa (60%) mixed with Dutch white clover, strawberry clover, and crimson clover (10% each).</td>
<td>Nature Farming Development Foundation 6495 Santa Rosa Road Lompoc, CA 93436 (805) 737-1536 FAX: (805) 736-9599</td>
</tr>
<tr>
<td>Green peach aphid on lettuce</td>
<td>California: W.E. Chaney of the UC Cooperative Extension in Salinas, CA, has done field trials interplanting insectary plants (which provide beneficial insects pollinifer and nectar) with vegetables for biological control of the green peach aphid. He used sweet alyssum interplanted every twenty rows in a field of lettuce. Alyssum was chosen because it can be seeded instead of using transplants, and will flower in about 30 days. It does not attract either aphids or tarnished plant bugs, is not aggressive, and provides a good food source for parasitic wasps. By adding sweet alyssum and other pollen and nectar plants to monoculture vegetables, beneficial parasites keep aphids and caterpillars under control; leafhopper and leaf miner prefer alfalfa in pest break strips to other hosts.” The large-scale trials occurred on a farm in central California. Managers made pest break strips five to seven beds wide (80-inch bed width) at intervals of 350 feet across the farm. Several mixes of grasses, legumes and wildflower were tested for effectiveness in supporting beneficial insects. The most effective mix was found to be predominantly alfalfa (60%) mixed with Dutch white clover, strawberry clover, and crimson clover (10% each).</td>
<td>W.E. Chaney U.C. Cooperative Extension 5424 Abbots St Salinas, CA 93901 (408) 759-7350</td>
</tr>
</tbody>
</table>
Appendix D

Examples of Farmscaping continued

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</tr>
</thead>
</table>
| Cabbage aphid in broccoli | Oregon   | In an on-farm research trial exploring the use of beneficial insectary flowers to increase the abundance of predatory insects, experimental plots using the insectary plant *Alyssum maritimum* showed a significant increase in predatory syrphid flies caught in traps and in number of syrphid eggs laid on broccoli leaves. Parasitism of the cabbage aphid was doubled in the alyssum plots. Bugg and Ellis (D4) observed that flowers of canola attracted adults of the following species of hoverflies (*Syrphidae*): *Allograpta obliqua* (Say), *Sphaerophoria spp.*, *Syrphus spp.*, and *Toxomerus spp.* Larvae of all of these species are predators of aphids.          | John Luna  
Oregon State University  
Dept. of Horticulture  
Corvallis, OR 97331  
(541) 737-5420 |
| Diamondback moth on Crucifers | Florida | Trap crops of highly fertilized collards planted in a border around cabbage fields are more attractive to egglaying adult female diamond back moths (dbms). This resulted in minimal damage from dbm to cabbages. In commercial cabbage fields, two rows of collards were planted around perimeters with seven collard plants planted on the ends of each cabbage row. Cabbage fields with collards required 75-100% fewer chemical applications than those without collards. Marketability from both collard and non-collard fields was the same. | Everett Mitchell  
USDA-ARS  
1600 S.W. 23rd Dr.  
Gainesville, FL 32604  
(352) 374-5710 |
| Black Flea beetles on crucifers | Eastern Colorado | Radish cultivar, *Japanese Daikon* as trap crop interplanted at 2’ intervals within broccoli rows, which were planted 16” apart. This technique reduced the numbers of black flea beetles colonizing broccoli compared to plots without interplanted radishes or with interplanted radishes at lower densities (D7). | Mohammed Al-Doghaithi  
1700 W. Plum St. #877  
Ft. Collins, CO 80521  
(970) 491-3005 or 5261 |
| Azalea lace bug on Landscape/ornamentals | New Jersey | The presence of flowering plants—shasta daisy plugs (*Little Princess Chrysanthemum maximum* and *Marconi Chrysanthemum maximum*) and coriander (*Coriander sativum*) reduced lacebug numbers because of the buildup of syrphids, lady beetles and other unidentified predators. There appears to be a seasonal impact of flower species on the duration of predator species and abundance. Coriander flowered earlier but more briefly than the two daisy species, and appeared to harbor less diversity than the daisy. However, there were more species of syrphids in the coriander. The azaleas were small, and researchers believe that many released lacewings left the plots. The flowers and azaleas established well, so prospects for clear results are high in 1999. | Paula M. Shrewsbury  
Rutgers University  
Dep. of Entomology  
14, Smith Hall  
P.O. Box 231  
New Brunswick NJ 08903  
(908) 932-9324 |
| Leafhoppers and flower thrips in vineyards | California | This study suggests that the creation of corridors of sequentially flowering native plant species can serve as a key strategy to allow natural enemies emerging from riparian forests to disperse over large areas of otherwise monoculture systems. This study examined distributions and abundance of western grape leafflower, *Lycorrhoea elegantula*, its parasitoid, *Coenurus spp.*, western flower thrips, *Frankliniella occidentalis*, and generalist predators (D6). | Miguel Altiere  
Center for Biological Control  
University of California  
Berkeley, CA 94720  
(510) 642-9802  
agreec3@nature.berkeley.edu |

A Recap: Steps to Farmscaping

Habitat enhancement for beneficial organisms can provide the foundation for a biologically integrated Pest Management (IPM) program. The steps presented below may help when attempting to increase the “directed diversity” of an agricultural ecosystem:

1. Keep good records of where, when, and what pests occur on the farm.
2. Obtain as much information as you can about both the pest’s and the beneficial organism’s life cycle and habitat requirements. Where are eggs laid and when do they hatch? Where does the pest/beneficial feed and how long does it need to develop into an adult? Where does the pest/beneficial overwinter and in what form? This information will not only aid in farmscaping, but will also aid pest management.
3. Make a list of tools that are available to create a friendlier habitat for the beneficials (or a more unfriendly habitat for pests). This may include various combinations of: insectary plants, crop rotations, hedg rows, intercropping schemes, planting or establishing beneficial habitat, trap crop) and

Federal Cost Share Programs for Habitat Development

USDA/NRCS

Conservation Reserve Program (CRP)

http://www.fsa.usda.gov/dapf/cepd/12crplogo/tableof.htm

Under the “new” CRP, erosion control remains a top priority, but now water quality and wildlife habitat improvement are also emphasized. Continuous sign-up is available to farmers implementing special projects such as filter strips, riparian buffer strips, windbreaks, and wildlife habitat plantings (hedgerows could be included in these categories). Participating farmers must sign up for a minimum of 10 years (with an option to renew for an additional 5 years) and develop a conservation plan that takes certain acres out of production. In return, the farmer receives annual rental payments on the land from the government, up to $50,000 per person per year. Participating farmers can also apply for 50% cost share on implementation of conservation practices agreed to in the conservation programs. For more information, contact your local Natural Resources Conservation Service (NRCS) office.
Bat Housing

The easiest way to construct bat housing is to simply add a sheet of plywood to a barn or house wall with 14" spacers between the sheet and wall. Placing the long axis of the plywood vertically will allow for greater temperature variation in the bat space. (See pages 13–14 for contacts who know about bat habitat and housing.)

Other construction considerations include (11):

- Use exterior-grade plywood with exterior-grade staples and bolts.
- Minimum bat house dimensions are 32" tall, 14" wide, with 3-6" landing pads
- Provide 1-4 roosting chambers, spaced at ¾. LANDING pad and roosting chamber should be roughened or a durable textured surface for the bats to grasp—no sharp points to tear bat wings!
- Front and side venting should be appropriate for local climate.
- All seams should be caulked to avoid leaks.
- Treating bat houses with diluted bat guano or allowing some weathering of a new bat house may help attract new "renters".

Considerations when locating a bat house (11):

- Any place that already has bats is best, particularly agricultural areas (vs. urban areas) due to insect abundance and habitat variety.
- Place the bat house near water—within a quarter mile is ideal.
- Place it near some sort of protective cover like a grove of trees—don’t place houses in a grove of trees, but 20-25 ft. away due to predator concerns, and at least 10 ft. above the ground.
- Don’t place bat houses near barn owl boxes—the barn owl is a bat predator. Place the two types of boxes a fair distance from each other facing in opposite directions.
- Do not mount bat houses on metal buildings (too hot for bats) or in locations exposed to bright lights.
- In California, bat houses in barns and on the north and west sides of buildings have had the greatest rate of occupancy. This may not be true for locations in other parts of the country.
- Paint the exterior with three coats of outdoor paint. Available observations suggest that the color should be black where average high temperatures in July are 80–85°F, dark colors (such as dark brown or gray) where they are 85–95°F, medium or light colors where they are 95–100°F, and white where they exceed 100°F. Much depends upon amount of sun exposure; adjust to darker colors for less sun. (14)

Bat Conservation International
P.O. Box 162603, Austin, TX 78716
(512) 327-9721
http://www.batcon.org/

Bat Housing

Treating bat houses with diluted bat guano

♦ All seams should be caulked to avoid leaks.
♦ Place the bat house near water—within a quarter mile is ideal.
♦ Place it near some sort of protective cover like a grove of trees—don’t place houses in a grove of trees, but 20-25 ft. away due to predator concerns, and at least 10 ft. above the ground.
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For further information about bats and bat houses, contact:

Bat Conservation International
P.O. Box 162603, Austin, TX 78716
(512) 327-9721
http://www.batcon.org/

or contact,
Rachael Freeman Long
Yolo County Farm Advisor
UC Cooperative Extension
(530) 666-8143

Examples of Farmscaping continued

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<tr>
<th>Cropping System &amp; Problem</th>
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</table>
| Leaffoppers and spidermites in vineyards | California: If properly managed, winter annual, legume/grass (oat/vetch) cover crops can reduce the reliance of grape growers on insecticides and miticides used to control leaffoppers and spider mites. Two systems: 1) the cover crop as dry mulch by cutting the cover crop biomass and placing it on row berm for weed suppression to reduce herbicide use, 2) cover crop was cut and left in row middles. If sulfur dust (used for disease control) was used sparingly in late Spring and early Summer, the presence of these cover crops increased early season activity of predatory mites, resulting in reduced spider mite infestations. Similarly, where leaffopper numbers were not very low and cover crops were properly maintained through early July, the presence of cover crops resulted in reduced infestations of leaffoppers. These reductions were attributed to enhanced activity of certain groups of spiders, which consistently attained higher densities in the presence of cover crops compared to the clean-cultivated systems. Leaffoppers were also utilizing the cover crops as non-host crops, which may have resulted in less time spent on vines. | Frank G. Zalom
Extension Entomologist
Department of Entomology
University of California Davis, CA 95616
(916) 752-8350
FAX: (916) 752-6004
E-Mail: fgzalom@ucdavis.edu |
| aphids in cereals | England: Recent research in England indicates that by planting border strips of Phacelia tanacetifolia Bentham (a North American annual that is a good source of pollen for syrphids—syrphid larvae feed on aphids) along cereal fields, significant reductions of aphid populations can be obtained. Increased populations of syrphid flies extended up to 180 meters (395 yards) from the border strips. The researcher notes that in seasons of early crop maturity, syrphid fly larvae may not be able to decrease aphid populations due to lack of attractiveness of the "older" wheat to ovipositing syrphids. | Janice M. Hickman
Department of Biology,
School of Biological Sciences,
Biomedical Sciences Building
The University,
Southampton, SO16 7PX
UK |
| Pest in vegetables | North Carolina: Organic vegetable grower plants an insectary strip every 36 feet or so (i.e., if growing canteloupes on 6 foot rows, the 7th row will be an insectary strip, or if growing peppers on 3 foot rows, every 13th row will be planted in an insectary strip). Rye/vetch mixtures are planted in the fall and will flower early in the spring and are plowed down and sequentially replaced with buckwheat prior to the rye/vetch going to seed. For example, one week a third of the rye/vetch rows may be plowed down and replaced with buckwheat. A few weeks later, another third will be plowed down, etc. This way, there is habitat as well as continual pollen and nectar sources for beneficial insects throughout most of the year. During the summer, the buckwheat is also replaced sequentially as it senesces. The farmer states that this system has been very successful. | Kenny Haines
Looking Back Farms
Rt. 2, Box 600D
Tyner NC, 27980
(252) 426-2218
FAX: (252) 426-9661 |
| Pests in cotton | Texas: This study examined the predator flux between adjacent planted cotton and grain sorghum fields. It was found that there was a general influx of generalist predators (Orius spp.—minute pirate bug, and Hippodamia convergens—convergent lady beetle) from sorghum to cotton, although dispersion of predators works in both directions and may be dependant on both crop phenology and associated food resources (i.e., lack of or abundance of herbivorous prey). | Jarra Prasifka
Department of Entomology
Texas A&M University,
College Station, TX
77843-2475
(409) 862-3407
Email: jrp7200@labs.tamu.edu |
Appendix D

Examples of Farmscaping continued

<table>
<thead>
<tr>
<th>Cropping System &amp; Problem</th>
<th>Location; Strategy (e.g. beneficial habitat, trap crop) and Details</th>
<th>Researcher and Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylloxera on Grapes</td>
<td>California: A recent 2-year field study (D8) by UC Davis researchers found that soil management practices can significantly influence the amount of root damage resulting from phylloxera-induced fungal infections. The researchers found that percent root populations of phylloxera did not significantly differ between organically managed vineyards (OMV) and conventionally managed vineyards (CMV), when both were infested with phylloxera. However, root samples from OMVs displayed significantly less root necrosis (9%) caused by fungal pathogens than did samples from CMV s (31%). Organic vineyard management is characterized by use of cover crops and comports and no synthetic fertilizers or pesticides. This study sampled four OMVs in Sonoma, Napa and Mendocino counties. Eight CMVs were initially sampled in these counties and San Joaquin County. This was later reduced to five CMVs for practical reasons. All vines except for those in San Joaquin (own-rooted) were on AXR#1 rootstock. No significant differences between OMVs and CMVs were found for single year comparisons of percent organic matter, total nitrogen, nitrate and percent sand/silt/clay. The pooled data for the two years tell a slightly different story: OMVs soil had a significantly higher (by 5%) percent organic matter (%OM) than CMVs soil and over all vineyards and all years there was a weak but significant inverse correlation between root necrosis and soil %OM. Cultures of the necrotic root tissue also revealed some interesting differences: significantly higher levels of the beneficial fungus Trichoderma were found in OMVs in 1997 (but not in 1998) and significantly higher levels of pathogens Fusarium oxysporum and Candida apya spp. were found in CMVs in 1998 (but not in 1997).</td>
<td>Dr. Jeffrey Granett  ( \text{380B Briggs Hall} ) ( \text{530} ) ( \text{752-1537} ) ( \text{<a href="mailto:granett@ucdavis.edu">granett@ucdavis.edu</a>} )</td>
</tr>
</tbody>
</table>

Sources:


The migration of certain species of beneficials from the cover crop(s) to the main crop is sometimes associated with senescence (or post-bloom period) of the cover crop. In these instances, moving the cover crops in alternate strips may facilitate their movement while the remaining strips continue to provide refuge for other beneficial species. Sickle-bar mowers are less disruptive to beneficials than flail mowers and rotary mowers.

Mulches

Although this publication generally focuses on living habitat, clearly some beneficial organisms, such as spiders and ground beetles, benefit from mulches (or a habitat that mimics some of the effects of mulches, such as that found in “no-till” fields). Much of the benefit lies in the fact that mulches provide overwintering habitat for these organisms in a moderated microclimate (9).

Trap Crops

A related strategy in farmscaping is the selection of plants that attract pests. These “trap crops” can then be plowed down or managed in some fashion that takes advantage of a vulnerable stage in the crop pest life cycle. See Appendix D for examples of farmers using trap crops.

**Farmscaping for Birds and Bats**

Birds and bats are important insect predators, particularly during the spring when they are raising young. Their activities complement each other. Birds are generally active during the day and feed on caterpillars and other insects, while bats feed during dusk and into the night on mosquitoes, moths, and other nocturnal insects.

Birds and bats are both amenable to living in artificial shelters—free-standing or attached to a building. This could be a slightly modified structural component of a building, such as nest shelves along eaves for barn swallows (10) or a spaced board attached to a beam for bat habitat. Bats, frequently found in man-made structures, prefer places that are warm, dry, and protected from disturbance (11).

Both birds and bats will benefit from having a small pond or body of water on the property or nearby. Bats require a watering area ideally 10 feet long, as they drink “on the fly.” Birds will be content with birdbath-size and larger water bodies. One difficulty in farmscaping for birds is the migration of certain species of beneficials from the cover crop(s) to the main crop and sometimes associated with senescence (9).

Bats not only eat insects that are a nuisance to humans (a small brown bat can devour up to 600 mosquitoes in an hour), but can provide significant agricultural pest control services. In one season, a typical colony of about 150 big brown bats in the Midwest eats 50,000 leafhoppers, 38,000 cucumber beetles, 16,000 June bugs, and 19,000 stink bugs (11)—not to mention thousands of moths such as adult corn borers, earworms, and cutworms.

<table>
<thead>
<tr>
<th>Bird Species</th>
<th>Comments</th>
<th>10, 12, 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluebird</td>
<td>Nest boxes should be located 5-6’ above the ground—best facing a tree or artificial perch. Place multiple houses 30 yards apart to allow individual birds to establish territories. The opening should be 1.5” in diameter.</td>
<td></td>
</tr>
<tr>
<td>Wrens</td>
<td>Feed on insects on ground and plants. Locate nest box close to stick piles and garden. Generally a summer resident only. Opening should be 7.5” in diameter</td>
<td></td>
</tr>
<tr>
<td>Barn Swallow</td>
<td>Attracted by nest shelves under eaves or other structures. Beware of droppings. Opening should be 1.5” in diameter.</td>
<td></td>
</tr>
<tr>
<td>Robin</td>
<td>Common insectivore, but consumes small fruits and cherries.</td>
<td></td>
</tr>
<tr>
<td>Starling</td>
<td>Common insectivore, but will eat small fruit and hollow out large fruit (apples). May forage in large flocks.</td>
<td></td>
</tr>
</tbody>
</table>

Birds and bats are both amenable to living in artificial shelters—free-standing or attached to a building. This could be a slightly modified structural component of a building, such as nest shelves along eaves for barn swallows (10) or a spaced board attached to a beam for bat habitat. Bats, frequently found in man-made structures, prefer places that are warm, dry, and protected from disturbance (11).

Both birds and bats will benefit from having a small pond or body of water on the property or nearby. Bats require a watering area ideally 10 feet long, as they drink “on the fly.” Birds will be content with birdbath-size and larger water bodies. One difficulty in farmscaping for birds is that some birds’ diets change from insects to seeds (or to fruit) after they have finished rearing their young. The following table lists some bird species that may be considered for farmscaping efforts.

<table>
<thead>
<tr>
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<th>10, 12, 13</th>
</tr>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>
Retention of the wasp and parasitization in patches with honeydew was comparable to patches without food—probably due to the rapid decrease in quality of honeydew as it dries, combined with low quantity per site and general low detectability of the food by the parasitoid. Honeydew is scattered about randomly within a field and on a plant. Extrafloral or floral nectaries, on the other hand, are always found at the same location on a particular plant, making it easier for beneficials to locate this food source.

Important characteristics of an ideal food source in the field are high quality, high quantity per site, high detectability, and high predictability of the food location. Nectar sources possess all these qualities.

To summarize this research, some species of parasitic wasps will stay in an area with nectar and general low quantity per site, high detectability and high predictability of the food location. Nectar sources possess all these qualities.

A study in California (8) revealed that beneficials in fact do feed on nectar and pollen provided by insectary plants, and will move up to 250 feet into adjacent crop lands. Further research is needed to determine the optimum spacing of insectaries within a particular crop and ecosystem so that parasites spend most of their time controlling pests (as opposed to searching for food) and producers know how much land insectaries will require and where they are most effectively placed.

The appearance of beneficials should be timed to coincide with peak need for biological control of pests associated with the main crop. Another way of looking at this is that an insectary should grow and bloom at a time that best meets the needs of beneficials for pollen, nectar, or alternate hosts. Strategies to prolong bloom include planting cover crops in strips on successive planting dates. Planting a mix of plants, particularly perennials, that bloom in succession and that meet the habitat needs of desired beneficials is another farmscaping option. It may be helpful to develop a diagram, such as the one below (from Appendix F), when planning habitat that will have something in flower year-round.

**Appendix E**

**Hedgerow Installation and Maintenance Cost Estimates**

For one hedgerow 1400 feet long x 15 feet wide (~.5 acre) planted with a strip of native grasses next to a line of shrubs.

Labor costs are estimated at $10/hr.

<table>
<thead>
<tr>
<th>Task</th>
<th>Date of Cost Estimate</th>
<th>Labor</th>
<th>Material</th>
<th>Equipment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgerow Installation</td>
<td>Nov. 96</td>
<td>$260.00</td>
<td>Survey flags: $8.00</td>
<td></td>
<td>$268.00</td>
</tr>
<tr>
<td>Roundup: summer weed control</td>
<td>Aug. 96</td>
<td>$200.00</td>
<td>Roundup: $30.00</td>
<td>ATV+sprayer: $8.00</td>
<td>$238.00</td>
</tr>
<tr>
<td>Disk: pre-plant weed control</td>
<td>Oct. 96</td>
<td>$10.00</td>
<td>Disc: $15.00</td>
<td>Tractor:</td>
<td>$25.00</td>
</tr>
<tr>
<td>Fertilize:preplant (tablets)</td>
<td>Nov. 96</td>
<td>$20.00</td>
<td>Fertilize: $43.50</td>
<td>Frill plow: $25.00</td>
<td>$88.50</td>
</tr>
<tr>
<td>Plant trees, shrubs, and forbs</td>
<td>Nov. 96</td>
<td>$120.00</td>
<td>$300.00</td>
<td></td>
<td>$620.00</td>
</tr>
<tr>
<td>Install 2 Tubex tree tubes</td>
<td>Nov. 96</td>
<td>$50.00</td>
<td>$172.00</td>
<td></td>
<td>$222.00</td>
</tr>
<tr>
<td>Plant grasses (broadcast)</td>
<td>Nov. 96</td>
<td>$20.00</td>
<td>Seed: $257.00</td>
<td></td>
<td>$277.00</td>
</tr>
<tr>
<td>Harvest to cover grass seed</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td>Harvest:</td>
<td>$75.00</td>
<td></td>
</tr>
<tr>
<td>Roundup: annual weed control</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td>$15.00</td>
<td></td>
<td>$25.00</td>
</tr>
<tr>
<td>Ronstar-G: apply in plant row</td>
<td>Nov. 96</td>
<td>$10.00</td>
<td>Ronstar-G: $25.00</td>
<td></td>
<td>$35.00</td>
</tr>
<tr>
<td>Install drip irrigation system</td>
<td>Mar. 97</td>
<td>$100.00</td>
<td>$200.00</td>
<td>Drip supplies:</td>
<td>$300.00</td>
</tr>
</tbody>
</table>

Total Installation $640.00 $1,319.00 $44.54 $2,033.54

**Hedgerow Maintenance**

<table>
<thead>
<tr>
<th>Task</th>
<th>Date of Cost Estimate</th>
<th>Labor</th>
<th>Material</th>
<th>Equipment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4 D: Broadleaf weed control</td>
<td>Mar. 97</td>
<td>$10.00</td>
<td>2,4 D: $20.00</td>
<td>ATV+sprayer:</td>
<td>$30.00</td>
</tr>
<tr>
<td>Hoe hedge plant row*</td>
<td>Mar-Apr 97</td>
<td>$20.00</td>
<td>Hoe: $30.00</td>
<td></td>
<td>$50.00</td>
</tr>
<tr>
<td>Irrigate twice/wk/no.</td>
<td>Mar-Apr 97</td>
<td>$20.00</td>
<td>Irrig: $8.25</td>
<td></td>
<td>$28.25</td>
</tr>
<tr>
<td>Mow grasses: annual weed control</td>
<td>Apr. 97</td>
<td>$10.00</td>
<td>Mower: $10.19</td>
<td>$20.19</td>
<td></td>
</tr>
<tr>
<td>Remove Tubex</td>
<td>May 97</td>
<td>$20.00</td>
<td></td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Roundup: spot-spray</td>
<td>May-Jun 97</td>
<td>$20.00</td>
<td>Roundup: $15</td>
<td></td>
<td>$35.00</td>
</tr>
<tr>
<td>Fertilize: preplant (tablets)</td>
<td>Sep. 97</td>
<td>$10.00</td>
<td>Fertilizer: $8.70</td>
<td></td>
<td>$18.70</td>
</tr>
<tr>
<td>2,4 D: spot-spray in grasses</td>
<td>Sep. 97</td>
<td>$10.00</td>
<td>2,4 D: $10.00</td>
<td></td>
<td>$20.00</td>
</tr>
<tr>
<td>Flame: annual grass weed control</td>
<td>Oct. 97</td>
<td>$10.00</td>
<td>Flam: $15.00</td>
<td>ATV+flame:</td>
<td>$29.00</td>
</tr>
<tr>
<td>Ronstar-G: entire hedgerow</td>
<td>Oct. 97</td>
<td>$20.00</td>
<td>Ronstar-G: $25.00</td>
<td></td>
<td>$45.00</td>
</tr>
<tr>
<td>Mow grasses twice weed control</td>
<td>May-Jun 98</td>
<td>$20.00</td>
<td>Mower: $20.38</td>
<td>$40.38</td>
<td></td>
</tr>
<tr>
<td>Hoe hedge plant row</td>
<td>Jun-Jul 98</td>
<td>$120.00</td>
<td></td>
<td>$120.00</td>
<td></td>
</tr>
<tr>
<td>Irrigate twice/wk</td>
<td>Apr-Sep 98</td>
<td>$20.00</td>
<td>Irrig:</td>
<td>$20.00</td>
<td></td>
</tr>
<tr>
<td>Hoe hedge plant row</td>
<td>Jun-Jul 98</td>
<td>$120.00</td>
<td>Hoe:</td>
<td>$120.00</td>
<td></td>
</tr>
<tr>
<td>Herbicide: 2,4 D (in grasses)</td>
<td>Aug. 98</td>
<td>$10.00</td>
<td>2,4 D: $10.00</td>
<td></td>
<td>$20.00</td>
</tr>
</tbody>
</table>

Total Cost $1,160.00 $411.95 $38.65 $1,614.14

Source:

Appendix F

Flowering Periods of California Native Insectary Plants

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Genus/ sp.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willow</td>
<td>Salix sp.</td>
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<tr>
<td>California lilac</td>
<td>Eriogonum sp.</td>
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<tr>
<td>Mule fat</td>
<td>Baccharis cinerea</td>
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<tr>
<td>Coffeeberry</td>
<td>Phorinus californica</td>
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<tr>
<td>Hollyleaf cherry</td>
<td>Prunus ilicifolia</td>
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<tr>
<td>Yarrow*</td>
<td>Achillea millefolium</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Silverleaf vine</td>
<td>Pygmaea aspera</td>
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<tr>
<td>Toyon</td>
<td>Heleomeles arbutifolia</td>
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<tr>
<td>Golden sticky monkeyflower</td>
<td>Mertensia guttata</td>
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<td></td>
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<tr>
<td>Elderberry</td>
<td>Sambucus mexicana</td>
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<tr>
<td>California buckwheat**</td>
<td>Eriogonum fasciculatum</td>
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<tr>
<td>Deergrass</td>
<td>Madigenia riga</td>
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<tr>
<td>Creeping boobialla</td>
<td>Mertensia parvispica</td>
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<tr>
<td>California fuchsia</td>
<td>Zauschneria californica</td>
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<td></td>
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<tr>
<td>Narrowleaf milkweed</td>
<td>Leucopetun fasciatus</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>St. Catherine’s lace</td>
<td>Digenonum giganteum</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Coyote bush</td>
<td>Baccharis pilularis</td>
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</tr>
</tbody>
</table>

*Insects prefer common yarrow over the ornamental (salmon-colored) yarrows. Yarrow reseeds itself well.
**California buckwheat is very attractive to beneficials, but also very sensitive to overwatering.

Source:
4. Insectary Establishment

- Seed and plant sources
- Cost of ground preparation, planting and maintenance (irrigation, weeding, etc.) for:
  ♦ at least one year following establishment of perennial
  ♦ needed number of plantings per season of beneficial habitat
  (remember that many annuals provide pollen or nectar for only a few weeks during the cropping season, so that either relay plantings or plant species mixes may be needed for beneficial habitat.)
- Equipment needs (Cost estimates for installation and first-year maintenance of a typical hedgerow in California are given in Appendix E.)

Other Considerations

Weather

Weather variations from year to year may cause a particular management practice to be beneficial one year and problematic the next. A flexible approach is needed in order to adjust beneficial habitat according to weather variations. An observant eye is the grower’s most valuable tool in this respect.

Perennial vs. Annual

The type of cropping system, perennial vs. annual, is an important factor in farmscaping. Perennial systems such as orchards possess an inherent ecological stability derived from the variety of tree-based habitats, which are not harvested or destroyed as in annual systems. Adding a cover crop to an orchard can increase and complement the biodiversity of the system.

Ideally, cover crops (CCs) in orchard systems should be selected and managed for the following attributes (1):

- CCs should not harbor important insect pests
- CCs should have some ability to divert generalist pests from the orchard crop
- CCs should confuse specialist pests visually or olfactorily (by smell) and thus reduce their colonization of orchard trees
- CCs should be capable of altering host-plant nutrition (without negatively impacting the crop) and thereby reduce pest success
- CCs should reduce dust and thereby reduce spider mite outbreaks
- CCs should change the microclimate and thereby reduce pest success
- CCs should increase natural enemy abundance or efficiency, thereby increasing biological control of arthropod pests.

Studies of commercial pecan orchards in Oklahoma (2) and almond plantations in California (3) have demonstrated the efficacy

Resources

For information about crop pests, their parasites and predators, and the ecological requirements of both, contact your local county extension service (under county listings in the phone book) or state Cooperative Extension Service (CES):

Biological Control: A Guide to Natural Enemies of North America:
http://www.nysaes.comell.edu/ent/biocontrol/

To receive a free copy of Suppliers of Beneficial Organisms of North America, call the California EPA’s Department of Pesticide Regulation:
(916) 324-4100 or download from:
http://www.cdpr.ca.gov/docs/dprdocs/goodbug/benefic.htm

Appendix G

Farmscaping Practices Defined

The practices described below can be integrated with an array of cultivation schemes. Each farm can take advantage of the variety of farmscaping tools available to create a cropping system especially suited to its unique environment.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companion planting</td>
<td>A mix of species of plants within a row or bed—was rated difficult to manage by farmers in one study (G1) due to varying cultural needs such as planting time, irrigation needs, and harvesting.</td>
</tr>
<tr>
<td>Strip planting, strip cropping</td>
<td>The practice of growing two or more crops in different strips across a field wide enough for independent cultivation, (e.g., alternating six-row blocks of soybeans and corn, or alternating strips of alfalfa with cotton) was rated as most easily adapted to vegetable production systems (G1). Like intercropping, strip cropping increases the diversity of a cropping area, which in turn may help “disguise” the crops from pests. Another advantage is that one of the crops may act as a reservoir and/or food source for beneficial organisms. However, much more research is needed to study the complex interactions between different crops and their pest and predator complexes.</td>
</tr>
<tr>
<td>Multiple cropping</td>
<td>The production of more than one crop on the same land in one year. Depending on the type of cropping sequence used, multiple cropping can be useful as a weed control measure, particularly when the second crop is interplanted into the first.</td>
</tr>
<tr>
<td>Interplanting</td>
<td>The seeding or planting of a crop into a growing stand, such as overseeding a cover crop into a grain stand.</td>
</tr>
<tr>
<td>Intercropping</td>
<td>The practice of growing two or more crops in the same, alternate, or paired rows in the same area. This technique is particularly appropriate in vegetable production. The advantage of intercropping is that the increased diversity helps “disguise” crops from insect pests, and if done well, may allow for more efficient utilization of limited soil and water resources.</td>
</tr>
<tr>
<td>Cover crops</td>
<td>Cover crops and green manures can be integrated into both perennial and annual cropping systems. Cover crops, often a legume or grass species, prevent soil erosion and suppress weeds. A cover crop can also be used as a green manure.</td>
</tr>
<tr>
<td>Green manures</td>
<td>Generally incorporated into the soil to provide nitrogen and organic matter for subsequent crops. When incorporated, some cover crops in the Brassica family (such as rapeseed, broccoli and radish) have the ability to suppress nematode pests (G2). Left in the field as residues, rye, wheat, and some other grasses will provide greater than 90 percent weed suppression (G3,G4).</td>
</tr>
<tr>
<td>Windbreaks</td>
<td>These are linear barriers of trees, shrubs, perennial forbs and grasses that are planted along field edges or other unused areas. When done correctly, they reduce windspeed and, as a result, modify the microclimate in the protected area. Aside from providing a microclimate favorable to beneficial organisms, windbreaks also protect against wind erosion of soil, decrease the desiccating effect of winds on crops, help enhance snow distribution and provide wildlife habitat.</td>
</tr>
<tr>
<td>Shelterbelts and Hedgerows</td>
<td>These are linear barriers of trees, shrubs, perennial forbs and grasses that are planted along field edges or other unused areas. When done correctly, they reduce windspeed and, as a result, modify the microclimate in the protected area. Side from providing a microclimate favorable to beneficial organisms, windbreaks also protect against wind erosion of soil, decrease the desiccating effect of winds on crops, help enhance snow distribution and provide wildlife habitat.</td>
</tr>
</tbody>
</table>

Sources:


G2) http://www.hort.purdue.edu/newcrop/proceedings1996/v3-615.html


Farmscaping to Enhance Biological Control
In other instances the beneficials may not exist in numbers sufficient to control pest populations during the time when pest populations generally increase. Predator/prey population balances are influenced by the timing of availability of nectar, pollen and alternate prey-hosts for the beneficials. Therefore, there is a strong argument to be made for having year-round beneficial organism habitat and food sources. The “beneficial habitat season” may be extended by adding plants that bloom sequentially throughout the growing season or the whole year.

When contemplating farmscaping, consideration should be given to the cost of developing beneficial habitat and maintenance of the habitat as well as the cost of any land that might be taken out of production. In any case, a more systematic, research-oriented approach to farmscaping can often help the grower avoid mistakes and develop desirable habitats that match the needs of the beneficial organisms as well as the pest management needs of the farm.

The following are key considerations in crafting a farmscaping plan:

1. Ecology of Pests and Beneficials
   - What are the most important (economic) pests that require management?
   - What are the most important predators and parasites of the pest?

2. Timing
   - When do pest populations generally first appear and when do these populations become economically damaging?
   - When do the most important predators and parasites of the pest appear?
   - When do food sources (nectar, pollen, alternate hosts, and prey) for beneficials first appear? How long do they last?
   - What native annuals and perennials can provide habitat?

3. Identification of Strategies
   - Reduction of pest habitat (i.e., reduce/alter overwintering pest sites, or reduce/alter locations from which pest invades.)
   - Augmentation of beneficial habitat (insectary establishment; consider both perennial options—permanent plantings such as hedgerows—and annual options.)
   - Trap Crops—planted specifically to be more attractive to the pest than is the crop to be harvested. This is due to the timing of the appearance of the trap crop or the fact that it is physiologically more attractive to the insect. (Please see appendices D and G for descriptions of planting systems that can be used in farmscaping.)
Introduction

“Farmscaping” is a whole-farm, ecological approach to pest management. It can be defined as the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, bats, and birds of prey.

In some respects, beneficial organisms should be considered—and managed as—mini-livestock. The larger varieties of livestock are healthier and reproduce more readily when provided an adequate and nutritious diet. Likewise, “mini-livestock” require adequate supplies of nectar, pollen, and herbivorous insects and mites as food to sustain and increase their populations. The best source of these foods is flowering plants.

Beneficial insects should be viewed as mini-livestock. They will be healthier, reproduce more readily, and be more effective biocontrols when provided habitat with an adequate and easily available diet of nectar, pollen, and herbivorous insects and mites.

However, farmscaping is not a magical cure for pest problems. It is simply an ecological approach to pest management that can be an integral component of a biointensive integrated pest management (IPM) program.

The use of farmscaping to increase beneficial organism habitat must be understood and practiced within the context of overall farm management goals. For example, when considering planting a perennial hedgerow the producer should evaluate the various costs and benefits likely to be associated with a hedgerow. Growers with farmscaping experience will likely be the best source for this kind of information.

Farmscape Planning

There are probably as many approaches to farmscaping as there are farmers. Some growers, after observing a cover crop harboring beneficial insects, plant strips of it in or around their crop fields. The advantages of this kind of approach are:

- It is simple to implement
- It is often very effective
- The farmer can modify the system after observing the results.

Problems arise when the beneficial insect habitat, unbeknownst to the grower, also harbors pest species. (For a more detailed discussion of this topic, visit: http://www.lib.uconn.edu/CANR/ces/ipm/feedback)
FARMSCAPING TO ENHANCE BIOLOGICAL CONTROL

Abstract: This publication contains information about increasing and managing biodiversity on a farm to favor beneficial organisms, with emphasis on beneficial insects. The types of information farmscapers need to consider is outlined and emphasized. Appendices have information about various types and examples of successful “farmscaping” (manipulations of the agricultural ecosystem), plants that attract beneficials, pests and their predators, seed blends to attract beneficial insects, examples of farmscaping, hedgerow establishment and maintenance budgets, and a sample flowering period table.