Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report

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SUGGESTED CITATION
Klausmeyer K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California.

Photo Caption: Riparian forest and wetlands along the Santa Clara River near Ventura, California.

CONTENTS

LIST OF ACRONYMS USED IN THIS DOCUMENT

CALVEG	Classification and Assessment with Landsat of Visible Ecological Groupings
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
FMMP	Farmland Mapping and Monitoring Program
FVEG	Name of digital mapping of California vegetation completed as part of the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program
GDE	Groundwater Dependent Ecosystem
GSP	Groundwater Sustainability Plan
iGDEs	Indicators of Groundwater Dependent Ecosystems
ISW	Interconnected Surface Water
NCCAG	Natural Communities Commonly Associated with Groundwater
NHD	National Hydrography Dataset
NHDPlus	National Hydrography Dataset Plus
NWI	National Wetlands Inventory
SGMA	Sustainable Groundwater Management Act
USFWS	United States Fish and Wildlife Service
VegCAMP	Vegetation Classification and Mapping Program
WHR	Wildlife Habitat Relationships

Riparian Forest along the Sacramento River. © Harold E. Malde

ABSTRACT

Many of California's diverse ecosystems include plant and animal species that rely on groundwater to survive. Here, 48 detailed wetland and vegetation datasets were compiled to generate a digital database of indicators of groundwater dependent ecosystems (iGDEs) in California's groundwater basins. Based on these existing datasets, the phreatophytic vegetation, perennial streams, regularly flooded natural wetlands, and springs and seeps that most likely indicate the presence of and depend on groundwater were identified. The extracted vegetation features represent iGDEs due to published and/or field observations of phreatophytic characteristics in California. The extracted wetland and stream features represent iGDEs due to their flooding frequency or classification as a perennial hydrologic feature. Finally, springs and seeps represent iGDEs because they are locations where groundwater naturally emerges at the ground surface.

> Please note: The California Department of Water Resources is the host and data steward of the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. This document refers to the NCCAG dataset as to the indicators of groundwater dependent ecosystems (iGDE) dataset. To access the data, visit gis.water.ca.gov/app/NCDatasetViewer/

BACKGROUND & SUMMARY

Groundwater is vital to people and nature, providing an important source of drinking and irrigation water, and meeting some or all the water requirements for plants and animals to survive. In some cases, groundwater serves as the primary source of water for certain plant species year-round. Recognizing the need for sustainable management of groundwater resources in California, the state passed the Sustainable Groundwater Management Act (SGMA) in 2014. SGMA states:

> It is the policy of the state that groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses. Sustainable groundwater management is best achieved locally through the development, implementation, and updating of plans and programs based on the best available science. (23 California Code of Regulations (CCR) §113)
>
> A groundwater sustainability plan shall include, where appropriate and in collaboration with the appropriate local agencies […] Impacts on groundwater dependent ecosystems. (23 CCR §10727.4(l))

The California Department of Water Resources (CDWR) developed regulations to implement SGMA and officially recognized groundwater dependent ecosystems (GDEs) in the Act. CDWR provided the following definitions:

> 'Groundwater dependent ecosystem' refers to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface (23 CCR § 351(m))
>
> 'Interconnected surface water' refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (23 CCR § 351(0))

This analysis uses CDWR's definition of GDEs and includes interconnected surface water (ISW) within the broader GDE context, since ISW features (i.e. springs, wetlands, rivers, and natural lakes) are hydrologic systems likely to host aquatic communities or species that may be dependent on groundwater.

METHODS

Approach

In 2010, the first systematic effort to identify and map GDEs in California was published by scientists at The Nature Conservancy of California (Howard & Merrifield 2010). The authors' approach was to compile existing vegetation and wetland datasets and identify specific vegetation and wetland types which are known to rely on groundwater.

The root system of an oak tree exposed by river erosion. © Laura Reige / The Nature Conservancy

The mapping methods used by Howard and Merrifield (2010) is one of several approaches used to map GDEs. Other researchers have used the following approaches:

- Analysis of sub-daily fluctuations in groundwater levels, since GDEs tend to transpire more water during the day than at night (Eamus et al. 2015). This method was not used for this analysis because sub-daily groundwater level records are not available for much of California.
- Isotope analysis of the water in the xylem of plants, since groundwater typically has a different isotopic signature than surface water (Eamus et al. 2015). This method can be a useful validation technique of a suspected GDE, but is not practical for a large scale state-wide analysis because it relies on expensive field and laboratory work.
- Analysis of remotely sensed data to compare the greenness of vegetation over time to see which areas remain green during seasonal or multi-year droughts (Jin et al. 2011; Lv et al. 2013). Other studies have used remotely sensed estimates of evapotranspiration to identify areas where local average annual evapotranspiration is greater than average annual precipitation to identify areas with possible groundwater dependence (van Dijk et al. 2015; Doody et al. 2017). These methods could be applied across large areas, but is complicated in areas such as California that have large scale modification to natural flow regimes. For example, some rivers that would historically go dry during the summer remain flowing because of releases from dams, wastewater treatment plant effluent, irrigation return flows, and/or urban run-off. These water sources can cause patches of vegetation to remain green during a dry period, thus mimicking the greenness patterns of a GDE, even if there is no access to groundwater.
- Compiling existing vegetation datasets and refining based on local geology, landform, soil, and groundwater depth to identify the areas most likely to support

GDEs (Mathie et al. 2011; Doody et al. 2017). This method is like the approach used by Howard and Merrifield (2010) and in this analysis.

This analysis follows the basic approach of the Howard and Merrifield (2010) study, with the following modifications. Baseflow estimates were not used because it was determined that baseflow data was too coarse for the scale of this analysis. Updated vegetation and wetland datasets were used because many of the datasets used in the 2010 study have been updated, and new detailed datasets have become available since the 2010 study. The term indicators of groundwater dependent ecosystems (iGDE) was used instead of GDE because identifying GDEs requires local detailed data about the land use, hydrology, and geology of a location. Since local detailed data are not available in all basins, this analysis used existing vegetation and wetland datasets to identify *indicators* of GDEs.

Review Process

To build the updated database of iGDEs in California, a working group consisting of the authors of this study was formed. The working group identified key datasets, reviewed and updated the methods used by Howard and Merrifield (2010), reviewed the vegetation and wetland types, reviewed draft results, and performed the location specific reviews. A larger technical advisory group was also convened for a 1-day workshop to review the methods and an earlier draft of the database (see Appendix 1: Technical Advisory Group). This technical advisory group included groundwater managers, state officials, water consultants, and academics. This group provided feedback on the draft database and many of their suggestions were incorporated into the process and methods used to develop the current version of the database, including a suggestion to add common names for vegetation species, identifying a database steward (CDWR), and providing clear documentation of the methods used to generate the database (this report). The mapped iGDE locations were reviewed in detail in as many locations as possible and compared to other datasets to screen out areas that are not likely to be iGDEs because of alternate water sources (e.g., seepage from irrigation canals), groundwater below the rooting zone (when possible), and agricultural and urban development. The final database includes data on iGDEs from 48 vegetation and wetland datasets (see Appendix 2: Data Sources) that were combined and analysed using the methods described below.

Mapping Indicators of Groundwater Dependent Ecosystems

Researchers have classified GDEs into three broad classes (Eamus 2006; Eamus & Froend 2006; Eamus et al. 2006, 2015):

- Class 1: Underground aquifer and cave systems where stygofauna (species adapted to living in underground water) reside.
- Class 2: Ecosystems that rely on the surface expression of groundwater, including springs, perennial wetlands, and rivers whose flow is augmented by groundwater.
- Class 3: Ecosystems that rely on the sub-surface presence of groundwater, including phreatophytes (plants that get a significant portion of the water they need from groundwater).

Due to a lack of data on the locations of stygofauna in California, this report focuses on mapping Class 2 and Class 3 GDEs. In this report, Class 2 GDEs are referred to as “Wetlands” and Class 3 GDEs are referred to as “Vegetation”. Figure 1 provides an overview of the input data and processing steps used to generate this database. The orange boxes in the figure represent the vegetation data sources, the blue boxes represent wetland data sources, and the red boxes represent additional data sources used to enhance or screen the vegetation and wetland data. The vegetation and wetland types underwent a process to select the types that best represent iGDEs (more detail on the process is provided below). The vegetation data was intersected with ecoregions to account for the fact that groundwater dependence for some species is influenced by broad physical and biological components of the environment which include climate, geology, geomorphology and soils. The wetland and vegetation iGDEs were screened for removal based on location-specific factors such as irrigated agricultural fields and developed areas. The result is a state-wide database of iGDEs within California's groundwater basins.

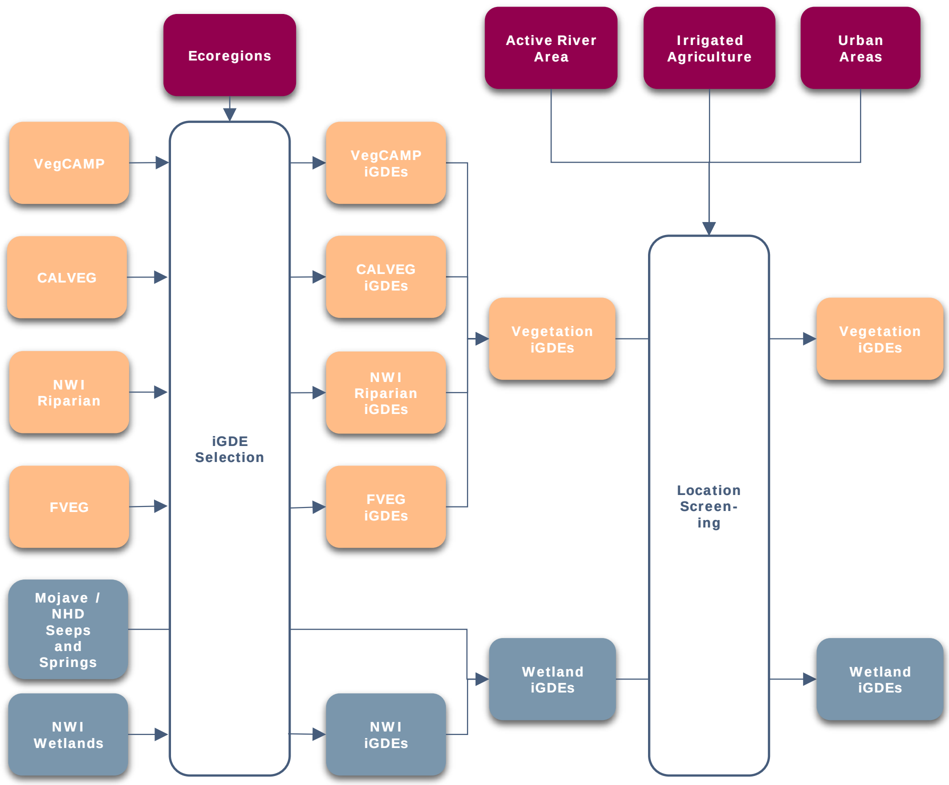

Figure 1: Overview of the datasets and processing steps to generate the iGDE database. Acronyms used in this figure are defined in the List of Acronyms at the beginning of this document.

Vegetation

To map vegetation iGDEs state-wide, vegetation datasets that identify dominant species for vegetation alliances were used. The dominant species data was combined with ecoregion data so that each species/ecoregion combination could be evaluated to determine if it was an iGDE. The database includes four existing vegetation datasets - (1) Vegetation Classification and Mapping program; (2) Classification and Assessment with Landsat of Visible Ecological Groupings; (3) National Wetland Inventory riparian vegetation; and (4) California Department of Forestry and Fire Protection multi-source vegetation layer.

Vegetation Classification and Mapping Program (VegCAMP)

The California Department of Fish and Wildlife (CDFW) compiled a set of high-resolution vegetation maps with consistent mapping and classification protocols as part of the

Vegetation Classification and Mapping program (VegCAMP) (California Department of Fish and Wildlife 2017). These datasets identify vegetation alliances associated with specific dominant plant species. The database includes all available VegCAMP datasets, including a composite layer that CDFW compiled for the Central Valley (See Appendix 2: Data Sources for a list of the VegCAMP datasets used). In areas of overlap between the coverage of the datasets, only the most up-to-date dataset was used (i.e., the dataset that used the most recent aerial imagery) in order to remove any areas of overlap.

To identify the iGDE areas in each VegCAMP dataset, the first step was to overlay the vegetation data with the ecoregion sub-sections of California (U.S. Forest Service 2007) and review each of the ecoregion/vegetation types to classify iGDEs. Vegetation alliance descriptions (Sawyer et al. 2009) (See Appendix 2: Data Sources), published lists of phreatophytes (Robinson 1958; Lichvar & Dixon 2007; Mathie et al. 2011)(See Appendix 3: Phreatophytes), field observations, peer-reviewed literature (Nilsen et al. 1984; Stromberg et al. 1996; Naumburg et al. 2005; Querejeta et al. 2009, 2007; Patten et al. 2008; Mahall et al. 2009; Miller et al. 2010; Máguas et al. 2011; Andrews et al. 2012; Merritt & Bateman 2012; Mclaughlin et al. 2013; Smith & Finch 2016; Xi et al. 2016), and other books and reports (Meinzer 1927; James et al. 1990; Van der Leeden 1990; Charlet 2006; Germanoski et al. 2007) were used during this review. For vegetation types with more general names (e.g., "Mixed Riparian Hardwood") the vegetation type description from the source metadata and/or reports for that data source were reviewed to see which species were dominant in that vegetation type. If more than half of the dominant species in that vegetation type were phreatophytes, the vegetation type was included in the database. All areas mapped as human-dominated landscapes such as urban areas, cultivated fields, irrigated pastures, and orchards were excluded. Water features were also excluded since they are mapped in more detail in the wetlands datasets. Finally, all ecoregion/vegetation types that are iGDEs were extracted and appended into one VegCAMP iGDE layer.

For each vegetation type, a dominant species was identified based on the vegetation type name. If multiple species names were listed in the vegetation type name, the first phreatophytic species listed was selected. If no species names were listed in the vegetation type name, a dominant species was not identified. For each dominant species, a common name and scientific name was identified based on a review of the species descriptions in the NatureServe database (http://www.natureserve.org/).

Classification and Assessment with Landsat of Visible Ecology Groupings (CALVEG)

Region 5 of the U.S. Forest Service completed detailed vegetation maps for almost 75% of California as part of its Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG) program (U.S. Forest Service 2016). Data for each ecoregion was downloaded and used to create a composite layer for the state. Because VegCAMP data has more detailed vegetation classifications, CALVEG data was only used in areas that do not have VegCAMP coverage. The CALVEG data includes ecoregion data, so a list of the 1,561 unique ecoregion/vegetation types was generated and the same review was performed as described for the VegCAMP dataset to classify the ecoregion/vegetation types with the addition of the CALVEG vegetation descriptions (U.S. Forest Service 2017). All the ecoregion/vegetation types that were classified as iGDEs were extracted to create a CALVEG iGDE layer.

National Wetland Inventory (NWI) Riparian Data

The United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) database includes mapping of riparian vegetation in the arid regions of the United States (U.S. Fish and Wildlife Service 2009). Riparian vegetation is defined as:

> Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: 1) distinctively different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland (U.S. Fish and Wildlife Service 2009)

Riparian vegetation is typically distinctive from neighbouring vegetation because it has better access to groundwater (Groeneveld & Griepentrog 1985; Stromberg et al. 1996) and in many cases is groundwater dependent. For this analysis, it was assumed that all mapped riparian vegetation is an iGDE. The VegCAMP and CALVEG datasets are more detailed than the NWI riparian data, so the NWI riparian data (not be confused with the NWI wetlands data described below) were only used in areas where VegCAMP and CALVEG data do not exist.

California Department of Forestry and Fire Protection (FVEG)

The California Department of Forestry and Fire Protection generated a multi-source vegetation layer (FVEG) as part of its Forest and Range Assessment Program (California Department of Forestry and Fire Protection 2015). This vegetation layer uses CDFWs Wildlife Habitat Relationships (WHR) vegetation type classification system. WHR only identifies dominant species for some vegetation types, which makes it more difficult to identify iGDEs. However, this vegetation layer covers the entire state. Thus, it was decided that FVEG would be used in areas where VegCAMP, CALVEG, or NWI riparian data do not exist. As with the other vegetation datasets, the vegetation polygons were intersected with ecoregions to generate a list of unique ecoregion/vegetation types and reviewed to determine which were iGDEs (California Department of Fish and Game 1988). All the ecoregion/vegetation types that were classified as iGDEs were extracted to create an FVEG iGDE layer.

Combining and Processing the iGDE Vegetation Data

The vegetation iGDE data were compiled into one composite layer for California. In areas where multiple vegetation data overlap, the data source with the more detailed vegetation classification was used over the other layers. As a result, the preference order for vegetation data is:

1. VegCAMP
2. CALVEG
3. NWI riparian
4. FVEG

To avoid double counting areas, any area of overlap between the various data sources was removed. Figure 2 depicts the data sources used for vegetation mapping in the state. Note that the NWI riparian data were only used in a small portion of the state in Southern California because VegCAMP or CALVEG data exists in all other places where the NWI riparian data were mapped.

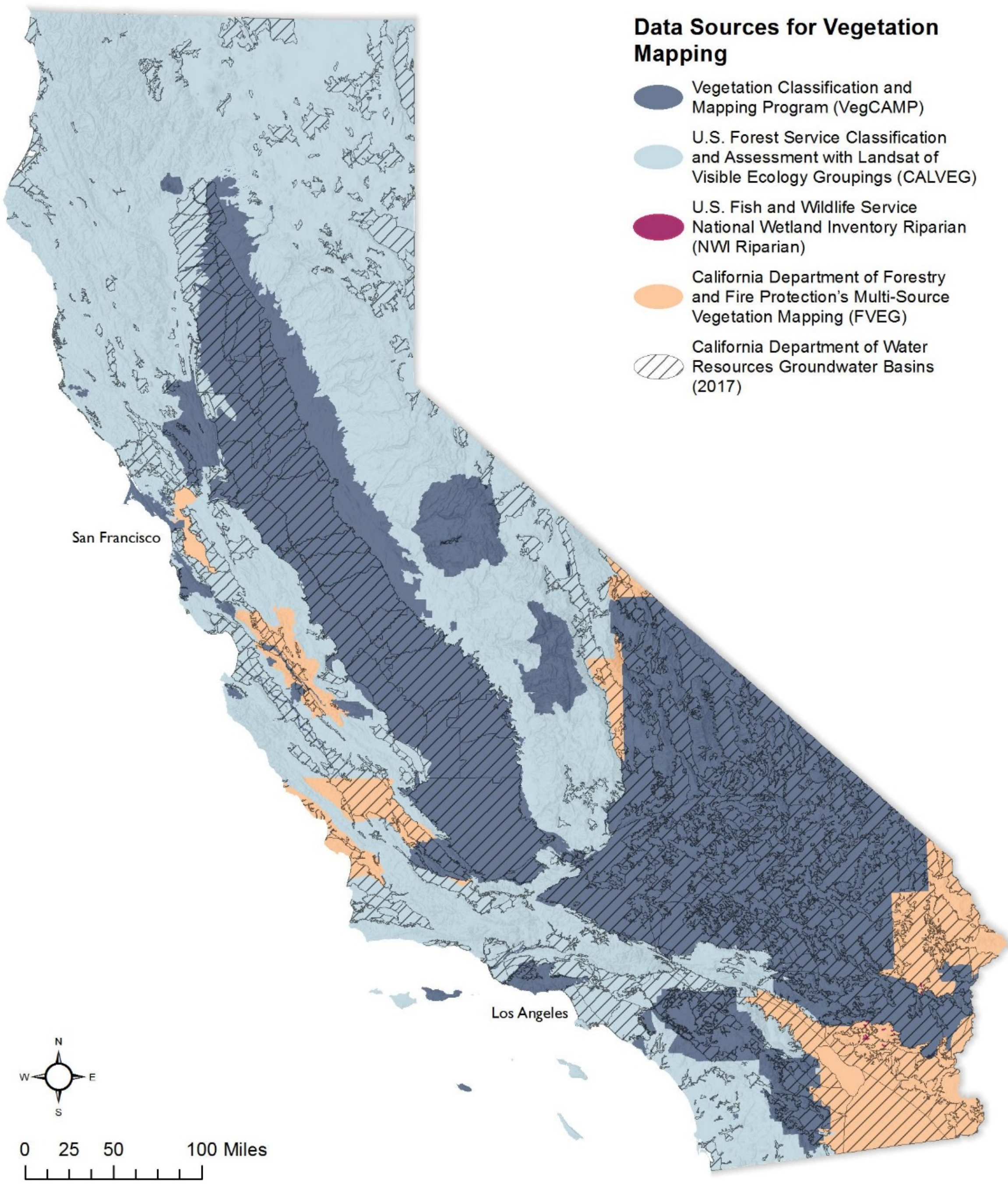

Figure 2: Map of the extent of the data sources used for mapping vegetation indicators of groundwater dependent ecosystems

Wetlands

National Wetland Inventory (NWI)

The USFWS NWI database was used to map wetland iGDEs (U.S. Fish and Wildlife Service 2016). The NWI defines wetlands as follows:

> **Wetlands** are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Federal Geographic Data Committee 2013, pages 6 and 7)

and

> **Deepwater habitats** are permanently flooded lands lying below the deepwater boundary of wetlands (Federal Geographic Data Committee 2013, page 8)

In California, wetlands and deepwater habitats are supported by surface water, groundwater, or both (White 1993; Harvey et al. 1996; Bencala 2000; Malard et al. 2002; Tonina & Buffington 2009; Lane et al. 2017). For this analysis, it was assumed that ephemeral wetlands irregularly covered by water are more likely to be supported by surface water and less likely to be supported by the surface expression of groundwater. In addition, some wetlands and deepwater habitats are artificially flooded by modifications to the hydrology of the systems and thus may be reliant on these alterations rather than on groundwater. These modifications include dams, pumps, levees, weirs, and irrigation systems. The NWI database provides a detailed classification of flooding frequency and human alteration that enables users to distinguish natural wetlands from modified wetlands.

Each record in the NWI database is classified based on a the Cowardin classification, a wetland classification for the United Stated developed in 1979 and updated by the Federal Geographic Data Committee in 2013 (Cowardin et al. 1979; Federal Geographic Data Committee 2013). The following types of wetlands were included or excluded in the iGDE database based on the following rational:

- Marine Habitats (System Name = "Marine") **excluded**. This classification includes all deepwater marine habitats and coastal habitats such as beaches and dunes. These habitats are dominated by water from the ocean and were therefore removed from the database.
- Estuaries (System Name = "Estuarine") **excluded**. While some estuarine systems in California have documented groundwater inputs (Monismith et al. 2005; Stillwater Sciences 2011), the majority have not been studied. Given the level of uncertainty around the relative inputs from marine and freshwater sources, estuaries were excluded from this database.
- Palustrine wetlands (System Name = "Palustrine") **mixed**. Wetlands are widely recognized as iGDEs because they are often formed in locations where the groundwater is at or near the land surface (Murray et al. 2003; Brown et al. 2010; Howard & Merrifield 2010; Kløve et al. 2011). All palustrine wetlands were included,

except for vernal pools. Vernal pools are seasonal wetlands that collect surface water due to an impermeable substrate and thus are not dependent on groundwater. Vernal pools do not have a category in the Cowardin classification, but one of the constituent mapping projects (the Sacramento National Wildlife Refuge Complex project) used specific wetland codes ("PEM1Ai", "PEM1Ci", "PEM1Ei") to identify vernal pool complexes (Patterson 2013).

- Riverine wetlands (System Name = "Riverine") **mixed**.
    - Perennial rivers (Sub-System Name = "Upper Perennial", and "Lower Perennial") **included**. Perennial rivers rely on groundwater inputs to maintain a base flow (Boulton & Hancock 2006; Eamus & Froend 2006; Brown et al. 2010; Howard & Merrifield 2010).
    - Tidally influenced freshwater rivers (Sub-System Name = "Tidal") **included**. These are freshwater rivers that are typically perennial with river stage and flow influenced by downstream tides, but they are not salt-water rivers. Many of these low elevation rivers have groundwater inputs.
    - Intermittent Streams (Sub-System Name = "Intermittent") **excluded**. While ephemeral streams are typically not groundwater dependent, groundwater can be important to extend the duration of flow of intermittent streams or to maintain wet pools within an intermittent stream that has stopped flowing (Boulton & Hancock 2006). Unfortunately, the NWI database does not provide enough detail to distinguish between groundwater dependent intermittent streams and non-groundwater dependent ephemeral streams, so all intermittent streams were excluded from the database.
- Lakes (System Name = "Lacustrine") **included**. Many of California's large natural lakes receive inflows from groundwater, including the Salton Sea (California Department of Water Resources 2003), Mono Lake (Blevins et al. 1987), and Laguna Lake (Hill & Otte 2014). All sub-systems were included, but human modified lakes (e.g., reservoirs, flooded fields) were excluded (see below).
- Human Modified Wetlands (Modifiers including "Farmed", "Diked/Impounded", "Artificially Flooded", "Artificial Substrate", "Excavated", "Spoil") **excluded**. Although groundwater may provide some water to these modified wetlands, the flooding regime is most likely dependent upon human intervention. Due to this dependence on human intervention, modified wetlands were removed from the database.

The Cowardin wetland classification used in the NWI database also includes information about the water regime for most of the mapped wetlands based on the duration and timing of surface inundation and groundwater fluctuations (Federal Geographic Data Committee 2013). The descriptions of some of the water regimes reference the depth to the groundwater table. The following are examples of the water regimes and their descriptions:

> **Semipermanently Flooded.** Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.
>
> **Seasonally Saturated.** The substrate is saturated at or near the surface for extended periods during the growing season, but unsaturated conditions prevail by the end of the season in most years. Surface water is typically absent, but may occur for a few days after heavy rain and upland runoff.

> **Temporarily Flooded**. Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season. (Federal Geographic Data Committee 2013, page 38)

For this analysis, the water regime was used to determine if the wetland is a good indicator of groundwater dependence. Wetlands with water regimes that are perennial (e.g., "Permanently Flooded", per Brown et al. 2010), almost perennial (e.g. “Semipermanently Flooded”), regularly flooded (e.g. “Seasonally Flooded”), and whose description indicates the substrate is saturated (e.g. “Continuously Saturated”) were included in the database. Wetlands that are flooded occasionally during wet periods (e.g. “Temporarily flooded”), or wetlands that are flooded because of tidal influences (e.g. “Regularly Flooded”) were excluded. Table 1 lists the NWI wetland type, water regime name, and whether it was included or excluded from the iGDE database.

Table 1: Wetland flooding regimes from the National Wetland Inventory database

Wetland Type	Water Regime	Included or Excluded
Nontidal	Continuously Saturated	Included
Nontidal	Intermittently Exposed	Included
Nontidal	Permanently Flooded	Included
Nontidal	Semipermanently Flooded	Included
Freshwater Tidal	Permanently Flooded	Included
Nontidal	Seasonally Flooded	Included
Nontidal	Seasonally Flooded/ Saturated	Included
Nontidal	Seasonally Saturated	Included
Freshwater Tidal	Seasonally Flooded	Included
Freshwater Tidal	Semipermanently Flooded	Included
Nontidal	Intermittently Flooded	Excluded
Nontidal	Temporarily Flooded	Excluded
Freshwater Tidal	Regularly Flooded	Excluded
Freshwater Tidal	Temporarily Flooded	Excluded

Seeps and Springs Data

Seeps and springs are by definition a surface expression of groundwater (Sada & Pohlmann 2002) and, thus, are essential to include in a database of iGDEs. Unfortunately, many seeps and springs are not identified in the NWI database. To resolve this issue, point locations of seeps and springs identified in the National Hydrography Dataset (NHD) for California (U.S. Geological Survey 2016) and a detailed survey of springs in the Mojave Desert (Zdon 2016) were used. A review of the point locations on detailed aerial photos indicated that most of the vegetation and wetlands associated with the seeps or springs are within 50 feet of the point location of the seep or spring. To include the seeps and springs as well as the associated vegetation and wetlands in the database, the point data was converted to circles with a radius of 50 feet (15.42 meters).

Palm trees surround a spring fed pool in the Coachella Valley Preserve. © Timothy Wolcott

Combining and Processing the iGDE Wetland Data

The wetland iGDE data was compiled into one composite layer for California. In areas where multiple wetland data overlap, seeps and springs data were used over the NWI wetlands data because seeps and springs are surface expressions of groundwater. For the two seeps and springs layers, the Mojave Desert data were used over the NHD data because they were mapped and field validated more recently than the NHD data. As a result, the preference order for combining the wetland data is:

1. Mojave Desert Seeps and Springs
2. NHD Seeps and Springs
3. NWI wetlands

To avoid double counting areas, any area of overlap between the various data sources was removed.

Additional Processing and Location Screening

Groundwater and dependent ecosystems could occur in many places state-wide, but most of the groundwater that is managed is in the mapped groundwater basins identified in CDWR's Bulletin 118. To provide detailed information on the iGDEs most relevant to groundwater management in California, all iGDE areas outside of the mapped groundwater basins (California Department of Water Resources 2017a) were removed.

During the screening, it was noticed that some areas have been developed as urban or agricultural areas since the vegetation or wetland mapping was completed. To remove agricultural areas from the dataset, the most recent and detailed map of irrigated agriculture available (Land IQ 2017) was used to remove any iGDE areas that overlapped with mapped agricultural areas. This dataset maps farm fields, so the areas in between fields were not removed in this processing step. Users should review these areas closely because in some cases they are not natural areas (e.g., roads) and should be excluded, while in other cases they are natural vegetation and should be retained. For urban areas, CDWR provided a compilation of urban mapping from local and state-wide datasets (California Department of Water Resources 2017b) (note that the geospatial data have not yet been published online so please contact roy.hull@water.ca.gov for a copy). In several areas, narrow riparian forests were mapped as "urban" in this dataset, but these riparian forests are valid iGDEs. To avoid deleting these areas, all urban areas were removed from the iGDE database except for any area mapped as urban that was within 100 meters of rivers and waterbodies mapped in the National Hydrography Dataset Plus (NHDPlus) version 2 dataset (U.S. Environmental Protection Agency et al. 2017).

During review of the initial results of the iGDE mapping effort, it was noticed that several vegetation types were mapped in areas on hillslopes where they are more likely to rely on surface water, rainfall, and fog drip than on groundwater. These vegetation types include those with the dominant species of *Carex barbarae, Juglans californica, Picea sitchensis, Pinus contorta, Quercus agrifolia, or Sequoia sempervirens* as well as the "Desert Mixed Wash Shrub" vegetation type. However, the vegetation types were also mapped along alluvial floodplains along rivers where they are assumed to be iGDEs. While these alluvial floodplains are not well mapped state-wide, a data layer generated by the U.S. Environmental Protection Agency to depict active river areas was used as a proxy for areas where these ecosystems are likely to depend on groundwater (U.S. Environmental Protection Agency 2013) (note that the geospatial data have not been published online so please contact fleming.terrence@epa.gov for a copy). The areas of these vegetation types that were found outside of the mapped active river areas were removed.

For other vegetation types, selective removals were done based on specific decision rules. For example, the "Alkali Desert Scrub" vegetation type was removed from all areas where it was interspersed within irrigated agricultural fields, such as near the Salton Sea, because this vegetation was more likely relying on irrigation runoff than groundwater. Based on a review of the scientific literature, it was assumed that playas with visible stands of vegetation indicate some groundwater is present and providing the necessary water for survival, while those without any vegetation likely do not contain enough groundwater or the groundwater is too deep for the roots of the vegetation to reach (Rosen 1994; Trent et al. 1997; Lichvar & Dixon 2007). A review of each mapped playa using imagery available in Google Earth was used to identify those playas with significant evident vegetation to include in the database and those without any indication of vegetation were excluded.

A cursory review of the mapped iGDEs within approximately 135 basins was conducted based on recent aerial photography to identify and remove any serious mapping errors. For example, portions of constructed canals and irrigation ditches were incorrectly characterized as perennial rivers in the NWI dataset, requiring them to be removed.

Some of the processing steps mentioned above altered the geometry of the vegetation and wetland polygons, which made them smaller than the minimum mapping unit defined for the source dataset. All polygons in the dataset that were smaller in area than the stated minimum mapping unit were removed. If there was no evident minimum mapping unit published in the metadata or associated reports for the source dataset, a minimum mapping unit of 1,000 square meters (~1/4 acre) as used. In some cases, the original data set included vegetation or wetland polygons that were smaller than the published minimum mapping unit. Using an automated script, all polygons smaller than the minimum mapping unit were compared to the polygons in the same location from the original source dataset. If the polygon in the iGDE database was identical to the polygon in the source dataset (i.e., it had not been modified by the processing steps listed above) it was retained.

The organizational structure and data fields included in the final vegetation and wetland iGDE data layers are included in Appendix 4: Data Fields and Description.

DISCUSSION

This report describes the methods used to map the locations of iGDEs in California's defined groundwater basins. The iGDE database incorporates the best available data to identify the location and type of iGDEs in California. This analysis was conducted to make the existing data from various sources accessible, transparent, and user friendly. However, there are some limitations and suggestions that users should consider when using the database:

Lower Garcia River as it enters the ocean. ©Douglas Steakley.

1. Mapping Errors. Land use changes may have occurred since the source datasets were mapped. The database was screened to remove the largest mapping errors, but due to time constraints, not all mapping errors were removed. Therefore, users should examine the most recent local landcover datasets (e.g., Farmland Mapping and Monitoring Program data, Cropscape data, and/or the U.S. National Land Cover Data) for their area of interest to identify areas that may have been converted to agriculture or developed land uses. Additionally, urban land use maps should be consulted.
2. Groundwater Conditions. The depth to groundwater is an important factor to determine if an ecosystem is likely groundwater dependent. Maps of depth to groundwater are either of course resolution, pertain to confined aquifers, or are missing in many of California's groundwater basins. Users should apply their knowledge of the local groundwater conditions to best identify GDEs in their area.
3. Dynamic Systems. GDEs are typically found along rivers and estuaries in California. These systems are highly dynamic and can change from year to year. For example, a large flood can completely remove patches of riparian vegetation that will take years to grow back. As such, the mapped configuration of wetlands and vegetation types may not represent current conditions. However, if groundwater conditions supported a GDE in the past in that general area, it is possible that it could support a GDE in the future.
4. Managed Systems. Stream flow modification occurs downstream from large dams. Users of the database should review riverine wetlands downstream from dams to determine if they are perennial due to groundwater inputs, dam releases, or a combination of both.
5. Missing iGDEs. There are likely additional iGDEs that are not included in this database. Users should apply their detailed knowledge of an area to identify missing iGDEs.
6. Overlapping iGDEs. Since the vegetation and wetland iGDE data came from different source datasets, there are many areas of overlap between the two datasets. This occurs because many wetlands include plants that were mapped in the vegetation source dataset. Users should take these areas of overlap into consideration when analysing the dataset (e.g., generating area estimates).

ACKNOWLEDGMENTS

The authors would like to thank the members of the Technical Advisory Group for input on the methods and review of early results of this analysis (see Appendix 1: Technical Advisory Group for a list of members). The authors would also like to thank Sandi Matsumoto and Melissa Rohde for their review of earlier versions of this paper. Finally, the authors would also like to thank the Water Foundation for providing financial assistance to support this work.

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APPENDIX 1: TECHNICAL ADVISORY GROUP

Technical Advisory Group Members that attended the May 6th, 2016 workshop on Mapping Indicators or Groundwater Dependent Ecosystems (iGDEs)

1. Amy Lyons, California Department of Water Resources
2. Andrew Fahlund, Water Foundation
3. Bryan Bondy, Calleguas Municipal Water District
4. Dave Miller, GEI
5. Derrik Williams, HydroMetrics
6. Jessica Bean, California State Water Resources Control Board
7. Jim Blanke, RMC
8. Karen LeFebre, California Department of Fish and Wildlife
9. Kristal Davis-Fadtke, California Department of Fish and Wildlife
10. Marcus Trotta, Sonoma County
11. Paul Gosselin, Butte County
12. Rich Juricich, California Department of Water Resources
13. Rob Swartz, Regional Water Authority
14. Roy Hull, California Department of Water Resources
15. Thomas Harter, University of California, Davis
16. Todd Keeler-Wolf, California Department of Fish and Wildlife
17. Tony Morgan, United Water Conservation District

APPENDIX 2: DATA SOURCES

Code	Name	Group	Citation
vc36	Anza-Borrego State Park	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 1998. Anza-Borrego SP. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc29	Ballona Wetlands Ecological Reserve	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2007. Ballona Wetlands. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
fv1	California Fire and Resource Assessment Program Vegetation (FVEG15_1)	FVEG	CA Dept. of Forestry and Fire Protection.2015. Fire and Resource Assessment Program (FRAP) FVEG [ESRI File Geodatabase]. Sacramento, CA. Accessed October 2016.
vc23	Central Mojave Vegetation Database	VegCAMP	US Geological Survey, Western Ecological Research Center. 2002. Central Mojave Vegetation Database. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc21	Clear Creek Management Area	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2006. Clear Creek Management Area. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc69	Cow Creek	VegCAMP	US Fish and Wildlife Service. 2015. Cow Creek. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
cv8	Existing Vegetation Central Coast	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation Central Coast, 1997-2013, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv7	Existing Vegetation Central Valley	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation Central Valley, 1998-2007, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv11	Existing Vegetation Great Basin	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation Great Basin, 1999-2009, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.

Code	Name	Group	Citation
cv3	Existing Vegetation North Coast - East	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation North Coast - East, 1998-2007, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv2	Existing Vegetation North Coast - Mid	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation North Coast - Mid, 1998-2007, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv1	Existing Vegetation North Coast - West	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation North Coast - West, 2000-2007, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv4	Existing Vegetation North Interior	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation North Interior, 1999-2009, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv5	Existing Vegetation North Sierra	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation North Sierra, 2000-2014, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv9	Existing Vegetation South Coast	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation South Coast, 2002-2010, v2 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv10	Existing Vegetation South Interior	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation South Interior, 2000-2008, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
cv6	Existing Vegetation South Sierra	CalVeg	US Department of Agriculture - Forest Service. 2014. Existing Vegetation South Sierra, 2000-2008, v1 [ESRI File Geodatabase]. MeClellan, CA. Accessed June 2016.
vc44	Fish Slough	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2014. Fish Slough. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc99	Great Valley Ecoregion	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2016. Great Valley Ecoregion. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.

Code	Name	Group	Citation
vc32	Joshua Tree National Park	VegCAMP	US National Park Service. 2014. Vegetation Mapping Inventory Project for Joshua Tree National Park. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc53	Liberty Island Remap	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2013. Liberty Island Remap. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc60	Manzanar National Historic Site	VegCAMP	US National Park Service. 2012. Geospatial Vegetation Information for the Manzanar National Historical Site Vegetation Inventory Project. Accessed January 2016.
vc58	Marin County Open Space District	VegCAMP	Marin County. 2008. Marin County Open Space District. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc10	Midpeninsula Regional Open Space District-Peninsula Open Space Trust	VegCAMP	Midpeninsula Regional Open Space District, Peninsula Open Space Trust. 2007. Vegetation - Mid Peninsula Open Space (ds997). Digital vegetation map managed through VegCAMP. Accessed January 2016.
zdon1	Mojave Desert Springs and Waterholes Survey	Mojave Spring Survey	Zdon, A. 2016. Mojave Desert Springs and Waterholes: Results of the 2015-16 Mojave Desert Spring Survey. Walnut Creek, CA.
vc7	Napa County and Blue Ridge Berryessa	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2002. Napa County and Blue Ridge Berryessa. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
nhdh1	National Hydrology Dataset High Resolution, Point Features	National Hydrography Dataset	US Geological Survey. 2016. National Hydrography Dataset, High Resolution, v220. Accessed October 2016.
nwi2	National Wetlands Inventory Riparian Vegetation	National Wetlands Inventory, v2.0	US Fish and Wildlife Service. 2016. National Wetlands Inventory, v2, California Riparian Vegetation. Accessed May 2016.

Code	Name	Group	Citation
nwi1	National Wetlands Inventory Wetlands	National Wetlands Inventory, v2.0	US Fish and Wildlife Service. 2016. National Wetlands Inventory, v2, California Wetlands. Accessed May 2016.
vc50	Orange County	VegCAMP	Nature Reserve of Orange County. 2012. Vegetation - Orange County (ds1336). Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc2	Pine Creek and Fitzhugh Creek Wildlife Areas	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2007. Pine Creek and Fitzhugh Creek Wildlife Areas. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc19	Pinnacles National Monument	VegCAMP	US National Park Service. 2009. Pinnacles National Monument. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc82	Point Mugu Naval Air Station	VegCAMP	US Naval Base Ventura County. 2013. Vegetation Classification and Mapping, Naval Base Ventura County, Point Mugu, California. Digital vegetation map managed through VegCAMP. Accessed January 2016.
vc8	Point Reyes and Golden Gate National Recreation Area	VegCAMP	US National Park Service. 2003. Pt. Reyes and Golden Gate NRA. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc20	Salinas River	VegCAMP	The Nature Conservancy. 2008. Salinas River. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc18	San Benito River	VegCAMP	The Nature Conservancy. 2007. San Benito River. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.

Code	Name	Group	Citation
vc35	San Felipe Valley Wildlife Area	VegCAMP	CA Dept. of Fish and Wildlife. 2005. San Felipe WLA (CDFW). Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc26	Santa Clara River Parkway	VegCAMP	CA Coastal Conservancy. 2007. Santa Clara River Parkway. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc43	Santa Lucia Preserve	VegCAMP	Santa Lucia Conservancy. 2013. Santa Lucia Preserve. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc28	Santa Monica Mountains National Recreation Area	VegCAMP	US National Park Service. 2007. Santa Monica Mountains NRA. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc6	Sierra Nevada Foothills-North	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2009. Sierra Nevada Foothills-North. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc38	Vegetation Map in Support of the Desert Renewable Energy Conservation Plan	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2012. Vegetation Map in Support of the DRECP. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc13	Vegetation Map of the Sacramento-San Joaquin River Delta	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2007. Vegetation Map of the Sacramento-San Joaquin River Delta. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc12	Vegetation Map Update for Suisun Marsh, Solano County, California (2012)	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2016. 2012 Vegetation Map Update for Suisun Marsh, Solano County, California. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.

Code	Name	Group	Citation
vc25	Vegetation of the California Department of Fish and Game Carrizo Plain Ecological Reserve	VegCAMP	US Bureau of Land Management. 2011. Vegetation of the Carrizo Plain Ecological Reserve. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc31	Western Riverside County	VegCAMP	CA Dept. of Fish and Wildlife, VegCAMP. 2005. Western Riverside County. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc51	Western Riverside County Vegetation Mapping Update	VegCAMP	Riverside County. 2015. Western Riverside County Update. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.
vc16	Yosemite National Park Vegetation Map	VegCAMP	US National Park Service. 2007. Yosemite National Park Vegetation Map. Digital vegetation map managed through the California Vegetation Classification and Mapping Program (VegCAMP). Accessed January 2016.

APPENDIX 3: PHREATOPHYTES

List of phreatophytic species from three studies. A “1” in a cell indicates that genus or species was listed as a phreatophyte in that study. The full citations for the studies are:

1. Robinson, T. W. (1958). Phreatophytes: U.S. Geological Survey Water Supply Paper 1423. Washington, D.C. Retrieved from https://pubs.usgs.gov/wsp/1423/report.pdf.
2. Mathie, A. M., Welborn, T. L., Susong, D. D., & Tumbusch, M. L. (2011). Phreatophytic Land-Cover Map of the Northern and Central Great Basin Ecoregion: Ecoregion: California, Idaho, Nevada, Utah, Oregon, and Wyoming. U.S. Geological Survey Scientific Investigations Map 3169. Reston, Virginia. Retrieved from http://pubs.usgs.gov/sim/3169.
3. Lichvar, R., & Dixon, L. (2007). Wetland Plants of Specialized Habitats in the Arid West. Hanover, NH. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA469459.

Scientific Name	Robinson, 1958	Mathie et al, 2011	Lichvar and Dixon, 2007
Acacia greggii	1	1	
Acer negundo	1	1	
Adenostoma fasciculatum			1
Adenostoma sparsifolium			1
Alhagi camelorum	1	1	
Allenrolfea occidentalis	1	1	1
Alnus spp.	1	1	
Ambrosia dumosa			1
Anemopsis californica	1	1	
Aplopappus heterophyllus	1	1	
Artemisia tridentata		1	
Aster spinosus	1	1	
Atriplex hastata	1		
Atriplex canescens	1	1	1
Atriplex confertifolia			1
Atriplex hymenelytra			1
Atriplex lentiformis	1	1	
Atriplex parryi		1	1
Atriplex polycarpa			1
Atriplex spinifera			1
Baccharis emoryi	1	1	
Baccharis glutinosa	1	1	
Baccharis pilularis			1
Baccharis salicifolia			1
Baccharis sarothroides	1	1	1
Baccharis sergiloides	1	1	1
Baccharis viminea	1	1	

Scientific Name	Robinson, 1958	Mathie et al, 2011	Lichvar and Dixon, 2007
Bigelovia hartwegii	1		
Carex spp.		1	
Ceanothus crassifolius			1
Ceanothus cuneatus			1
Ceanothus greggii			1
Ceanothus tomentosus			1
Ceanothus verrucosus			1
Celtis reticulata	1	1	
Cercidium floridum	1	1	
Chilopsis linearis	1	1	
Chrysothamnus nauseosus		1	
Chrysothamnus nauseosus consimilis	1		
Chrysothamnus nauseosus graveolens	1		
Chrysothamnus nauseosus mohavensis	1		
Chrysothamnus nauseosus oreophilus	1		
Chrysothamnus nauseosus viridulus	1		
Chrysothamnus pumilus	1	1	
Cowania stansburiana	1	1	
Cynodon dactylon	1	1	
Dalea spinosa	1	1	
Dasiphora fruticosa	1	1	
Distichlis spicata	1	1	1
Distichlis stricta	1	1	
Elymus condensatus	1	1	
Elymus triticoides	1	1	
Encelia farinosa			1
Eragrostis obtusiflora	1	1	
Ericameria cooperi			1
Ericameria nauseosa			1
Eriogonum fasciculatum			1
Eriogonum inflatum			1
Eucalyptus globulus			1
Frankenia jamesii			1
Fraxinus velutina	1	1	1
Gutierrezia microcephala			1
Gutierrezia sarothrae			1
Hedysarum boreale	1	1	
Heliotropium curassavicum	1	1	
Heterotheca grandiflora			1
Hymenoclea monogyra	1	1	1
Hymenoclea salsola	1	1	1

Scientific Name	Robinson, 1958	Mathie et al, 2011	Lichvar and Dixon, 2007
Isocoma acradenia			1
Isocoma menziesii			1
Juglans microcarpa	1	1	
Juncus balticus	1	1	
Juncus cooperi	1	1	1
Juniperus scopulorum	1	1	
Lepidium latifolium			1
Lepidospartum squamatum			1
Leptochloa fascicularis	1	1	
Lotus scoparius			1
Medicago sativa	1	1	
Petalonyx thurberi			1
Phragmites australis			1
Phragmites communis	1	1	
Picea engelmanni	1	1	
Plantanus racemosa			1
Platanus wrightii	1	1	
Pluchea odorata			1
Pluchea sericea		1	1
Populus acuminata		1	
Populus angustifolia		1	
Populus balsamifera		1	
Populus deltoides		1	
Populus fremontii		1	1
Populus sargentii		1	
Populus spp.	1		
Populus texana		1	
Populus tremuloides		1	
Populus tremuloides aurea	1		
Populus trichocarpa		1	
Populus weslizeni		1	
Prosopis glandulosa			1
Prosopis juliflora	1	1	1
Prosopis pubescens	1	1	1
Prosopis velutina	1	1	
Pulchea sericea	1		
Quercus agrifolia	1	1	1
Quercus chrysolepis			1
Quercus dumosa			1
Quercus lobata	1	1	
Rhus integrifolia			1

Scientific Name	Robinson, 1958	Mathie et al, 2011	Lichvar and Dixon, 2007
Rhus ovata			1
Ribes speciosum			1
Rosa spp.		1	
Salicornia europaea	1	1	
Salicornia rubra	1		
Salicornia utahensis	1		
Salix exigua			1
Salix gooddingii			1
Salix laevigata			1
Salix lasiolepis			1
Salix spp.	1	1	
Salsola kali			1
Sambucus spp.	1	1	
Sarcobatus vermiculatus	1	1	1
Schoenoplectus americanus			1
Scirpus spp.		1	
Sequoia gigantea	1	1	
Sesuvium portulocostrum	1	1	
Sesuvium verrucosum	1	1	
Shepherdia spp.	1	1	
Sporobolus airoides	1	1	1
Sporobolus wrightii	1	1	
Suaeda depressa	1	1	
Suaeda fruticosa		1	
Suaeda moquinii			1
Suaeda suffrutescens	1	1	1
Suaeda torreyana	1	1	
Tamarix aphylla	1	1	1
Tamarix gallica	1	1	1
Tamarix parviflora			1
Tamarix pentandra		1	
Tamarix ramosissima			1
Washingtonia filifera	1	1	1
Xanthium strumarium			1
Yucca brevifolia			1

APPENDIX 4: DATA FIELDS AND DESCRIPTION

i02_NCCAG_Vegetation		
Field	**Data Type**	**Description**
***ID	Object Id	Auto generated by ArcMap
POLYGON_ID	Long	Unique ID for each vegetation polygon.
VEGETATION_NAME	Text	Name of the first phreatophytic vegetation species identified in the source feature (if applicable)
DOMINANT_SCIENTIFIC_NAME	Text	Scientific name of the dominant species (if applicable) of the mapped vegetation type.
DOMINANT_COMMMON_NAME	Text	Common name of the dominant species (if applicable) of the mapped vegetation type.
SOURCE_CODE	Text	Unique code for the source dataset; refers to original source of the boundary and attribute information (lookup in related i02_NCCAG_Sources table).
DATE_DATA_REFERS_TO	Date	Year the imagery was taken for mapping this vegetation polygon (note: defaults to first day of year).
COMMENTS	Text	Any user-provided comments.
LAST_MODIFIED_DATE	Date	Date record was last modified.
MODIFIED_BY	Text	Name of person who last modified the record.

i02_NCCAG_Wetlands		
Field	**Data Type**	**Description**
***ID	Object Id	Auto generated by ArcMap.
POLYGON_ID	Long	Unique ID for each wetland, stream, or seep and spring polygon.
WETLAND_NAME	Text	Name of the mapped wetland type.
ORIGINAL_CODE	Text	Original code for the wetland type.
SOURCE_CODE	Text	Unique code for the source dataset; refers to original source of the boundary and attribute information (lookup in related i02_NCCAG_Sources table).
DATE_DATA_REFERS_TO	Date	Year the imagery was taken for mapping this wetland polygon (note: defaults to first day of year).
COMMENTS	Text	Any user-provided comments.
LAST_MODIFIED_DATE	Date	Date record was last modified.
MODIFIED_BY	Text	Name of person who last modified the record.

i02_NCCAG_Sources		
Field	**Data Type**	**Description**
***ID	Object Id	Auto generated by ArcMap.
SOURCE_CODE	Text	Source data unique code.
SOURCE_NAME	Text	Source data name.
SOURCE_GROUP	Text	Source data type.
CITATION	Text	Source citation.
WEBSITE_URL	Text	Source URL.
REPORT_URL	Text	Source report or metadata URL.
DATA_ACCESS_URL	Text	Source data URL.
MINIMUM_MAPPING_UNIT_SQMETERS	Double	Minimum mapping unit as reported in the source metadata (in square meters).
OVERALL_CLASSIFICATION_ACCURACY_PERCENT	Double	The average of user's and producer's accuracy for the entire source dataset.
POSITIONAL_ACCURACY_METERS	Double	The positional accuracy as reported in the source metadata (in meters).
DATE_DATA_REFERS_TO	Date	Source publication date (note: defaults to first day of year).
COMMENTS	Text	Any user-provided comments.
LAST_MODIFIED_DATE	Date	Date record was last modified.
MODIFIED_BY	Text	Name of person who last modified the record.