Evaluating the influence of landscape heterogeneity on the effectiveness of on-farm floral resource provisioning to enhance biological control of leafhopper pests in North Coast California vineyards.

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ABSTRACT:

Floral resource provisioning (FRP) is a form of on-farm habitat management that can enhance biological control of insect pests. The FRP hypothesis assumes that in simplified agroecosystems natural enemies are limited by the availability of nectar, pollen, and suitable habitat. While provision of floral nectar has in some cases been found to extend longevity and fecundity of certain natural enemies, use of on-farm FRP to reduce pest densities has shown mixed results.

Landscape heterogeneity – the diversity and area of non-crop habitat surrounding an agroecosystem – has also been shown to influence biological control. Multiple mechanisms could be responsible for natural enemy response to landscape heterogeneity, including natural enemy dispersal patterns and over-wintering habitat requirements. Landscape heterogeneity could potentially influence the effectiveness of field-scale floral resource provisioning to enhance biological control.

This project will evaluate the influence of landscape heterogeneity on the effectiveness of FRP to enhance biological control of key wine grape pests in North Coast California vineyards. This will be done by comparing biological control in paired FRP-Treament and Control plots in 20 vineyards situated along a gradient of landscape heterogeneity. By doing this it may be possible to determine thresholds of landscape heterogeneity within which field-scale FRP most effectively enhances biological control of key wine grape pests.

INTRODUCTION:

Habitat simplification in agriculture occurs at multiple spatial scales. At a field scale, expansion of monocultures are replacing more biodiverse agroecosystems. As multiple farms become simplified through monoculture, biodiversity is eliminated at the landscape scale as well. **Loss of agrobiodiversity can reduce or eliminate key ecosystem services** (e.g., pollination, nutrient cycling, biological control) **and can lead to increased dependence on off-farm inputs** (e.g., rented bees, synthetic fertilizer, pesticides) (Altieri, 2002). In the field, genetic pest resistances to insecticides, as well as an increase in cost and regulations oblige agriculturalists to explore alternative pest control approaches. **Biological control is a non-chemical pest management strategy that aims to suppress pests by understanding and encouraging natural enemies** (Mills and Daane, 2005). There are three types of biological control: classic, augmentative and conservation. In classic biological control, host-specific natural enemies are introduced to the environment from the pest's region of origin. Augmentative biological control consists of annual inundation of crop fields with natural enemies that are released into the field whenever necessary. Conservation biological control is an approach that seeks to conserve both pest and natural enemy populations year round by providing functional habitat specifically selected for the natural enemy; the goal is that by better understanding natural enemy-pest interactions farmers can managed pests without resorting to chemical controls (Mills and Daane, 2005).

1. *Daucus carota*

2. *Phacelia tanacetifolia*

3. *Ammi majus*

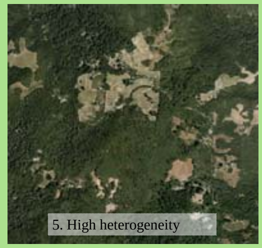
Images 1, 2, and 3 are flowers used in this project as FRP to attract natural enemies

Floral resource provisioning (FRP) is a form of on-farm habitat management that can enhance conservation biological control of insect pests by providing necessary resources for natural enemies over the entire season (Landis, Wratten and Gurr, 2000). **The FRP hypothesis assumes that in simplified agroecosystems natural enemies are limited by the availability of nectar, pollen, and suitable habitat** (Mills and Daane, 2005). While provision of floral nectar has in some cases been found to extend longevity and fecundity of certain natural enemies, use of on-farm FRP to reduce pest densities has shown mixed results (Nicholls *et al*., 2000; Begum *et al*., 2006). Since landscape influence was not evaluated in these studies, we hypothesize that such mixed results could be due to the influence of landscape heterogeneity on the observed effectiveness of FRP in these studies.

Landscape heterogeneity – the diversity and area of non-crop habitat surrounding an agroecosystem – has been shown to influence biological control (Weibull *et al.*, 2003; Bianchi, 2006). A scientific literature review found that 74% of studies had higher natural enemy populations and 45% of studies lower pest populations in areas that have a heterogeneous landscape versus a simplified landscape (Bianchi *et al.*, 2006). Multiple mechanisms could be responsible for natural enemy response to landscape heterogeneity, including natural enemy dispersal patterns and over-wintering habitat requirements (Bianchi *et al*., 2006). Thus it is possible that landscape heterogeneity could potentially influence the effectiveness of field-scale FRP to enhance biological control. We hypothesize that a vineyard with no adjacent vegetation (low heterogeneity) will likely have a lower abundance of natural enemies coming from distant source habitats in significant numbers. In this case, in-field FRP may not be as important as the restoration of functional vegetational diversity in crop field borders (i.e. hedgerows). Vineyards surrounded by complex landscapes will likely not benefit much from FRP as long as natural enemies are able to colonize from field borders. Alternatively, in complex landscapes, it may be that natural enemies are able to more easily colonize and disperse through vineyards with in-field flower strips serving as corridors (Nicholls *et al*., 2001). **We hypothesize that vineyards surrounded by simple landscapes (intermediate heterogeneity) will benefit most from in-field FRP.**

INTRODUCTION (Cont):

4. Low heterogeneity



5. High heterogeneity

6. Intermediate heterogeneity

Images 4, 5 and 6 provide examples of vineyards in landscape heterogeneity gradients. An intermediate heterogeneity gradient is hypothesized to benefit most from in-field FRP.

This project will evaluate the influence of landscape heterogeneity on the effectiveness of in-field FRP to enhance biological control of the Western Grape Leafhopper (WGLH) (*Erythroneura elegantula*, Homoptera: Cicadellidae) a key wine grape pest in Napa and Sonoma County, California. This organism represents a pest of economic concern to wine grape growers and management often depends on chemical controls (UC IPM 2010). Long-term viability of pesticides is uncertain due to decreasing pesticide effectiveness (Van Driesche, 1996), elevated costs, and an increasingly restrictive regulatory environment; therefore new approaches to pest management must be constantly tested and developed. The demand for such alternatives is manifested in the increasing number of wine grape growers throughout California that have expressed interest in the development and improvement of ecologically-based pest management tools. The development of novel pest management strategies is timely as there is also an increasing consumer demand for "green" farming practices and organic produce (Wine Institute 2007). **This project will provide new information of pest and natural enemy response to changes in habitat diversity at both the field- and landscape-scale. This research is intended to provide better information for growers interested in use of FRP to enhance biological control as an alternative to chemical pest control.**

MATERIALS AND METHODS:

Landscape Study

This study will evaluate the influence of landscape heterogeneity on the effectiveness of in-field floral resource provisioning in 20 Napa and Sonoma County vineyards. We will seek to use vineyards with similar vine age, trellis system, soil moisture conditions, irrigation infrastructure, and pest management history. The landscape heterogeneity of these sites will be situated along a gradient assessed by six circular sectors (0.5 km, 1 km, 1.5 km, 2 km, 2.5 km, 3 km) around each vineyard site. Landscape heterogeneity will be quantified as the relative area of non-crop habitat per landscape (i.e. area that is not vineyard, orchard, annually cultivated land or dense settlement). In the first year, vineyards will be assessed using a control block only. In the second year an in-field FRP treatment will be established with *Phacelia tanacetifolia*, *Ammi majus*, and *Daucus carota* (single replicate split-block, FRP-Treatment x Control). These 3 flowers were chosen specifically because they are drought tolerant, nectar abundant, able to attract natural enemies, and can readily be integrated into standard vineyard management. We will evaluate biological control over the 2011 and 2012 growing seasons via the following sampling methods:

a) Pest and Natural Enemy Population Assessment

Following UC IPM protocols, grape leafhopper nymph densities will be assessed by sampling 1 leaf from 60 randomly selected grape vines. Adult leafhoppers will be monitored with the placement of five yellow-sticky traps in the canopy of randomly selected vines. The same yellow sticky traps will be used to monitor parasitoids and generalist predators *Anagrus* spp. wasps, *Orius* spp., *Nabis* spp., *Chrysopidae*, *Syrphidae*, *Coccinellidae*. To account for less mobile natural enemies, such as spiders, five vine canopy assessments will be conducted by using a "beat-funnel" sampling method as described by Costello and Daane (1997).

b) Pest Parasitism Rates

Levels of parasitism by the leafhopper egg parasitoid, *Anagrus* spp., will be assessed following peak emergence of 1st and 2nd generation leafhopper nymphs. 20 individual grape leaves will be collected and examined under a dissecting microscope for the presence of parasitized or healthy leafhopper eggs. These procedures will determine the proportion of infested leaves and rates of leafhopper egg parasitism by the *Anagrus* wasp.

c) Yield and Quality Assessment

At harvest, total number of clusters and total yield will be recorded from 10 randomly selected vines at each site. Brix is a measurement of dissolved sugar-to-water mass ratio of a liquid and is commonly used to asses wine grape quality. Brix measurements will be recorded for at least 100 randomly selected vines at each site.

MATERIALS AND METHODS (Cont):

Dispersal Study

This study will evaluate pest and natural enemy densities at different distances from two common semi-natural habitats in Napa and Sonoma County. We will monitor 3 vineyards abutting to riparian habitat and 3 vineyards abutting to oak woodland. Pest and natural enemy densities and parasitism will be evaluated at -50m, 0m, 10m, 100m and 200m from the semi natural habitat. In the first year, vineyards will be assessed using a control block only. In the second year dispersal will be monitored into FRP-Treatment and Control blocks. The goal of this study is to compare biological control within the vineyard relative to its proximity to riparian habitat or oak woodland and presence/absence of FRP-Treatment.

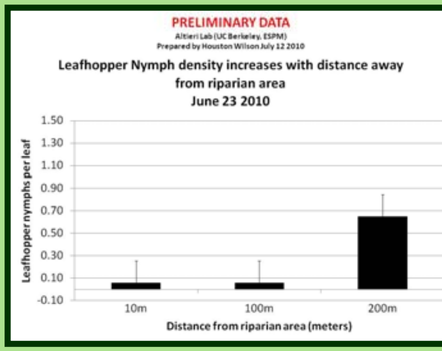
Anagrus Overwintering Habitat Study

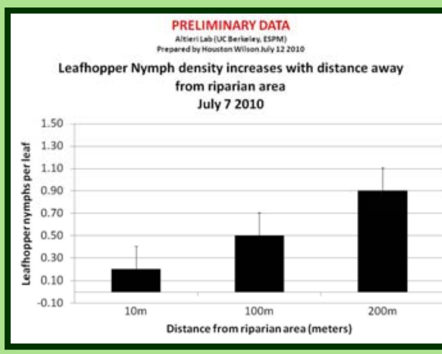
Anagrus overwintering will be assessed using methods adapted from Lowery *et al*. (2007) and Williams and Martinson (2000). Between February and June of 2011 and 2012, dormant plant hosts potentially containing overwintering *Anagrus* will be gathered from riparian and oak woodland habitats in Napa and Sonoma County. At least 500g of plant material will be collected from each candidate plant and placed into cylindrical paper cartons. All candidate plants will be identified to genus or species. These containers with plant material will brought back to the lab and held under controlled conditions (30oC, 14:10 h (L:D) cycle, and 50% RH for 4 weeks) to encourage emergence of overwintering *Anagrus* wasps. A glass vial containing 70% ethanol will be secured to the top of the container to allow light to enter the chamber and attract emerging wasps. All emerging adult *Anagrus* will be collected in the vials and identified to species.

PRELIMINARY RESULTS AND DISCUSSION

Preliminary data supports Bianchi *et al.* (2006) showing that heterogeneous habitats are related to an augmentation of biodiversity in agricultural habitats and therefore can be key in maintaining high natural enemy populations that aid in pest population suppression. As a result, landscapes that hold most biodiversity also perform the most effective biological pest control. At present, biodiversity as a form of natural pest control lacks sufficient scientific support to be accepted as a widespread method for farmers (Bianchi *et al.* 2006).

Graphs 1 and 2. Preliminary data that agrees with Bianchi *et al.*, 2006. suggesting leafhopper density shows an indirect correlation with proximity riparian area.





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Images:

1. http://www.backyardbutterflygarden.com/monarch-butterfly
2. http://www.flickr.com/photos/arjuna/481721807
3. http://www.visoflora.com/images/original/ammi-majus-apiacees-visoflora-7345.jpg

4, 5 & 6. Property of Houston Wilson