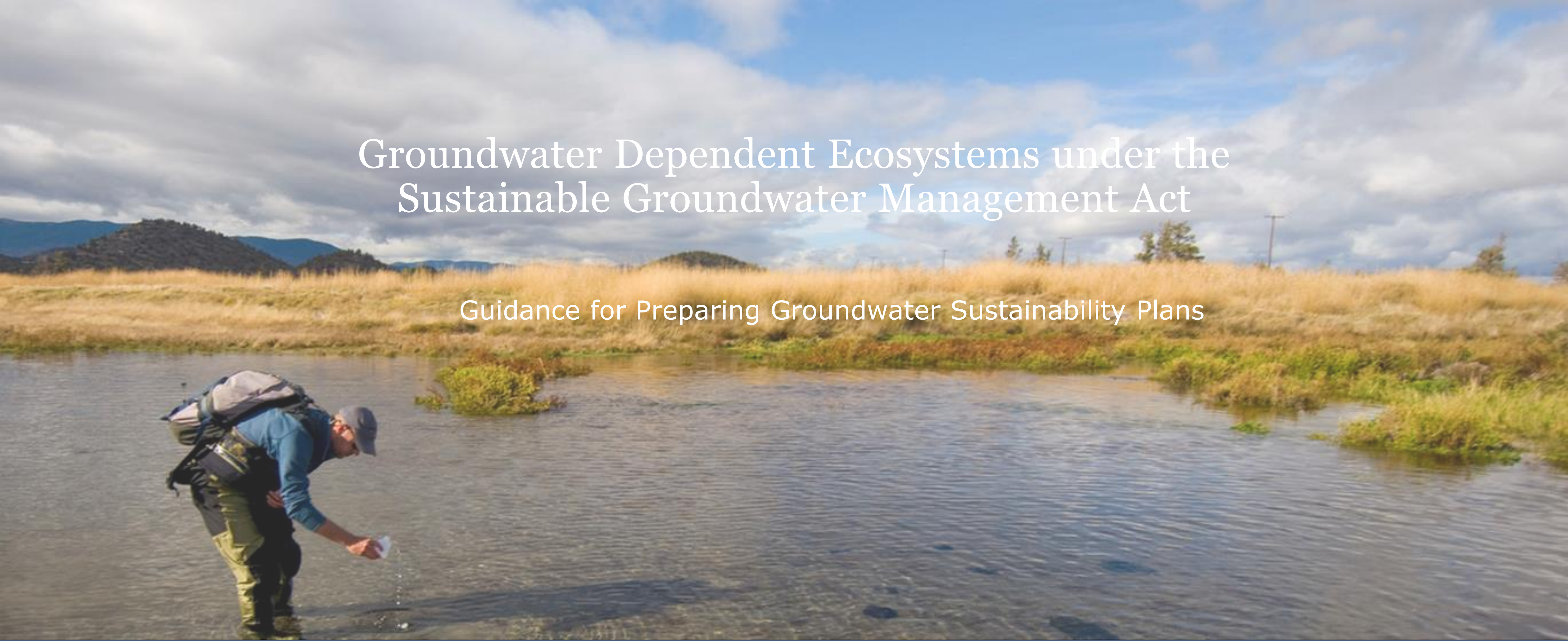
Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act

Guidance for Preparing Groundwater Sustainability Plans



The Nature Conservancy
Protecting nature. Preserving life.

MELISSA M. ROHDE
GROUNDWATER SCIENTIST
CALIFORNIA WATER PROGRAM
melissa.rohde@tnc.org

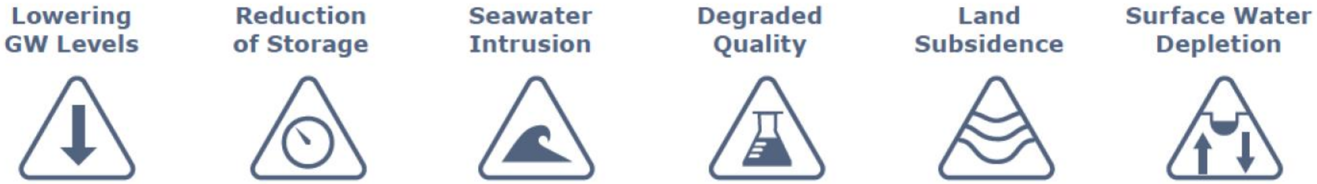
Groundwater-Dependent Ecosystems:

Ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.

The Sustainable Groundwater Management Act

Groundwater Dependent Ecosystems
(a beneficial use of groundwater) **are a required element for GSPs**

- identify (map)
- describe potential effects due to groundwater conditions
- monitor impacts due to groundwater conditions



OUR MISSION:

To conserve the lands and water on which all life depends

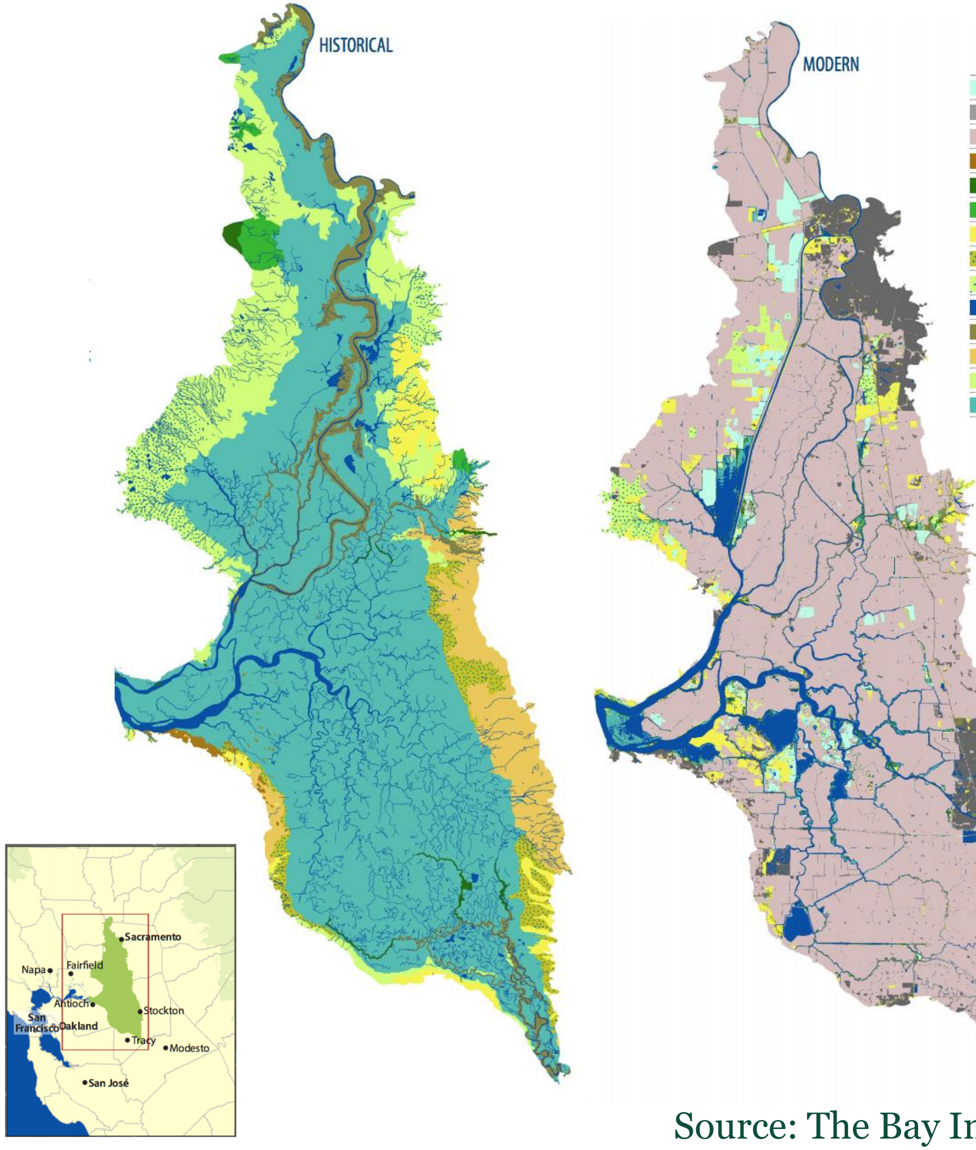


SANTA CLARA RIVER

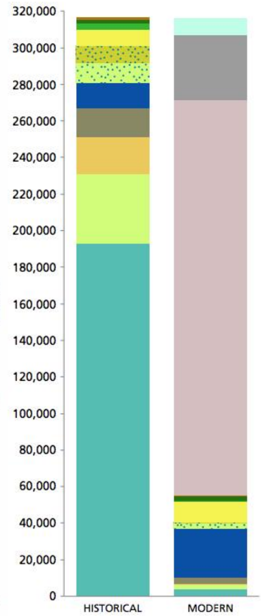
Depletions of Surface Water

< 5% of Wetlands
6% habitat along rivers

REMAIN



Habitat Type	Area (ha) Historical	Modern	% Change
Managed wetlands	0	9,454	∞
Urban/Barren	0	35,517	∞
Agriculture/Non-native/Ruderal	0	216,085	∞
Stabilized interior dune veg.	1,032	4	-99
Willow riparian scrub/shrub	1,637	2,878	+76
Willow thicket	3,567	132	-96
Grassland	9,108	11,800	+30
Alkali seasonal wetland complex	9,193	238	-97
Vernal pool complex	11,262	3,007	-73
Water	13,772	26,530	+93
Valley foothill riparian	15,608	4,010	-74
Oak woodland/savanna	20,460	0	-100
Wet meadow/Seasonal wetland	37,561	2,445	-93
Freshwater emergent wetland	193,224	4,253	-98



Habitat change. The extent of wetland habitats has decreased in the modern Delta while the extent of open water and grasslands has increased. Agriculture and managed wetlands make up a large portion of the modern Delta and provide some important wildlife support but are not equivalent to historical habitats. Oak woodlands and interior dune scrub have mostly been eliminated.

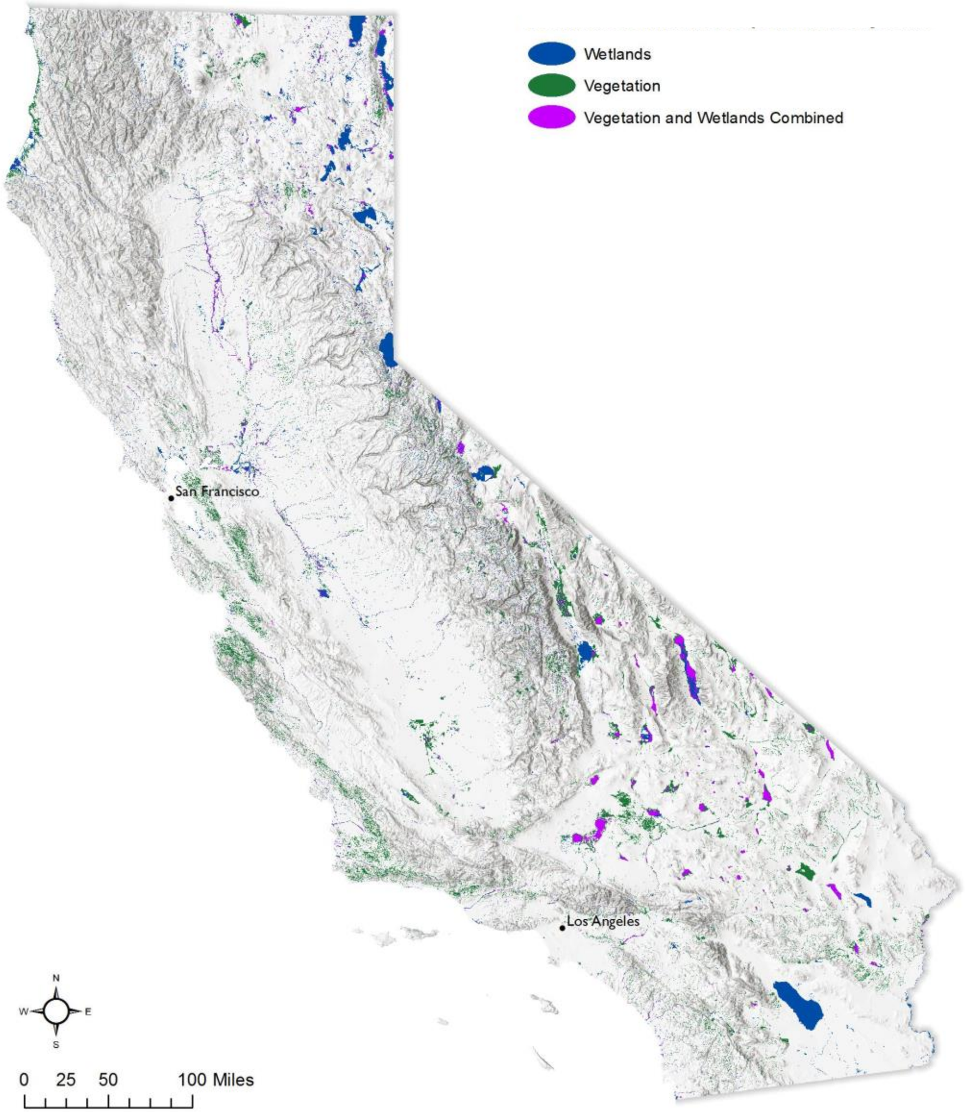
Source: The Bay Institute, 1998; SFEI-ASC, 2016

Aquatic Ecosystems

In 50 years, nearly **HALF** of California Native Salmon, Steelhead and Trout will be **Extinct**

Source: Moyle et al., 2017

MAPPING GDEs



OPEN ACCESS Freely available online
PLoS one

Mapping Groundwater Dependent Ecosystems in California

Jeanette Howard*, Matt Merrifield

The Nature Conservancy, San Francisco, California, United States of America

Abstract

Background: Most groundwater conservation and management efforts focus on protecting groundwater for drinking water and for other human uses with little understanding or focus on the ecosystems that depend on groundwater. However, groundwater plays an integral role in sustaining certain types of aquatic, terrestrial and coastal ecosystems, and their associated landscapes. Our aim was to illuminate the connection between groundwater and surface ecosystems by identifying and mapping the distribution of groundwater dependent ecosystems (GDEs) in California.

Methodology/Principal Findings: To locate where groundwater flow sustains ecosystems we identified and mapped groundwater dependent ecosystems using a GIS. We developed an index of groundwater dependency by analyzing geospatial data for three ecosystem types that depend on groundwater: (1) springs and seeps; (2) wetlands and associated vegetation alliances; and (3) stream discharge from groundwater sources (baseflow index). Each variable was summarized at the scale of a small watershed (Hydrologic Unit Code-12; mean size = 9,570 ha; n = 4,621), and then stratified and summarized to 10 regions of relative homogeneity in terms of hydrologic, ecologic and climatic conditions. We found that groundwater dependent ecosystems are widely, although unevenly, distributed across California. Although different types of GDEs are clustered more densely in certain areas of the state, watersheds with multiple types of GDEs are found in both humid (e.g. coastal) and more arid regions. Springs are most densely concentrated in the North Coast and North Lahontan, whereas groundwater dependent wetlands and associated vegetation alliances are concentrated in the North and South Lahontan and Sacramento River hydrologic regions. The percentage of land area where stream discharge is most dependent on groundwater is found in the North Coast, Sacramento River and Tulare Lake regions. GDE clusters are located at the highest percentage in the North Coast (an area of the highest annual rainfall totals), North Lahontan (an arid, high desert climate with low annual rainfall), and Sacramento River hydrologic regions. That GDEs occur in such distinct climatic and hydrologic settings reveals the widespread distribution of these ecosystems.

Conclusions/Significance: Protection and management of groundwater-dependent ecosystems are hindered by lack of information on their diversity, abundance and location. By developing a methodology that uses existing datasets to locate GDEs, this assessment addresses that knowledge gap. We report here on the application of this method across California, but believe the method can be expanded to regions where spatial data exist.

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* E-mail: Jeanette_howard@tnc.org

Introduction

Only , 1% of freshwater resources on the Earth's surface are contained within surface waters – such as rivers, lakes, and swamps. The remaining 99% is stored in either icecaps/glaciers (69%) or in groundwater (30%). Because of groundwater's accessibility and quantity, groundwater is a vital source of freshwater for human communities throughout the world [1], [2], [3].

In the U.S. and other developed countries, the value of groundwater for drinking water, irrigation, and industry is reflected in government policies that control groundwater availability and quality (e.g. U.S. EPA 2002). Some governments, including Australia [4] and European countries through The European Union (EU) Groundwater Directive (GWD Directive 2006/118/EC) [5] also now require the ecological condition of groundwater ecosystems to be considered when making policy decisions. However, in the U.S. few or no policies consider groundwater dependent ecosystems when allocating resources.

Most groundwater conservation and management efforts focus on protecting groundwater for drinking water and for other human uses with little understanding or focus on the ecosystems that depend on groundwater. The disconnect between ecological and human uses of groundwater is key as it suggests that policies and regulations that protect groundwater for human purposes may not necessarily protect groundwater dependent ecosystems (GDEs).

Although groundwater monitoring is incomplete in many parts of the world, available data suggest that groundwater supply and quality are widely threatened by over-extraction and contamination [1]. This loss and degradation are likely to increase in the future, as a result of climate-change-induced drought and human population growth, with serious consequences for both people and ecosystems [1].

GDEs UNDER SGMA:
What's true?

MISCONCEPTION #1

SGMA is going to require GDEs to be restored to pre-settlement conditions


Redwood Logging


Walnut Orchard, Orange County, 1938

MISCONCEPTION #2

All impacts to GDEs are the responsibility of GSAs.

LITTLE TO NO IMPACT

Healthy Ecosystem

SHORT-TERM ADVERSE IMPACTS

Water Stress

PROLONGED ADVERSE IMPACTS

Reduced Growth

Reduced Reproduction

Habitat Loss

SEVERE ADVERSE IMPACTS

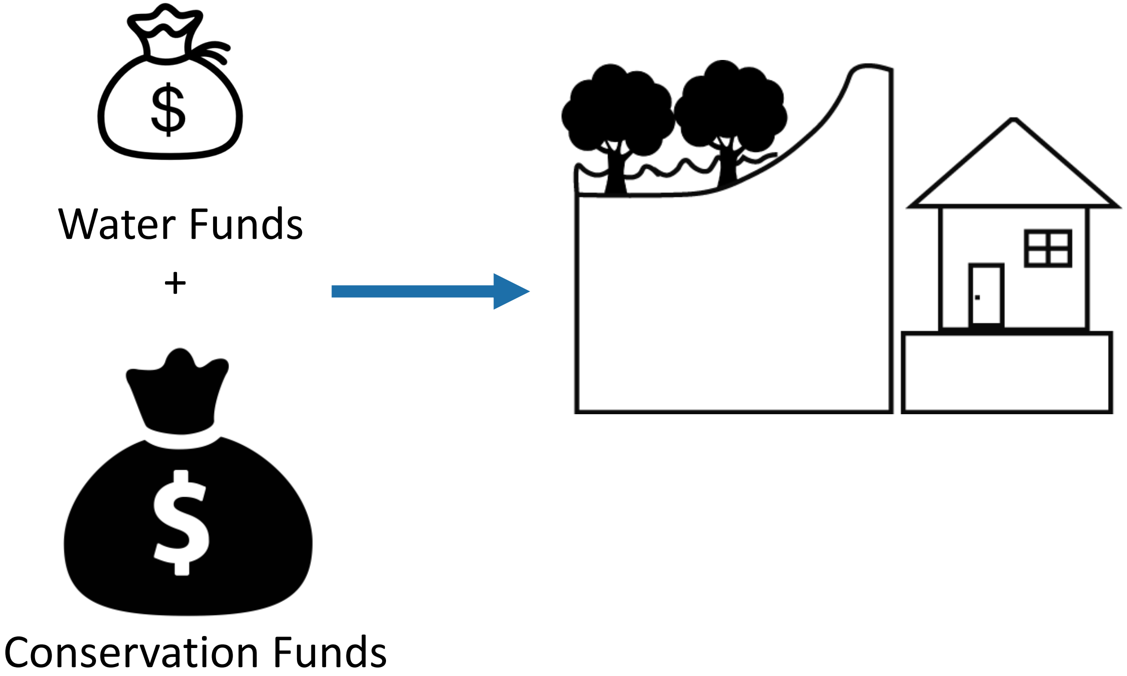
Ecosystem Collapse

OPTIMAL — GROUNDWATER CONDITIONS — POOR

MISCONCEPTION #3

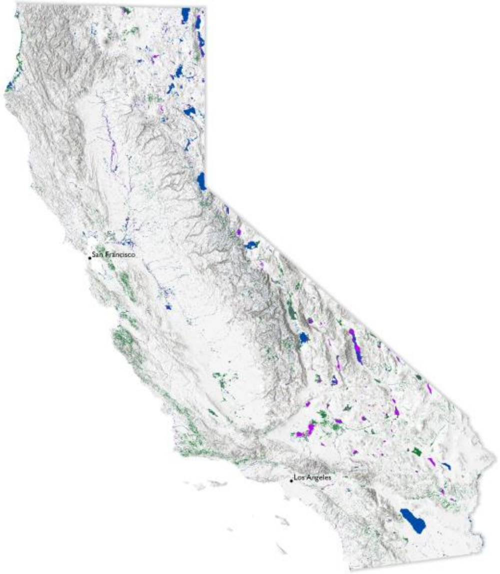
Protecting GDEs will cost too much.

Multi-Benefit Approach

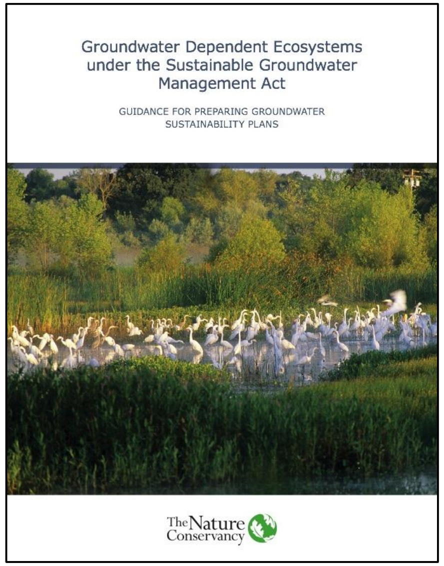


GDE TOOLS

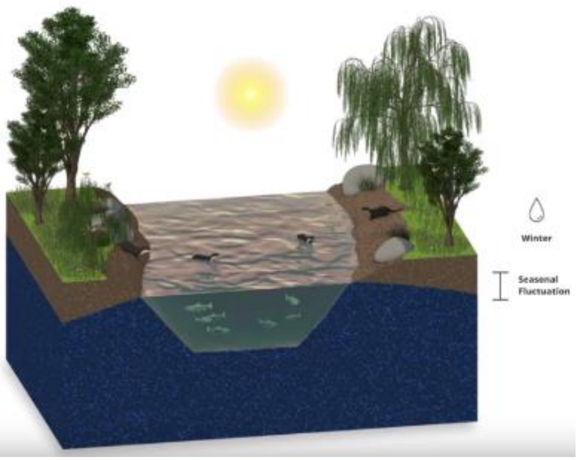
Statewide GDE Indicators Database



GDE Guidance for GSPs

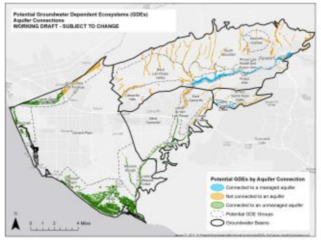


Educational Resources



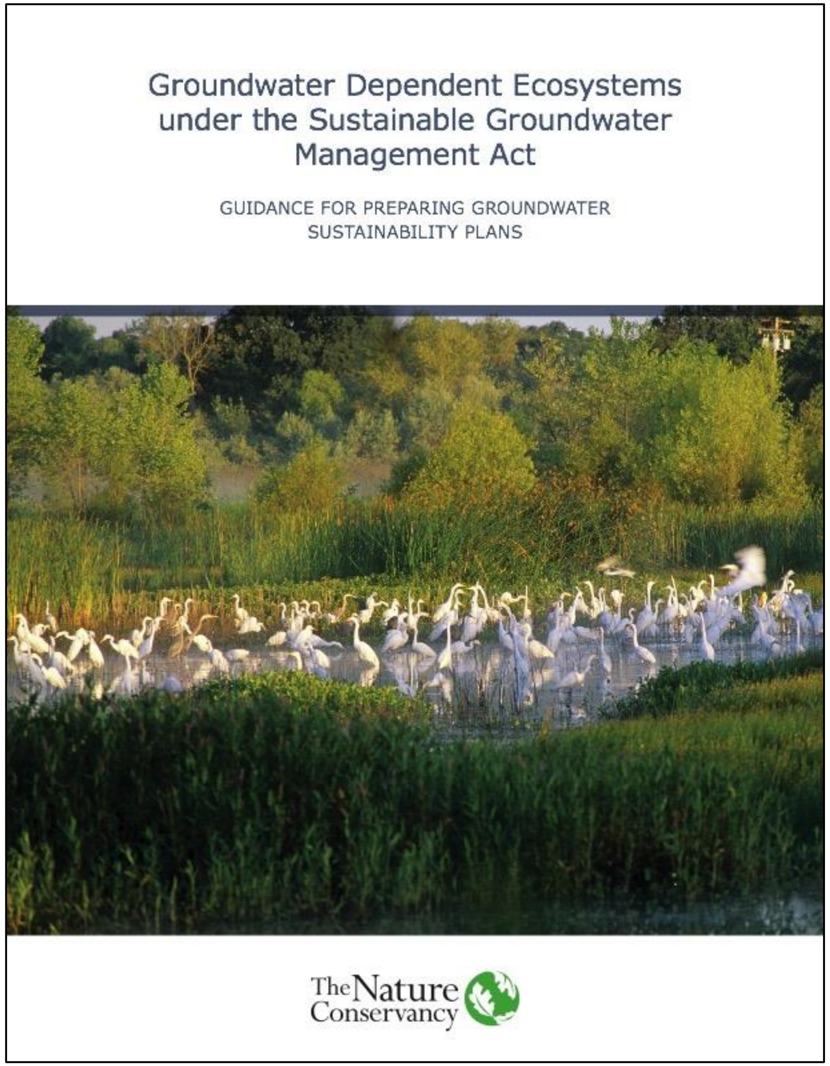
Data & Research

Case Studies



www.GroundwaterResourceHub.org

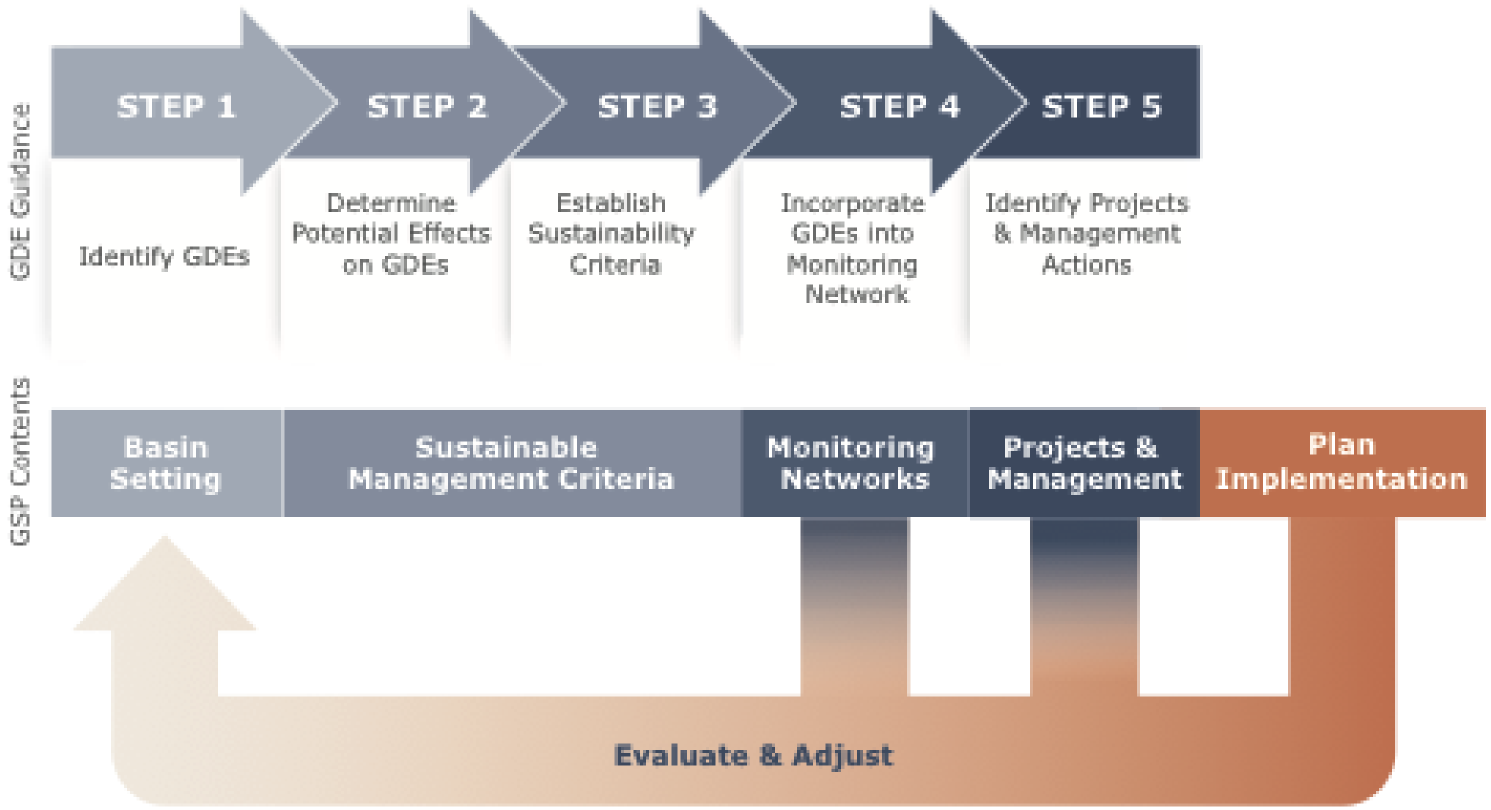
GDE GUIDANCE DOCUMENT



DESIGN PRINCIPLES:

1. Consistent with SGMA & GSP Regulations
2. Based on Best Available Science
3. Facilitate Local Control
4. Practical and Easy-To-Use

GDE GUIDANCE DOCUMENT



Customizable

PRACTICAL RESOURCES

BOX 5. WHAT YOU NEED

STATEWIDE DATA

- **Critical Habitat for Threatened and Endangered Species**
  The Environmental Conservation Online System (ECOS) contains spatial data of critical habitat for threatened and endangered species. The ECOS spatial data can be downloaded as shapefiles.

  http://ecos.fws.gov/ecp/report/table/critical-habitat.html

- **California Special Status Species**
  The California National Diversity Database (CNDDB) contains text and spatial information on California's special status species. The CNDDB spatial data can be downloaded as a shapefile or accessed via the BIOS Data Viewer. Users must have a CNDDB subscription to access RareFind and CNDDB spatial data downloads.

  https://www.wildlife.ca.gov/Data/CNDDB/Maps-and-Data#43018407-rarefind-5

- **California Protected Areas**
  The California Protected Areas Data Portal (CPAD) contains spatial information about lands that are protected for open space purposes by more than 1,000 public agencies or non-profit organizations. The CPAD spatial downloadable GIS data contain shapefiles and geodatabases.

  http://www.calands.org/data

- **Areas of Conservation Emphasis**
  The Areas of Conservation Emphasis (ACE) Project contains spatial data on native species richness, rarity, endemism, and sensitive habitats for six taxonomic groups: birds, fish, amphibians, plants, mammals, and reptiles. Information on the location of four sensitive habitat types (i.e., wetlands, riparian habitat, rare upland natural communities, and high-value salmonid habitat) are also summarized. The ACE dataset is available statewide at a 2.5-square-mile hexagon grid. The ACE spatial data are available online or downloadable for GIS.

  https://www.wildlife.ca.gov/Data/Analysis/ACE

LOCAL DATA

- **Beneficial Use Designations**
  Regional Water Quality Control Board basin plans contain a list of beneficial uses of surface waters, groundwater, marshes, and wetlands that pertain to water quality objectives. According to the State Water Resources Control Board, "beneficial use designations for any given water body do not rule out the possibility that other beneficial uses exist or have the potential to exist."

  http://www.waterboards.ca.gov/plans_policies/#plans

- **Local Plans or Studies**
  Local plans or studies (e.g., habitat conservation plans, conservation plans, wildlife corridor plans, ecological and biological assessment studies, natural resource management plans developed for specific areas) often contain descriptions and assessments of the species and habitat for specific areas.

- **Takes advantage of local and statewide information to inform local decision making**
- Summary of relevant science
- Worksheets

PRACTICAL RESOURCES

APPENDIX IV: GDE ASSESSMENT TOOLBOX

This table provides a summary of the methods and approaches used in Australia to identify GDEs and determine their reliance on groundwater (modified from Richardson et al. 2011). Citations for case study examples and key references related to the assessment tools below can be found in Richardson et al. (2011).

Assessment Tool	Description	Data Sources/Methods	Pros	Cons
Landscape Mapping	• Location and identification of ecosystems that are potentially groundwater dependent based on biophysical parameters (i.e., depth to water table, soil type, vegetation type) • Assessment of primary productivity, water relations, and/or condition of vegetation communities using remote sensing images to infer use of groundwater	• Native vegetation cover, wetlands, and drainage maps • Vegetation composition • Root depth • Geol[...] struc[...] • Grou[...] and e[...] table • Land[...] • Soil t[...] • Vege[...] • Leaf [...]	• Provides a map/list of potential GDE areas • Utilizes available local, state, federal, and worldwide datasets	• Analysis needs to be repeated over time since data offers one time slice • Some components rely on prior knowledge or datasets
Conceptual Modeling	• Documentation of a conceptual understanding of the location of GDEs and interaction between ecosystems and groundwater • Qualitatively links hydrologic, soil, and climate processes to GDE elements and processes • Clarifies the relationships and interactions between hydrology and ecology	• Hydr[...] boun[...] grou[...] • Clima[...] • Geol[...] • Land[...] • Topo[...] eleva[...] • Gene[...] desc[...] • Vege[...] • Profe[...] sever[...] • Scier[...] • AB 3[...] Mana[...]		

TABLE 2. Examples of measurable thresholds and objectives for GDEs under water management regimes outside SGMA.
Note: The thresholds listed here were compiled from published scientific literature or from water management standards and are provided as examples only. GDE thresholds are location specific and will vary based on differences in species composition, soil type, local climate, and hydrologic regime, among other factors.

Measurable Thresholds and Objectives	Observed Biological Change or Rationale	Location (Reference)
GROUNDWATER LEVELS		
Depth to water of 2 m for grasslands and 4 m for shrub	Maintain groundwater levels to support terrestrial vegetation based on maximum effective depth of rooting and confirmed by soil water and annual vegetation conditions.	Inyo County, California (Inyo County and City of Los Angeles 1990)
75th percentile of maximum depth to water table	Based on quantitative relationships between the position of the water table and wetland indicator plant species. A maximum depth to water table of 0.9–34.8 cm for fen plants and 16.6–32.2 cm for peat accretion can be tolerated in these wetlands.	Fremont-Winema National Forest, Oregon (Aldous & Bach 2014)
Average decline in groundwater levels must not exceed 30 feet over the next 50 years	Limit the decline in groundwater elevation to provide for sustainable yield.	Dockum Aquifer, Texas (TWDB 2016)
INTERCONNECTED SURFACE WATER		
Water level decline at the GDE level not to exceed 0.05 m/year	Groundwater flows will no longer support functioning wetlands due to chronic lowering of groundwater levels.	Tindall Limestone Aquifer, Katherine, Australia (Christian-Smith & Abhold 2015)

PRACTICAL RESOURCES

- Takes advantage of local and statewide information to inform local decision making
- **Summary of relevant science**
- Worksheets

WORKSHEETS

WORKSHEET 1. ASSESS A CONNECTION TO GROUNDWATER

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Use the following questions to assess whether iGDE polygons are connected to groundwater.	Yes	No	Insufficient Data
GENERAL QUESTIONS FOR ALL GDE TYPES			
Is the iGDE underlain by a shallow unconfined or perched aquifer that has been delineated as being part of a Bulletin 118 principal aquifer in the basin?			
Is the depth to groundwater under the iGDE less than 30 feet?			
Is the iGDE located in an area known to discharge groundwater (e.g., springs/seeps)?			
*If you answer **Yes** to any of the above questions, then you likely have a GDE. Stop here. If you selected **No** or **Insufficient Data** or cannot confidently answer any of the above questions, then answer the following questions to infer groundwater dependency.*			
RIVERS, STREAMS, AND ESTUARIES			
Is the iGDE located in a portion of a river or stream that is likely a gaining reach?			
Are water temperatures around the iGDE relatively constant over time, indicating a potential for gaining conditions?			
Are there stable/permanent natural flows detected by stream gauges near the iGDE, indicating a potential for gaining conditions?			
Is there water or flows around the iGDE during summer months?			
For iGDEs near estuaries, does the salinity drop below that of seawater in the absence of surface water inputs (e.g., surface runoff or stormwater)?			
Are the isohaline contour lines of the saline wedge relatively constant under an iGDE?			
WETLANDS			
Is the level of water around the iGDE maintained during extended dry periods without surface water inflow or management?			

WORKSHEET 3. POTENTIAL EFFECTS ON GDE SUMMARY

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GDE Unit ID_____________

Ecological Value (Step 1.2)—*Check the one that applies* ☐ High ☐ Moderate ☐ Low ☐ Insufficient Data/Not Applicable

Susceptibility to Changing Groundwater Conditions (Step 2.1)—*Check the one that applies*
☐ High ☐ Moderate ☐ Low ☐ Insufficient Data/Not Applicable

Corresponding Sustainability Indicator	Groundwater Levels	Groundwater Storage	Seawater Intrusion	Water Quality	Land Subsidence	Interconnected Surface Water
Hydrologic Data (Step 2.1)						
Baseline Average (Step 2.1)						
Baseline Range (Step 2.1)						
Biological Data (Step 2.2)						
Description of Adverse Impacts to GDE (Step 2.3)						

NEXT STEPS

Check out our website:
www.GroundwaterResourceHub.org

Designate an environmental representative on the GSA board – see our case study on the Hub!

Budget time (and funds) for GSA technical staff or consultant to use this document during GSP development

Help us help you! Give us feedback and questions about support needed.

melissa.rohde@tnc.org

Thank You