BLUEBERRY ECOLOGY AND A LANDSCAPE PERSPECTIVE

Evolutionary Ecology

Forty thousand years ago, glaciers covered Maine. With the retreat of the glaciers, much of the flora and fauna familiar today colonized the ice-scoured habitat. As the glaciers retreated, they cleaved and fractured the surface bedrock, leaving the sandy, nutrient-poor soil in which much of wild blueberry is found (though the plant can also be found in silt and loam soils). The ancestral habitat of the lowbush blueberry is significant in that wild blueberry has evolved under low-nutrient and drought-stressed environments. Blueberries have adapted to this environment by forming an association or symbiotic relationship with mycorrhizal fungi that aid in the uptake of nutrients, especially phosphorus (P). An understanding of this history can help growers as they try to provide a competitive edge to their blueberry crop by modifying the environment to favor the growth of blueberry while handicapping the growth of some of its competitors.

The wild blueberry is also a long-lived plant naturally found in the forest understory. It has been suggested that some individual clones may live for two centuries or more. Under natural unmanaged conditions, blueberry plants may spend a large proportion of their lifespan within the plant community of the forest understory, growing vegetatively and hardly ever flowering because low light levels inhibit flower bud formation. Growers should keep in mind this relationship between flower bud formation and light level when considering the impact of weeds or fields that abut forests on the productivity of blueberry fields.

Because they evolved in a climate and landscape where forest fires due to lightning strikes were commonplace, blueberry plants are adapted to disturbance events such as burning. Only 30% of the wild blueberry plant's biomass is aboveground, allowing the 70% of belowground plant biomass to quickly regenerate the aboveground shoots and leaves. Growers take advantage of this when they prune fields by mowing or burning. It has been demonstrated that wild blueberry plants attain higher yields over the course of many production cycles when they are pruned every other year. In the year after the plants are pruned, new vegetative shoots grow from the rhizomes. There is a stimulating effect that produces more shoots from a growing point when pruned. At the end of the year, flower buds form that produce flowers in the subsequent growing season. If plants are not pruned regularly, they will not produce much new growth and will also shade themselves. Flower buds will not form on lower branches, and thus the number of berries on the plant will be reduced.

Based upon some of the general ecological relationships of the wild blueberry, we believe that organic management of this crop should be firmly grounded in ecology and the associated landscape that blueberry evolved in and occupies today.

A Landscape Perspective for Blueberry Management

Organic blueberry growers face many challenges. They cannot (1) rotate their crop (although they can rotate the crop cycle, i.e., cropping vs prune cycle), (2) plant cover crops or green manures, or (3) mechanically cultivate the soil to reduce weeds. Additionally they have a limited number of organically approved pesticides available. Their best chance to manage wild blueberries organically is to manipulate the crop environment or landscape in a manner that favors fruit production and puts pests (weeds, plant pathogens, and plant-feeding insects) at a disadvantage. In some ways this can be considered the "Zen" approach to blueberry production, or working within the turbulent forces of nature with awareness. The following tenets suggest means of approaching this strategy.

Plant relatedness

Blueberries often grow in landscapes as part of the heath community (Family: Ericaceae), which includes other plant species such as huckleberries, cranberries, and rhododendrons. The implications of this are a "two-edged sword" as far as blueberry production is concerned. These closely related plants evolved under the same conditions and may share pests and pathogens, as well as beneficial organisms such as pollinators. For example, both huckleberries and lowbush blueberries are hosts of the fungal pathogen *Pestalotia vaccinii* and the insect pest blueberry maggot fly (*Rhagoletis mendax* Curran). And although a blueberry field may be free of other ericaceous plant species, they are often found in surrounding forests bogs, fens, and meadows, providing a reservoir for pests and pathogens. Knowing the sources of pests that might colonize a blueberry field is the first step in managing pests. It is important, therefore, to realize that adjacent blueberry fields are not the only source of infestations, but the entire surrounding forested and wetland landscapes are a second source.

An additional aspect of the heath community is the species composition of blueberry plants in a field. The other common *Vaccinium* species found in blueberry fields is sour top blueberry. The pollen of sour top is incompatible with and causes fruit abortion in the low sweet blueberry. If a particular field has a high percentage of sour top plants (30%–50% or greater), a grower will probably not experience high yields of berries from the low sweet blueberries, no matter how many bees are present during bloom. In fact, a high abundance of bees can reduce productivity. If all of the sour-top plants are confined to one area of the field, however, they may not negatively affect overall yield. Growers can use this information on incompatibility to assess the productivity potential of a given field and when making the decision on whether to commit resources to a field.

Clonal nature of growth

Wild blueberries spread clonally, creating a patchwork mosaic in blueberry fields. Each clone has genetically different attributes, including leaf and flower color, sprout emergence, bloom time, and resistance to pests. In addition, not all clones will be equally productive either because of compatibility with its own pollen or with pollen from neighboring clones, or because the plant may not inherently produce abundant flowers. Growers should map their fields specific to this clone mosaic and keep records over several years on which clones are the most productive. Rather than spending time and capital trying to improve the yield of all clones, the poor producers included, growers can use these maps to target the more productive clones for intense management.

Blueberry fields as islands

The size of a field may affect the crop production and pest levels. In the 1960s the "theory of island biogeography" was developed to explain the relationship between the number and abundance of plant and animal species on islands, and the size of the island. Some of the basic tenets of this theory are (1) large islands have a higher animal and plant diversity than small islands, and (2) more isolated islands (islands further from the mainland or large islands) have less diversity than less isolated islands; therefore (3) small and isolated islands are more prone to species extinctions and instability (rapid change of plant and animal communities) due to their low diversity.

We have found that, at least as far as natural enemies, insect pests, and pollinators are concerned, blueberry fields are islands… islands in a sea of a forest landscape and that, on average, these tenets hold true. So, what can we glean from this? Large fields will tend to have a higher number and diversity of species due to their size. This means that they will, on average, have a potential for more frequent pest outbreaks, but at the same time they will have a larger, more stable natural enemy complex to dampen the explosive increase and spread of a pest population during an outbreak. Smaller fields will have fewer and less diverse species present, meaning they are less likely to experience the full suite of wild blueberry insect pests found throughout the state (at least at any one point in time). But they also will have a lower diversity of natural enemies and thus will be more prone to a population explosion should a pest or pathogen find its way into the field. Fields isolated in the middle of forested areas are more likely to be low in pest diversity; however, a single pest may present serious problems compared to fields adjacent to large production areas, such as the barrens of Washington County. Growers with large fields may face continual lower-level pest and pathogen problems, while growers with smaller fields might expect fewer but larger-scale attacks. Of course, the problem with simple generalizations is that there are always exceptions, especially in the light of the specific management that individual fields receive.

Ecological or Landscape Management

Managing for plant species diversity

There are many ways for growers to manipulate the environment to favor wild blueberries. One way to do this is by promoting and managing flowering plants for beneficial natural enemies and pollinators (see Drummond and Stubbs 2003). Flowering plants that provide good pollen and nectar resources for pollinators include willow, maple, wild strawberry, raspberry, lilac, hawthorn, white clover, red clover, meadowsweet, asters, and goldenrod. A more extensive list is included in the fact sheet by Drummond and Stubbs (2003). By carefully enhancing and promoting plant diversity, growers can provide for a wide range of pollinators. Additionally, some insect parasites are associated with certain plants, so by managing these plants, it may be possible to lower insect pest numbers. We have found that plants associated with high levels of parasitoid wasps are sheep laurel (*Kalmia angustifolia*), bunchberry (*Cornus canadensis*), bush honeysuckle (*Diervilla lonicera*), dogbane (*Apocynum androsaemifolium*), and withe-rod (*Viburnum cassinoides*). Of course, growers must be careful not to enhance the abundance of competing weeds in the field interior that are of minimal resource value to natural enemies, such as some of the grasses and tree species.

Managing for bees

Growers can also improve pollination by enhancing bee populations through the increase of nesting sites. Growers can do this by planting or encouraging woody shrubs with soft pith stems such as elderberry, encouraging standing deadwood, maintaining stonewalls in fields, and managing bare soil habitats for soil-nesting bees and by providing them with other necessities such as water, mating sites, and protected overwintering sites. Bees require protection from high wind and extreme cold, which can be provided by planting or maintaining windbreaks that provide snow cover in the winter. Bees also require a water supply less than a mile (generally the closer the better) from their nest; vegetation at the edge of the water allows the bees to land and drink. Bees use a water source to incorporate with the leaves, plant resins and oils, and mud they use in their nests. More detailed discussion of these landscape management tactics are discussed in Drummond and Stubbs (2003) and Stubbs et al. (2000).

Managing the crop cycle

By managing the cropping cycles of isolated fields, growers may be able to lower the likelihood of pathogens or insect pests attacking the crop. Many fields are divided in half, with one half in a prune year and the other half in a crop year. Insect pests such as the blueberry maggot fly, however, can simply fly to fruit-bearing sections of fields, resulting in a continual population increase each year unless managed with insecticides. An isolated field that is all in the prune cycle in a given year provides no food source for the blueberry maggot fly. This pest then must emigrate from the field, and its numbers will be reduced significantly. Pathogens such as the mummy berry-causing fungus can survive because not all of the mummies germinate in a given year. If it is possible to keep all of the fields in an area on one cycle for several years in succession then this may diminish the pathogen inoculum. However, this may not be feasible if you only have one field and need income each year, or if any neighboring fields are not kept on the same cycle.

Managing blueberry competitiveness

Because wild blueberries are not competitive for nutrients and sunlight with many other plants, the landscape needs to be managed to favor their growth and productivity. Weeds such as grasses can be managed by lowering the soil pH to around 4.0 using S because this favors blueberry growth but not pH-sensitive weeds. More details on this are given in the organic weed management section of this bulletin.

Managing blueberry in adjacent forest habitats

Blueberries grow and produce fruit in unmanaged forest blowdowns or clear-cut areas adjacent to blueberry fields. Pests and pathogens may colonize and reproduce in these areas. This can be a significant source of invading pest populations. By encouraging reforestation of these areas, growers can reduce sources of disease along with fruit-infesting pests over time.

The interface between blueberry field and forest can both provide beneficial resources and challenges for pest management. Flowering plants used by natural enemies and pollinators, as well as the pest insects themselves, have been found in abundance at the edge of the forest and 10 m into the forest. However, pests are also found in this borderland habitat. The blueberry leaf beetle (*Pyrrhalta vaccinii* (Fall)) over-winters in the forest edge and then moves into the field in the spring, stopping once it finds blueberry foliage. Because of this behavior, this pest is most often found along the edge of the blueberry field, sometimes in such high abundance that it results in defoliation of large contiguous patches of blueberry. This knowledge may not result in a direct habitat management tactic, but it should result in increased vigilance and monitoring of edge habitat by growers. A similar ecology associated with the blueberry maggot fly and invasive weeds is discussed in the insect pest and weed management sections.

Simulating the natural process of fire

By burning rather than mowing as a pruning method, growers can decrease pest and pathogen sources. The heat of the fire destroys insects and fungal over-wintering structures, leaving fewer organisms to attack the crop in the next year. However, the benefits of this tactic have to be weighed against its cost, both monetary and lost soil organic matter. More details concerning this management tactic are presented in the organic insect pest management and organic weed management sections.

Within-field management

Field heterogeneity affects crop health and productivity. Tall weeds shade blueberry plants, reducing flower production and subsequently yield. Weeds can also be a source of floral competition, resulting in less bee visitation to blueberry. Field heterogeneity also affects the distribution of pests. Weedy areas, troughs and other low spots in fields tend to be wetter or more humid, which favors pathogens such as the mummy berry-causing fungus and the blueberry maggot fly, which causes more damage and lays more eggs in these areas. Identification of pest "attractors" is key to spot treatments or edge treatments using tactics such as burning, hand weeding, or organic pesticides.

Conclusions

Knowledge of blueberry ecology allows growers to develop and practice landscape management. This management philosophy is in its infancy, and ecologically minded growers can make much progress in developing better management practices. The foundation of this approach is keen observation in blueberry fields and the surrounding landscape over several years. Coupling observations with record taking and mapping is a powerful tool for farm management. By creating a map of a field and its adjacent habitat, growers can keep track of weeds, disease- and insect-prone areas, and high-yielding clones. This will also help maximize time and effort by allowing the grower to pinpoint areas that should be managed most intensively. Ecological awareness is crucial to managing the blueberry's growing environment to decrease disease and pests and increase yield, and this can only be appreciated by walking fields during all seasons of the year. The next two sections of this bulletin discuss pest-specific management tactics.