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User Guide: Pollinator Habitat Benefits Quantification Tool

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Cover photos:
Clockwise from upper left: Ecosystem services field team at an almond orchard adjacent to Dry Creek in Waterford, CA; yellow-faced bumblebee (*Bombus vosnesenskii*) on California button willow (*Cephalanthus occidentalis*); Van Dyke's bumblebee (*Bombus vandykei*) on California phacelia (*Phacelia californica*); and, pollinator habitat at the Lockeford Plant Materials Center in Lockeford, CA.

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1 INTRODUCTION

1.1 Introduction to Ecosystem Services Quantification

Farmers and ranchers can provide many ecosystem services – clean air and water, biodiversity, carbon storage, and scenery. However, without a framework for valuing ecosystem services, the true value of benefits produced by healthy ecosystems is difficult to incorporate into land-use decisions. Market-based approaches to valuing ecosystem services provide a cost-effective means to achieve environmental results while sustaining and enhancing working, natural landscapes. In order to include the value of ecosystem services in our economy, we need to develop realistic, tractable and scientifically based tools for assessing ecosystem services provided by parcels of land and water. This guide is for the application of one such tool, developed to quantify changes in ecosystem services brought about through shifts in natural resources management on a parcel by parcel scale. The tool allows for varying levels of specificity in input information and resulting outputs (e.g., you can still use it even if you are just trying a desk-top gaming exercise).

1.2 Tool and User Requirements Include:

- Access to and familiarity with Excel 2003 or a more recent version
- Access to Google Earth or other similar Geographic Information System
- One to three days to gather and input information and to run the tool, depending on the size and complexity of the Project Area
- User has a B.S. in Environmental Science or corollary and is experienced with basic landscape characterization and interpretation
- User is proficient at identifying common flowering plants to the genus level, given a species list

This User Guide is specific to the Pollinator Habitat Ecosystem Service Quantification Tool (QT) and provides specific step-by-step instructions on tool application, including:

1. Defining the Project Area
2. In-the-office preparation and information collection
3. In-the-field data collection
4. Post site visit data input to tool
5. Generating Ecosystem Service Scores
6. Score interpretation

1.3 Intended Use of Tool

This tool is intended to be accessible to landowners and/or agency staff so that potential increases in ecosystem services brought about through specific restoration actions at a given site can be assessed. For example, the tool can be used to 'game' potential changes in environmental benefits before and after restoration and over time post-restoration, given specific changes in management actions. One to three days of effort, depending on the size of the site, split roughly equally between the field and the office should yield a score for ecosystem services provided by a particular site, along with potential changes in those services that could co-occur with changes in resources management. No destructive field techniques are involved. Ecosystem service scores are developed based on easily accessible field and landscape scale information directly linked to

the pollinator habitat needs. Linkages between pollinator habitat needs and the field metrics are briefly described in the quantification tool spreadsheet, along with citations for more in-depth explanation. The change in ecosystem services score (a percent of the site's estimated potential score based on the assessment criteria) can then be used to demonstrate, in a transparent and tractable manner, increases ecosystem services associated with changes in management practices.

1.4 Geographic Scope

This tool is designed to apply to lands within the mid and northern Great Valley ecoregion of California (Sawyer et al. 2008), otherwise known as the mid and north and Central Valley of California, as indicated in Figure 1-1.

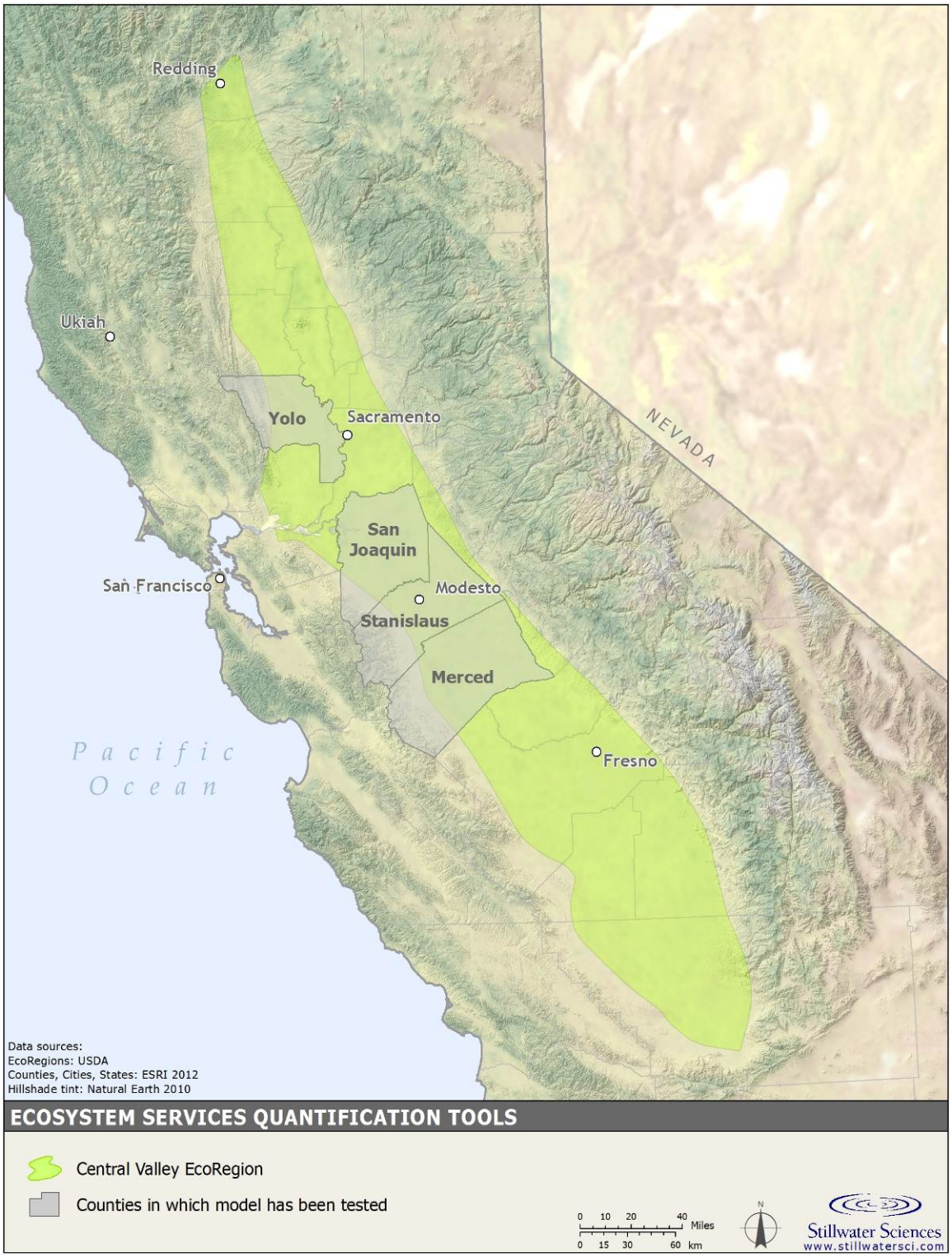


Figure 1-1. Geographic extent of tool applicability, showing counties in which the tool has been ground tested.

1.5 History of Tool Development

This project was conceived of and funding procured by Sustainable Conservation of San Francisco, California. Sustainable Conservation contracted Stillwater Sciences in Berkeley, California, to develop the tool itself, in close consultation with a carefully selected Advisory Committee (see Appendix A for members) in early 2011. During 2011, Stillwater Sciences, in consultation with Sustainable Conservation and the AC, developed draft quantification tools for three ecosystem services:

- Supporting native and non-native pollinator populations
- Supporting native riparian bird populations
- Providing shade to support cool water aquatic habitat and associated fish species

Stillwater Sciences worked closely with the Xerxes Society in developing the pollinator tool described here-in and many of the criteria used were originally developed through this organization. During 2012 team members from PRBO Conservation Science and the Xerxes Society field tested these tools at seven sites, including one reference site for each tool. Feedback from these initial field tests and user responses regarding ease-of-use were used to refine the models and field data sheets.

The Quantification Tool does not translate changes in ecosystem service to changes in market or dollar values. It also does not provide estimates of changes in specific quantities of a service that is provided, such as changes in bird or pollinator population numbers, or changes in water temperature. Modeling for accurate changes in these end point values would require an enormous amount of resources for each site, and even then the certainty (aka precision) of such model outputs would be low. Instead, this Quantification Tool uses only information that is well known and understood to develop relative scores of habitat quality. This approach allows us to include important but not well quantified information into consideration. We believe the results are more accurate, reliable, and transparent than if the Quantification Tool were a more technically sophisticated model that was over-reaching in relation to its scientific grounding. The relatively simple construction of this Quantification Tool, in which all assumptions and parameters are stated, gives the Tool transparency and the potential for adjustment as our understanding of pollinator habitat needs evolves and new information becomes available.

2 BACKGROUND ON POLLINATION

Pollinators are critical to approximately 35% of crop production worldwide and worth $15 to $21 billion dollars in the United States alone (Mburu et al. 2006). These values are based primarily on pollination services provided by domestic hives of non-native honey bees. The estimated value of native pollinators alone in the United States is also significant and estimated at $3 billion dollars (Losey and Vaughan 2006, as cited in NRCS 2009; Klein et al. 2007). Of the large pollinator community, which includes a wide variety of insects, birds, bats, and other mammals, in most areas bees are the most important pollinator (Kremen et al. 2007). Although historically, the agricultural industry has relied heavily upon the domesticated honey bee (*Apis mellifera*) in recent years, dramatic declines in this commercially managed pollinator have been well-documented and attributed to everything from honey bee pests, parasites and pathogens, to pesticide use (Committee on the Status of Pollinators in North America et al. 2007). Thus, increased attention has focused on the importance of our diverse native bee community and its contribution to pollination services for agriculture (Klein et al. 2007). In this Quantification Tool, we recognize three categories of bee pollinators: non-native managed pollinators such as the honey bee, native managed pollinators such as the blue orchard bee, and native wild pollinators such as the California bumble bee (*Bombus californicus*), the yellow-faced bumble bee (*Bombus vosnesenskii*), and the squash bees (Peponapis sp.).

Several variables are important to the native bee community. These include suitable nesting materials and substrates, a diversity of floral resources throughout the bee life cycle (which is usually significantly longer than the period of crop bloom), and, for the blue orchard bee and honey bees, water (NRCS 2009, Parametrix 2009, Xerces Society for Invertebrate Conservation 2011). Because bees are mobile organisms, the temporal and spatial distribution of these resources is also important, and relates to the foraging and dispersal range of the particular bee species (Klein et al. 2007). Distribution of nest boxes and the timing and availability of floral resources are also important to managed pollinators. These and other important factors are incorporated into the Pollinator Habitat Benefits Quantification Tool.

3 TOOL STRUCTURE

Processes that support ecosystem services are performed in a landscape and historical context which affects the importance and value of the services. In particular, this ecosystem service quantification tool distinguishes between opportunity, value, and site capacity, as described below and outlined if Figure 3-1:

- *Opportunity:* The extent to which the surrounding landscape currently provides, or could provide in the foreseeable future, the Project Area an opportunity to perform a particular ecosystem service (e.g., source pollinator populations and accommodate increased production of pollinator populations).
- *Value:* The extent to which the product of the ecosystem service is able to be used or useful, where "useful" can apply to goals such as supporting biodiversity, increasing resilience to effects of climate change, and supporting local and state food production (see Daily 1997). In the case of pollinator habitat, the 'value' is increased crop pollination and biodiversity.
- *Site Capacity:* The extent to which existing or potential physical and biological attributes of the site enable it to provide ecosystem services (e.g., does the Project Area itself provide good habitat for sustainable pollinator populations).

A hypothetical example can be used to better illustrate these concepts. Site characteristics such as number and extent of flowering plants that bloom early, in the middle, and late in the season, the amount of friable bare ground (ground-nesting bees), and the amount of other nesting materials (cavity-nesting bees) will affect the degree to which that area can support diverse and large bee populations (site capacity). However, the degree to which the surrounding landscape can provide source bee species, and can support and accommodate a growing population is determined by landscape location characteristics such as percent of surrounding landscape that is 'wild' and amount of pollinator dependent crops nearby (opportunity). Finally, the increase in crop yield that results from supporting diverse native pollinator populations would be valued by producers of pollinator-dependent or assisted crops (value).

The Quantification Tool generates two separate scores: one for the project site's opportunity and value and the other for the site's capacity to provide the target ecosystem service. Both of these scores are presented as a percent of potential in relation to reference conditions for the Central Valley. While the Opportunity and Value score is left as a percent of potential, the Site Capacity Score is translated into habitat-acres by multiplying the percent value as a fraction of one times the number of acres being restored or alternatively managed in the Project Area (e.g., a 5-acre Project Area that receives a score of 80% translates to 0.80 * 5 acres = 4 habitat acres).

The pollinator habitat quantification tool also can be used to estimate future changes in site capacity based on growth of vegetation over time. A set of calculations, based on observations and best available information on native riparian plants in the Central Valley, provides estimates of the change in height, crown diameter, and crown density through time so that a user can enter information on plant species composition and planting density for year 1 (Y1) and estimate increased pollinator habitat quality for subsequent years using the Pollinator Habitat Quantification Tool's '*Veggiematic Growth Model*' sub-routine.

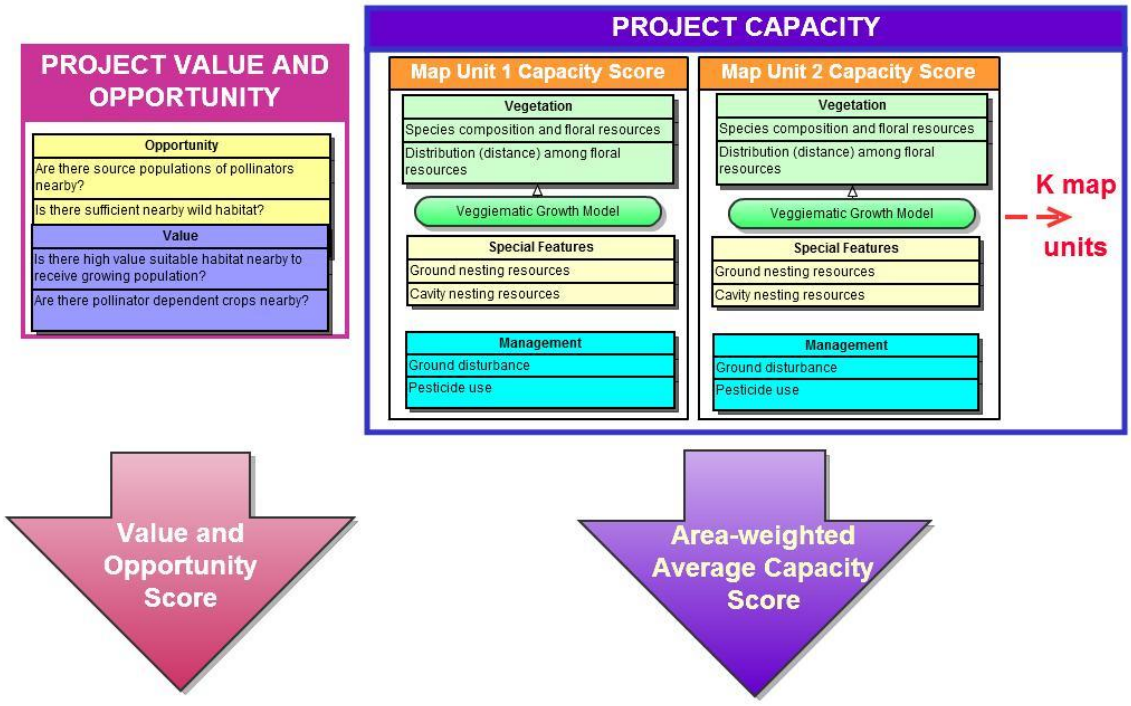


Figure 3-1. Structure of the Pollinator Habitat Quantification Tool.

The Quantification Tool is built in Excel software and includes data input sheets that reflect the structure and format of the field data sheets to ease data transfer from hard field copies to the Excel tool spreadsheet. The actual ecosystem service scores and habitat-acres are calculated and provided to the user in the 'Bee_Scoring' worksheet of the Quantification Tool. There are a total of seven worksheets (tabs) in the Tool spreadsheet, three of which require user input, as outlined in Table 3-1.

Table 3-1. List of worksheets in the Riparin Bird Habitat Quantification Tool.

Worksheet	Description	User input required?
Read Me	Provides general rules and guidelines for using Quantification Tool	N
Office Form	Opportunity and Value input data from on-line (Google Earth, websites), and Manager interviews	Y
Field Form	Site Capacity input data gathered in field on site capacity	Y
Vegetation Data	Vegetation specific data entered and generated through the *Veggiematic Growth Model* for assessing Site Capacity through time; initial data gathered in field and/or restoration plans	Y
Score Sheet	Retrieves and scores information from other worksheets to calculated ecosystem service quantification scores	N
Vegetation Parameters	Source file used by tool to estimate growth rates and extent by plant species and groups of species	N
Citations	Provides full citations for tool parameters and assumptions	N

4 PREPARATION

Application of the Pollinator Habitat Quantification Tool (Quantification Tool) will require

- 1 to 3 days, depending on project size and complexity (1 day for areas <30 ac)
- Microsoft Excel 2003 or higher
- Google Earth or similar GIS system
- Access to the web
- Basic knowledge in natural resources management and local plant species
- Information on proposed management or restoration (planting plan by species and density)
- Information on current management practices (soil treatment, herbicide and pesticide use)
- An electronic version of the Quantification Tool file (it is an Excel spreadsheet in version 2010)
- Hard copies of the Office and Field Data Sheets and Vegetation Data Sheet (Appendix B)

Suggestions for making your experience with the Quantification Tool expeditious:

1. Take a minute to read the directions before following your intuition. It will save you time.
2. Do not delete any of the rows in the Quantification Tool spreadsheet. That would break critical links among the worksheets that are required for developing the ecosystem services score for your site.
3. Do not enter any information or make any changes in cells that are gray. Data is only entered into white and yellow cells; gray and green cells include formulas and links.
4. No data is entered into the Bee_Scoring worksheet.
5. Explanations and documentation, including assumptions and scientific citations, are included in the Bee_Scoring worksheet, columns K and L. Full citations are provided in the Citations worksheet.

5 OFFICE ASSESSMENT FORM: A STEP BY STEP GUIDE

There are eleven questions that must be answered in the Office Assessment Form. You will need access to the internet and Google earth or similar geographical information system and will also need the exact location of the Project Area so that you can locate it on Google earth or in an aerial image. You can either:

- Enter answer directly into a saved copy of the Quantification Tool or
- Record responses on a hard-copy of the Office Data Sheet and then transfer those answers to the Quantification Tool spreadsheet.

When using the Quantification Tool spreadsheet, go to the second tab, labeled 'OfficeForm', and follow the directions below for entering data there.

Field Data Sheet, pp. 1-2
QT: second worksheet: OfficeForm

5.1 Questions on Project Surroundings

Question 1. Percent cover by land use categories within 0.5 miles of Project Area.

Mark out a **0.5 mile** buffer around the Project Area boundary. This is most easily done in Google earth (Figure 5-1). In Google earth, use the 'Polygon' function to draw a polygon around the Project Area (found under the 'Add' menu if not already appearing as an icon in the ribbon across the top of the Google earth view). Then use the Google earth 'ruler' (found under the 'Tools' menu if not already appearing in the ribbon across the top of the Google earth view) to measure 0.5 miles out from the Project Area. Select the 'Line' tab (vs. 'Path' tab) in the pop-up ruler menu and ensure that the units are miles by clicking on the arrow next to the value in the right hand box and selecting 'miles'. Once you have a visual of how far 0.5 miles is from your Project Area, draw a polygon 0.5 miles out from your Project Area boundary.

- Look within the 0.5 mile wide buffer (but outside of the Project Area) and estimate the percent cover of each of the following land use categories (categories from Kremen 2010; values provided in brackets are for the example shown in Figure 5-1):
    - Urban/built: impervious/paved areas (paved parking lots, industrial and commercial areas), dams [0 %]
    - Paved Road: paved county roads, highways [3 %]
    - Suburban open: neighborhoods with little canopy cover (includes streets, yards, houses) [5 %]
    - Suburban wooded: neighborhoods with dense canopy cover [2 %]
    - Exurban: Farm operations and homesteads in areas where neighbors are not close together, often adjacent to agricultural fields (includes yards, trees, paved driveways, garages) [2 %]
    - Dirt road: Includes possible gravel roads [3 %]
    - Annual crop: agricultural fields planted with seasonal row crops [5 %]

- Orchard-vineyard crop: agricultural fields planted with perennial crops, includes orchards and vineyards [50 %]
- Rice: agricultural fields planted with rice [0 %]
- Non-agricultural planted: non-agricultural plantings; examples include hedgerows, rows of Eucalytpus along road, plantings along irrigation ditches, and other plantings that are clearly not naturally occurring but do not fit into "crop" categories [1 %]
- Bare: appears to be bare dirt [like dirt road] but is not a road; could be dirt parking area, road shoulder, or bare patch in field [2%]
- Weedy/sparse scrub: areas that appear to have more than just grassy vegetation (presumably weeds), sometimes including an occasional shrub; road and field edges often fit into this category [1 %]
- Grass: includes mowed, unmowed, annual and perennial [5 %]
- Chaparral: located usually on SW facing slopes of more xeric areas, near oak woodland, usually low canopy height [0 %]
- Oak savannah: natural-looking grassy/scrubby areas with mixed oak/pine tree spp. scattered throughout [0 %]
- Oak woodland: also includes scrub-oak: natural-looking areas containing mixed oak/pine tree spp. growing more densely than "oak savannah" [5 %]
- Riparian forest: land along natural waterways (not irrigation ditches) containing dense tree growth, even if forest strip consists of a single line of trees [6 %]
- Riparian scrub: land along waterways containing shrubs or trees but not dense canopy cover [2 %]
- Water: ponds, rivers, canals, drainage ponds, etc. [5 %]
- Emergent herbaceous wetlands: wetlands often adjacent to open water but not riparian scrub [3 %]

- Record absolute percent cover for each category on the datasheet and/or Column D of the Office Form worksheet in the Quantification Tool.
- If necessary, double-check or 'ground truth' these habitat types during the field visit.

Tools and examples for estimating percent area are provided in Appendix C

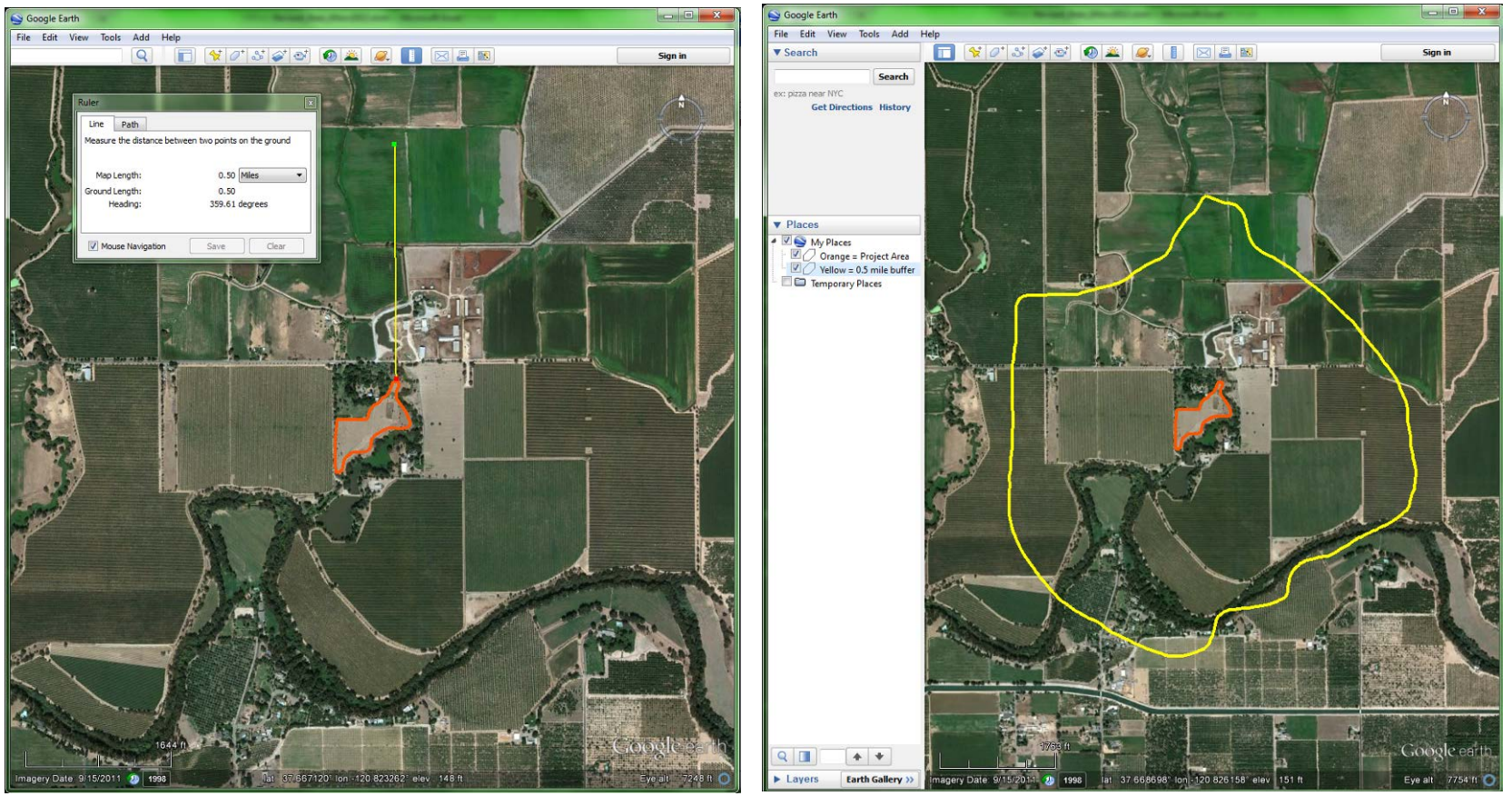


Figure 5-1. Project Area (orange polygon), 0.5-mile buffer and resultant area (yellow polygon) used to identify percent cover of various types of land use within **0.5 miles** of the Project Area.

Drawing Lines and Polygons on Google Earth

Polygons and lines can be drawn into Google earth to create and save site maps. After locating your Project Area in Google earth, click on 'View' button along the top and in the pull down menu, check the 'tool bar' so that options are visible:

Use the push pin option to label lines and polygons or special locations. Use either the polygon or the line drawing option, located to the right of the push pin option, to create lines or polygons for things such as Project Area boundaries, channel location, or vegetation boundaries. In order to edit and save your drawings, click on the 'menu view' option, to the left of the push pin, to see a list of the items you are adding to the figure. Each item can be edited by right-clicking on it and selecting 'properties', where you will find options for changing the label or line color and contents, as well as moving its location. Save your work by going to 'file' along the top ribbon and 'Save place as' to save your 'temporary locations' (all the pieces you have added to the Google earth image) as a give_it_a_name.kmz file on your hard drive. This can be clicked upon in the future to open up Google earth, go to your location and make any additions or edits.

5.2 Other Questions on Project Area Management

Question 2. Percent cover of pollinator dependent crops within 0.5 miles of Project Area.

- This is most easily done in Google Earth using the same **0.5-mile** buffer area created to answer Question 1 (Figure 5-1).
- Within this buffer area (but outside of the Project Area), estimate the percent cover of pollinator dependent crops that occur and record on the datasheet (2a) and/or Column D of the Office Form worksheet in the Quantification Tool.
- Also note what types of crops are present (2b).
- If necessary, double-check or 'ground truth' the crop types during the field visit.

Pollinator dependent crops or crops that benefit from insect pollination include almonds, coffee, strawberries, sunflowers, watermelon, blueberries, cherries, apples, raspberries, blackberries, tomatoes, squash, pumpkins, and many other fruits and vegetables (see Klein et al. 2007). Pollinator dependent crops indicate both a value and opportunity for increased pollinator services. Overall, a 1.5 to 25 ratio of pollinator habitat to pollinator dependent cropsis recommended (NRCS 2009). This translates to providing pollinator habitat on six percent or more of cropped land, but does not require that land be solely dedicated to pollinator habitat – it can be managed for multiple purposes, including crop production.

Question 3. Are pesticides (insecticides, fungicides, etc.) used two or more times a year, between March 1st and November 1st?

- Through talking with land managers, determine the pesticide use/application in the Project Area or surrounds. Answer the question for (1) within the Project Area itself including a 50-ft buffer around the Project Area and (2) within the 0.5-mile buffer (but not including the Project Area).
- Enter a '1' for Yes or a '0' for No on the datasheet and/or Columns D and E of the Office Form worksheet in the Quantification Tool.

Question 4. If insecticides are used two or more times a year (between March 1st and November 1st), are broad-spectrum or soil fumigants used, or any pesticides that are labeled toxic to honeybees?

- Through talking with land managers, determine if broad-spectrum, soil-fumigants, or pesticides that are labeled toxic to honeybees are used in the Project Area or surrounds. Answer the question for (1) within the Project Area itself including a 50-ft buffer around the Project Area and (2) within the 0.5-mile buffer (but not including the Project Area).
- An excellent information source on pesticide toxicity is provided by the Oregon PSW Agricultural Extension: http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf
- Enter a '1' for Yes or a '0' for No on the datasheet and/or Columns D and E of the Office Form worksheet in the Quantification Tool.

Question 5. If insecticides are used two or more times a year (between March 1st and November 1st), are they used outside of the crop blooming period?

- Through talking with land managers, determine if pesticide use occurs outside of the crop blooming period (application during crop bloom results in greatest exposure to pollinators). The crop blooming period is specific to the crops in and around the Project Area. Answer the question for (1) within the Project Area itself including a 50-ft buffer around the Project Area and (2) within the 0.5-mile buffer (but not including the Project Area).
- Enter a '1' for Yes or a '0' for No on the datasheet and/or Columns D and E of the Office Form worksheet in the Quantification Tool.

Question 6. If insecticides are used two or more times a year (between March 1st and November 1st), are they only used when bees are not active (i.e., at night)?

- Through talking with land managers, determine if pesticide use occurs only during the night, when bees are not active. Answer the question for (1) within the Project Area itself including a 50-ft buffer around the Project Area and (2) within the 0.5-mile buffer (but not including the Project Area).
- Enter a '1' for Yes or a '0' for No on the datasheet and/or Columns D and E of the Office Form worksheet in the Quantification Tool.

Question 7. If insecticides are used two or more times a year (between March 1st and November 1st), what is the application method?

- Through talking with land managers, determine the application method for pesticides. Methods include hand application, tractor and boom application, precision sprayers, and other ground-based methods, aerial application via an air craft. Answer the question for (1) within the Project Area itself including a 50-ft buffer around the Project Area and (2) within the 0.5-mile buffer (but not including the Project Area).
- On the datasheet and/or Columns D and E of the Office Form worksheet in the Quantification Tool, enter '4' for no pesticides applied; '3' for hand application; '2' for tractor and boom application; '1' for other ground based method; and '0' for aerial application via an air craft. If you entered '1', enter method in Column G.

Question 8. Do you host managed honeybees anytime except winter (November–February) and/or during crop bloom time?

- In Google Earth create a **2.0-mile** buffer area around the Project Area (extending 2 miles from Project Area boundaries) and refer to the area within this buffer (including Project Area itself) to answer this question.
- Through talking with land managers, determine when managed honeybees are hosted.
- On the datasheet and/or Column D of the Office Form worksheet in the Quantification Tool, enter '1' for Yes and '0' for No.

Question 9. If you answered 'Yes' to #8, are the managed bee hives within the 2 mile buffer of the Project Area?

- Refer to the **2.0-mile** buffer area created for Question 8.
- Through talking with land managers, determine if managed bee hives are within the 2-mile buffer of the Project Area.
- On the datasheet and/or Column D of the Office Form worksheet in the Quantification Tool, enter '1' for Yes and '0' for No, even if you answered No for the above question(s).

Question 10. If you answered 'Yes' to #9, is there more than one hive of managed bees per acre of habitat within Project Area and a 2 mile buffer, where habitat can include both Project Area and permanently protected other habitat?

- Refer to the **2.0-mile** buffer area created for Question 8.
- Through talking with land managers, determine if there is more than one hive of managed bees per acre of habitat within Project Area and a 2 mile buffer, where habitat can include both Project Area and permanently protected other habitat.
- On the datasheet and/or Column D of the Office Form worksheet in the Quantification Tool, enter '1' for Yes and '0' for No, even if you answered No for the above question(s).

Question 11. If you answered 'Yes' to #10, write down how many hives you have/host within the Project Area and within a 2 mile buffer during the non-winter and no crop bloom periods.

- Refer to the **2.0-mile** buffer area created for Question 8.
- Through talking with land managers, determine how many hives are hosted within the Project Area and within a 2 mile buffer during the non-winter and no crop bloom periods.
- On the datasheet and/or Column D of the Office Form worksheet in the Quantification Tool, enter '1' for Yes and '0' for No, even if you answered No for the above question(s).

6 FIELD ASSESSMENT FORM: A STEP BY STEP GUIDE

For a site of less than 20 acres, the Field Assessment Form can be completed in one day in the field and a half-day in the office to enter the data and run the Quantification Tool. In this section, you are provided with step-by-step instructions on filling out the field form and entering the data into the Quantification Tool spreadsheet.

The most important piece of equipment you take into the field will be a good Project Area Map and knowledge of the local plants and land management practices.

Field equipment list

- Project Area Map
- Project Area boundary field markers or known extent in the field
- Field data sheets
- Local plant species list and/or plant identification guide/book
- This User Guide
- Pencils
- Colored fine-tipped markers (2 to 3 colors recommended)
- Water, sun screen, snacks, and other field supplies

6.1 Project Area Map

Although most of the remaining questions for the Quantification Tool need to be answered in the field, a hard copy aerial photograph or image of the Project Area must be generated in the office before heading out to the field. A well labeled, accurate aerial photograph of the Project Area is an important piece of the Pollinator Habitat Quantification Tool and will become the Project Area Map. This map will indicate the location and sizes of each area surveyed, and will be a useful overall reference for assessing current and future conditions in the Project Area. Take care to record information on this image; the resulting map should be clean, well-labeled, and accurate.

The Project Area Map can be printed out on an 8.5x11" sized paper, and must:

- Show boundary of entire Project Area;
- Be based on a recent aerial image, such as from NAIP or Google earth; and
- Show the month and year of the photograph in one corner of the image.

Project Area Boundaries: Use Google earth or a similarly high resolution aerial image of the Project Area to clearly delineate the Project Area boundaries, either on Google earth or on the hard copy using a brightly colored sharpie.

Map Unit Boundaries: If the Project Area extends over 10 acres or 0.5 miles long, then you must divide the Project Area into ≤10-acre or ≤0.5 mi-long 'Map Units'. If there is large variation in site topography, spatial position, management practices, or the habitat/communities present , then divide the Project Area into smaller Map Units,. Site-specific information will be collected for each Map Unit on habitat features, vegetation, and management practices. Setting the maximum size for these assessment areas at 10 acres is intended to ensure that the entire Project Area is well described and characterized in the Quantification Tool.

Give each Map Unit on the Project Area Map a unique numeric code, starting with 1; label each Map Unit on the map that goes with the Field Assessment Form. It is very important that these Map Units are clearly outlined and uniquely labeled on the Project Area map. Record responses to each of the questions from the Pollinators Field Data sheet for each of these Map Units.

Two examples of hypothetical Project Areas and their Map Units are provided in Figure 6-1.

Figure 6-1. Left image shows a hypothetical Project Area (red outline) along southern edge of river in the Central Valley with 10 separate Map Units, each < 10 acres and outlined in yellow. Right image shows a smaller Hypothetical Project Area with two linear hedge rows subjected to different management practices.

6.2 Project Area Overview Questions

Seven questions must be answered on the overall Project Area.

Field Data Sheet, p. 3
QT: Third worksheet: FieldBeeForm

A. Overall Pollinator Habitat Project Area (in acres).

The Project Area is designated by the land owner, and must be clearly delineated as part of the restoration and management plan for restoring or improving any pollinator resources – including both floral and nesting resources. For example, if logs will be staged near the planted area for potential nesting material, the Project Area should include the area with logs. The Project Area includes land where the management priority is to improve and maintain high quality pollinator habitat for the long-term. Record the number of acres in the Project Area on the Field Form, to the tenth of an acre precision or more (e.g., 9.2 acres).

B. Percent of Project Area that currently supports pollinator foraging habitat.

Provide an estimate of the absolute percent cover of pollinator foraging habitat currently supported within then Project Area. This can be a rough estimate of the total cover of floral resources.

Pollinator Foraging Habitat Characteristics

- Flowering plants present that provide pollen and nectar
- Wide variety of plants with a succession of flowers from February through November
- Diverse flower colors, shapes, and sizes

C. Number of 10 (or less)-acre Map Units in Project Area.

After subdividing the total Project Area into smaller Map Units, as described in Section 6.1 Project Area Map, enter the total number of Map Units included in the Project Area. For example, the Project Areas shown in Figure 6-1 have ten and two Map Units, respectively.

D. Assessment Year.

For this question, you need to write down the how many years since the restoration or enhancement project was implemented. If it has not yet been implemented, then indicate this by assigning it a '0' assessment year. If the project was implemented (e.g., planted) one growing season ago, then indicate it is year '1'; if two growing seasons have passed, then indicate year '2' etc. If it is a mature site with large trees you can either estimate the age of the most common trees, or indicate it is 'mature' by recording '60'. Sixty is the oldest age site recognized by the Pollinator Habitat Quantification Tool.

E. Farm size (acres).

Enter the total acres of land in the farm where the Project Area is located. Knowing the acreage of total farm area makes it possible to assess the percentage of a farm that is being managed for pollinator habitat. In this way, smaller farms that can manage a large proportion of their lands for pollinator habitat get 'credit' for higher percentages vs. straight acreage. Having many different pollinator habitat areas across the landscape supports pollinators over a broader matrix of lands, and is especially valuable where there are many small farms. Ten percent of the farm acreage was set as the most one can hope for from an active farm.

F. Map Unit area (square feet).

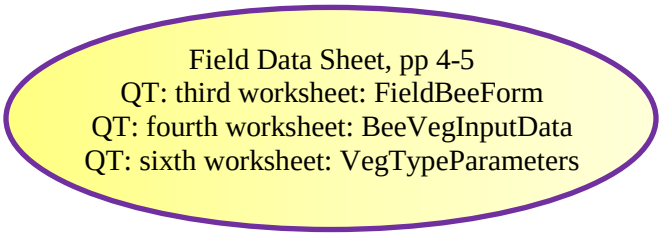
For each Map Unit, provide the size in square feet. The size may be calculated based on either field measurements or GIS/Google earth based calculations from digitized maps. If Project Area is less than ten Map Units, leave spaces provided for additional units blank.

G. Percentage of Map Units supporting floral resources.

For each Map Unit, as done for Question B, provide an estimate of the absolute percent cover of the area that supports floral resources.

6.3 Map Unit Questions

For every map unit, you must answer a series of 22 questions. Sets of Map Unit Questions are first recorded in the field on the field data sheet, pages 4 (variables 12-17 in the Floral Resources Table) and 5 (variables 18-33). Make additional copies of page 4 if you have more than one Map Unit in your Project Area. If you have over ten, you will need to break the Project Area into two projects, as described below. Information from the Floral Resources Table (page 4 of the field data sheet) is entered into the Quantification Tool in the fourth worksheet, BeeVegInputData. The *Veggiematic* then automatically fills in vegetation specific questions in the third worksheet, FieldBeeForm. Answers to questions 18-33 are entered directly into the third worksheet, the FieldBeeForm, for each Map Unit.



A set of information for each Map Unit is entered into the Quantifcation Tool spreadsheet. Information for Map Unit 1 is entered into rows 18 through 43 of the FieldBeeForm worksheet, and information for Map Unit 2 is recorded in rows 71 through 96 of the FieldBeeForm worksheet, etc. Each set of Map Unit Questions is topped by a green-highlighted row with the Map Unit number. There is room for ten Map Units for each Quantification Tool spreadsheet. If you have more than ten Map Units in one Project Area, you will need to divide the Project Area into two separate Project Areas and calculate the Ecosystem Service scores for each. If you have less than ten Map Units in one Project Area, enter data for the first set of Map Units in the worksheet. If for some reason, your Map Units numbers start at something greater than 1, start at Map Unit 1 anyway, and progress sequentially through the Map Unit entry sets provided in the 'FieldForm' worksheet. Do not skip down to Map Unit entry sets without filling in the sets above because the ecosystem service scores are bundled together sequentially in the Quantification Tool spreadsheet.

Remember: Do not delete any of the rows in the Quantification Tool spreadsheet. That would break critical links among the worksheets that are required for developing the ecosystem services score for your site.

For each Map Unit, 22 questions are broken out into four categories:

- Floral resources (6 questions)
- Nesting resources (6 questions)
- Management: Soil disturbance (5 questions)
- Management: Vegetation/ground disturbance (5 questions)

6.3.1 Floral resources

For this section, you will need to record information per Map Unit from the field and office on page 4 of the data form (Floral Resources Table). You will then transfer this information to the 'BeeVegInputData' worksheet of the Quantification Tool. This information will be used in the Veggiematic subroutine to automatically generate responses to questions 12 through 17 in the FieldBeeForm worksheet. *This is the most detail-intensive part of the Quantification Tool scoring process!*

6.3.1.1 Floral resources: in field

For all plant species within the Map Unit with at least 1-5% absolute cover, record the following on the Floral Resources Table, page 4 of the field data form:

a. Vegetation Type/ Plant Species Name

Record the actual species observed on the ground in Column a of the Floral Resources table; use latin names where possible, since they are more specific than common names (the same common name can actually refer to several species). See Appendix E, *Table E-1 Vegetation type list and parameters*, for a list of plant species and vegetation types commonly found in agricultural landscapes of the Central Valley. If a species is not listed in Appendix E, record it anyway.

b. Code

Again, refer to Appendix E, *Table E-1 Vegetation type list and parameters*, and record the Species/VegType Code listed for the species observed. If the species is not listed in Table E-1, select the most appropriate type that is listed, based on whether or not it is used by pollinators, its blooming period, size, and whether or not it is an annual or perennial.

Go to the website http://www.xerces.org/pollinators-california-region/ to get information on the pollinator value of a plant species that is not listed in Table E-1 for the Central Valley.

c. Percent Cover for Map Unit

Record the absolute percent cover of the species within the Map Unit using cover class bins provided below. Examples of images with different percent covers are provided in Appendix C. *Estimating Percent Area*.

Percent Cover: Use Cover Class Bins

Range	Midpoint
1–5%	3%
5–25%	15%
25–50%	37.5%
50–75%	62.5%
75–95%	85%
>95%	97.5%

Tools and examples for estimating percent area are provided in Appendix C.

d. Age

Record the average age of this plant species or vegetation type. Use the age bins provided in the table below.

Average Age

Category	Label	Definition
Annual/ Seedling	S	< 1 year old or < 1-inch diameter-at-breast-height (dbh)
Sapling	Sa	1–2 years old or 1–3 inches dbh
Pole	P	2–4 years old or 3–5 inches dbh
Mature	M	>5 years old or >5 inches dbh
Decadent	D	>10 years old or >10 inches dbh with >25% of canopy dead/dying

6.3.1.2 Floral resources: post-field data entry

For each plant species recorded, determine the following and record on the Floral Resources Table, found on page 4 of field data form:

e. Blooming Season

Refer to in Appendix E, *Table E-1 Vegetation type list and parameters* to look up the blooming season for each plant species and record here.

Blooming seasons
Early: February–May
Mid: June–July
Late: August–January

If there are plants in the Map Unit that are not listed Appendix E, *Table E-1 Vegetation type list and parameters*, then look up the plant species blooming period using *The Jepson Manual* (http://ucjeps.berkeley.edu/IJM.html). Search this eFlora for a name, click on the plant species name, and locate the blooming period at the end of the species description (see Figure 6-2 below). If a species straddles blooming periods, only count the species as "in" a season if it straddles over half the season. Record the blooming period on the field data form.

f. Weeds: Nonnative (y/n)

Again, if a species is not listed in Appendix E, *Table E-1 Vegetation type list and parameters*, use *The Jepson Manual* eFlora database to look up whether or not the plant species is native or naturalized (nonnative) (see Figure 6-2 below). Record whether the species is native or nonnative on the field data form.

g. Weeds/Invasive: If the plant is an invasive species.

Many naturalized non-native plant species can be relatively benign, meaning they do not spread rapidly or out-compete native species. These are referred to as non-invasive nonnative species. The list of invasive species of concern in the Great Valley from California Invasive Plant Council (Cal-IPC 2006) is provided in Appendix D.

Record whether the species is invasive or not based on whether or not it is listed in Appendix D on the field data form. For native species, enter 'n' for no. New invasive nonnative species are continuously moving into new territory. If you find a species that you believe is invasive but not listed in Appendix D, look up its most recent status at the Cal-IPC website: http://www.cal-ipc.org/ip/inventory/weedlist.php. If the species is listed with a moderate to high overall rating, then enter 'y' for invasive. Otherwise, enter 'n' for no.

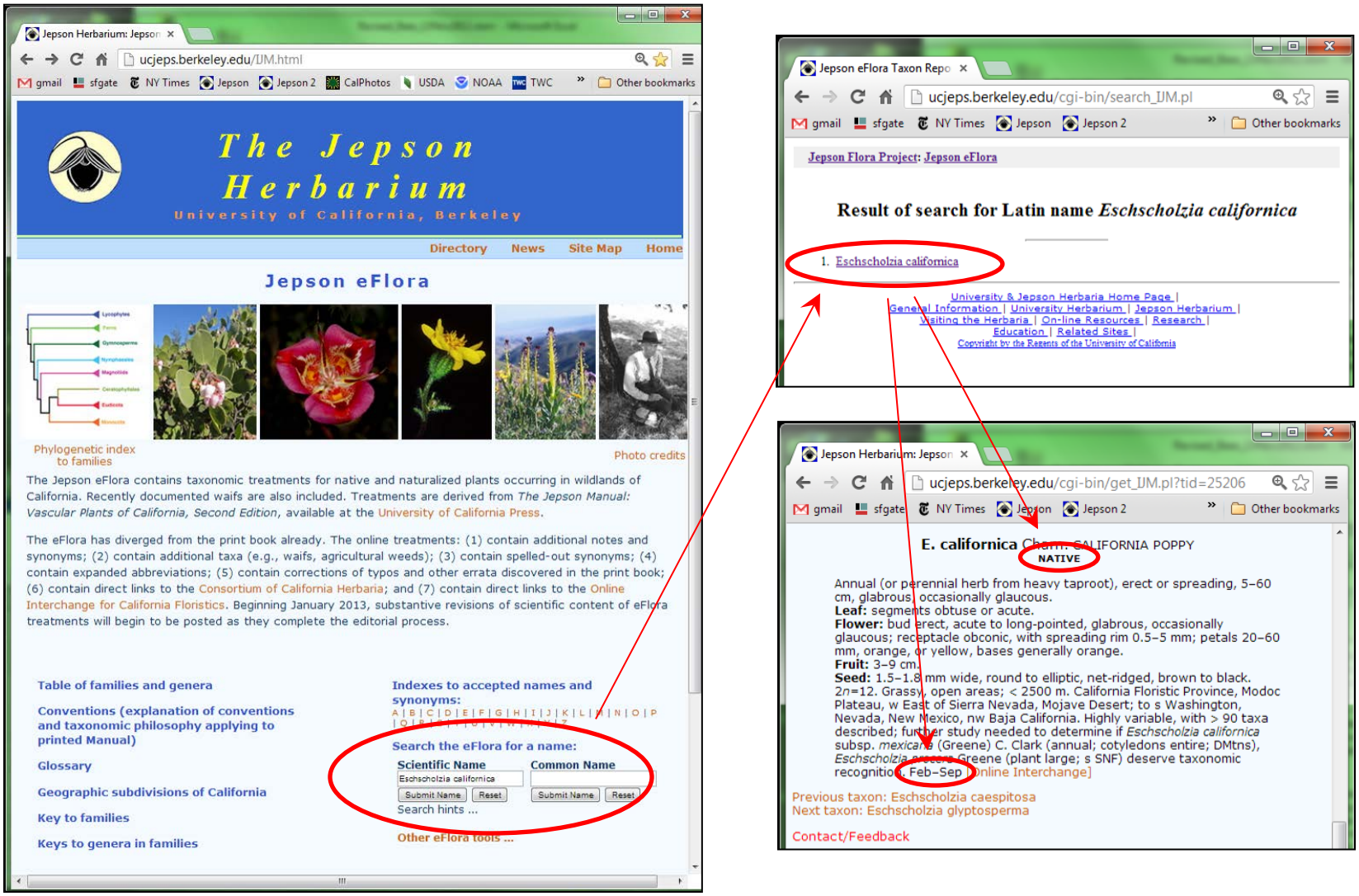


Figure 6-2. The left image shows the Jepson eFlora search box; the upper right image shows the species name results page; and the bottom right image shows the species description. Note the location of the blooming period and plant's native status. This species should be counted as both an early- and mid-blooming plant, as the blooming window encompasses over 50% of these blooming seasons.

Entering Summarized Vegetation Information in Quantification Tool Spreadsheet

To enter responses into the Quantification Tool, you must enter data into the fourth worksheet 'BeeVegInputData'.

> Only enter data into the yellow highlighted cells. Do not edit or change any of the other cells in the 'BeeVegInputData' worksheet.

Enter information for each Map Unit separately per Map Unit block. For example, data for the first Map Unit should be entered in rows 9 through 43 of the 'BeeVegInputData' worksheet, and for Map Unit 2 in rows 62 through 96. You may enter vegetation information for up to 10 Map Units.

Within each Map Unit, you can have multiple species/vegetation types and multiple entries for the same species/vegetation type but of different ages (e.g., *Lupinus* spp. 1 year and *Lupinus* spp. 4 years). You may enter as many as 35 different species/veg types for each Map Unit. If you have more than 35 entries; lump similar species into a single code.

For each Map Unit:

a. Enter the size of each Map Unit in Column C just one time under the first line for that Map Unit, in square feet. This information was recorded for each Map Unit on page 3, Variable F, in the Field Data Sheet.

b. Copy from the Field Data Form information on Cover Class (percent cover), Code, and Age for each vegetation type and age group (columns E, F, and G, respectively).

c. Once completed, leave the bottom-most army-green colored rows where values are automatically calculated and will be 'collected' by the FieldBeeForm worksheet and go from there (automatically) into the Bee Scoring tool.

> Note: If there are any invasive weed species (from Appendix D) or plant species considered 'not beneficial to pollinators' on the list, make sure you have coded them with an appropriate species/veg code (i.e., one with a blooming season of "Never" in the 'VegTypeParameters' worksheet). This will ensure appropriate scoring in the tool output.

Plant Age and Estimating Changes in Vegetation through Time

The Quantification Tool allows you to estimate or 'game' changes in vegetation though time and to estimate the effects of these changes on the benefits provided by floral resources by simulating

- Implementation of various restoration designs by inputting specific planting plan information (species density and distribution); and

- Growth of vegetation 2 to 60 years from present (no changes will be apparent after that since all trees will be assumed fully grown at 60 years).

Changes in ecosystem service scores (and habitat-acres) will be generated with each time series, assuming all other variables remain the same (such as special habitat features, management, and landscape relationships). Parameters used to estimate change over time for Vegetation Types recognized by the spreadsheet are listed in Appendix E.

If you are using the Quantification Tool to understand changes in a restored site over time:

- Enter the ages for each vegetation type under Column G of the BeeVegInputData worksheet for Year 1.

- Enter the number of years since implementation under Variable D in the FieldBeeForm (cell E11) (also see: "Assessment Year", *6.2 Project Area Overview Questions* of this User Guide).

The Quantification Tool will use the sum of Year 1 age and the Assessment Year as the age for the dominant plants in each polygon. In other words, for 'gaming' changes in a site through time, keep the Year 1 age entered in the BeeVegInputData worksheet constant (column G), and change the "Assessment Year" entered in the FieldBeeForm (cell E11).

Floral Resources Questions 12- 17 in the FieldBeeForm worksheet are automatically addressed for each Map Unit based on calculations performed in the 'Veggiematic subroutine' using data entered into the BeeVegInputData worksheet. Enter nothing for these lines in the FieldBeeForm.

Variable Number	Variable	Data	Min of range	Max of range	Explanations and Definitions		
12	Number of different flowering plant species present during early-blooming (Feb-May) period		7	7	Enter nothing here. These values will be automatically entered in Columns F and G based on your entries to the BeeVegInputData worksheet. Enter data in to that worksheet (directions are at top of worksheet).		
13	Number of different flowering plants present during mid-blooming (Jun-Jul) period		10	10			
14	Number of different flowering plants present during late-blooming (Aug-Jan) period		7	7			
15	Estimated surface area of flowering plants present during **early**-blooming (Feb-May) period		0%	24	34	0%	Enter nothing here. These values will automatically be entered from the BeeVegInputData worksheet. Enter data in to that worksheet.
16	Estimated surface area of flowering plants present during **mid**-blooming (Jun-Jul) period		0%	12	18	0%	
17	Estimated surface area of flowering plants present during **late**-blooming (Aug-Jan) period		0%	10	14	0%	

Figure 6-3. Rows for one Map Unit in the FieldBeeForm worksheet that are automatically addressed using the 'Veggiematic' based on data entered into the BeeVegInputData worksheet.

6.3.2 Nesting resources

Nesting resources are a critical part of pollinator habitat. Questions 18 through 23 address the most important factors that can help provide nesting habitat for a diverse pollinator community.

Question 18. Percent cover of friable bare ground present.

Friable bare ground is bare or sparsely-vegetated (<50% cover of vegetation) areas of soil (not sand or clay). Record the percent of area within the Map Unit that is friable bare ground in the following bins:

- 0%
- 1–10%
- 11–20%
- 21–30%
- 31–100%

Ideally, there is between 10–30% friable bare ground. Enter the minimum and maximum value from the range in Columns F and G.

Tools and examples for estimating percent area are provided in Appendix C

Question 19. Number of rodent holes present.

Enter the number of rodent holes present in the Map Unit as '0' for none, '1' for a few (i.e., 1–10), and '2' for many (>10). The target is to have few or many rodent holes.

Question 20. Amount of bunch grasses present.

Enter the percent cover of bunch grasses present in the Map Unit using the following bins (target is between 5-25%):

- 0% (enter '0')
- 1–5% (enter '1')
- 5–25% (enter '2')
- 25–100% (enter '2')

Question 21. Amount of snags/stumps present.

Record the total number of snags and/or stumps present using the following bins:

- '0' for none
- '1' for few (1–10)
- '2' for many (>10)

Question 22. Amount of nest boxes or nest bundles present.

The goal is to have many nesting holes available that are spread out; therefore a greater number of blocks with fewer holes per block is preferable to a few blocks with many holes. And maybe also simplify the scoring, especially btw 1 and 1.5 scoring Record the number of nest boxes and/or nest bundles present using the following categories (the maximum score is 3):

- '0' for none
- '0.5' for few (1-3) that are close together and/or not maintained annually
- '1' for few (1-3) with either greater than 50 holes or fewer than 50 but maintained annually
- '1.5' for few (1-3) that are both greater than 50 holes and maintained annually
- '2' for many (>3) that are both greater than 50 holes and maintained annually.
- '+1' award an extra point for nest boxes with multiple sized holes and/or small blocks w/less than 20 holes.

Question 23. Amount of plants with pithy tissue present.

Record the amount of plants with pithy tissue present in Column E using the following bins:

- '0' for <1%
- '1' for 1–5%
- '2' for >5%

Pithy tissue refers to the dense, sponge-like tissues found in plants such as elderberry and sumac.

6.3.3 Management: Soil disturbance

An interview with the manager to determine what the most common management practices are, how often they are applied, and during what season, will enable you to answer these three important management questions. Variation in management is likely from one year to the next; try to identify the most common management pattern to address these questions.

Question 24. Is the Map Unit tilled at some point during the year?

Determine if the Map Unit is tilled (agricultural preparation of the soil which digs/overturns the soil) at all during the year. Enter '1' for yes and '0' for no.

Question 25. Is the Map Unit flood-irrigated at some point during the year?

Determine if the Map Unit is flood-irrigated at all during the year. Enter '1' for yes and '0' for no.

Question 26. Is plastic mulching used within the Map Unit?

Determine if plastic mulching is used within the Map Unit. Enter '1' for yes and '0' for no.

Question 27. Does road-grading or road-making occur on the Map Unit?

Determine if the Map Unit experiences road-grading or road-making. Enter '1' for yes and '0' for no.

Question 28. Total percent cover of the Map Unit that experiences any soil disturbance.

Enter the percent cover of all types of soil disturbance (tilling, flood irrigation, plastic mulching, road-grading/road-making) in the following categories:

- 0%
- 1–10%
- 10–30%
- 30–60%
- 60–90%
- 90–100%

6.3.4 Management: Vegetation/ground disturbance

Question 29. Total cover of invasive noxious weeds.

Enter the total cover of invasive noxious weeds (see Appendix D for a list of species considered highly invasive). Use the following cover class categories:

- 0
- 0–1%
- 1–5%
- 5–25%
- 25–50%
- 50–75%
- 75–95%
- 95–100%

Question 30. Total number of invasive noxious weed species.

Enter the total number of invasive noxious weed species present within the Map Unit (see Appendix D for a list of species considered highly invasive).

Question 31. Percent of the Map Unit burned during the blooming season (February–September).

Determine if the Map Unit is burned at all during the year. To answer this question, you will need to interview the manager. Variation in management is likely from one year to the next; try to identify the most common management pattern to address this question. Enter using the following categories:

- 0%
- 1–10%
- 10–30%
- 30–60%
- 60–90%
- 90–100%

Question 32. Percent of the Map Unit mowed and/or hayed during the blooming season (February–September).

Determine if the Map Unit is mowed and/or hayed at all during the year. To answer this question, you will need to interview the manager. Variation in management is likely from one year to the next; try to identify the most common management pattern to address this question. Enter using the following categories:

- 0%
- 1–10%
- 10–30%
- 30–60%
- 60–90%
- 90–100%

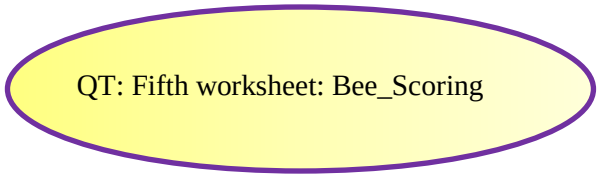
Question 33. Total percent of the Map Unit burned, mowed, or hayed during the blooming season (February–September).

Enter using the following categories:

- 0%
- 1–10%
- 10–30%
- 30–60%
- 60–90%
- 90–100%

7 READING AND UNDERSTANDING SITE SCORES

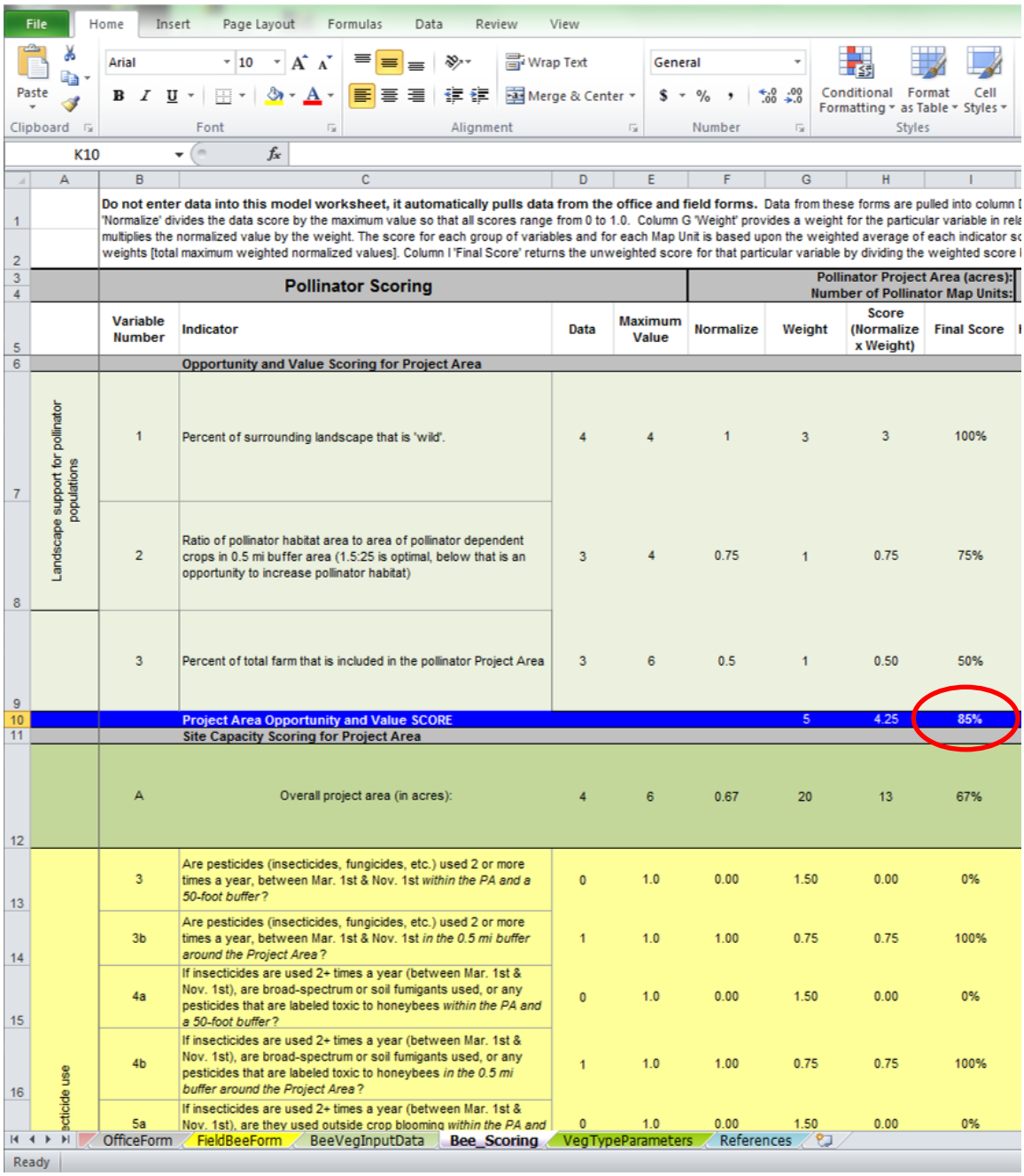
Once all of the data and information from the office, field, and vegetation data sheets have been entered and checked for accuracy, scores will automatically be generated in the 'Bee_Scoring' worksheet of the Quantification Tool.



As described in Section 3. Tool Structure, the Quantification Tool provides two scores for each Project Area: the Opportunity and Value score and the Site Capacity score. The Bee_Scoring worksheet presents both scores a percent of potential, based on conditions that have been observed in the Central Valley and based on known requirements of bee pollinators.

7.1 Opportunity and Value Scores

The Opportunity and Value Score is presented separately, as a percentage, in in cell I10 of the Bee_Scoring worksheet, as illustrated for a hypothetical location in Figure 7-1.



Do not enter data into this model worksheet, it automatically pulls data from the office and field forms. Data from these forms are pulled into column D 'Normalize' divides the data score by the maximum value so that all scores range from 0 to 1.0. Column G 'Weight' provides a weight for the particular variable in rela multiplies the normalized value by the weight. The score for each group of variables and for each Map Unit is based upon the weighted average of each indicator sc weights [total maximum weighted normalized values]. Column I 'Final Score' returns the unweighted score for that particular variable by dividing the weighted score

Pollinator Scoring

Pollinator Project Area (acres):
Number of Pollinator Map Units:

	Variable Number	Indicator	Data	Maximum Value	Normalize	Weight	Score (Normalize x Weight)	Final Score
		Opportunity and Value Scoring for Project Area						
Landscape support for pollinator populations	1	Percent of surrounding landscape that is 'wild'.	4	4	1	3	3	100%
	2	Ratio of pollinator habitat area to area of pollinator dependent crops in 0.5 mi buffer area (1.5:25 is optimal, below that is an opportunity to increase pollinator habitat)	3	4	0.75	1	0.75	75%
	3	Percent of total farm that is included in the pollinator Project Area	3	6	0.5	1	0.50	50%
		Project Area Opportunity and Value SCORE				5	4.25	85%
		Site Capacity Scoring for Project Area						
	A	Overall project area (in acres):	4	6	0.67	20	13	67%
ecticide use	3	Are pesticides (insecticides, fungicides, etc.) used 2 or more times a year, between Mar. 1st & Nov. 1st *within the PA and a 50-foot buffer*?	0	1.0	0.00	1.50	0.00	0%
	3b	Are pesticides (insecticides, fungicides, etc.) used 2 or more times a year, between Mar. 1st & Nov. 1st *in the 0.5 mi buffer around the Project Area*?	1	1.0	1.00	0.75	0.75	100%
	4a	If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are broad-spectrum or soil fumigants used, or any pesticides that are labeled toxic to honeybees *within the PA and a 50-foot buffer*?	0	1.0	0.00	1.50	0.00	0%
	4b	If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are broad-spectrum or soil fumigants used, or any pesticides that are labeled toxic to honeybees *in the 0.5 mi buffer around the Project Area*?	1	1.0	1.00	0.75	0.75	100%
	5a	If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are they used outside crop blooming *within the PA and*	0	1.0	0.00	1.50	0.00	0%

OfficeForm | FieldBeeForm | BeeVegInputData | Bee_Scoring | VegTypeParameters | References

Ready

Figure 7-1. Bee_Scoring worksheet of the Pollinator Habitat Quantification Tool, showing the 'score' for the Opportunity and Value of a hypothetical site in the Central Valley.

Weights and scoring rules for each of the three variables used to develop this Opportunity and Value Score are detailed in the spreadsheet itself, as well as the Table 7-1 below.

Table 7-1. Explanations and rationales for indicators used to develop Opportunity and Value Scores for Pollinator Habitat.

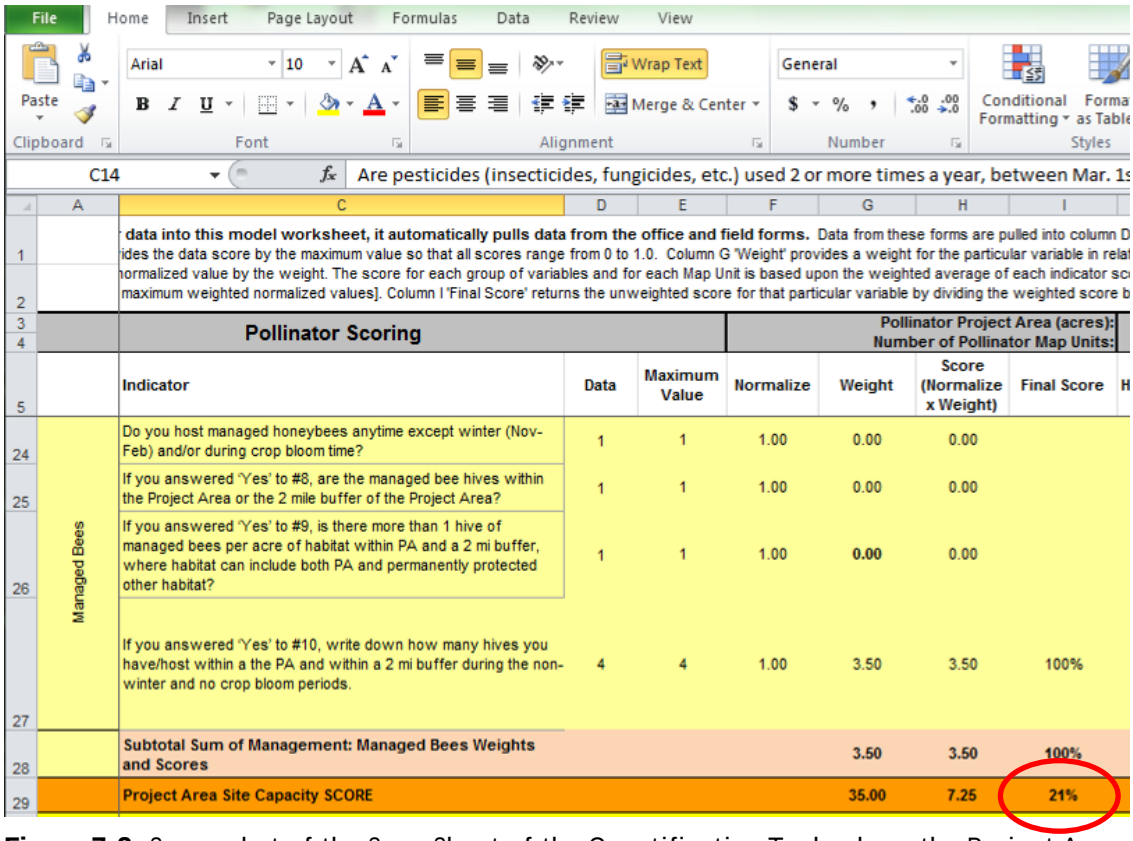
Indicator	Weight	Explanation and rationale	Citations
1. Percent of surrounding landscape that is 'wild'.	3	If there is very little wild habitat surrounding the project site, then there is a greater opportunity to improve pollinator services in the area and thus a higher score for opportunity. However, if there is no wild habitat at all, then the Project Area may not have a source bee population - thus, sites with no surrounding wild habitat do not get the maximum score but rather a score of 75%. Opportunity was weighted equal to value.	Klein et al. 2007; Kremen et al. 2004, Williams and Kremen 2007, Winfree et al. 2007, extrapolated from NRCS 2009 0.5-mi scale
2. Ratio of pollinator habitat area to area of pollinator dependent crops in 0.5 mi buffer area (1.5:25 is optimal, below that is an opportunity to increase pollinator habitat)	1	If there are pollinator dependent crops in the surrounding landscape, then providing pollinator habitat benefits these crops. NRCS 2009 suggests 1 to 2 acres of pollinator habitat for every 25 acres of every cropped (pollinator dependent crop) acre. Thus, if ratio is much higher (e.g. 5 acres habitat per 25 acres crops), then the opportunity and need is not high. Value was weighted equal to opportunity. Bin scores assigned by ratios of pollinator crop dependent acres to proposed pollinator habitat acres: >40:1 = 4; 30 to 39:1 =3; 20-29:1=2; <20:1=1.	Chaplin-Kramer et al. 2011, Greenleaf and Kremen 2006, Morandin and Winston 2006, Klein et al. 2007; Winfree et al. 2007, extrapolated from NRCS 2009 0.5-mi scale
3. Percent of total farm that is included in the pollinator Project Area	1	Having many different pollinator habitat areas across the landscape supports pollinators over a broader matrix of lands, and is especially valuable. Ten percent of the farm acreage was set as the most one can hope for from an active farm.	Winfree et al. 2007

7.2 Project Area Capacity Score

The ability of the Project Area to support pollinator populations is assessed using three indicators:

1. The ratio of the size of the Project Area to the farm;
2. The insecticide use in and around the Project Area; and
3. The management of managed bees at the Project Area.

Thus, the extent of pollinator habitat (acres) and the degree of consolidation of this habitat (estimated by the percent of the total Project Area) along with relevant resource management practices are used to assess the Project Area capacity. This score alone is not used but rather is combined with information on site characteristics and habitat quality gathered for each Map Unit. The Project Area Capacity score does represent 60% of the overall combined capacity score for the Project Area and the Map Units, as detailed below. The Project Area Site Capacity score can be found in cell I29 of the Bee_Scoring in the Pollinator Habitat Quantification Tool (Figure 7–2).



		Indicator	Data	Maximum Value	Normalize	Weight	Score (Normalize x Weight)	Final Score
		Pollinator Scoring					Pollinator Project Area (acres): Number of Pollinator Map Units:	
24	Managed Bees	Do you host managed honeybees anytime except winter (Nov-Feb) and/or during crop bloom time?	1	1	1.00	0.00	0.00	
25		If you answered 'Yes' to #8, are the managed bee hives within the Project Area or the 2 mile buffer of the Project Area?	1	1	1.00	0.00	0.00	
26		If you answered 'Yes' to #9, is there more than 1 hive of managed bees per acre of habitat within PA and a 2 mi buffer, where habitat can include both PA and permanently protected other habitat?	1	1	1.00	**0.00**	0.00	
27		If you answered 'Yes' to #10, write down how many hives you have/host within a the PA and within a 2 mi buffer during the non-winter and no crop bloom periods.	4	4	1.00	3.50	3.50	100%
28		**Subtotal Sum of Management: Managed Bees Weights and Scores**				3.50	3.50	100%
29		**Project Area Site Capacity SCORE**				35.00	7.25	21%

Figure 7-2. Screenshot of the ScoreSheet of the Quantification Tool, where the Project Area Site Capacity Score is displayed.

7.3 Combined Capacity Score for Project Area and Map Units

The capacity of each Map Unit to provide pollinator habitat is assessed in up to ten 33-row blocks, which begin in a green colored row and end in a orange-colored row. The Map Unit

capacity scores, combined with the overall Project Area capacity score, is tallied up at the bottom of each Map Unit block, based on the Map Unit scores presented in above blocks.

As detailed in Table 7-2, weighting in the Map Unit Capacity score is distributed between four types of site characteristics.

Table 7-2. Summary of score weighting used to assign capacity scores to each Map Unit.

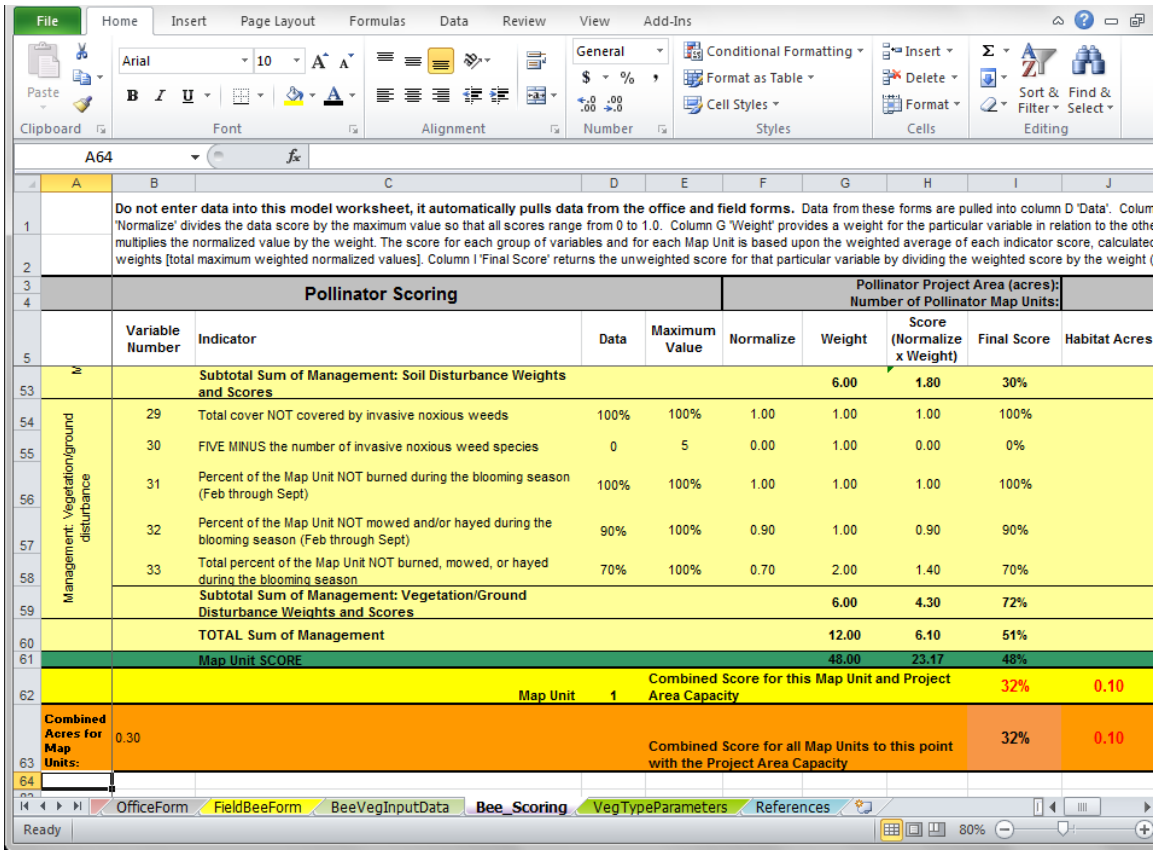
Indicator group	Number of indicators	Weight
Map Unit Characteristics	2	12
Floral Resources	6	12
Nesting Resources	7	12
Management	10	12
Total	25	48

In the example shown in Figure 7-3 below, the capacity score for Map Unit 1alone is 32% as shown in cell I61; for Map Unit 1 combined with the Project Area capacity, the capacity score is 32%, as displayed in cell I62. The habitat acres credited for this map unit are 0.32 * 0.30 (capacity score times acres in map unit), or 0.10 acres. The scores of additional Map Units, which must be entered in sequence, are combined using the area-weighted average of the Map Units:

$$\textit{Weighted Average MU Capacity Score} = \frac{\textit{(MU1ac*MU1score + MU2ac*MU2score + MU3ac*MU3score)}}{\textit{(sum MU1, MU2 and MU3 ac)}}$$

The Project Area capacity score is then combined with the weighted average MU capacity score using a 60/40 ratio:

*Combined Capacity Score = PA Capacity Score *0.6 + Weighted Avg MU Capacity Score * 0.4*



Do not enter data into this model worksheet, it automatically pulls data from the office and field forms. Data from these forms are pulled into column D 'Data'. Colum
'Normalize' divides the data score by the maximum value so that all scores range from 0 to 1.0. Column G 'Weight' provides a weight for the particular variable in relation to the othe
multiplies the normalized value by the weight. The score for each group of variables and for each Map Unit is based upon the weighted average of each indicator score, calculate
weights [total maximum weighted normalized values]. Column I 'Final Score' returns the unweighted score for that particular variable by dividing the weighted score by the weight (

		Pollinator Scoring						Pollinator Project Area (acres): Number of Pollinator Map Units:		
	Variable Number	Indicator	Data	Maximum Value	Normalize	Weight	Score (Normalize x Weight)	Final Score	Habitat Acres	
53		Subtotal Sum of Management: Soil Disturbance Weights and Scores				6.00	1.80	30%		
54	29	Total cover NOT covered by invasive noxious weeds	100%	100%	1.00	1.00	1.00	100%		
55	30	FIVE MINUS the number of invasive noxious weed species	0	5	0.00	1.00	0.00	0%		
56	31	Percent of the Map Unit NOT burned during the blooming season (Feb through Sept)	100%	100%	1.00	1.00	1.00	100%		
57	32	Percent of the Map Unit NOT mowed and/or hayed during the blooming season (Feb through Sept)	90%	100%	0.90	1.00	0.90	90%		
58	33	Total percent of the Map Unit NOT burned, mowed, or hayed during the blooming season	70%	100%	0.70	2.00	1.40	70%		
59		Subtotal Sum of Management: Vegetation/Ground Disturbance Weights and Scores				6.00	4.30	72%		
60		TOTAL Sum of Management				12.00	6.10	51%		
61		Map Unit SCORE				48.00	23.17	48%		
62		Map Unit 1		Combined Score for this Map Unit and Project Area Capacity				32%	0.10	
63	Combined Acres for Map Units: 0.30			Combined Score for all Map Units to this point with the Project Area Capacity				32%	0.10	
64										

Management: Vegetation/ground disturbance

OfficeForm | FieldBeeForm | BeeVegInputData | Bee_Scoring | VegTypeParameters | References

Ready 80%

Figure 7-3. Capacity scores for the first Map Unit alone and when combined with the Project Area capacity score are displayed in cells I61 and I62, respectively.

Weights and scoring rules for each of these 25 variables used to develop the Map Unit capacity score are detailed in the spreadsheet itself, as well as the Table 7-3 below.

Table 7-3. Explanations and rationales for indicators used to develop Map Unit Capacity scores for Pollinator Habitat.

Indicator group	Variable number	Indicator	Explanation and rationale	Citations
Map Unit Characteristics	F	Acres of Map Unit	The more area of the Map Unit that provides nesting and/or foraging habitat for the pollinators, the better. Credit assigned linearly up to 10% of the total farm area (maximum).	Zurbuchen et al 2010, NRCS 2009
	G	Percent of Map Unit that is covered with pollinator habitat	Higher density habitat, vs. diffuse habitat, reduces energy required for pollinators and is therefore also better habitat. Bins set at <1, 1-10, 10-25, 25-50, 50-75, 75-85, >85.	NRCS 2009, Sih and Baltus 1987
Floral Resources	12, 13, 14	Number of different flowering plant species present during early-blooming (Feb-May), mid-blooming (June-July) and late-blooming (August-Jan) period	Research has shown that it is ideal to have 5 or more flowering plant species present during all seasons (the greater diversity of plants, the greater abundance and diversity of bees).	NRCS 2009, Bosch and Kemp 2001, Pontin et al. 2006, NRCS 2009, Pywell et al. 2005
	15, 16, 17	Estimated surface area of flowering plants present during early-blooming (Feb-May), mid-blooming (June-July), and late-blooming (August-Jan) period	Having floral resources available throughout the year supports diversity of pollinator species. Scoring is set at 0, 1 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, and over 25% for maximum score.	Zurbuchen et al 2010, NRCS 2009, NRCS 2009, Pywell et al. 2005
Nesting Materials Management	18	Percent cover of friable bare ground present	70% native bees nest in soil.	Morandin and Winston 2006, Carvell 2002, Potts et al. 2005, Xerces Society for Invertebrate Conservation 2011
	19 and 20	Amount of rodent holes and/or bunch grasses	30% native bees nest in cavities including blue orchard bees.	Thorp et al. 1983, Kearns and Thomson 2001, McFrederick and LeBuhn 2006
	21, 22, 23	Amount of snags/stumps, nest boxes/bundles, pithy tissue	Bumble bees often nest or overwinter in rodent holes or within bunch grasses.	Bosch and Kemp 2001; Michener 2000; Xerces Society for Invertebrate Conservation 2011
	18 through 23	Diversity of available nesting materials	A diversity of nesting materials will support a diversity of pollinators.	Tscharntke et al. 1998, Cane 2001, Potts et al. 2005, Westrich 1996

Indicator group	Variable number	Indicator	Explanation and rationale	Citations
Nesting Materials Management	24	Is the Map Unit tilled at some point during the year?	Soil tilling disturbs ground nesting bees and favors aggressive nonnative plants.	Shuler et al. 2005, NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	25	Is the Map Unit flood-irrigated at some point during the year?	Flood irrigation drowns the underground life stages of ground nesting bees.	Vaughn et al. 2007, NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	26	Is plastic mulching used at the Map Unit?	Plastic mulching traps the underground life stages of ground nesting bees.	NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	27	Does road-grading or road-making occur on the Map Unit?	Road-grading/making disturbs the underground life stages of ground nesting bees.	NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	28	Total percent cover of map unit that does NOT experience soil disturbance.	The less of the site with ground disturbance, the less the impact to bees.	NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	29	Total cover NOT covered by invasive noxious weeds	Aggressive nonnative plant species reduce overall plant diversity, which influences bee diversity.	Williams et al. 2010, NRCS 2009, Bosch and Kemp 2001, Pontin et al. 2006, NRCS 2009, Pywell et al. 2005
	30	FIVE MINUS the number of invasive noxious weed species		
	31	Percent of the Map Unit NOT burned during the blooming season (Feb through Sept)	Burning disturbs ground nesting bees and floral resources.	Black et al. 2008, Hartley et al. 2007, Smallidge and Leopold 1997, Manguira and Thomas 1992, NRCS 2009, Xerces Society for Invertebrate Conservation 2011
	32	Percent of the Map Unit NOT mowed and/or hayed during the blooming season (Feb through Sept)	Mowing/haying disturbs ground nesting bees and floral resources.	
	33	Total percent of the Map Unit NOT burned, mowed, or hayed during the blooming season	The less of the site with vegetation/soil disturbance, the less the impact to bees.	

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Appendices

Appendix A

Advisory Committee Members

Table A-1. Advisory Committee Members.

Name	Job title	Organization
Paul Adamus	Wetland Scientist and Ecologist	Oregon State University and Adamus Resource Assessment, Inc.
Dick Cameron	Senior Conservation Planner	The Nature Conservancy
Tom Griggs	Senior Restoration Ecologist	River Partners
Paul Jones	Life Scientist	Environmental Protection Agency, Wetlands Office, Region 9
Lora Morandin	Postdoctoral scholar in Kremen lab	Department of Environmental Science, Policy, and Management, UC Berkeley
Steve Peterson	Entomologist	AgPollen, LLC
Lucinda Roth	Climate Change Specialist	Natural Resource Conservation Service (NRCS), Modesto Field Office
Jeremy Sokulsky	President	Environmental Incentives, LLC: Environmental Incentives
Diana Waller	District Conservationist	NRCS, Modesto Field Office
Kristin Guy	Soil Conservation Technician	NRCS, Modesto Field Office
Kimiora Ward	Research Associate	Department of Entomology, UC Davis
Core Team Partners		
Jessa Guisse	California Pollinator Habitat Restoration Specialist	Xerces Society
Nat Seavy	Research Director	PRBO Conservation Science, Terrestrial Ecology Division

Appendix B

Office and Field Data Sheets

Office Data Sheet: Ecosystem Services Pollinator Habitat

Project Area Name: _____ Observer: _____ Date: _____

Project Area Acreage[1]: _____ Notes: _____
_____

Variable	Measurement	Value		Value	Notes
1. Percent cover by landuse categories within 0.5 miles of Project Area.	Urban/built (%) (impervious/paved areas [paved parking lots, industrial and commercial areas], dam)		Bare (%) (appears to be bare dirt [like dirt road] but is not a road; could be dirt parking area, road shoulder, or bare patch in field)		Use Google Earth or a NAIP image to locate the Project Area and mark out a 0.5-mile buffer around from the Project Area boundary. Within the buffer area (but outside of the Project Area), estimate the percent cover of each of the landuse categories that occur and record in the column to the left. ***If necessary, double-check or 'ground truth' these habitat types during the field visit.***
	Paved Road (%) (paved county roads, highways)		Weedy/sparse scrub (%) (areas that appear to have more than just grassy vegetation [presumably weeds], sometimes including an occasional shrub; road and field edges often fit into this category)		
	Suburban open (%) (neighborhoods with little canopy cover [includes streets, yards, houses])		Grass (%) (includes mowed, unmowed, annual and perennial)		
	Suburban wooded (%) (neighborhoods with dense canopy cover)		Chaparral (%) (located usually on SW facing slopes of more xeric areas, near oak woodland, usually low canopy height)		
	Exurban (%) (farm operations and homesteads in areas where neighbors are not close together, often adjacent to ag fields [includes yards, trees, paved driveways, garages])		Oak savannah (%) (natural-looking grassy/scrubby areas with mixed oak/pine tree spp. scattered throughout)		
	Dirt road (%) (includes possible gravel roads)		Oak woodland (%) (also includes scrub-oak: natural-looking areas containing mixed oak/pine tree spp. growing more densely than "oak savannah")		
	Annual Crop (%) (agricultural fields planted with seasonal row crops)		Riparian forest (%) (land along natural waterways [not irrigation ditches] containing dense tree growth, even if forest strip consists of a single line of trees)		
	Orchard-Vineyard Crop (%) (agricultural fields planted with perennial crops, includes orchards and vineyards)		Riparian scrub (%) (land along waterways containing shrubs or trees but not dense canopy cover)		
	Rice (%) (agricultural fields planted with rice)		Water (%) (ponds, rivers, canals, drainage ponds, etc.)		
	Non-Agricultural Planted (%) (non-agricultural plantings; examples include hedgerows, rows of Eucalytpus along road, plantings along irrigation ditches, and other plantings that are clearly not naturally occurring but do not fit into "crop" categories)		Emergent herbaceous wetlands (%) (wetlands often adjacent to open water but not riparian scrub)		

[1] Area set out for implementation targeting pollinator habitat (Project Area), determined by client/design plans (in acres) (Source: Kremen 2010).

Office Data Sheet: Ecosystem Services Pollinator Habitat

Variable	Response		Explanations and Definitions
2. Percent cover of pollinator dependent crops **within 0.5 miles of Project Area.**	2a.Total % cover: 2b. Crop type(s) : _____ _____ _____ _____ _____		• Use the same 0.5-mile buffer around the Project Area boundary created for Variable 1. • Within this buffer area (but outside of the Project Area), estimate the percent cover of pollinator dependent crops that occur and record in the column to the left. • Please note what types of crops are present. • ***If necessary, double-check or 'ground truth' the crop types during the field visit.***
Management	Within PA + 50-ft buffer	Within 0.5-mile buffer	On the project area map, draw a 50' buffer around the Project Area and refer to the area inside this buffer, including the PA itself, to answer the left side columns Use the 0.5mile buffer created for Variable 1, but only including lands that are managed and/or controlled by the applicant to answer the right side columns.
3. Are pesticides (insecticides, fungicides, etc.) used 2 or more times a year, between Mar. 1st & Nov. 1st?			In the first column, enter '1' for Yes or a '0' for No for application within the PA and a 50 foot buffer. In the second column, enter '1' for Yes or a '0' for No for application within a 0.5 mi buffer of, but not including, the PA.
4. If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are broad-spectrum or soil fumigants used, or any pesticides that are labeled toxic to honeybees?			
5. If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are they used outside of the crop blooming period?			
6. If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), are they only used when bees are not active (i.e., at night)?			
7. If insecticides are used 2+ times a year (between Mar. 1st & Nov. 1st), what is the application method?			In the first and second columns (for PA +50' and 0.5 buffer, respectively), enter '4' for no pesticides applied; '3' for hand application; '2' for tractor and boom application; '1' for other ground based method; and '0' for aerial application via an air craft. If you entered '1', enter method here: _____
8. Do you host managed honeybees anytime except winter (Nov-Feb) and/or during crop bloom time?			Enter '1' for yes and '0' for no in the first column.
9. If you answered 'Yes' to #8, are the managed bee hives within the 2 mile buffer of the Project Area?			Enter '1' for yes and '0' for no, even if you also said 'no' to question 8.
10. If you answered 'Yes' to #9, is there more than 1 hive of managed bees per acre of habitat within PA and a 2 mi buffer, where habitat can include both PA and permanently protected other habitat?			Enter '1' for yes and '0' for no, even if you also said 'no' to questions 8 and 9.
11. If you answered 'Yes' to #10, write down how many hives you have/host within the PA and within a 2 mi buffer during the non-winter and no crop bloom periods.			Enter the number of managed bee hives you host, within the PA and a 0.5 mi buffer, outside of winter and outside of crop bloom time. Enter '0' for no, even if you also said 'no' to questions 8-10.

Field Data Sheet: Ecosystem Services Pollinator Habitat

Project Area Name: _____ Observer: _____ Date: _____
Notes: _____

Project Overview Information: Fill out A – G

Variable	Value	Explanation
A. Project Area (acres): *Area set out for implementation targeting pollinator habitat (Project Area), determined by client/design plans.*	ac	The Project Area should include the area planned to include any pollinator resources – including both floral and nesting resources. For example, if logs will be staged near the planted area for potential nesting material, the Project Area should include the area with logs.
B. Percent of Project Area that currently supports pollinator foraging habitat.	%	Pollinator foraging habitat characteristics are described in the User Guide[2]
C. Number of 10 (or less) –acre Map Units in Project Area		If project area extends over 10 acres or 0.5 miles long, then divide project area into ≤10-acre or ≤0.5 mi-long Map Units. If site topography, layout, or the habitat/communities present facilitate the use of smaller Map Units, then divide into smaller units, as is practical.
D. Assessment Year		(Current year/pre-restoration = 0, one year post-restoration = 1, two years post-restoration = 2, etc.)
E. Farm size (acres)		Enter total acres of land in the farm.

F. Map Unit Areas (sq ft)	MU1	MU2	MU3	MU4	MU5	MU6	MU7
G. Percentage of Map Units supporting floral resources (%)							

Pollinators Map of Entire Project Area
Using 8.5 x 11" hard copy aerial photograph (NAIP imagery or from Google Earth), draw locations of the following characteristics on map; check when completed: ___ Project Area Boundary ___ Map Unit boundaries ___ Map Unit labels **Pollinator Map Notes:**

[2] See **User Guide** for more complete definition and guidelines on what can be considered 'pollinator foraging habitat'.

Variables 12–17. FLORAL RESOURCES TABLE: (for more map units, make additional copies of this page)

MAP UNIT #: _____							
a. Vegetation Type/ Plant Species Name[3]	**b. Code**	**c. Percent Cover for MU[4]**	**d. Age[5]**	*Fill out post-field in office*			**Notes**
				e. Blooming Season[6] Early=February-May Mid=June-July Late=August-January	**Weeds**		
					f. Nonnative (y/n)	**g. Invasive (y/n)**	

[3] Refer to list of species and vegetation types on the Vegetation Type Parameters list (see Appendix E of User Guide or VegTypeParameters worksheet of Quantification Tool). If species is not on list, record its actual name in column a, but select a code for the most similar listed type under column b.
[4] Use cover class bins, only include plants with over 1% cover (midpoints in parentheses): 1–5% (3%), 5–25% (15%), 25–50% (37.5%), 50–75% (62.5%), 75–95% (85%), >95% (97.5%).
[5] This is the average plant age using bins: S (annual or seedling: <1yr or <1”dbh); Sa (sapling: 1-2yr or 1-3”dbh), P (pole: 2-4yr or 3-5” dbh), M (mature: >5yr or >5”dbh), D (decadent: >10yr or >10” with >25% of canopy dead/dying).
[6] Only need to determine blooming season for plants not listed in Vegetation Type Parameters list (see Appendix E of User Guide or VegTypeParameters worksheet of Quantification Tool).

Variables 18-33	**MU 1**	**MU 2**	**MU 3**	**MU 4**	**MU 5**	**MU 6**	**MU 7**
18. Percent cover of friable bare ground (not sand or clay; sparsely-vegetated areas ok if <50% cover of vegetation) *Enter appropriate range: (0, 1-10, 11-20, 21-30,31-100)*							
19. Number of rodent holes present *Enter bins ('0' for none, '1' for few [1-10], and '2' for many [>10])*							
20. Amount of bunch grasses present *Enter appropriate range:(0, 1-5, 5-25, 25-100)*							
21. Amount of snags/stumps present *Enter bins ('0' for none, '1' for few [1-10], and '2' for many [>10])*							
22. Amount of nest boxes or nest bundles present *Enter bins ('0' for none, '0.5' for few [1-3] that are close and/or not maintained, '1' for few [1-3]) with >50holes or are maintained, '1.5' for few [1-3] that are both >50 holes and maintained, '2' for many [>3] that are both 50 holes and maintained. Extra point for multiple sized holes and/or small blocks w/less than 20 holes. 3 = maximum score.*							
23. Amount of plants with pithy tissue present *Enter appropriate range:(<1, 1-5, 6-100).*							
24. Is the Map Unit tilled at some point during the year? *Enter '1' for yes or '0' for no.*							
25. Is the Map Unit flood-irrigated at some point during the year? *Enter '1' for yes or '0' for no.*							
26. Is plastic mulching used at the Map Unit? *Enter '1' for yes or '0' for no.*							
27. Does road-grading or road-making occur on the Map Unit? *Enter '1' for yes or '0' for no.*							

28. Total percent cover of the Map Unit that experiences any soil disturbance. *Enter appropriate range :(0, 1-10, 10-30, 30-60, 60-90, 90-100).*							
29. Total cover of invasive noxious weeds *Enter total combined for all invasive noxious weeds documented min and max values (0, 0-1, 1-5, 5-25, 25-50, 50-75, 75-95, 95-100).*							
30. Number of invasive noxious weed species (see list of weed species in User Guide)							
31. Percent of the Map Unit burned during the blooming season (Feb through Sept) *Enter appropriate range: (0, 1-10, 10-30, 30-60, 60-90, 90-100).*							
32. Percent of the Map Unit mowed and/or hayed during the blooming season (Feb through Sept) *Enter appropriate range:(0, 1-10, 10-30, 30-60, 60-90, 90-100).*							
33. Total percent of the Map Unit burned, mowed, or hayed during the blooming season Enter percent cover range min and max values (0, 1-10, 10-30, 30-60, 60-90, 90-100).							

Appendix C

Estimating Percent Area

One method for estimating percent cover is to delineate a circular plot and subdivide it into halves, quarters and eighths. One can then look at the vegetation in each eighth pie-section and estimate the percent of that pie piece that is covered in vegetation. Since one-eighth is 12.5%, then a pie piece that is one-quarter covered represents approximately 3% cover. If you add up the eight percentages of each pie piece, you should have the total percent cover of the circular plot (Figure C-1).

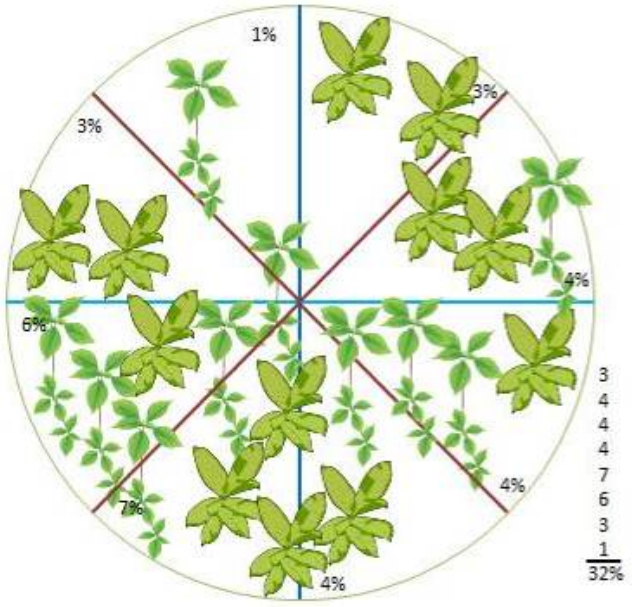

Figure C-1. Estimating percent cover one-eighth of the plot at a time and then summing.

If there is very low vegetation cover, another alternative is to imagine clustering all of the vegetation to one quarter of the circular plot and 'visualizing' how much of that quarter plot would be covered (Figure C-2). In this example the percent cover is approximately 50%, which for the whole plot, would translate to approximately 12.5%.

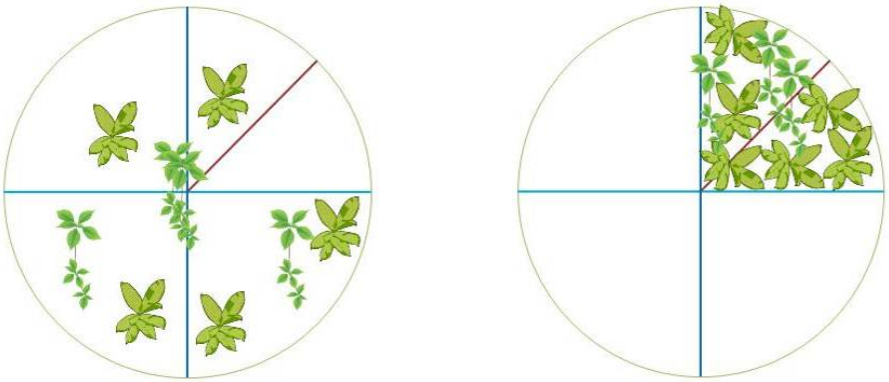

Figure C-2. Estimating percent cover in sparsely vegetated areas.

Percent cover estimates from the California Native Plant Society are presented below (Figures C-3 and C-4).

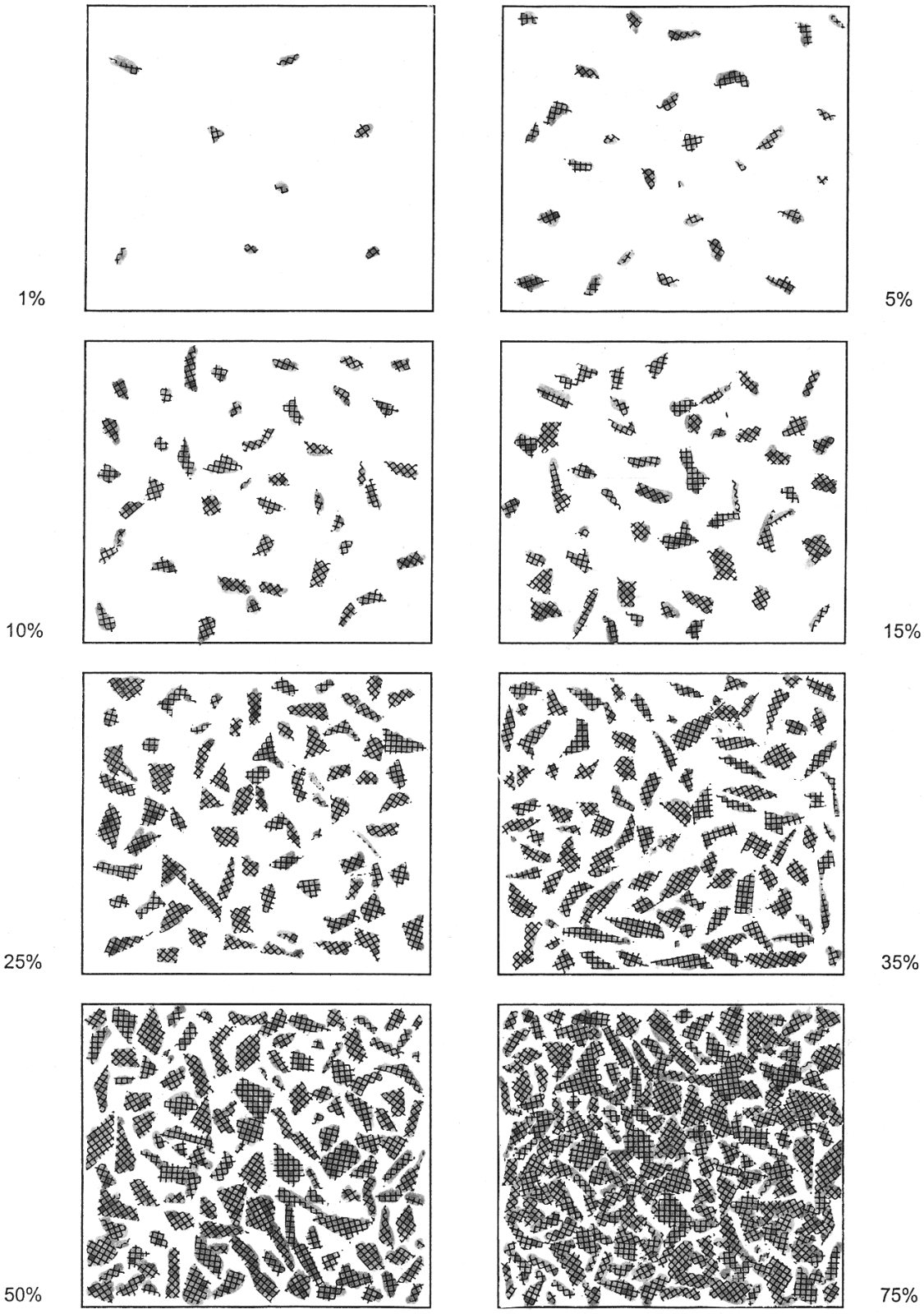

Figure C-3. CNPS cover diagrams.

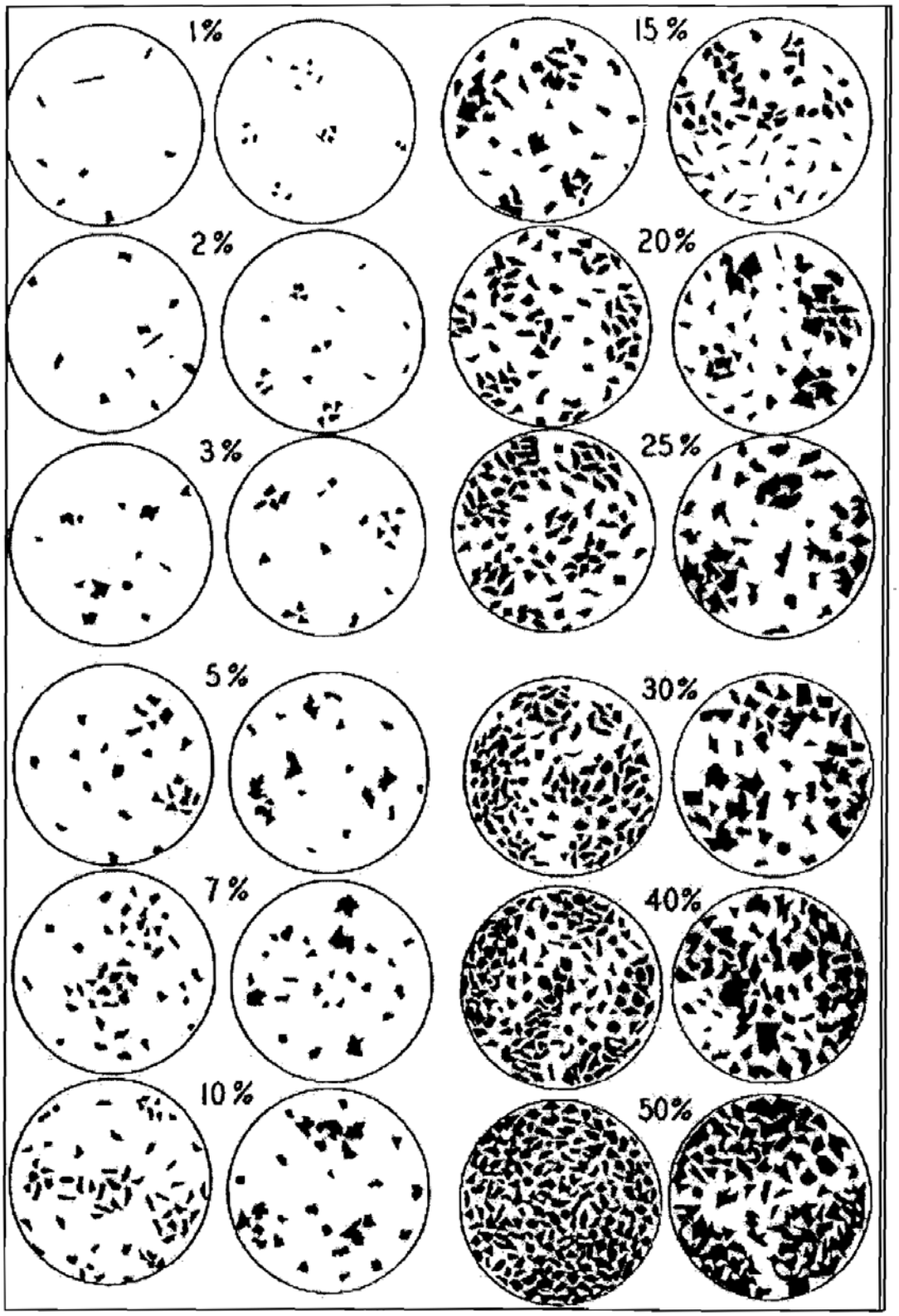

Figure C-4. Reference plots for cover estimation.

Appendix D

California Invasive Plant Council's list of invasive species of concern in the Great Valley

Table D-1. List of high- and moderate-rated invasive weed species in the Great Valley from California Invasive Plant Council (Cal-IPC 2006).

Scientific name	Common name(s)	Rating
Acacia dealbata	Silver wattle	Moderate
Acroptilon repens	Russian knapweed	Moderate
Aegilops triuncialis	Barb goatgrass	High
Ageratina adenophora	Croftonweed, eupatorium	Moderate
Ailanthus altissima	Tree-of-heaven	Moderate
Alhagi maurorum	Camelthorn	Moderate
Alternanthera philoxeroides	Alligator weed	High
Ammophila arenaria	European beachgrass	High
Anthoxanthum odoratum	Sweet vernalgrass	Moderate
Arctotheca calendula (fertile)	Fertile capeweed	Moderate
Arctotheca calendula (sterile)	Sterile capeweed (synonym of *Arctotheca prostrata*)	Moderate
Arundo donax	Giant reed	High
Asparagus asparagoides	Bridal creeper	Moderate
Asphodelus fistulosus	Onionweed	Moderate
Atriplex semibaccata	Australian saltbush	Moderate
Avena barbata	Slender wild oat	Moderate
Avena fatua	Wild oat	Moderate
Brachypodium distachyon	Annual false-brome, false brome, purple false broom, stiff brome	Moderate
Brachypodium sylvaticum	Perennial false-brome	Moderate
Brassica nigra	Black mustard	Moderate
Brassica tournefortii	Saharan mustard, African mustard	High
Bromus diandrus	Ripgut brome	Moderate
Bromus madritensis ssp. *rubens*	Red brome	High
Bromus tectorum	Downy brome, cheatgrass	High
Cardaria chalepensis	Lens-podded white-top	Moderate
Cardaria draba	Hoary cress	Moderate
Carduus nutans	Musk thistle	Moderate
Carduus pycnocephalus	Italian thistle	Moderate
Carpobrotus chilensis	Sea-fig, iceplant	Moderate
Carpobrotus edulis	Hottentot-fig, iceplant	High
Carthamus lanatus	Woolly distaff thistle	Moderate
Centaurea calcitrapa	Purple starthistle	Moderate
Centaurea debeauxii	Meadow knapweed	Moderate
Centaurea diffusa	Diffuse knapweed	Moderate
Centaurea maculosa	Spotted knapweed	High
Centaurea melitensis	Malta starthistle, tocalote	Moderate
Centaurea solstitialis	Yellow starthistle	High

Scientific name	Common name(s)	Rating
Centaurea virgata ssp. *squarrosa*	Squarrose knapweed	Moderate
Chondrilla juncea	Rush skeletonweed	Moderate
Chrysanthemum coronarium	Crown daisy	Moderate
Cirsium arvense	Canada thistle	Moderate
Cirsium vulgare	Bull thistle	Moderate
Conium maculatum	Poison-hemlock	Moderate
Cortaderia jubata	Jubatagrass	High
Cortaderia selloana	Pampasgrass	High
Cotoneaster franchetii	Orange cotoneaster	Moderate
Cotoneaster lacteus	Parney's cotoneaster	Moderate
Cotoneaster pannosus	Silverleaf cotoneaster	Moderate
Cynara cardunculus	Artichoke thistle	Moderate
Cynodon dactylon	Bermudagrass	Moderate
Cynoglossum officinale	Houndstongue	Moderate
Cynosurus echinatus	Hedgehog dogtailgrass	Moderate
Cytisus scoparius	Scotch broom	High
Cytisus striatus	Portuguese broom	Moderate
Delairea odorata	Cape-ivy, German-ivy	High
Dipsacus fullonum	Common teasel	Moderate
Dipsacus sativus	Fuller's teasel	Moderate
Dittrichia graveolens	Stinkwort	Moderate
Egeria densa	Brazilian egeria	High
Ehrharta calycina	Purple veldtgrass	High
Ehrharta erecta	Erect veldtgrass	Moderate
Ehrharta longiflora	Long-flowered veldtgrass	Moderate
Eichhornia crassipes	Water hyacinth	High
Elaeagnus angustifolia	Russian-olive	Moderate
Emex spinosa	Spiny emex, devil's-thorn	Moderate
Erechtites glomerata, E. minima	Australian fireweed, Australian burnweed	Moderate
Eucalyptus globulus	Tasmanian blue gum	Moderate
Euphorbia esula	Leafy spurge	High
Euphorbia terracina	Carnation spurge	Moderate
Festuca arundinacea	Tall fescue	Moderate
Ficus carica	Edible fig	Moderate
Foeniculum vulgare	Fennel	High
Gazania linearis	gazania	Moderate
Genista monspessulana	French broom	High
Geranium dissectum	Cutleaf geranium	Moderate
Glyceria declinata	Waxy mannagrass	Moderate
Halogeton glomeratus	Halogeton	Moderate

Scientific name	Common name(s)	Rating
Hedera helix, H. canariensis	English ivy, Algerian ivy	High
Hirschfeldia incana	Shortpod mustard, summer mustard	Moderate
Holcus lanatus	Common velvet grass	Moderate
Hordeum marinum, H. murinum	Mediterranean barley, hare barley, wall barley	Moderate
Hydrilla verticillata	Hydrilla	High
Hypericum canariense	Canary Island hypericum	Moderate
Hypericum perforatum	Common St. John's wort, klamathweed	Moderate
Hypochaeris radicata	Rough catsear, hairy dandelion	Moderate
Ilex aquifolium	English holly	Moderate
Isatis tinctoria	Dyer's woad	Moderate
Kochia scoparia	Kochia	Moderate
Lepidium latifolium	Perennial pepperweed, tall whitetop	High
Leucanthemum vulgare	Ox-eye daisy	Moderate
Limnobium laevigatum	South American spongeplant,	High
Linaria genistifolia ssp. *dalmatica*	Dalmation toadflax	Moderate
Linaria vulgaris	Yellow toadflax, butter and eggs	Moderate
Lolium multiflorum	Italian ryegrass	Moderate
Ludwigia hexapetala	Uruguay water-primrose	High
Ludwigia peploides ssp. *montevidensis*	Creeping water-primrose	High
Lythrum salicaria	Purple loosestrife	High
Mentha pulegium	Pennyroyal	Moderate
Mesembryanthemum crystallinum	Crystalline iceplant	Moderate
Myoporum laetum	Myoporum	Moderate
Myriophyllum aquaticum	Parrotfeather	High
Myriophyllum spicatum	Eurasian watermilfoil	High
Nicotiana glauca	Tree tobacco	Moderate
Onopordum acanthium	Scotch thistle	High
Oxalis pes-caprae	Bermuda buttercup, buttercup oxalis, yellow oxalis	Moderate
Pennisetum setaceum	Crimson fountaingrass	Moderate
Phalaris aquatica	Hardinggrass	Moderate
Polygonum cuspidatum	Japanese knotweed	Moderate
Polygonum sachalinense	Sakhalin knotweed	Moderate
Potamogeton crispus	Curlyleaf pondweed	Moderate
Retama monosperma	Bridal broom	Moderate
Rubus armeniacus	Himalaya blackberry	High
Rumex acetosella	Red sorrel, sheep sorrel	Moderate
Saccharum ravennae	Ravennagrass	Moderate
Salsola soda	Oppositeleaf Russian thistle	Moderate
Salvinia molesta	Giant salvinia	High

Scientific name	Common name(s)	Rating
Sapium sebiferum	Chinese tallowtree	Moderate
Sesbania punicea	Red sesbania, scarlet wisteria	High
Sisymbrium irio	London rocket	Moderate
Spartina alterniflora (and *S. alterniflora* x *foliosa* hybrids)	Smooth cordgrass and hybrids, Atlantic cordgrass	High
Spartina anglica	Common cordgrass	Moderate
Spartina densiflora	Dense-flowered cordgrass	High
Spartium junceum	Spanish broom	High
Stipa capensis	Mediterranean steppegrass, twisted-awned speargrass	Moderate
Taeniatherum caput-medusae	Medusahead	High
Tamarix parviflora	Smallflower tamarisk	High
Tamarix ramosissima	Saltcedar, tamarisk	High
Tanacetum vulgare	Common tansy	Moderate
Torilis arvensis	Hedgeparsley	Moderate
Trifolium hirtum	Rose clover	Moderate
Ulex europaeus	Gorse	High
Vinca major	Big periwinkle	Moderate
Vulpia myuros	Rattail fescue	Moderate
Washingtonia robusta	Mexican fan palm	Moderate
Zostera japonica	Dwarf eelgrass	High

Appendix E

Vegetation Type List and Parameters

Table E-1. Vegetation type list and parameters.

Species/ VegType Code	Scientific name or description	Common name or description	Ht max (m)	Ht rate (m/y)	Canopy width max (m)	Canopy width rate (m/y)	Blooming season
1000	*Acmispon* (*Lotus*) spp.	bird's-foot trefoil	1.50	0.50	1.75	0.50	Early/Mid
1100	*Amorpha* spp.	desert false indigo	3.00	0.38	6.00	0.75	Mid
1200	*Amsinckia* spp.	fiddleneck	0.50	0.50	0.20	0.20	Early/Mid
1300	Row crops	Annual crops	0.00	0.00	0.00	0.00	Never
1400	*Arctostaphylos* spp.	Manzanita	3.00	0.70	3.00	0.11	Early/Mid
1500	*Asclepias* spp.	milkweed	0.80	0.80	0.20	0.20	Early/Mid/Late
1600	*Atriplex* spp.	saltbush	3.00	3.30	5.00	7.11	Mid/Late
1700	*Baccharis pilularis*	coyote brush	2.00	0.34	2.00	0.39	Late
1800	*Baccharis salicifolia*	mule's fat	4.00	5.70	2.50	6.90	Early/Mid/Late
1900	Bunch grass/sedge	Bunch grass/sedge	1.09	0.78	0.68	0.49	Mid
2000	*Ceanothus* spp.	buckbrush, California lilac, deerbrush	3.00	0.35	3.67	0.47	Early/Mid
2100	*Cephalanthus* spp.	button willow, button bush	3.50	0.53	3.00	0.61	Late
2200	*Cercis* spp.	California redbud	7.00	0.70	6.00	0.60	Early
2300	*Chamerion* spp.	fireweed	3.00	9.00	1.00	3.00	Mid
2400	*Chrysothamnus* spp.	yellow rabbitbrush	1.50	0.60	1.00	0.40	Mid
2500	*Clarkia* spp.	clarkia	0.40	0.40	0.10	0.10	Early/Mid
2600	*Cornus* spp.	redosier dogwood	4.00	0.67	4.00	0.67	Mid
2700	Emergent wetland plants	Emergent wetland plants	0.00	0.00	0.00	0.00	Never
2800	*Epilobium* spp.	California fuchsia	0.20	0.10	1.00	0.20	Mid/Late
2900	*Erigeron* spp.	horseweed	2.00	2.00	0.50	0.50	Early/Mid/Late
3000	*Eriodictyon* spp.	California yerba santa	3.00	0.75	4.00	1.00	Early/Mid
3100	*Eriogonum* spp.	Buckwheat	1.83	0.88	1.83	0.63	Early/Mid/Late
3200	*Eriophyllum* spp.	common woolly sunflower	0.40	0.40	0.30	0.20	Mid
3300	*Eschscholzia* spp.	California poppy	0.30	0.60	0.15	0.30	Early/Mid
3400	*Euthamia* spp.	western goldentop	2.00	2.00	0.50	0.50	Mid/Late
3500	*Ficus carica* spp.	fig	0.00	0.00	0.00	0.00	Never
3600	*Frangula* spp.	California buckthorn	5.50	2.75	3.50	1.70	Early/Mid
3700	*Fremontodendron* spp.	Fremontia (Flannel bush)	3.20	0.21	4.00	0.27	Early/Mid

Species/ VegType Code	Scientific name or description	Common name or description	Ht max (m)	Ht rate (m/y)	Canopy width max (m)	Canopy width rate (m/y)	Blooming season
3800	*Gilia* spp.	bird's-eye gilia	0.30	0.60	0.15	0.30	Mid
3900	*Glycyrrhiza* spp.	American licorice	1.20	0.40	1.20	0.40	Mid
4000	*Grindelia* spp.	Great Valley gumweed	2.50	1.67	2.00	1.33	Mid/Late
4100	*Helenium* spp.	rosilla	1.60	1.60	0.50	0.50	Mid
4200	*Helianthus* spp.	sunflower	2.50	6.50	0.75	1.25	Mid/Late
4300	*Heliotropium* spp.	Heliotrope	0.30	0.30	1.00	1.00	Early/Mid/Late
4400	*Heteromeles* spp.	toyon	5.00	0.83	6.00	1.00	Mid
4500	*Holodiscus* spp.	oceanspray	4.00	0.20	4.00	0.20	Mid
4600	*Horkelia* spp.	Horkelia	0.75	0.75	1.00	0.75	Early/Mid
4700	*Juglans* spp.	Walnut	30.00	1.00	12.00	0.75	Early
4800	*Lavandula* spp.	Lavender	0.50	0.50	0.50	0.25	Early/Mid/Late
4900	*Layia* spp.	Tidytips	0.50	0.70	0.10	0.10	Early/Mid
5000	*Lupinus* spp.	lupine	3.00	0.98	3.00	1.08	Early/Mid/Late
5100	*Madia* spp.	Madia	0.50	0.50	0.10	0.10	Early/Mid/Late
5200	*Mahonia* spp.	Oregon grape	2.00	0.80	2.00	0.80	Early/Mid
5300	*Medicago* spp.	alfalfa	0.50	0.50	0.70	0.70	Mid/Late
5400	*Mimulus* spp.	sticky monkey flower	1.00	0.30	1.50	0.30	Mid
5500	*Monardella* spp.	coyote mint	0.50	0.25	0.50	0.25	Mid
5600	Native forbs and graminoids not beneficial to pollinators	Native forbs and graminoids not beneficial to pollinators	0.00	0.00	0.00	0.00	Never
5700	Native trees and shrubs not beneficial to bees	Native trees and shrubs not beneficial to bees	0.00	0.00	0.00	0.00	Never
5800	*Nemophila* spp.	fivespot	0.15	0.45	0.15	0.45	Early
5900	*Oenothera* spp.	Hooker's evening primrose	1.70	1.70	0.30	0.30	Mid
6000	Orchard	peach/plum/almond/cherry/apple	10.00	0.50	6.00	0.50	Early
6100	Other early blooming native plants beneficial to pollinators	Other early blooming native plants beneficial to pollinators	1.00	0.25	0.50	0.25	Early
6200	Other late blooming native plants beneficial to pollinators	Other late blooming native plants beneficial to pollinators	1.00	0.25	0.50	0.25	Late

Species/ VegType Code	Scientific name or description	Common name or description	Ht max (m)	Ht rate (m/y)	Canopy width max (m)	Canopy width rate (m/y)	Blooming season
6300	Other mid blooming native plants beneficial to pollinators	Other mid blooming native plants beneficial to pollinators	1.00	0.25	0.50	0.25	Mid
6400	*Penstemon* spp.	Penstemon	1.00	0.40	1.00	0.40	Mid
6500	*Phacelia* spp.	Phacelia	0.83	0.97	0.37	0.67	Early/Mid
6600	*Philadelphus lewisii*	Lewis' mock orange	3.00	0.20	3.00	0.20	Mid
6700	*Phyla nodiflora*	turkey tangle fogfruit	0.10	0.30	0.50	1.50	Mid/Late
6800	*Punica granatum*	pomegranate	6.00	0.30	8.00	0.50	Mid
6900	*Rosa californica*	California wildrose	1.50	1.00	2.00	1.00	Early/Mid/Late
7000	*Salix* (shrub)	shrub willows	3.50	0.73	2.50	0.55	Early
7100	*Salix* (tree)	Tree willows	12.00	2.00	10.00	0.24	Early
7200	*Salix* spp.	Willows (many species)	10.00	0.73	7.50	0.55	Early
7300	*Salvia*	sage	1.75	0.50	3.00	1.00	Early/Mid
7400	*Sambucus*	blue elderberry	5.00	0.50	3.50	0.38	Early
7500	*Scrophularia*	Figwort	1.20	1.20	0.30	0.30	Early/Mid
7600	*Solidago*	California goldenrod	1.50	1.50	0.50	0.50	Mid/Late
7700	*Stachys*	Hedgenettle	2.50	2.50	0.50	0.50	Mid
7800	*Symphyotrichum (Aster)*	Pacific aster	5.00	2.00	1.00	0.50	Mid/Late
7900	*Trichostema*	vinegarweed	1.00	1.00	0.50	0.50	Mid/Late
8000	*Triteleia*	Ithuriel's spear	0.60	0.60	0.20	0.20	Early/Mid
8100	*Vineyard*	Vineyard	2.00	0.50	2.00	0.55	Never
8200	Water	Water	0.00	0.00	0.00	0.00	Never
8300	Weeds invasive and not beneficial to pollinators	Weeds invasive and not beneficial to pollinators	0.00	0.00	0.00	0.00	Never
8400	Weeds, non-invasive and not beneficial to pollinators	Weeds, non-invasive and not beneficial to pollinators	0.00	0.00	0.00	0.00	Never
8500	Other Exotic Shrubs	Other exotic shrubs	3.00	2.00	3.00	1.00	Early/Mid/Late
8600	Other Exotic Trees	Other exotic trees	30.00	1.00	15.00	0.25	Early/Mid/Late