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Habitat Conservancy  
30 Muir Road  
Martinez, CA 94553

Final Technical Memorandum: Update of the 2016 Weed Mapping of Nunn Acquisition in Support of the Knightsen Wetland Restoration and Flood Protection Project, East Contra Costa County Habitat Conservancy, Contra Costa County, California

Dear Ms. Fateman,

The purpose of this technical memorandum is to update the results of 2016 weed mapping of the 639-acre Nunn property to support restoration planning for the East Contra Costa County Habitat Conservancy (Conservancy)’s Knightsen Wetland Restoration and Flood Protection Project (project) The Knightsen Wetland Restoration and Flood Protection Project is a multi-objective effort to attenuate flooding in the community of Knightsen, restore a mosaic of wetland and upland habitats for special status species, provide water quality benefits, and provide recreation and Delta access. This project will contribute to the conservation goals of the East Contra Costa Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP).

The HCP/NCCP contains Conservation Measure 4.1. Prepare and Implement an Exotic Plant Control Program for the Preserve System to control the spread of noxious weeds into new areas and to control infestations of noxious and serious weeds, where feasible. Noxious weeds and invasive exotic plants are defined and ranked by the California Department of Food and Agriculture and the California Invasive Plant Council. The purpose of the invasive weed mapping is to identify invasive weeds that may be impacting sensitive biological resources, provide a baseline prior to implementation of the restoration project, plan any invasive weed control that should occur prior to project implementation, and to help direct invasive weed control efforts following project implementation. Initial invasive weed mapping was conducted in 2016 with a follow-up visit in November 2017 to field check the southeast portion of the 2016 map.

This memorandum contains all of the original information produced in the 2016 weed mapping effort, as well as updates based upon additional surveys conducted in the fall of 2017, and provides: (1) a brief description of the study area; (2) criteria for identification of target invasive weed species; (3) weed mapping methodologies used in the field and in aerial imagery analysis; (4) limitations of the survey; (5) invasive weed survey results; (6) management recommendations for control of specific invasive weed species in sensitive land cover types, (7) recommended Best Management Practices during restoration project construction; and (8) maps that identify the locations of the weed infestations and sensitive land cover types found on site. Species accounts of each species are included as an Attachment B.

STUDY AREA
The study area for this report comprises 639 acres and includes two parcels bisected by Delta Road, both owned by the Conservancy. The 78-acre “northern parcel” (APN 020-171-001) is north of Delta Road and is used as pasture. The 561-acre “southern parcel” (APN 020-172-004) lies south of Delta Road and east of Byron Highway, and is currently used to grow row crops such as leeks, wheat and hay. The location of the project footprint within the study area has not been determined as the project is still in the conceptual design phase. The GPS coordinates of the center of the property are 37.967224, -121.631303. The entire northern parcel was surveyed. Only ruderal margins and irrigation ditches of the southern parcel were surveyed for invasive weed species, since the majority of the property is currently in agricultural use and routinely tilled.

IDENTIFICATION OF TARGET WEED SPECIES

Non-native species were considered invasive weeds and were mapped if they were ranked by the California Invasive Plant Council (Cal-IPC 2018a) or were included on the California Department of Food and Agriculture’s list of noxious weeds (CDFA 2018). These lists were compiled based on individual species invasion potential, ecological impact, and current California distribution (Cal-IPC 2018a, CDFA 2018). The Cal-IPC ratings are used to identify weed species that infest natural areas (Cal-IPC 2018a) and the CDFA list report invasive species that threaten agricultural land uses such as rangeland and cropland (CDFA 2018). These lists are generally accepted as tools to prioritize invasive species for management and control in California.

Widespread non-native grassland species such as wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), Italian ryegrass (*Festuca perennis*), and prickly lettuce (*Lactuca seriola*) were not mapped or inventoried. Though some of these grass species are considered invasive (Cal-IPC 2018a) they were ubiquitous throughout the northern parcel and the agricultural margins and irrigation ditches of the southern parcel, and were too abundant to map. Although some native plant species can be weedy in growth patterns and distribution, none were included as target weeds for this effort.

WEED MAPPING METHODS

**TerrAvion Aerial Imagery**

As a part of the weed mapping effort, aerial imagery of the study area was captured by TerrAvion, Inc. using fixed wing fly-over technology. Aerial imagery supplied by TerrAvion was high resolution with pixel sizes averaging 10 centimeters. Dates of fly-overs were June 20-26, July 18-24, August 15-21, and August 22-28, 2016. Three types of aerial images were generated from each flyover:

1) Normal Color (NC): natural aerial background with no alteration of the image from normal human eyesight.
2) Normalized Difference Vegetation Index (NDVI): measures the amount of chlorophyll (i.e. photosynthesis) detected and shows living plant material in a warm color spectrum.
3) Color Infrared (CIR): captures the infrared reflectance spectrum in false color hues of reds and blues.

Aerial imagery was delivered by TerrAvion as georectified TIFF images that are compatible with existing GIS datasets already produced and acquired by the Conservancy. These aerial images were loaded into ArcGIS software and were used to aid in drawing infestation boundaries and estimating densities. Remote sensing techniques, including utilizing these various bands of high-resolution imagery, coupled with on-the-ground fieldwork allowed for identification of invasive weed populations in the study area with greater efficiency and accuracy than using an on-the-ground, fieldwork-only approach.

**Personnel and Field Surveys**

Nomad botanists Brian Peterson and Jaclyn Inkster conducted an initial invasive weed survey on June 28, 2016. This survey focused entirely on the northern parcel to capture summer blooming weed species as
well as to calibrate remote sensing techniques for identifying specific weed species on aerial imagery. On December 21 and 27, 2016, Nomad botanists Jaclyn Inkster and Adam Chasey conducted invasive weed surveys to record invasive weeds in the agricultural margins and irrigation ditches of the southern parcel. On January 5 and 26, 2017, Jaclyn Inkster conducted final surveys to ground-truth previous field mapping data. On November 8, 2017 Adam Chasey conducted a follow-up survey in the southeast portion of the study area to determine if there were significant changes to the 2016 invasive weed map.

Surveys for target species in the northern parcel were conducted by walking transects up to 20 meters apart depending on the target species, topography, or subject plant community, which covered 100 percent of the northern parcel. In the cropland of the southern parcel, surveys for target species were restricted to the field margins and irrigation ditches, and were conducted in transects less than 10 meters apart. The main fields were not surveyed because they were either densely occupied by crops, were recently tilled post-harvest, or had been treated with herbicide and did not contain vegetation. Patches underneath electrical towers or poles that were not tilled were also surveyed. Surveys were conducted entirely on foot.

**Data Collection and Definitions**

In the field, data were collected at the locations of invasive weeds using handheld GPS units. A data point or polygon was recorded for each location of target weed species encountered, and all relevant attributes were recorded. The locations of invasive weeds on bordering properties were noted and described but not mapped in detail.

The methodology for this data collection is based on the California Weed Mapping Handbook (CDFA 2002) and the North American Invasive Plant Mapping Standards (NAWMA 2002). All weed data collected in the field and entered into GIS attribute tables is compatible with Calflora (2018). The following attributes were collected for each infestation that was mapped:

- **Observer Name** – Person collecting the data
- **Observation Date** – Date that the infestation information was recorded
- **Target Weed Species** – The target weed species corresponding to each data point or polygon. A point or polygon was taken for each species at a location.
- **Gross Area** – An estimate of the size of the general area where the target weed species occurred, including land and other plant species between target weed species individuals (by drawing an imaginary line around outside of infestation). Area was recorded in acres with <0.01 acre as the minimum unit. If more than 1 acre was observed, the Gross Area was rounded to the nearest acre. If less than 1 acre, one of the following fractions of an acre was assigned:
  - 0.01 acre
  - 0.05 acre
  - 0.1 acre
  - 0.25 acre
  - 0.5 acre
- **Infested Area** – An estimate of the area actually covered with target weed species if there were no spaces between the plants. Does not include land and other plant species. This area is smaller than Gross area. Area was recorded in acres with <0.01 acre as the minimum unit. If more than 1 acre, it was rounded to nearest acre. If less than 1 acre, one of the above fractions of an acre was assigned.
- **Cover Class** – Cover is the estimated percent of the gross area actually covered by the Target weed species. This attribute is separated into classes (Table 1).
• **Number of Individuals** – An estimate of the number of individual plants in the infested area. This attribute is separated into classes (Table 2).

• **Distribution Categories** – A description of how the target weed species were distributed across the landscape.
  - Single Plant – a single individual or 2 of the species
  - Single Patch – target weed species comprising one or a few individuals; otherwise devoid of that particular plant
  - Scattered Patches – target weed species occurring in groups
  - Scattered Plants – target weed species readily occurring throughout a specific area
  - Linear – target weed species occurring in linear patches such as along a road
  - Dense Monoculture – target weed species comprising a dominant stand of one particular species

• **Phenology** – life cycle stage of the majority of plants of infestation.
  - seedling/rosette
  - bolting
  - flowering
  - fruiting
  - dead/senescent
  - mature

• **Habitat** – The habitat or vegetation community where target weed species were observed

• **Habitat Value**
  - High – high quality or sensitive habitat such as native grassland or wetlands
  - Moderate – mostly native but common vegetation
  - Low – disturbed or weedy habitat such as roadsides and ruderal areas

• **Notes** – Notes on target weed species that pose a threat to sensitive resources, obvious signs of disturbance, location, and trends.
Table 1. Cover Classes for Target Weed Species.

<table>
<thead>
<tr>
<th>COVER CLASS</th>
<th>PERCENT COVER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace (T)</td>
<td>0-1%</td>
<td>Trace</td>
</tr>
<tr>
<td>1</td>
<td>1 – 5%</td>
<td>Low, occasional plants</td>
</tr>
<tr>
<td>2</td>
<td>5 – 25%</td>
<td>Moderate, scattered plants</td>
</tr>
<tr>
<td>3</td>
<td>25 – 50%</td>
<td>High, fairly dense</td>
</tr>
<tr>
<td>4</td>
<td>50 – 75%</td>
<td>Dense</td>
</tr>
<tr>
<td>5</td>
<td>75 – 95%</td>
<td>Very dense</td>
</tr>
<tr>
<td>6</td>
<td>95 – 100%</td>
<td>Solid stand</td>
</tr>
</tbody>
</table>

Table 2. Number Classes for Target Weed Species.

<table>
<thead>
<tr>
<th>NUMBER CLASS</th>
<th>NUMBER OF INDIVIDUALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace (T)</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 – 10</td>
</tr>
<tr>
<td>2</td>
<td>11 – 100</td>
</tr>
<tr>
<td>3</td>
<td>101 – 1,000</td>
</tr>
<tr>
<td>4</td>
<td>1,001 – 10,000</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 10,000</td>
</tr>
</tbody>
</table>

GIS Mapping

Following the completion of field work, an invasive weed map was created in a GIS platform (ESRI ArcGIS 10.3.1) in a two-step process. First, the field-collected GPS attribute data was imported and used to create point and polygon features from field estimates and aerial imagery analysis. Second, the aerial imagery from TerrAvion was analyzed to refine infestations of specific species.

During the first phase of GIS mapping, each weed infestation mapped during the inventory was entered in GIS and was assigned a unique Population ID number for identification. Invasive weeds polygons were drawn using data points and corresponding spatial notes from the field data sheets. Digital color aerial photography interpretation was used in conjunction with the notes to delineate polygon boundaries, through a “heads-up” digitizing process (i.e. a photo interpreter manually drew polygons around each invasive weed population). The base imagery used during this phase of mapping was 2012 digital orthophoto imagery provided for Contra Costa County by the National Agricultural Imagery Program (NAIP), 2014 high resolution aerial photography provided by Contra Costa County, and the summer 2016 NC aerial imagery from TerrAvion. Boundaries were heads-up digitized at scales of 1:300, 1:500 or 1:800 (depending on the size of the infestation) with a few exceptions. Point features were used if the infestation had 10 or fewer individuals (class T or 1, Table 1) or were observed over an area of 0.01 acres or less. Infestations were recorded as polygon features if there were greater than 10 individuals (exceeding class 1, Table 2) and/or the plants were observed over an area greater than 0.01 acres. In few cases, there were two field records of infestations of the same species within 30 feet of one another. These records were incorporated into a single polygon, yet gross area of the resultant polygon did not exceed 0.01 acres.

During the second phase of GIS mapping, aerial imagery from TerrAvion was used to refine areas of dense infestations. By correlating NC and NDVI aerial images and using the locations of known weed infestation from the field GIS spatial data, visual signatures for weed species were identifiable. This was
method was particularly effective for Russian thistle (*Salsola tragus*) and was used to create nested densities for individual infestations.

Barbed wire fences and roads served as the primary boundary markers for the study area. These on-the-ground features did not exactly align with the GIS shapefile of the study area boundary. There are several weed infestation features (points and polygons in Attachment A) that appear to be outside or overlap with the property boundary, but at least overlap with the physical (fenced) study area.

**LIMITATIONS**

Based on the timing of the surveys (June and December 2016, January and November 2017) not all invasive weed plant species were identifiable. This report is not floristic in nature. A complete determination of the presence or absence of potentially occurring botanical resources would require focused surveys to be conducted during all appropriate blooming periods (CNPS 2001, CDFG 2000, and USFWS 2000). Additionally, certain plant species, especially annuals, may not be present in all years due to annual variations in temperature and rainfall, which influence plant phenology. Colonization of new populations within an area may also occur from year to year.

**WEED SURVEY RESULTS**

The distribution and locations of target invasive weed species within the study area are depicted in Attachment A. The map set includes an overview map that shows all the invasive weed infestations mapped in the study area, and following “zoomed in” detail maps of the northern parcel and the southern parcel.

Each weed species was assigned a distribution rating of limited, moderate or widespread (Table 3). Species characterized as limited in distribution had 6 or fewer infestations and/or had a gross area of less than 0.50 acres, moderate distribution species had 7-11 infestations and had a gross area of 0.50-1.00 acre, and widespread distribution species had 12 or more infestations and had a gross area of greater than 1.00 acre.

Overall, a total of 18 target invasive weed plant species were mapped at a total of 211 locations (data features) (Tables 3 and 4). The six species with the greatest number of features were:

- Black mustard (*Brassica nigra*); 52 total features, 22 points, 30 polygons
- Milk thistle (*Silybum marianum*); 31 total features, 19 points, 12 polygons
- Perennial pepperweed (*Lepidium latifolium*); 30 total features, 17 points, 13 polygons
- Yellow starthistle (*Centaurea solstitialis*); 21 total features, 13 points, 8 polygons
- Russian thistle (*Salsola tragus*); 12 total features, 3 points, 9 polygons
- Bull thistle (*Cirsium vulgare*); 8 total features, 5 points, 3 polygons

Each data location also recorded the size of the area that contained the target weed. The six species with the largest total gross area were:

- Russian thistle (43.06 acres)
- Black mustard (14.35 acres)
- Perennial pepperweed (4.65 acres)
- Milk thistle (2.01 acres)
- Yellow starthistle (1.14 acres)
- Common water hyacinth (*Eichhornia crassipes*) (0.95 acre)
Table 3. Target Invasive Weed Species Recorded in the study area

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>SPECIES NAME</th>
<th>CAL-IPC RATING1</th>
<th>CDFA RATING2</th>
<th>NUMBER OF DATA FEATURES</th>
<th>TOTAL GROSS AREA (ACRES)3</th>
<th>TOTAL INFESTED AREA (ACRES)</th>
<th>DISTRIBUTION RATING4</th>
</tr>
</thead>
<tbody>
<tr>
<td>giant reed</td>
<td><em>Arundo donax</em></td>
<td>High</td>
<td>On List</td>
<td>1</td>
<td>0.04</td>
<td>0.03</td>
<td>Limited</td>
</tr>
<tr>
<td>black mustard</td>
<td><em>Brassica nigra</em></td>
<td>Moderate</td>
<td>-</td>
<td>52</td>
<td>14.35</td>
<td>0.77</td>
<td>Widespread</td>
</tr>
<tr>
<td>slender flower thistle</td>
<td><em>Carduus tenuiflorus</em></td>
<td>Limited</td>
<td>On List</td>
<td>11</td>
<td>0.62</td>
<td>0.01</td>
<td>Moderate</td>
</tr>
<tr>
<td>yellow starthistle</td>
<td><em>Centaurea solstitialis</em></td>
<td>High</td>
<td>On List</td>
<td>21</td>
<td>1.14</td>
<td>0.02</td>
<td>Widespread</td>
</tr>
<tr>
<td>bull thistle</td>
<td><em>Cirsium vulgare</em></td>
<td>Moderate</td>
<td>On List</td>
<td>8</td>
<td>0.05</td>
<td>&lt;0.01</td>
<td>Limited</td>
</tr>
<tr>
<td>poison hemlock</td>
<td><em>Conium maculatum</em></td>
<td>Moderate</td>
<td>--</td>
<td>7</td>
<td>0.52</td>
<td>0.07</td>
<td>Moderate</td>
</tr>
<tr>
<td>pampas grass</td>
<td><em>Cortaderia selloana</em></td>
<td>High</td>
<td>--</td>
<td>1</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td>Limited</td>
</tr>
<tr>
<td>Bermuda grass</td>
<td><em>Cynodon dactylon</em></td>
<td>Moderate</td>
<td>--</td>
<td>9</td>
<td>0.62</td>
<td>0.02</td>
<td>Limited</td>
</tr>
<tr>
<td>Stinkwort</td>
<td><em>Dittrichia graveolens</em></td>
<td>Moderated</td>
<td>--</td>
<td>0³</td>
<td>0³</td>
<td>0³</td>
<td>Limited</td>
</tr>
<tr>
<td>common water hyacinth</td>
<td><em>Eichhornia crassipes</em></td>
<td>High</td>
<td>--</td>
<td>2</td>
<td>0.95</td>
<td>0.04</td>
<td>Limited</td>
</tr>
<tr>
<td>blue gum</td>
<td><em>Eucalyptus globulus</em></td>
<td>Limited</td>
<td>--</td>
<td>4</td>
<td>0.50</td>
<td>0.20</td>
<td>Limited (around home site)</td>
</tr>
<tr>
<td>bristly ox tongue</td>
<td><em>Helminthotheca echoides</em></td>
<td>Limited</td>
<td>--</td>
<td>7</td>
<td>0.20</td>
<td>&lt;0.01</td>
<td>Limited</td>
</tr>
<tr>
<td>Mediterranean hoary mustard</td>
<td><em>Hirschfeldia incana</em></td>
<td>Moderate</td>
<td>--</td>
<td>1</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>Limited. Many areas that were mapped as black mustard also contained hoary mustard.</td>
</tr>
<tr>
<td>perennial pepperweed</td>
<td><em>Lepidium latifolium</em></td>
<td>High</td>
<td>On List</td>
<td>30</td>
<td>4.65</td>
<td>0.63</td>
<td>Widespread</td>
</tr>
<tr>
<td>olive</td>
<td><em>Olea europaea</em></td>
<td>Limited</td>
<td>--</td>
<td>5</td>
<td>0.20</td>
<td>0.11</td>
<td>Limited</td>
</tr>
<tr>
<td>hardinggrass</td>
<td><em>Phalaris aquatica</em></td>
<td>Moderate</td>
<td>--</td>
<td>1</td>
<td>0.01</td>
<td>&lt;0.01</td>
<td>Limited</td>
</tr>
<tr>
<td>Himalayan blackberry</td>
<td><em>Rubus armeniacus</em></td>
<td>High</td>
<td>--</td>
<td>8</td>
<td>0.12</td>
<td>0.09</td>
<td>Limited</td>
</tr>
<tr>
<td>Russian thistle</td>
<td><em>Salsola tragus</em></td>
<td>Limited</td>
<td>On List</td>
<td>12</td>
<td>43.06</td>
<td>0.86</td>
<td>Widespread</td>
</tr>
<tr>
<td>COMMON NAME</td>
<td>SPECIES NAME</td>
<td>CAL-IPC RATING(^1)</td>
<td>CDFA RATING(^2)</td>
<td>NUMBER OF DATA FEATURES</td>
<td>TOTAL GROSS AREA (ACRES)(^3)</td>
<td>TOTAL INFESTED AREA (ACRES)</td>
<td>DISTRIBUTION RATING(^4)</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>-------------------</td>
<td>-------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>milk thistle</td>
<td>Silybum marianum</td>
<td>Limited</td>
<td>--</td>
<td>31</td>
<td>2.01</td>
<td>0.03</td>
<td>Widespread</td>
</tr>
</tbody>
</table>

1 California Invasive Plant Council rating as listed in the California Invasive Plant Inventory Database (Cal-IPC 2018a).
2 California Department of Food and Agriculture listed in the online Encycloweedia Data Sheets (CDFA 2018).
3 Data points that were assigned a value of <0.01 acre for Gross Area or Infested Area were given the value 0.002 for calculation purposes.
4 Distribution Rating was assigned a value of Limited, Moderate, or Widespread based on the number of data points and where they were located as detailed under Weed Survey Results.
5 Stinkwort was observed in the southeast corner of the study area during rare plant surveys. It was not mapped during invasive weed mapping surveys.

Table 4. Target Invasive Weed Species Recorded in the Study Area

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>SPECIES NAME</th>
<th>NORTH OF DELTA ROAD (PASTURE)</th>
<th>SOUTH OF DELTA ROAD (CROPLAND)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NUMBER OF DATA FEATURES(^1)</td>
<td>TOTAL GROSS AREA (ACRES)</td>
</tr>
<tr>
<td>giant reed</td>
<td>Arundo donax</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>black mustard</td>
<td>Brassica nigra</td>
<td>12</td>
<td>4.07</td>
</tr>
<tr>
<td>slender flower thistle</td>
<td>Carduus tenuiflorus</td>
<td>7</td>
<td>0.59</td>
</tr>
<tr>
<td>yellow starthistle</td>
<td>Centaurea solstitialis</td>
<td>17</td>
<td>1.12</td>
</tr>
<tr>
<td>bull thistle</td>
<td>Cirsium vulgare</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>poison hemlock</td>
<td>Conium maculatum</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>pampas grass</td>
<td>Cortaderia selloana</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bermuda grass</td>
<td>Cynodon dactylon</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>common water hyacinth</td>
<td>Eichhornia crassipes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>blue gum</td>
<td>Eucalyptus globulus</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>bristly ox tongue</td>
<td>Helminthotheca echioides</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Mediterranean hoary mustard</td>
<td>Hirschfeldia incana</td>
<td>1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>perennial pepperweed</td>
<td>Lepidium latifolium</td>
<td>19</td>
<td>1.24</td>
</tr>
<tr>
<td>olive</td>
<td>Olea europaea</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>COMMON NAME</td>
<td>SPECIES NAME</td>
<td>NORTH OF DELTA ROAD (PASTURE)</td>
<td>SOUTH OF DELTA ROAD (CROPLAND)</td>
</tr>
<tr>
<td>-------------</td>
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<td></td>
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<td></td>
<td>OF DATA</td>
<td>GROSS AREA</td>
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<tr>
<td></td>
<td></td>
<td>FEATURES</td>
<td>(ACRES)</td>
</tr>
<tr>
<td>harding grass</td>
<td>Phalaris aquatica</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Himalayan blackberry</td>
<td>Rubus armeniacus</td>
<td>1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Russian thistle</td>
<td>Salsola tragus</td>
<td>7</td>
<td>36.96</td>
</tr>
<tr>
<td>milk thistle</td>
<td>Silybum marianum</td>
<td>10</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td>75</td>
<td>44.38</td>
</tr>
</tbody>
</table>

1 Includes point and polygon features.

**MANAGEMENT RECOMMENDATIONS**

Goals for management of the invasive weed species in the study area include:

- controlling and preventing infestation in sensitive land cover types,
- prioritizing control of ecologically damaging invasive species or species that are not widespread and may be feasibly controlled
- and preventing invasive weed spread during restoration project construction.

Each of these goals and recommendations are detailed below.

**Sensitive Land Cover Types**

Sensitive land cover types on site are considered high priority for protection per the HCP/NCCP, therefore invasive weed should be controlled in these areas as feasible. Sensitive land cover types on the property that are high priority for protection and that are threatened by invasive weeds include alkali wetland, alkali grassland, and remnant interior dunes (Table 5). The majority are located in the northern parcel, with one small area in the southern parcel.

Other sensitive communities on site include alkali wetland (cropland), channel, permanent wetland, riparian woodland/scrub, and slough, however all of these features are highly manipulated and disturbed during agricultural activities on site and will likely be disturbed during restoration project implementation, therefore they are not considered high priority for protection.
Table 5. Sensitive Land Cover Types that are Priority for Invasive Weed Control

<table>
<thead>
<tr>
<th>LAND COVER TYPE</th>
<th>LOCATION IN STUDY AREA</th>
<th>INVASIVE WEEDS IN IMMEDIATE VICINITY</th>
<th>RECOMMENDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali Wetland</td>
<td>Northern parcel</td>
<td>perennial pepperweed Russian thistle</td>
<td>Control these species in the vicinity of and within alkali wetland features.</td>
</tr>
<tr>
<td>Alkali Grassland</td>
<td>Northern parcel with one feature in southern parcel.</td>
<td>black mustard yellow starthistle slender flower thistle milk thistle poison hemlock perennial pepperweed Russian thistle</td>
<td>Portions of the alkali grassland are very weedy. Control should focus on areas that are less weedy to hold the boundaries of invasive weeds and prevent the spread of invasive weeds from weedier areas.</td>
</tr>
<tr>
<td>Remnant Interior Dune</td>
<td>Northern parcel with one feature in the southern parcel.</td>
<td>black mustard yellow starthistle slender flower thistle perennial pepperweed milk thistle Russian thistle</td>
<td>Russian thistle is widespread throughout the dunes and forms dense monocultures, and should be targeted for control.</td>
</tr>
</tbody>
</table>

Alkali Wetland
Several alkali wetland features are found in the northern parcel (Nomad 2018a). There are three infestations of weeds in alkali wetland or in the immediate vicinity including perennial pepperweed and Russian thistle. Weed management actions should remove invasive weeds from the wetlands and prevent these weeds from spreading further into the alkali wetland.
Alkali Grassland
Approximately 5.94 acres of alkali grassland were mapped in the northern parcel, and 0.45 acres in one patch on the cropland in the southeast corner of the southern parcel (Nomad 2018). North of Delta Road there are 34 infestations of weeds (40.02 gross acres) overlapping the alkali grassland or within 100 feet. These infestations include black mustard, yellow starthistle, slender flower thistle, milk thistle, poison hemlock, perennial pepperweed, and Russian thistle. The single patch of alkali grassland in the southern parcel has six infestations (2.03 gross acres) of weeds overlapping or within 100 feet. These infestations include black mustard, milk thistle, and perennial pepperweed. Weed management should be implemented to prevent these weeds from spreading further into the alkali grassland.

Remnant Interior Dunes
The remnant dune features are found primarily in the northern parcel; there is one feature in the southern parcel. There are 34 infestations (38.95 gross acres) of weeds overlapping the remnant dunes or within 100 feet. These infestations include black mustard, yellow starthistle, slender flower thistle, perennial pepperweed, milk thistle, and Russian thistle. The densest patches of Russian thistle were on the remnant dunes. These infestations should be prioritized for control in the northern parcel especially to support reestablishment of the interior dune flora. The dune in the southern parcel is disked regularly and is mostly free of invasive weeds.

Control of Specific Weed Species
There are 18 species of invasive weeds present in the study area. All 18 invasive species are discussed in Attachment B, including general information, relevant life history information, general management strategies, and distribution in the study area.

Eight species have been identified as priority for control because they have a Cal-IPC rating of High (and are ecologically damaging) or are limited in distribution and control is feasible (Table 6). Six of these species have a Cal-IPC ranking of “High” and should be prioritized for control throughout the entire
property. These include yellow starthistle, common water hyacinth, perennial pepperweed, Himalayan blackberry, pampas grass, and giant reed. Of these high rated species, common water hyacinth, Himalayan blackberry, pampas grass, and giant reed are limited in distribution and feasible for control. Of these High rated species, perennial pepperweed and yellow starthistle are widespread. Perennial pepperweed is well distributed along drainage ditch banks in the southeastern corner of the property and may not be feasible to control. It is infeasible to control all infestations prior to restoration project implementation but specific infestations may be prioritized for control based on project design in order to control its spread on site. In addition, grading and topsoil management should be strategized to avoid spreading this species throughout the restoration site. Similarly, yellow starthistle is scattered throughout the northern parcel and is not likely feasible to control. However yellow starthistle is limited in the southern parcel, and so it should be controlled prior to restoration implementation (if feasible) or monitored and controlled afterwards.

Stinkwort and harding grass (Table 6) are limited in distribution currently but have the potential to spread on site. They should be controlled as feasible to prevent further spread on site. In addition, these species should be controlled prior to the start of restoration construction to avoid spread.

All herbicide use should occur in consultation with a licensed Pest Control Advisor and should follow all herbicide labels. Any invasive weed control in the vicinity of sensitive biological resources should occur in consultation with a biologist.
Perennial pepperweed along the eastern boundary of the southern property, facing south. Photo taken April 20, 2017.

Table 6. Invasive Weed Species that are High Priority for Control

<table>
<thead>
<tr>
<th>COMMON NAME SPECIES NAME</th>
<th>CAL-IPC RATING(^1)</th>
<th>CDFA RATING(^2)</th>
<th>NUMBER OF DATA FEATURES</th>
<th>DISTRIBUTION RATING(^3)</th>
<th>DISTRIBUTION AND RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal-IPC High Rated Species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>giant reed <em>Arundo donax</em></td>
<td>High</td>
<td>On List</td>
<td>1</td>
<td>Limited</td>
<td>Single patch located on eastern property boundary, monitor for spread onto property and control as feasible.</td>
</tr>
<tr>
<td>yellow starthistle <em>Centaurea solstitialis</em></td>
<td>High</td>
<td>On List</td>
<td>21</td>
<td>Widespread</td>
<td>Widespread throughout northern parcel and scattered in southern parcel. Control prior to restoration implementation if feasible.</td>
</tr>
<tr>
<td>pampas grass <em>Cortaderia selloana</em></td>
<td>High</td>
<td>--</td>
<td>1</td>
<td>Limited</td>
<td>Single patch located on the adjacent RV storage property off of Byron Highway, but are large enough that they have spread into the study area. Control as feasible.</td>
</tr>
<tr>
<td>common water hyacinth <em>Eichhornia crassipes</em></td>
<td>High</td>
<td>--</td>
<td>2</td>
<td>Limited</td>
<td>Present in the slough and drainage ditch at the southern property boundary. Monitor to ensure it doesn’t spread into the restoration project.</td>
</tr>
<tr>
<td>perennial pepperweed <em>Lepidium latifolium</em></td>
<td>High</td>
<td>On List</td>
<td>30</td>
<td>Widespread</td>
<td>Widespread throughout southeastern portion of the project. Infeasible to control prior to restoration project implementation but grading and topsoil management should be strategized to avoid spreading this species throughout restoration site.</td>
</tr>
</tbody>
</table>
### Himalayan blackberry

*Rubus armeniacus*

- **CAL-IPC Rating:** High
- **CDFA Rating:** --
- **Number of Data Features:** 8
- **Distribution Rating:** Limited

*Distribution and Recommendations:* Scattered in a few patches on the eastern property boundary of the southern parcel, along the slough, and on the southern boundary of the northern parcel. Patches should be controlled as feasible, and monitored to ensure it does not spread during restoration implementation.

### Other Species that are High Priority for Control

**Stinkwort**

*Dittrichia graveolens*

- **CAL-IPC Rating:** Moderated
- **CDFA Rating:** --
- **Number of Data Features:** 0
- **Distribution Rating:** Limited

*Distribution and Recommendations:* This species was not mapped during surveys however it was observed in the southeastern corner of study boundary during rare plant surveys. It is limited on site and feasible for control. This species should be controlled to prevent its establishment on site.

**Hardinggrass**

*Phalaris aquatica*

- **CAL-IPC Rating:** Moderate
- **CDFA Rating:** --
- **Number of Data Features:** 1
- **Distribution Rating:** Limited

*Distribution and Recommendations:* Only mapped in 1 location in ditch on eastern property boundary of southern parcel. Monitor to ensure species does not spread during restoration implementation.

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2. California Department of Food and Agriculture listed in the online Encyclowedia Data Sheets (CDFA 2018).
3. Distribution Rating was assigned a value of Limited, Moderate, or Widespread based on the number of data points and where they were located as detailed under Weed Survey Results.

### Restoration Project Construction Invasive Weed Best Management Practices

Construction of the restoration project increases the risk of spread of invasive weeds as it will create disturbance and bare soil, which favors the colonization of invasive weeds and it will likely move soil (and invasive weed propagules it contains) around the project area. In addition, invasive weed propagules may be introduced to the site or spread on site via construction material and equipment.

These Invasive Weed Best Management Practices are based on *Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers* (Cal-IPC 2012) and modified slightly to be project specific.

- Prevention training will be provided to staff and contractors prior to starting work. Invasive weed identification and avoidance measures will be included in the preconstruction environmental tailboard meeting. The training will include field identification of invasive plants in the project area, reproductive biology of invasive plants, and invasive plant prevention Best Management Practices. The biological monitor will ensure that contractors understand provisions for invasive plant prevention throughout the project. Invasive plant considerations will be routinely addressed during regular tailboard meetings. The monitoring biologist shall ensure that all staff have participated in the training by establishing and keeping a sign-in sheet that will record attendees.

- Cleaning BMPs will be integrated into the project. There will be a designated cleaning area for tools, equipment, and vehicles. Tools, equipment, and vehicles will be inspected and cleaned before entering and leaving the worksite.

- All construction material sources will be weed-free. Only rice straw or weed-free straw or fiber roll logs will be used.
• Travel routes will be planned to reduce the risk of invasive plant spread. Invasive weeds listed in Table 2 will be controlled along travel routes to prevent the spread along roads and access routes.

• Soil disturbance and transport will be managed. In areas that have a substantial population of invasive plant species, the topsoil may be scraped and stockpiled separately, taking care not to spread the topsoil and invasive weed propagules it contains. The weedy topsoil may be buried to create on site features such as a levee.

• Select invasive plants in the project area will be controlled prior to project implementation as feasible to avoid spreading them throughout project.

Sincerely,

Erin L. McDermott
Principal
Senior Vegetation and Restoration Ecologist
ISA Certified Arborist – WE7318A
Nomad Ecology, LLC

Jaclyn N. Inkster
Botanist and Restoration Ecologist
Nomad Ecology, LLC

ATTACHMENTS
Attachment A: Mapped Features (3 Sheets)
Attachment B: Invasive Weed Species Accounts

REFERENCES

California Department of Fish and Game (CDFG). 2000. Guidelines for Assessing the Effects of Proposed Projects on Rare, Threatened, and Endangered Plants and Natural Communities. May 8.


Jones & Stokes. 2006. East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan. October. (J&S 01478.01.) San Jose, CA.


Attachment A - Sheet 1

Invasive Weed Surveys Results
Knightsen Wetland Restoration and Flood Protection Project
East Contra Costa County Habitat Conservancy

Contra Costa County, California
Legend
Study Area Boundary
Sensitive Land Cover Types
remnant dunes
alkali wetland
alkali grassland
Invasive Weeds (polygon)
Brassica nigra
Carduus tenuiflorus
Centaurea solstitialis
Conium maculatum
Lepidium latifolium
Salsola tragus, 0-4%
Salsola tragus, 5-10%
Silybum marianum
Invasive Weeds (points)
Brassica nigra
Carduus tenuiflorus
Centaurea solstitialis
Conium maculatum
Hirschfeldia incana
Lepidium latifolium
Rubus armeniacus
Silybum marianum

Sources: NAIP 2012; Contra Costa County. Projection: NAD 83 UTM Zone 10 North.

Contra Costa County, California

Invasive Weed Surveys Results
Northern Parcel (North of Delta Road)
Knightsen Wetland Restoration and Flood Protection Project
East Contra Costa County Habitat Conservancy

Attachment A - Sheet 2
2016 & 2017 Invasive Weed Survey

Feet
Legend

- Study Area Boundary
- Sensitive Land Cover Types
  - remnant dunes
  - slough/channel
  - alkali wetland
  - alkali grassland
- Invasive Weeds (points)
  - Brassica nigra
  - Carduus tenuiflorus
  - Centaurea solstitialis
  - Cirsium vulgarare
  - Conium maculatum
  - Cirsium vulgare
  - Conium maculatum
  - Centaurea solstitialis
  - Cirsium vulgare
  - Conium maculatum
  - Cirsium vulgare
  - Conium maculatum
- Invasive Weeds (polygons)
  - Arundo donax
  - Brassica nigra
  - Carduus tenuiflorus
  - Centaurea solstitialis
  - Cirsium vulgare
  - Conium maculatum
  - Cirsium vulgare
  - Conium maculatum
  - Cirsium vulgare
  - Conium maculatum

Sources: NAIP 2012; Contra Costa County. Projection: NAD 83 UTM Zone 10 North.

Contra Costa County, California

Attachment A - Sheet 3

Invasive Weed Surveys Results
Southern Parcel (South of Delta Road)
Knightsen Wetland Restoration and Flood Protection Project
East Contra Costa County Habitat Conservancy

October 2018
ATTACHMENT B  INVASIVE WEED SPECIES ACCOUNTS

**Giant reed (Arundo donax)**

*General Information*
Giant reed is a bamboo-like perennial with well-developed rhizomes in the grass family (Poaceae). Plants are typically terrestrial but tolerate periodic flooding. Giant reed has become problematic in riparian corridors throughout the state. Dense stands typically develop which can displace native vegetation, diminish wildlife habitat, and increase flooding and siltation in natural areas (DiTomaso and Healy 2007). Giant reed inhabits riparian areas, floodplains, and ditches, typically on sites with low slope. This species grows best in well-drained moist soils but tolerates some salinity and extended periods of drought (DiTomaso and Healy 2007).

*Relevant Life History*
Giant reed reproduces vegetatively from rhizomes and stem fragments. Fragments disperse with water, mud, and human activities. Viable seed has not been observed in North America (DiTomaso and Healy 2007).

*General Management Strategies*
Rhizomes must be removed or killed to eradicate infestations. Manually removing small populations can prevent the development of large problematic infestations. Mechanical removal may fragment rhizomes and stems, which may develop into new plants if not removed from the site. Systemic herbicide treatment of mature plants is most effective in late summer to early fall after the flowering period (July-October). Treatment of regrowth is most effective from March through July. Cutting the stems of mature plants and treating the stumps with systemic herbicide is effective from March to October (DiTomaso and Healy 2007).

*Distribution in the Study Area and Priority for Control*
There are no infestations of giant reed directly in the study area, but one small infestation on the eastern border in adjacent cropland in the southern parcel. This species was included in this report due to its High ranking by Cal-IPC (2018a) and potential to spread into the study area. Following restoration this species should be monitored for, and controlled immediately to avoid spread into the restoration project.

**Black mustard (Brassica nigra)**

*General Information*
Black mustard is an erect winter annual in the mustard family (Brassicaceae) that exists as a basal rosette until flowering stems develop at maturity. This species is native to Europe. The foliage, roots, and seeds of black mustard are toxic to livestock when consumed in large quantities over time. Black mustard grows along roadsides, fields, disturbed waste places, and grasslands, especially in coastal areas. In coastal grasslands, dense stands of black mustard outcompete native vegetation. Newly burned sites are subject to invasion (DiTomaso and Healy 2007).

*Relevant Life History*
Black mustard reproduces by seed. Most seeds fall near parent plants but disperse to greater distances with water, soil movement, human activities, and animals. Black mustard usually develops a large, persistent seed bank (DiTomaso and Healy 2007).
General Management Strategies
Annual hand pulling of plants before seeds mature can eventually deplete the seedbank. Plants are also readily eaten by livestock. Chlorosulfuron herbicide can also be used on preemergent or early post emergent plants when weeds are germinating or actively growing. Triclopyr herbicide can be used during post emergence when weeds are small and rapidly growing (CDFA 2018).

Distribution in the Study Area
Black mustard is the most widespread invasive weed in the study area. There are 52 total features recorded (12 in the northern parcel, 40 in the southern parcel). The infestations in the northern parcel that threaten alkali wetland, alkali grassland and remnant dune features should be prioritized for control.

Slender flower thistle (*Carduus tenuiflorus*)

General Information
Italian thistle is a winter annual, sometimes biennial, in the sunflower family (Asteraceae) and native to the Mediterranean region. It colonizes disturbed open sites, roadsides, pastures, annual grasslands, and waste areas, inhabiting sandy to clay soils (DiTomaso and Healy 2007). In general, thistles compete poorly with healthy, established grasses and other vegetation. Disturbances such as fires, overgrazing, or trampling can create prime sites for thistle colonization (DiTomaso and Healy 2007).

Relevant Life History
Italian thistle reproduces only by seed. Most disk seeds are wind-dispersed and can travel several hundred feet. Disk seeds also have a thin gummy coating, which allows them to attach to animals and machinery. Ray seeds generally remain in the flower head until it drops. These seeds can persist in the soil for up to 10 years. The germination rate is high, and germination typically takes place in the fall. Italian thistle overwinters as a rosette. Flowering can be continuous until soil moisture is depleted (Cal-IPC 2018a).

General Management Strategies
Hand digging plants below the root crown is very effective for removal. Mowing while the plant is in the bolting phase just before flowering (May-July) will significantly reduce seed set. Livestock grazing thistles in general will not be effective since most ruminant species avoid plants with spines. Various herbicides (including amonopyralid, clopyralid, triclopyr and glyphosate), can be used from post-emergence through flower-bud stage (CDFA 2018).

Distribution in the Study Area
Slender flower thistle is found in small patches in the northern parcel and in the southern parcel. There are 11 total features recorded; seven in the northern parcel and four in the southern parcel. The infestations in the northern parcel that threaten alkali wetland, alkali grassland and remnant dune features should be prioritized for control.

Yellow starthistle (*Centaurea solstitialis*)

General Information
Yellow starthistle is a winter annual and occasionally biennial in the sunflower family (Asteraceae). Plants are highly competitive and typically develop dense, impenetrable stands that displace desirable vegetation. Yellow starthistle is considered one of the most serious rangeland weeds in the western United States. It inhabits open disturbed sites, open hillsides, grassland, rangeland, open woodlands, fields, pastures, roadsides, waste places, and cultivated fields (DiTomaso and Healy 2007).

Relevant Life History
Yellow starthistle reproduces by seed. Seed head production is highly variable and depends on a variety of factors including soil moisture and competition. Seeds fall near the parent plant and are dispersed short
distances by wind, and to greater distances by human activities, animals, water, and soil movement. Large flushes of seeds typically germinate after the first fall rains, but smaller germination flushes can occur in winters and early spring. Shaded conditions reduce flower production and root growth. Plants exist as basal rosettes through winter and early spring until flower stems develop in late spring or early summer (DiTomaso and Healy 2007).

**General Management Strategies**

Hand pulling individuals prior to flowering is probably the most effective treatment and can prevent spread. Other management techniques include grazing, mowing, burning, and cultivation when used over a period of 2-3 years or more, depending on the degree of infestation and other factors. These methods must be properly timed to be effective. High-intensity short duration grazing should be implemented during the period when plants have bolted to just before they produce spiny heads. Mowing is most effective when plants are cut below the height of the lowest branches and 2-5% of the total population of seed heads is in bloom. Mowing too early can result in higher seed production (DiTomaso and Healy 2007). For grazing to be effective as a control method, grazing must be heavy enough, occur at least twice a year to prevent flowering, and occur for at least three years to reduce populations (Davison et al. 2006). Herbicides including Clopyralid and Aminopyralid are effective if applied from the rosette to the bolting stage. The infestations in the northern parcel that threaten alkali wetland, alkali grassland and remnant dune features should be prioritized for first control.

**Distribution in the Study Area**

Yellow starthistle is found in small patches in the northern and in the southern parcel. The infestations in the northern parcel that threaten alkali wetland, alkali grassland and remnant dune features should be prioritized for control.

**Bull thistle (Cirsium vulgare)**

**General Information**

Bull thistle is a coarse biennial, sometimes annual or short-lived perennial in the sunflower family (Asteraceae). The thistle is native to Eurasia. Bull thistle inhabits open disturbed sites, hillsides, rangeland, forest openings, fields, pastures, roadsides, orchards, and crop fields. This plant typically does not tolerate deep shade or constantly wet soils. It grows best on heavy fertile soils (DiTomaso and Healy 2007).

**Relevant Life History**

Bull thistle reproduces by seed. Plants exist as rosettes until flowering stems develop at maturity. Seeds fall near the parent plant or are dispersed short distances with wind and to greater distances with human activities, water, soil movement, and as seed or hay contaminants. Most seeds germinate after the first fall rains or in spring. Soil disturbance facilitates seed germination and seedling establishment. Plants on very poor soils or in shade can take two or more seasons to mature. Plants in grazed pastures often produce more seed than plants in adjacent ungrazed areas due to reduced competition from grazed plants. Most seeds germinate within the first year (DiTomaso and Healy 2007).

**General Management Strategies**

Cultivation, mowing, or hand-pulling just before flowering can control infestations. Cut flower heads can still develop viable seed and should be bagged (DiTomaso and Healy 2007). Bull thistle plants on the side of the road can flower on very short stalks shortly after being mowed. Heavy disturbances that create bare soil patches facilitate seedling establishment and survival. Growth regulating herbicides such as Aminopyralid, Picloram, and 2,4-D, are best applied to post-emergent seedlings up until the bud stage of flowering (DiTomaso et al. 2013).
Distribution in the Study Area
Bull thistle is found in small patches or individually in the southern parcel. There are eight total features recorded.

**Poison hemlock (Conium maculatum)**

*General Information*
Poison hemlock is an erect biennial (sometimes annual or short-lived perennial) in the carrot family (Apiaceae). Plants exist as large basal rosettes of leaves during the first year. All plant parts are highly toxic to humans and animals when ingested. Most animals avoid eating poison hemlock when suitable forage is available. It is native to Europe. Poison hemlock inhabits fields, pastures, roadsides, ditches, riparian areas, cultivated fields, and other disturbed often moist sites (DiTomaso and Healy 2007).

*Relevant Life History*
Poison hemlock reproduces by seed. Seeds fall near the parent plant but some may disperse to greater distances with human activities, water, soil movement, and animals. After dispersal, most seeds can germinate almost immediately if conditions are favorable, but a small proportion remains dormant. Germination occurs with the first fall rains through early spring. Seeds can survive up to about 3 years under field conditions (DiTomaso and Healy 2007).

*General Management Strategies*
Plants do not regenerate when hand pulled or cut below the crown. Removing plants before seeds mature every year will eventually deplete the seedbank. Repeated mowing or repeated cultivation can eventually control poison hemlock (DiTomaso and Healy 2007). Growth regulating herbicides (2,4-D, Triclopyr, and Aminocyclopyrachlor) can be used on post-emergent seedlings up to the rosette stage. Amino acid inhibiting herbicides (Glyphosate, Chlorsulfuron, Imazapyr, and Metsulfuron) can be used on pre-emergent up to bolting plants (DiTomaso et al. 2013).

Distribution in the Study Area
Poison hemlock is found in patches northern and in the southern parcel. There are seven total features recorded; one in the northern parcel and six in the southern parcel. The single infestation in the northern parcel that threatens alkali grassland should be prioritized for control.

**Pampas Grass (Cortaderia selloana)**

*General Information*
Pampas grass is a large densely tufted perennial grass in the grass family (Poaceae). Pampas grass was introduced as a landscape ornamental and erosion control but has escaped cultivation. Mature plants are highly competitive with native vegetation. Pampas grass inhabits disturbed areas, dunes, bluffs, roadsides, roadcuts, logged forests, coastal scrub, grasslands, and adjacent inland areas moderated by fog or other maritime influences (DiTomaso and Healy 2007).

*Relevant Life History*
Pampas grass reproduces by seed. Seeds can only develop when adjacent male and female plants are present for pollination. Seeds can disperse long distance with wind (to about 30 km) and human activities. Each female plant seed bearing plume can produce up to 100,000 seeds. Sites with bare, sandy soil are most favorable for establishment. Germination occurs in the fall after the first rains and continues through spring. Seeds generally survive for less than 6 months under field conditions and a persistent seed bank does not accumulate. Individual plants are capable of surviving up to 15-20 years (DiTomaso and Healy 2007).
Management Strategies
Hand pulling seedlings can prevent the spread of this species. Manually cutting mature plants below the crown will kill the plant. Consistently removing plumes before seed matures helps to prevent population expansion. However, plants that have had plumes removed may develop more plumes during the flowering season. Any soil disturbance that creates bare ground, including natural disturbances such as landslides and human-caused disturbance, promotes invasion by pampas grass. Heavily mulching bare sites or planting desirable vegetation may prevent or reduce seedling establishment (DiTomaso and Healy 2007). Fluazifop, Glyphosate, and Imazapyr herbicides are best used on post-emergent plants in late summer early fall at the base of rhizomes and tillers (DiTomaso et al. 2013).

Distribution in the Study Area
Pampas grass is found in a single small patch in the southern parcel. The plants are on the adjacent RV storage property off of Byron Highway, but are large enough that they have spread into the study area, however habitat quality in this area is currently low.

Bermuda grass (Cynodon dactylon)

General Information
Bermuda grass is a perennial low growing graminoid in the grass family (Poaceae). Vegetative plants have creeping rhizomes and stolons that root at the nodes. Inflorescences are in distinctive umbel-like spikelet branches 3-7 cm in length. Bermuda grass is usually found near areas with warm season moisture such as disturbed sites and agricultural land. It can tolerate acidic, alkali and saline conditions in addition to limited flooding. It is native to Africa (DiTomaso and Healy 2007).

Relevant Life History
Bermuda grass can preproduce by seed and vegetatively from the rhizomes and stolons spreading over the ground surface. Regrowth from plant stem and root fragments (up to 5 cm soil depth) remaining after removal can occur. Rhizomes are very hardy tolerating drought conditions. The plant flowers June-September and produces viable seed. Seeds disperse with water and soil movement, and various human activity.

General Management Strategies
Manual removal by hand pulling, tilling ordisking of rhizomes and stolons multiple times per year can eventually eliminate Bermuda grass. Use of herbicide after flowering and before winter dormancy is the most effective control. Mowing can prevent the immediate spread of this species, but mowers and other tools used should be cleaned thoroughly after use to prevent spread of rhizomes and stolons to new areas (DiTomaso and Healy 2007).

Distribution in the Study Area
Bermuda grass is found in patches in the southern parcel primarily in ruderal areas. A total of nine features were recorded.

Stinkwort (Dittrichia graveolens)

General Information
Stinkwort is an erect, fall-flowering aromatic annual with sticky glandular foliage in the sunflower family (Asteraceae). It is native to Europe. Stinkwort inhabits disturbed places, fields, pastures, roadsides, levees, washes, and margins of tidal marshes, primarily in the San Francisco Bay region. It forms dense stands in late summer/early fall with few plant competitors. Often grows in areas of human disturbance such as right of ways, roads, trails, levees, and dams. Also grows in areas with open or sparse plant cover (DiTomaso and Healy 2007).
Relevant Life History Traits
Stinkwort flowers from September to December and reproduces by seed. Plants produce prolific amounts of seed. It spreads by water, soil movement, wind, animals, and human activities by attaching to vehicles, clothing, and shoes. It grows rapidly late in the year from small rosette to over 1 meter tall. Seeds last no more than 3 years in the soil (DiTomaso and Healy 2007).

General Management Strategies
Stinkwort has a relatively shallow root system that can be controlled by hand pulling or hoeing. Protective wear (gloves, long sleeves and pants) should be worn to protect against the irritating oils. Mowing more than once in a growing season may provide some control (DiTomaso et al. 2013). The flowers can mature and produce seed after the plant is removed from the ground so if plants are removed during flagging, they need to be placed in bags and removed from the site. Grazing is not recommended as this plant likely not palatable to livestock. This plant invades recently disturbed areas and thrives in sites that were recently burned. Burning followed by heavy application of pre-emergent herbicide may be effective (DiTomaso et al. 2013). Aminopyralid, dicamba and triclopyr are broadleaf selective herbicides that can be applied up until bolting. Glyphosate is a non-selective herbicide that can be applied after competing plants have senesced in early summer (DiTomaso et al. 2013).

Distribution in the Study Area
Stinkwort was not mapped during surveys however it was observed in the southeastern corner of study boundary. It is limited on site and feasible for control. This species should be controlled via hand pulling to prevent its establishment on site.

Common water hyacinth (*Eichhornia crassipes*)

General Information
Water hyacinth is a floating perennial with stolons and emergent leaves that grow up to 40 cm tall. It occurs nearly globally in warm-temperate and tropical regions and is considered one of the most serious aquatic weeds (DiTomaso and Healy 2007). Populations rapidly form dense mats that can clog waterways and alter water temperature, pH, and oxygen levels. Plants tolerate pH as low as 3, but do not tolerate salinity above 1.6% (DiTomaso and Healy 2007).

Relevant Life History
Water hyacinth reproduces vegetatively from stolons and by seed. Vegetative and seed propagules disperse easily with water and by human activity, as well as by clinging to the feet and feathers of birds (DiTomaso and Healy 2007). Under favorable conditions, vegetative reproduction can be extremely rapid, with plant numbers doubling in as little as five days. New plants can flower in 3-4 weeks. Plants flower June-October, and seed production peaks in the middle of the flowering season. Flowers are insect pollinated. Seedlings germinate in mud along shorelines where water levels fluctuate and on mats of decomposing water hyacinth. Seedling detach from roots and float if they become submerged. Seeds have been reported to survive for 15-20 years in dried mud in temperate regions (DiTomaso and Healy 2007).

General Management Strategies
Water hyacinth is favored by still water conditions such as those created by dams. Mechanical harvesting, herbicide treatments and bio-control agents can help control infestations (DiTomaso and Healy 2007).

Distribution in the Study Area
Water hyacinth is found in two patches in the southern parcel; a large patch in the slough on the southeastern edge of the property connecting to the Delta waters and at the eastern edge of the smaller inland slough feature just north of the southern boundary. Since this species is aquatic and only in two
areas largely unconnected to drainage ditches or other standing water features, it is unlikely to spread further in the study area except when the restoration project connects the slough to other wetland features.

**Blue gum (*Eucalyptus globulus*)**

*General Information*

Blue gum is a fast-growing tree in the myrtle family (Myrtaceae). It is the most common Eucalyptus species in California. It is widely planted as a landscape and windbreak tree, but it has escaped cultivation and is invasive in some coastal areas. Blue gum litter, fog and rain drip, and shading appear to create conditions that inhibit the growth of seedlings and most other plants in the understory. Mature blue gum trees can create a safety hazard in public places because they tend to drop limbs continually. Leaves and branches decompose very slowly. Blue gum inhabits disturbed places, especially in riparian areas, coastal grasslands, and forests (DiTomaso and Healy 2007).

*Relevant Life History*

Blue gum reproduces by seed. Most seeds are released from capsules while still attached to the tree. Seeds typically fall within 100 meters from the parent plant, although some may disperse to greater distances with water, soil movement, animals, and human activities. Under favorable conditions, seeds germinate a few weeks after release from capsules, usually late fall through spring, but if conditions are dry seeds may remain dormant for several years. Blue gum grows best on deep, well-drained soils where roots can tap deep soil moisture. Seedlings and juveniles are more sensitive to frost and drought than mature trees (DiTomaso and Healy 2007).

*General Management Strategies*

Mechanical pulling of small plants and cutting of trees can prevent seed set. Resprouts are common on cut stumps and can be controlled with chemical treatment. Prescribed burning alone is not effective, but is a useful tool to decrease persistent blue gum bark and leaf litter. Burning can stimulate seed germination and may need to be followed with further mechanical and/or chemical treatment of seedlings. Glyphosate is the most effective herbicide for control of blue gum. It should be applied as spot treatment to seedlings or to cut stumps to prevent resprout (DiTomaso and Healy 2007).

*Distribution in the Study Area*

Blue gum is found in patches in the southern parcel. There are 4 total features recorded. Two of the features are found on the adjacent RV storage property off Byron Hwy, and the canopy and litter extend into the study area.

**Mediterranean hoary mustard (*Hierschfieldia incana*)**

*General Information*

Mediterranean hoary mustard is biennial or short-lived perennial, sometimes winter annual in the mustard family (Brassicaceae). It is native to the Mediterranean region. Inhabits disturbed places, roadsides, fields, pastures, agronomic crops, orchards, vineyards, ditch banks, and dry washes (DiTomaso and Healy 2007).

*Relevant Life History*

Hoary mustard reproduces by seed. Seeds fall near the parent plant or disperse to greater distances with water, mud, agricultural activities, as seed and feed contaminants, and animals. Seed production can be high. Fruiting stems die at the end of summer or early fall when soil moisture is low. New foliage grows from the rootstock after the first fall rain (DiTomaso and Healy 2007).

*General Management Strategies*

Manual removal or cultivation before seeds develop, particularly during the seedling stage, can control populations. Control methods implemented over a period of years will eventually exhaust the seedbank.
Glyphosate herbicide applied during early post-emergence up to small plants can suppress Mediterranean hoary mustard (DiTomaso et al. 2013).

**Distribution in the Study Area**
There is one infestation of Mediterranean hoary mustard mapped in the northern parcel, however this species is more widespread on the property than mapped and was grouped with black mustard in many locations.

**Perennial pepperweed (Lepidium latifolium)**

**General Information**
Perennial pepperweed is highly competitive, often forming dense colonies that displace native vegetation. Since its introduction in the mid-1930s, it has spread rapidly. Perennial pepperweed inhabits non-crop areas including wetlands, riparian areas, meadows, vernal pools, salt marshes, flood plains, sand dunes, roadsides, and irrigation ditches. It typically grows on moist or seasonally wet sites (DiTomaso and Healy 2007).

**Relevant Life History**
Perennial pepperweed reproduces vegetatively from root fragments and by seed. Plants usually produce abundant, often highly viable seed, but seedlings are seldom detected in the field. Seedlings are not often encountered, but appear to emerge mid-winter through mid-spring. Fluctuating temperatures appear to stimulate seed germination (DiTomaso and Healy 2007).

**General Management Strategies**
Dense infestations are difficult to control. Techniques such as repeated mowing, hand-digging, cultivation, grazing, and burning do not adequately control established perennial pepperweed infestations, except in the early stages of establishment. Mowing at the flower bud stage and treating regrowth at the bolting to flower stage with systematic herbicide can significantly reduce populations (DiTomaso and Healy 2007).

**Distribution in the Study Area**
Perennial pepperweed is the third most widespread invasive weed in the study area and forms large stands. There are 28 total features recorded; 19 in the northern parcel and 9 in the southern parcel. The infestations that threaten alkali wetland, alkali grassland and remnant dune features should be prioritized for control. Specific infestations may be prioritized for control based on project design in order to control its spread on site.

**Olive (Olea europaea)**

**General Information**
Olive is an evergreen tree with opposite leaves in the olive family (Oleaceae). Olive sometimes escapes cultivation. It inhabits disturbed places in the Central Valley, San Francisco Bay region, southern North Coast Ranges, South Coast, and Santa Cruz Island. Birds primarily disperse the fruits (Baldwin et al. 2012). It has also been observed establishing away from any apparent disturbance (Cal-IPC 2018b).

**Relevant Life History**
Olive reproduces by seed. It is likely dispersed by birds and can self-pollinate. Seeds are dormant for 20 months and are vulnerable to rodent herbivory during that time. (Cal-IPC 2018b).

**General Management Strategies**
Manually removing seedlings and saplings with roots before they mature is effective. This species readily resprouts when cut, grazed or burned, so follow up treatment is necessary (Cal-IPC 2018b).
Distribution in the Study Area
Olive is found in small patches in the southern parcel. There are 5 total features recorded.

**Harding grass (Phalaris aquatica)**

**General Information**
Harding grass is a coarse, tufted perennial in the grass family (Poaceae). Occasionally harding grass is toxic to livestock when consumed in quantity. It was introduced to provide extra-seasonal forage on pastures and rangeland, but it has escaped cultivation in riparian areas and other moist places in California. Harding grass is generally more invasive in coastal regions. It is native to Mediterranean Europe and was introduced as a cultivar from Australia. Harding grass inhabits riparian areas, ditch banks, and fields. It tolerates frost and drought (DiTomaso and Healy 2007).

**Relevant Life History**
Harding grass flowers from May-September and reproduces by seed. Seeds typically fall near the parent plant or disperse to greater distances with agricultural and other human activities, soil movement, water, and animals. Seeds germinate when moisture is available and temperatures are favorable. Seedlings compete poorly with established vegetation, but larger plants can displace native vegetation. Most active growth occurs fall through spring when moisture is plentiful. Under suitable conditions, rhizome fragments can develop into a new plant (DiTomaso and Healy 2007).

**General Management Strategies**
Regular manual removal of these species before seeds mature can help control unwanted populations. For disturbed sites in natural areas, enhancing the cover of desirable species before seeds mature can help to control unwanted populations. For disturbed sites in natural areas, enhancing the cover of desirable species can help prevent the establishment of harding grass seedlings (DiTomaso and Healy 2007). Herbicides such as Chethodim, Fluazifop, and Glyphosate, are best applied to young or plants with new growth in early spring (DiTomaso et al. 2013).

Distribution in the Study Area
Harding grass is found in a single small patch in the southern parcel.

**Himalayan blackberry (Rubus armeniacus)**

**General Information**
Himalayan blackberry is a mounded, climbing, and trailing shrub in the rose family (Rosaceae). It is a vigorous cultivar introduced from Eurasia and is the most common non-native bramble invading natural areas in California. Himalayan blackberry inhabits disturbed moist open sites, roadsides, fencerows, fields, canal and ditch banks, and riparian areas in many plant communities. It tolerates periodic flooding and brackish water (DiTomaso and Healy 2007).

**Relevant Life History**
Himalayan blackberry reproduces by seed, roots sprouts, and stem tip rooting. New shoots can grow from buds on the roots. Under favorable conditions, root fragments of root-sprouting species may develop into new plants. Fruits typically disperse to greater distances with animals, especially birds. Seeds without the flesh may also disperse with water and soil movement. Seed germination occurs mainly in spring (DiTomaso and Healy 2007).

**General Management Strategies**
Small populations may be controlled effectively by manual removal. However, only removing the aboveground portion of the plant usually stimulates the growth of root sprouts. Cutting or burning can be
effective if root sprouts are controlled when small. Repeated cutting, especially at flowering time can help exhaust root stores. Cutting in fall can prevent stems from tip rooting. Goats readily consume blackberry. The most effective strategy for control is the use of systemic herbicides in summer to early fall (DiTomaso and Healy 2007).

**Distribution in the Study Area**

Himalayan blackberry is found in small patches in the southern parcel and one patch located on the southern boundary fence in the northern parcel. There are eight total infestations. It should be managed to avoid spread into the restoration area.

**Russian thistle (Salsola tragus)**

**General Information**

Russian thistle is a bushy, large summer annual with rigid branches in the chenopod family (Chenopodiaceae). Under certain circumstances Russian thistle can be toxic to livestock. Russian thistle was introduced from Russia to South Dakota in flax seed around 1874. Russian thistle inhabits disturbed sites, waste places, roadsides, fields, cultivated fields, and disturbed natural and semi-natural plant communities. It grows best on loose, sandy soils (DiTomaso and Healy 2007).

**Relevant Life History**

Russian thistle flowers from July to October and reproduces by seed. Seeds disperse when plants break off at ground level and tumble with the wind. Seeds require an after-ripening period before germination can occur. Most seeds germinate the spring following maturation. Seeds require very little moisture to germinate and germination occurs rapidly in a few hours. Seedlings require loose soil for germination. Most seeds survive one year and may survive up to 3 years under field conditions (DiTomaso and Healy 2007).

**General Management Strategies**

Seedlings cut just above the cotyledons seldom survive. Properly timed cultivation of seedlings prevents seed production and can control infestations, but cultivation must be repeated for a couple of years until the short-lived seedbank becomes depleted (DiTomaso and Healy 2007). Many herbicides (2,4-D, Dicamba, Picloram, Triclopyr, Glyphosate, Propoxycarbazone-sodium) will be most effective on seedlings or young plants. Other herbicides (Aminopyralid, Chlorsulfuron, Imazapic, Imazapyr, Propoxyxcarbazone-sodium, Sulfometuron and Hexazinone) can be used pre-emergence up to post-emergent plants less than 3 inches tall (DiTomaso et al. 2013).

**Distribution in the Study Area**

Russian thistle has the highest total gross area and highest infested area in the study area. There are 12 total features recorded with a gross area of 43.06 acres; 7 in the northern parcel, 5 in the southern parcel. The denser infestations (5-10% cover) on the remnant dune features in the northern parcel should be a priority for control.

**Milk thistle (Silybum marianum)**

**General Information**

Milk thistle is an erect winter or summer annual or biennial in the sunflower family (Asteraceae). Milk thistle often occurs in dense, competitive stands. Depending on the amount of soil moisture plants can range from very small to very tall. It inhabits disturbed sites, roadsides, pastures, fields, agronomic crops, waste places, orchards, and trail margins in chaparral and woodlands. Milk thistle grows best on fertile soils. It is native to the Mediterranean region. (DiTomaso and Healy 2007).

**Relevant Life History**
Milk thistle flowers from April to July and reproduces by seed. Seeds probably disperse only short distances with wind but they can disperse to greater distances from human activities, water, soil movement, animals and as a crop seed or feed contaminant. Most seeds germinate after the first fall rain, but some can germinate throughout winter and early spring. Seeds can survive at least nine years under field conditions (DiTomaso and Healy 2007).

General Management Strategies
Cultivation can control seedlings. Mowing mature plants before flowers open can help control stands. Tillage can be an effective control option for younger plants. Glyphosate herbicide can be applied to plants in the rosette stage in spring. Other herbicides such as Aminopyralid and Clopyralid can be used on post-emergent to bolting individuals (DiTomaso and Healy 2007). Infestations in the northern parcel that threaten remnant dune features should be prioritized for control.

Distribution in the Study Area
Milk thistle is the second most widespread invasive weed in the study area. There are 31 total features recorded; eleven in the northern parcel and 20 in the southern parcel. Infestations in the northern parcel that threaten remnant dune features should be prioritized for control.