
CALIFORNIA
Traceland
ORGANIC
AVOCADOS
CREEK LANDS
Conservation
WESTERN
SARE
Sustainable Agriculture
Research & Education
Rehydration &
Restoration Workshop
Image 3/5/24

High Level Timeline

Ate Acorns at the LAVRA

201
9

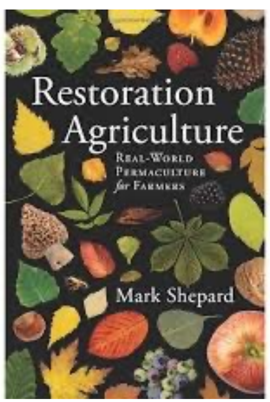
Creek Lands Conservation

202
1

Designed Rehydration System

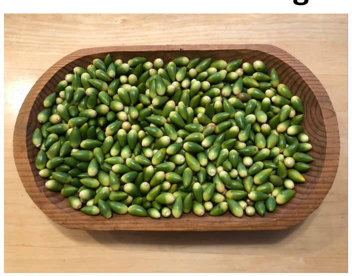
202
3

Developed Earthworks



202
0

First time harvesting acorns



WESTERN SARE
Sustainable Agriculture Research & Education

202
2

Started oak & walnut nursery

202
4

First Successful Oak Graft


Traceland Watersheds
Legend
Rehydration Watershed
Toro Creek Watershed
Traceland
9,000 acres
Cayucos
Morro Bay
Where are we?
• What is a watershed?
• Traceland is less than 1% of Toro
Google Earth
Image © 2024 Airbus
Data CSUMB SFML, CA OPC
2 mi

Agenda

1. **Concepts and Definitions**
    1. Thinking like a Watershed
    2. What is Rehydration?
    3. Biodiversity Conservation
    4. Broadscale Permaculture
2. **Design Principles**
    1. Keyline design
    2. Restoration Agriculture
    3. Oak Savanna Biomimicry

Field Trip

3. **Rehydration System Metrics**
    1. Design Details
    2. Dimensions
4. **Western SARE Farmer/Rancher Project**
    1. Objectives
    2. Results

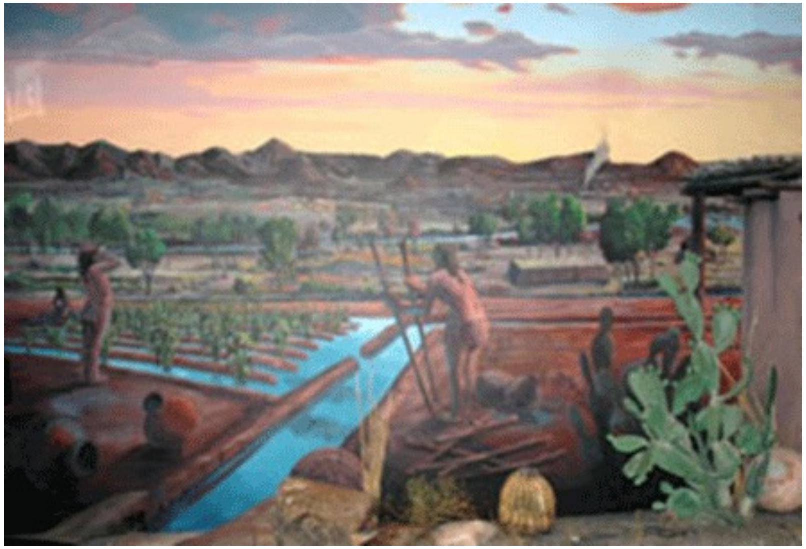
Historical Human Water Diversion

Sumerians

Tigris & Euphrates

6,500 to 4,100 BP

Anasazi



Rio Grande and Little Colorado

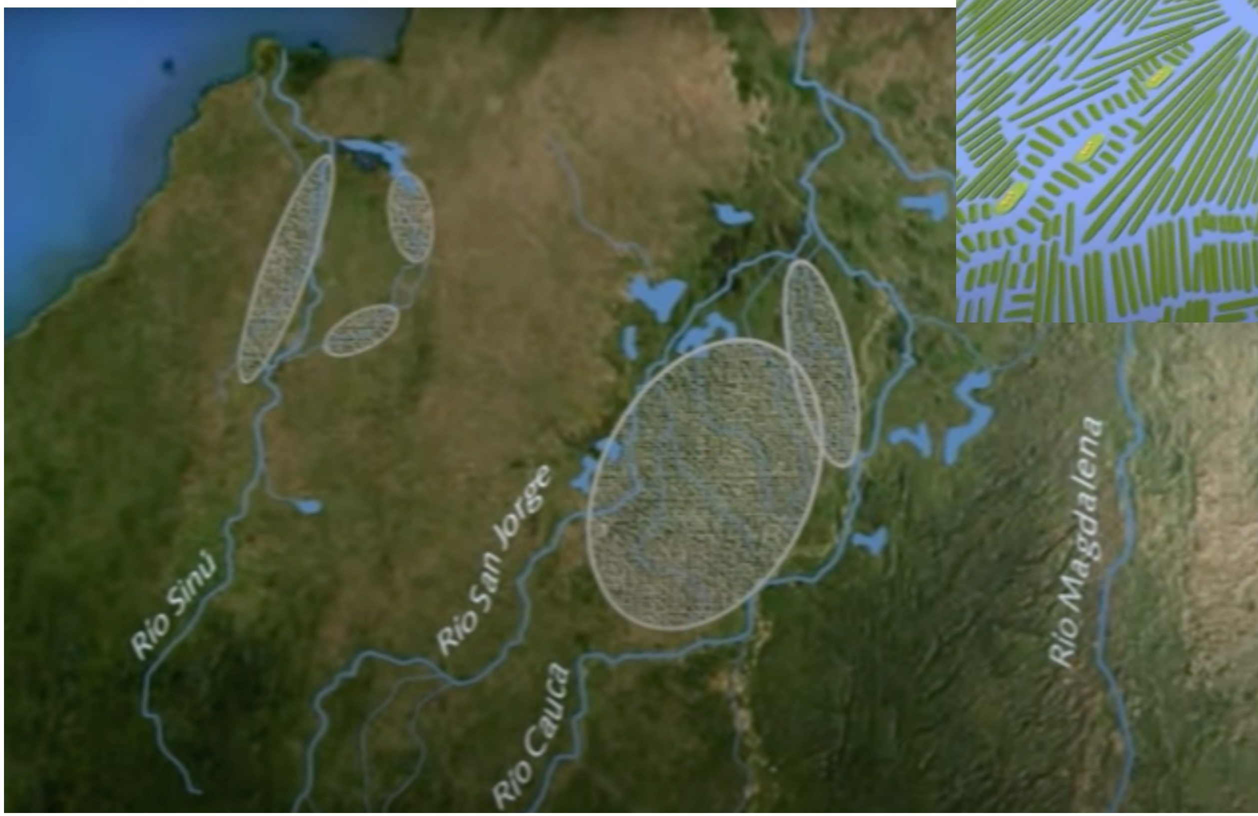
2,200 BP to 700 BP

Desert Climates

Capturing Water and Sediment


The Sinu River &
The Sinu Society
2,200
BP to
800 BP
Tropical Highland Savanna

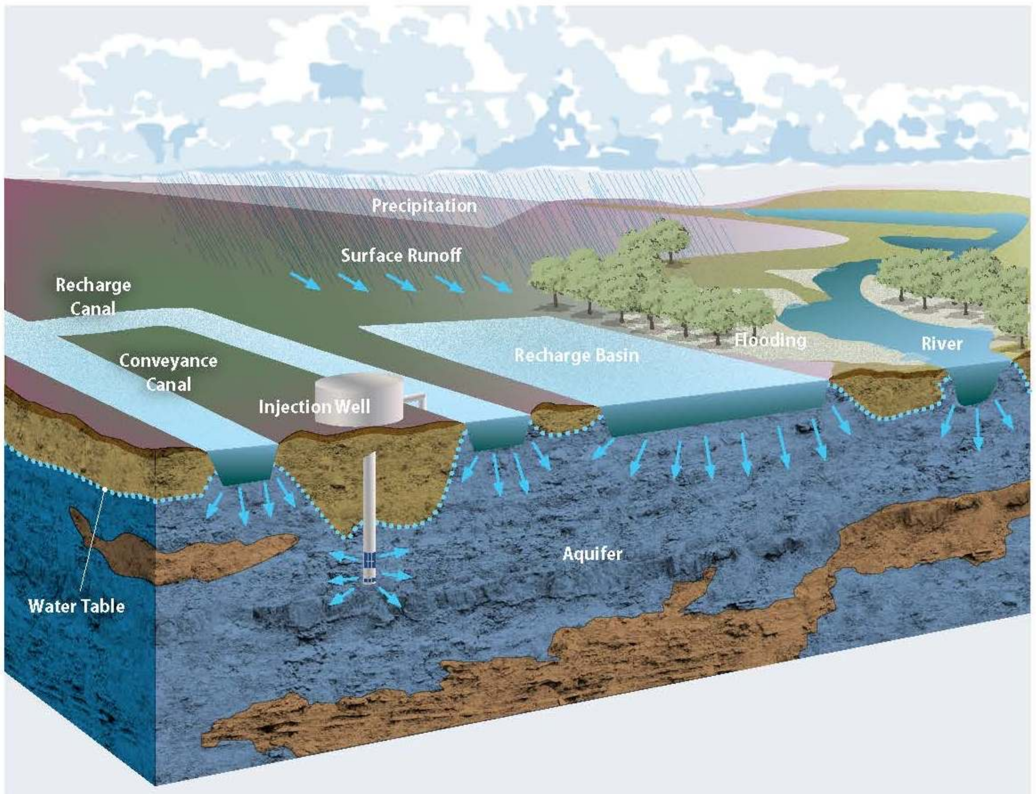
Northern Colombia



A system of **surface water diversion** developed to slow, spread and sink the water to **capture sediments**, catch fish and increase plant growth.

https://www.youtube.com/watch?v=ylg33zx1CvI&ab_channel=MuseodelOroColombia

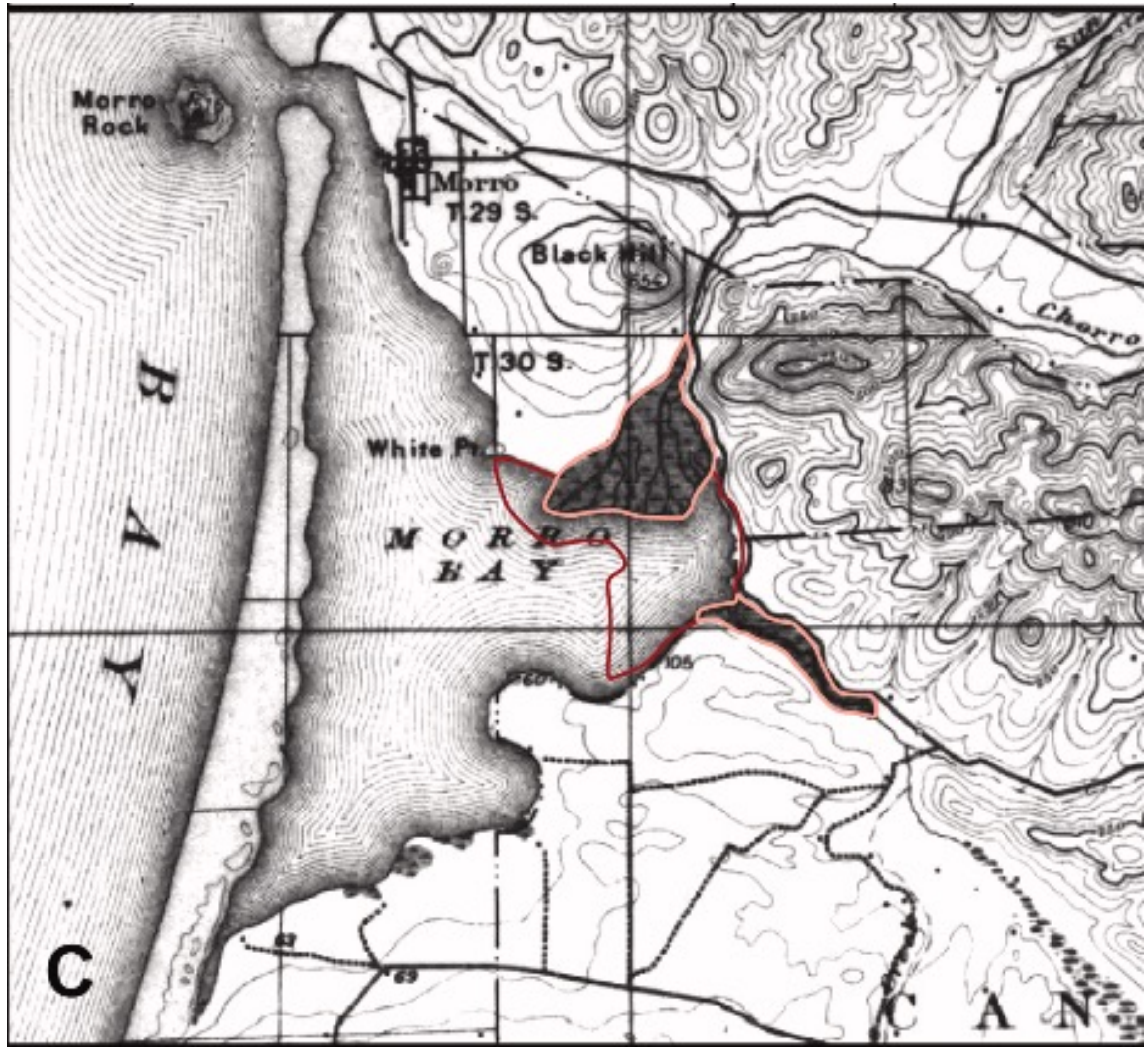
What is Rehydration?



The diversion of stormwater or runoff away from its natural path to achieve a certain goal:

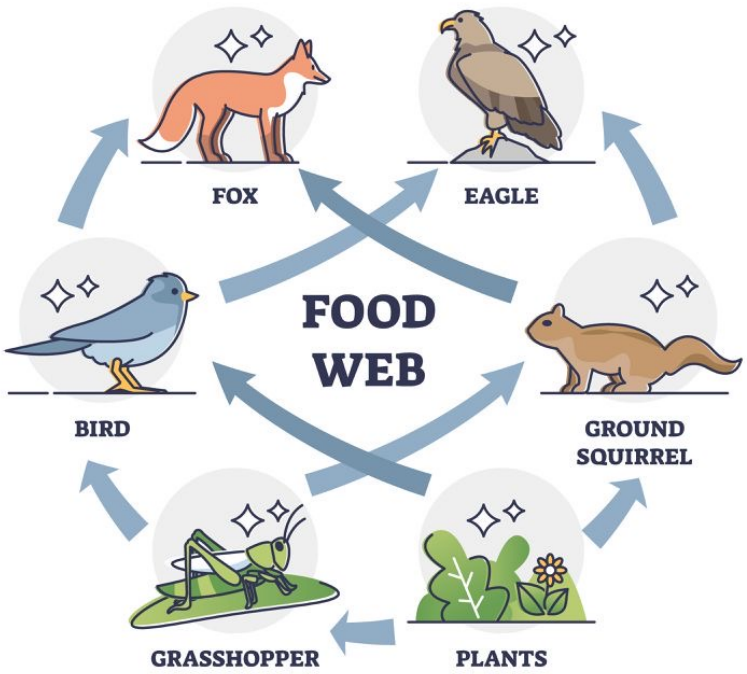
- Aquifer recharge
- Habitat restoration
- Flood control
- Prolong late season stream flows
- Sediment Capture
- Passively irrigate perennial-agricultural

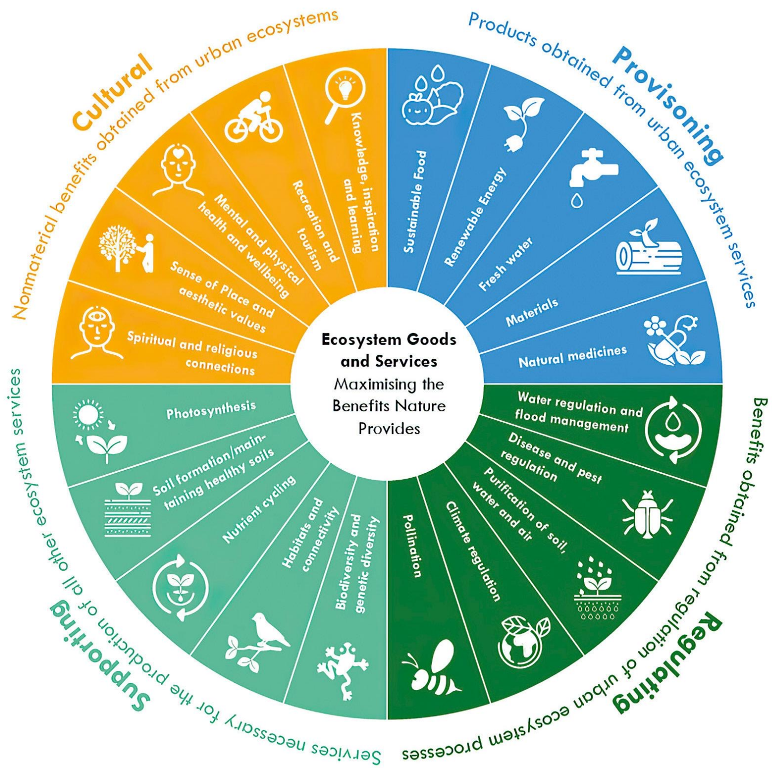
Historical map showing the extent of the Morro Bay salt marsh (MBSM) in 1897 CE (United States Geological Survey, 1903).



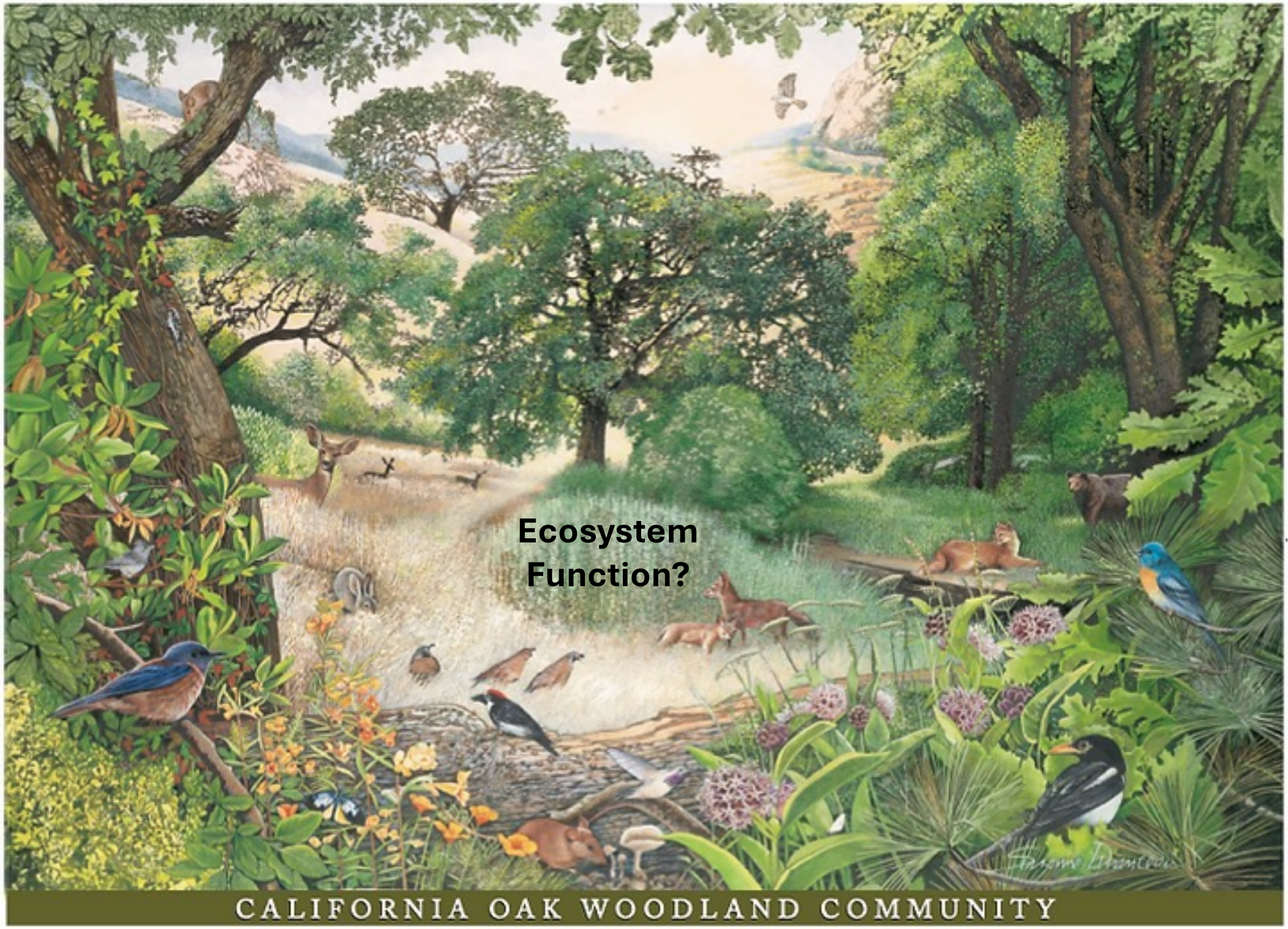
Google Maps imagery of the MBSM region from 2017 CE, showing expanded salt marsh extent since 1897 CE.

Why is Biodiversity Important?





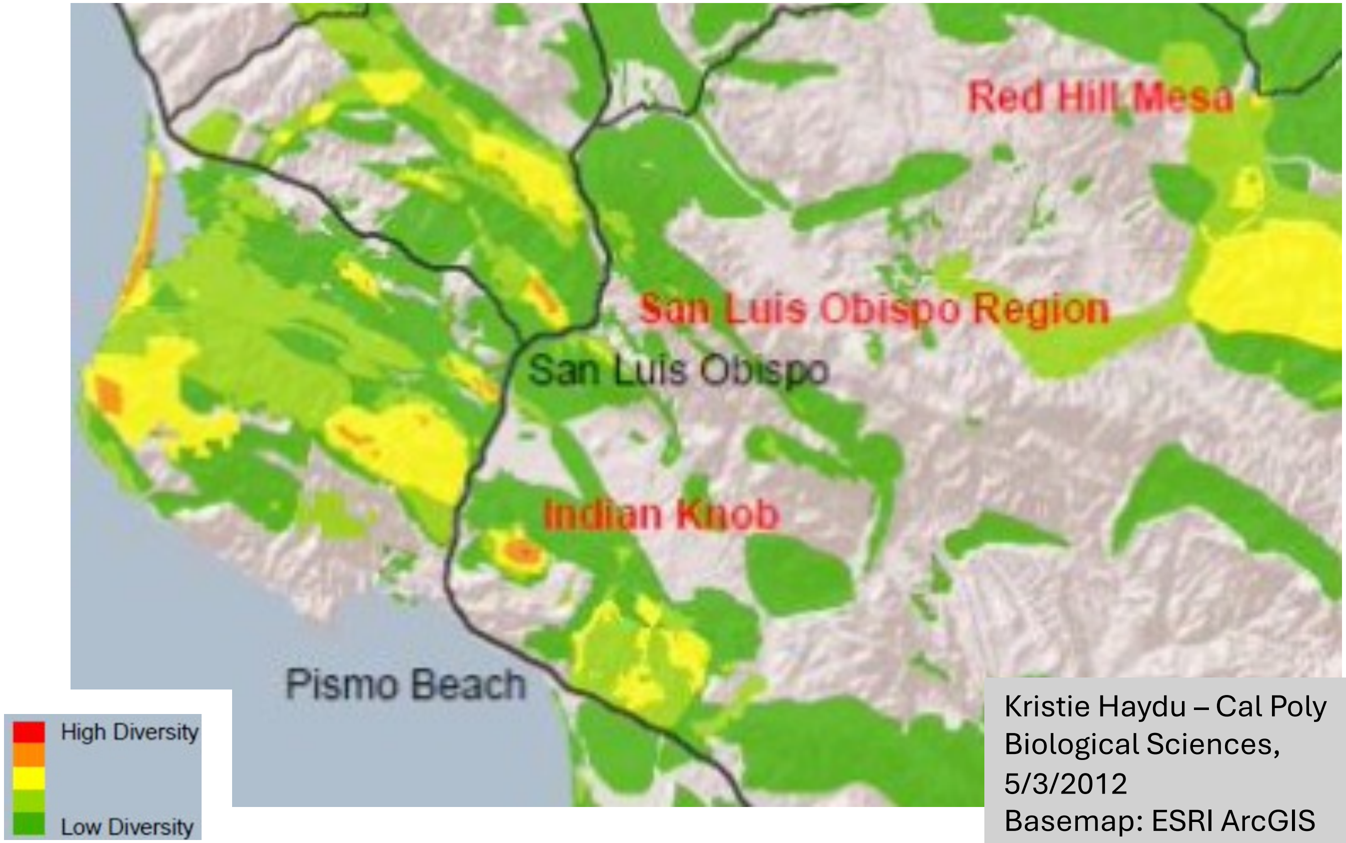
In California, at least **300 terrestrial vertebrate** species (Block, Morrison, and Verner 1990), **1,100 native vascular plant** species (CalFlora Database 1998), **370 fungal** species and an estimated **5,000 arthropod** species (Swiecki et al. 1997a) are associated with California oak woodlands.



Endangered Species

California Plant Diversity

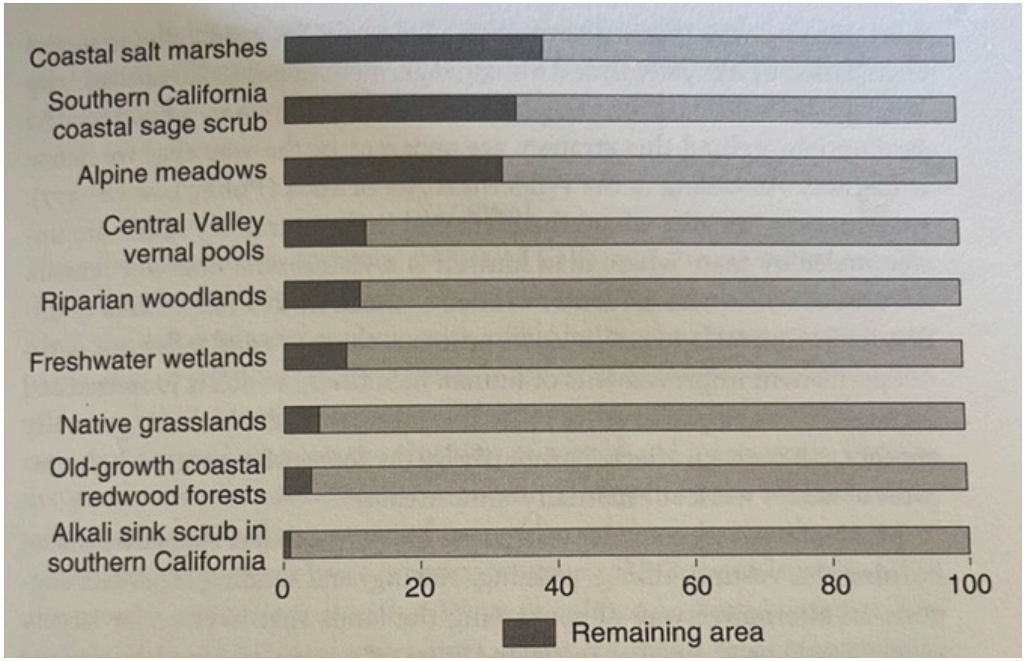
Mapping Plant Biodiversity Hotspots at the county scale



Kristie Haydu – Cal Poly Biological Sciences, 5/3/2012
Basemap: ESRI ArcGIS Online,2009

Special Status Plant Collections:

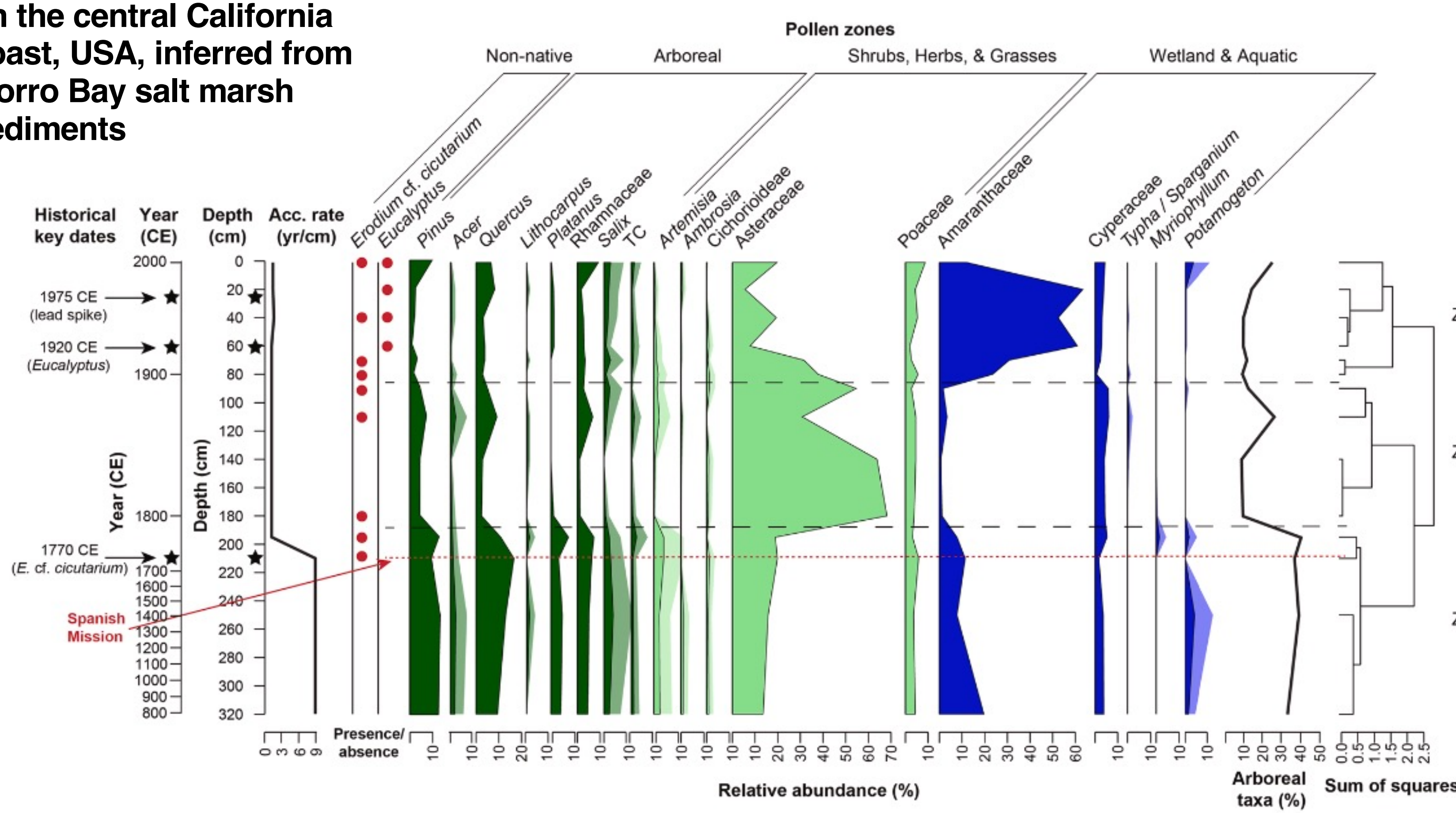
Hoover Herbarium (OBI) Cal Poly 177 Species – 1599 Digitized


Coastal salt marshes
Southern California coastal sage scrub
Alpine meadows
Central Valley vernal pools
Riparian woodlands
Freshwater wetlands
Native grasslands
Old-growth coastal redwood forests
Alkali sink scrub in southern California
0
20
40
60
80
100
Remaining area


Tending the Wild

Late Holocene human-environment interactions on the central California coast, USA, inferred from Morro Bay salt marsh sediments

A Window to the Past



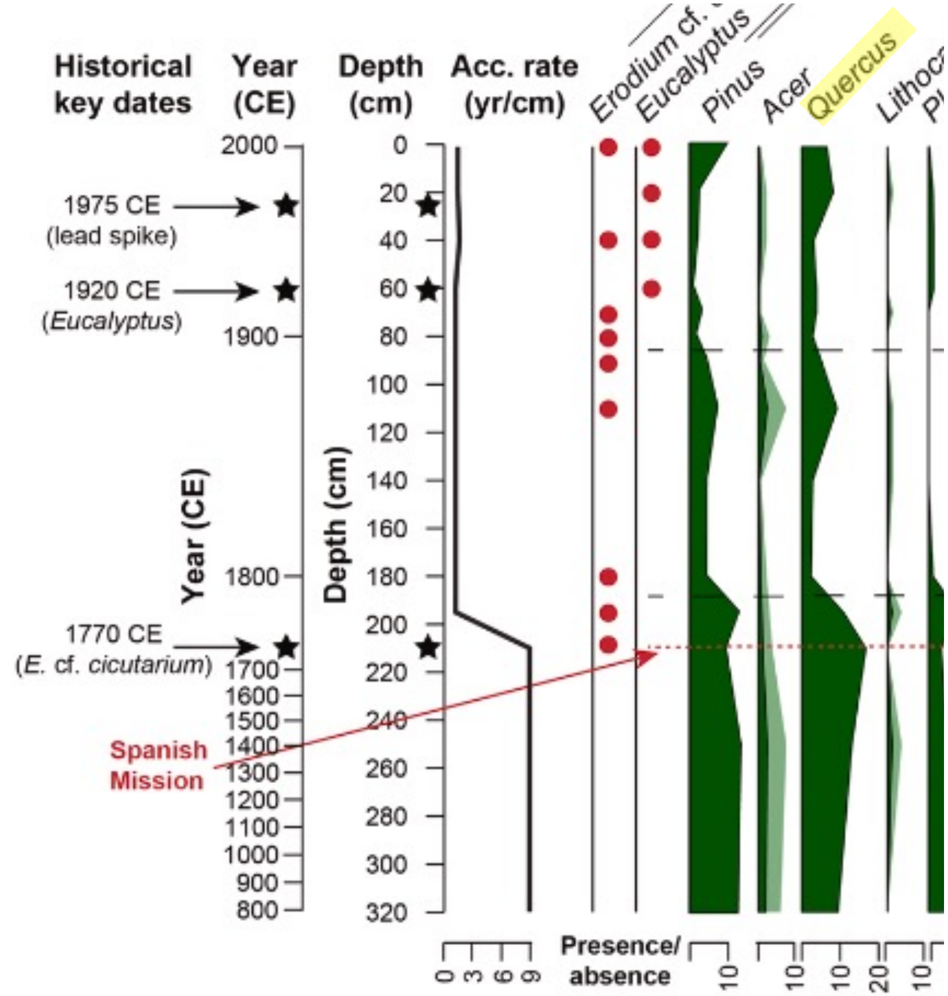


Fig. 6. Relative abundance of dominant and ecologically or historically important pollen taxa in Chorro marsh core **Morro-02**, shown with approximate ages inferred from pollen and lead (Pb) that were used in the corresponding age-depth model in Fig. 2, and with sediment accumulation rate in years per centimeter. The percentage of arboreal taxa in the total pollen and spore count is also shown. Though "non-native" pollen types as shown here include only Erodium cf. cicutarium and Eucalyptus, some members of the Asteraceae and Poaceae families included in these data are likely also non-native. Dashed black lines delineate the CONISS-designated clusters shown on the right, and the red dashed line shows the approximate timing of Spanish settlement and the establishment of the Mission San Luis Obispo de Tolosa. Data were analyzed and plotted using the R packages Rioja (v.0.9–26; Juggins, 2017) and Vegan (v.2.5–7; Oksanen et al., 2007). The abbreviation "TC" includes taxa in the Taxaceae and Cupressaceae families (Adam et al., 1981).

Food For Thought

1/3 of all food in the U.S. is wasted and goes to a landfill.

Imagine if we replaced that 1/3 with wildlife habitat

Geoff Lawton

"Permaculture is a design system for ecological and sustainable living, integrating plants, animals, people, buildings, and communities.

There is nothing wrong with having several definitions, as long as you understand the core principles, the ethics, and the applications of permaculture."

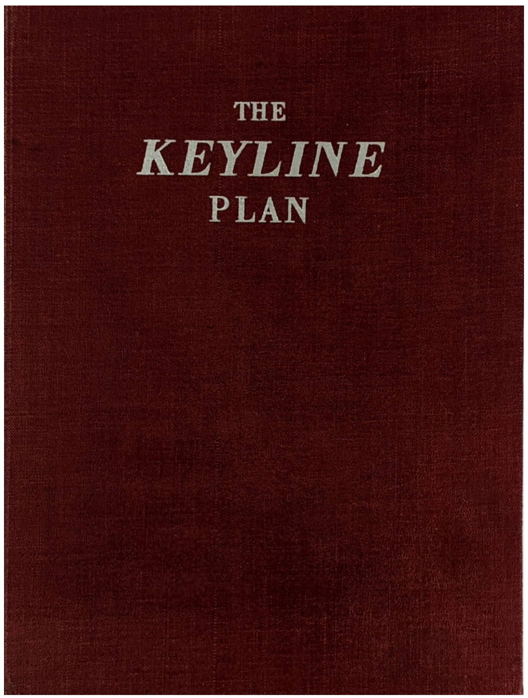
Permaculture

Broad Scale - Permaculture

New Forest Farm - Viola, Wisconsin
Keyline Farm Design

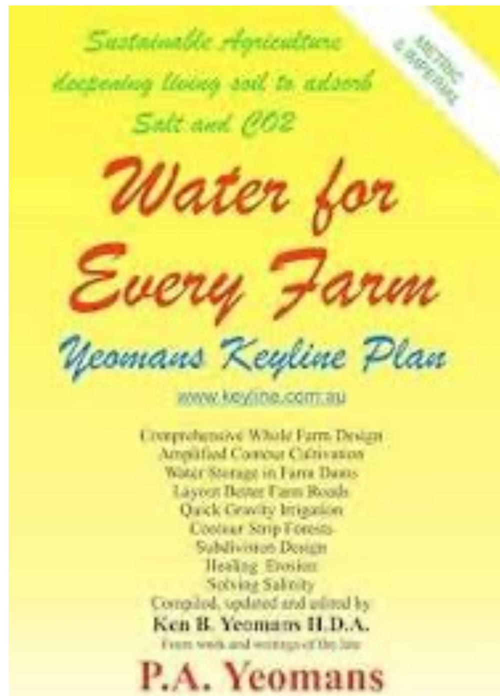
Keyline Water Management

Percival Yeomans



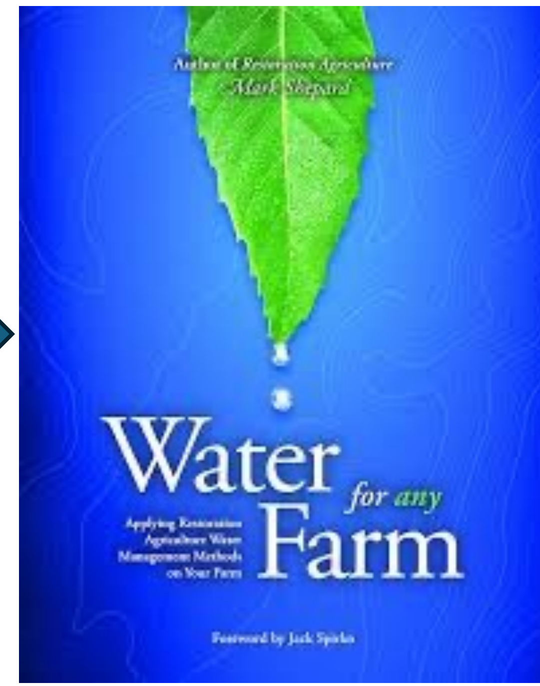
1954

Ken Yeomans

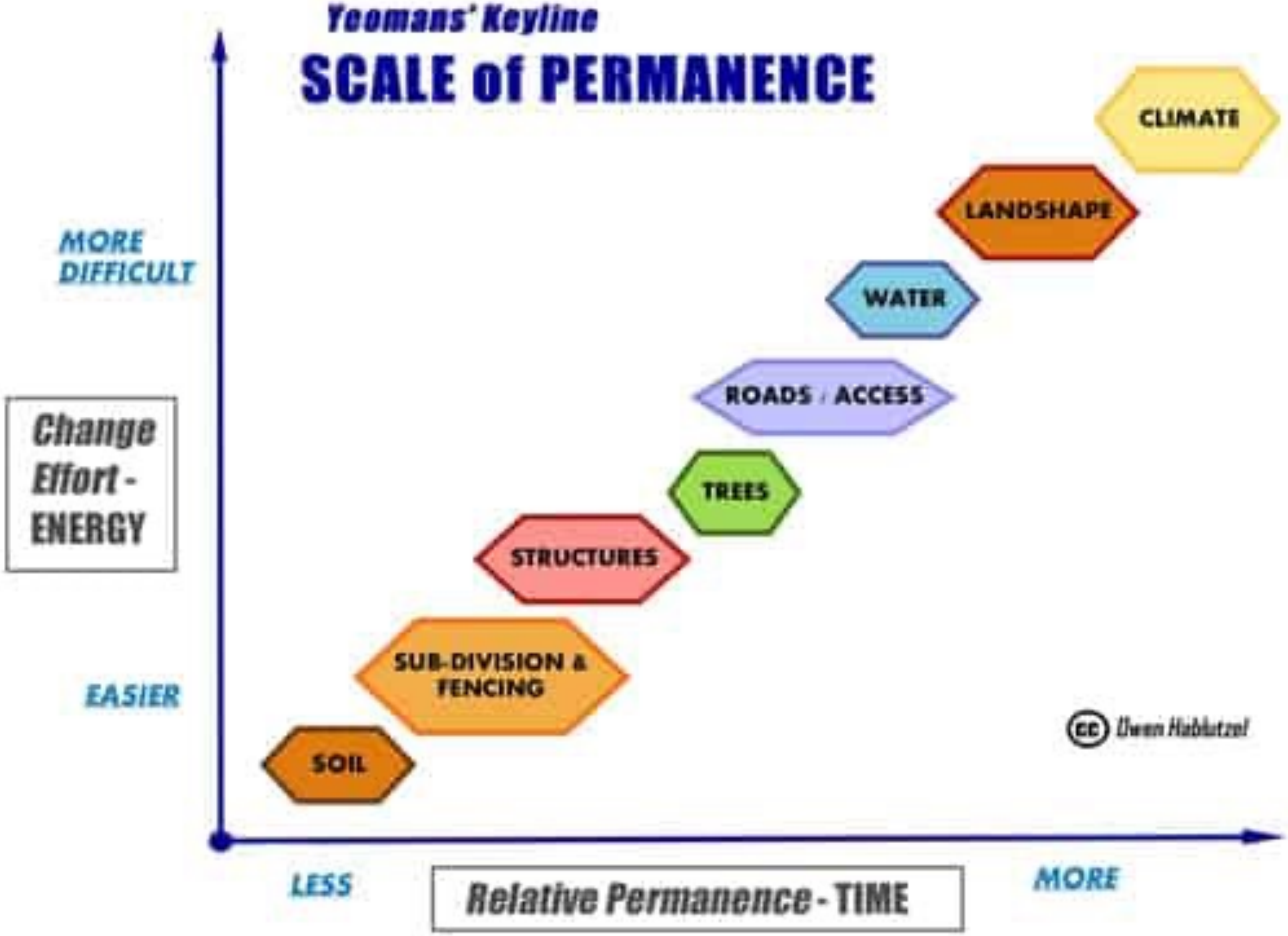


1965

Mark Shepard



2019


Yeomans' Keyline
SCALE of PERMANENCE
MORE DIFFICULT
EASIER
Change Effort - ENERGY
CLIMATE
LANDSHAPE
WATER
ROADS / ACCESS
TREES
STRUCTURES
SUB-DIVISION & FENCING
SOIL
Owen Hablutzel
LESS
Relative Permanence - TIME
MORE


Water Management

The Keyline Plow


nationalatlas.gov™
Where We Are
PRECIPITATION
CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
CUBA
THE BAHAMAS
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
Average Annual Precipitation
(inches)
1961-1990
180.1-200
140.1-180
120.1-140
100.1-120
80.1-100
70.1-80
60.1-70
50.1-60
40.1-50
35.1-40
30.1-35
25.1-30
20.1-25
15.1-20
10.1-15
5.1-10
5 and less
Albers equal area projection
U.S. Department of the Interior
U.S. Geological Survey
The National Atlas of the United States of America®

Keyline Design Steps:

1. Land shape
- Observation

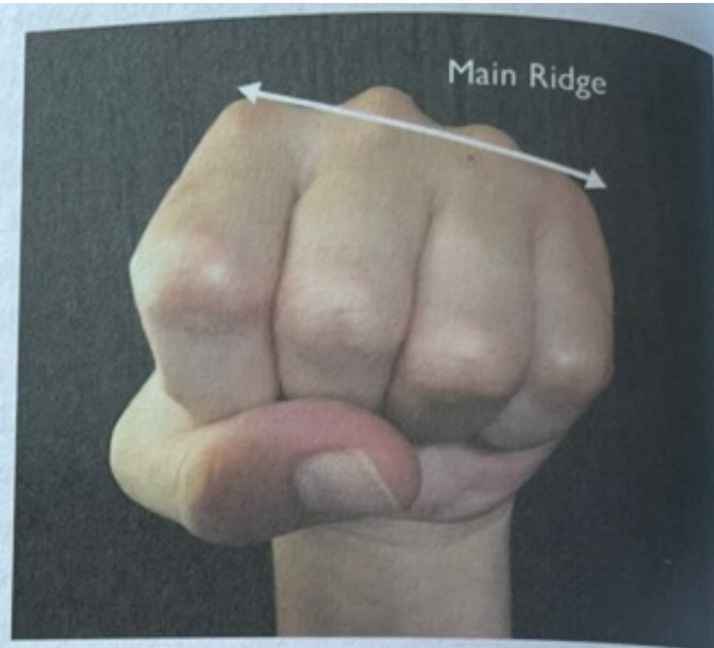
2. Slope
- Rise / Run

3. Infiltration / Runoff
- Perc test

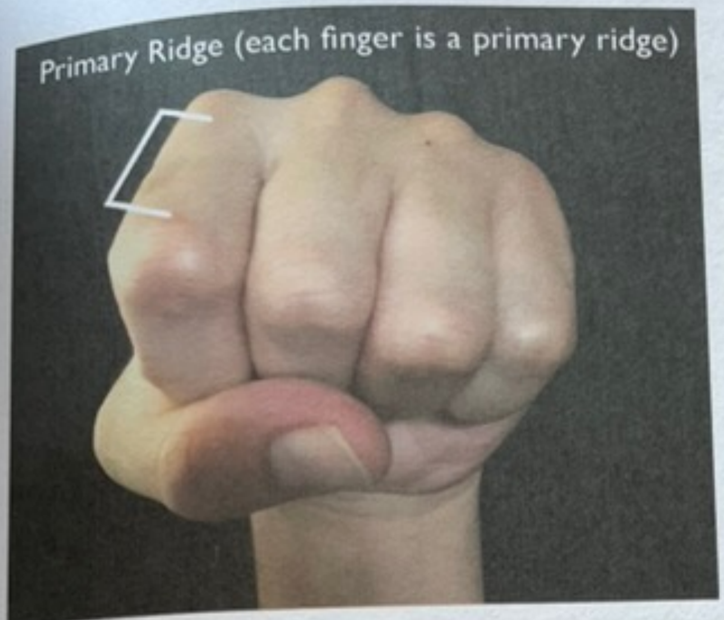
4. Evaporation rate
- Local reservoir

1. Land Shape

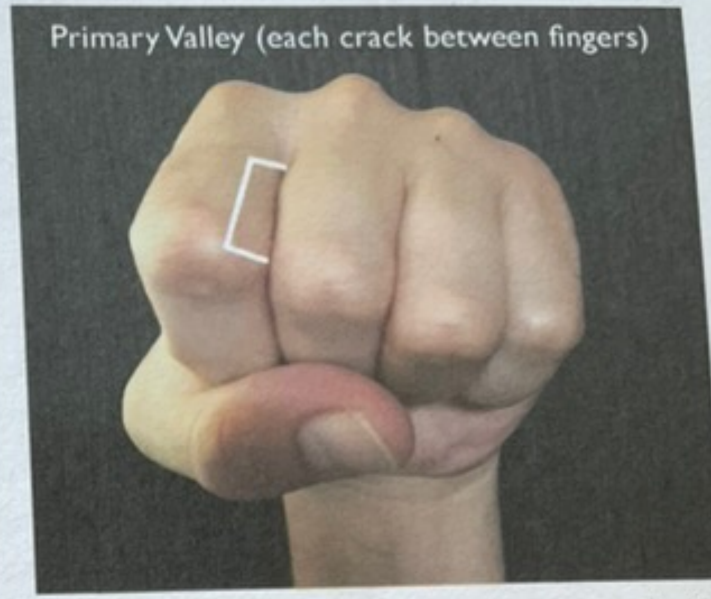
The human hand is an excellent tool for demonstrating the vocabulary describing land forms.



The line between your index finger knuckle and your pinky finger knuckle is the "main ridge" of your handscape.



Descending from each hill on the main ridge are "primary ridges."

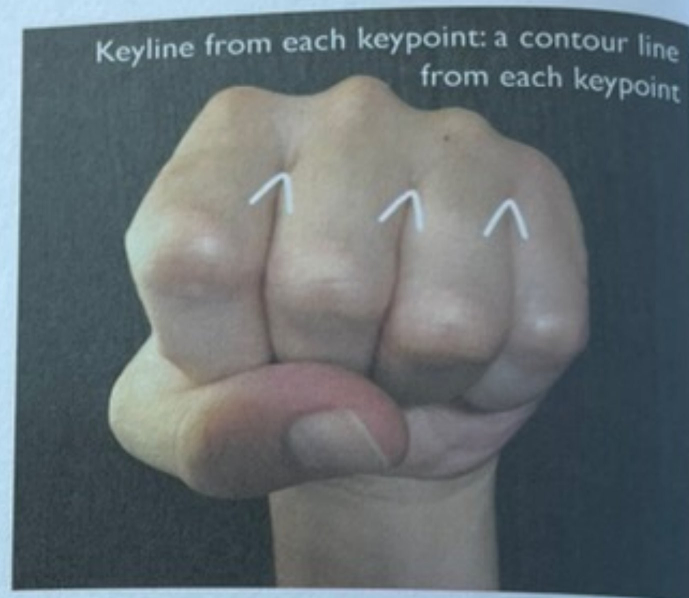


Descending from each saddle is a "primary valley." Water from the hills and saddles above, as well as from the sides of adjacent primary valleys migrates down into the primary valleys.

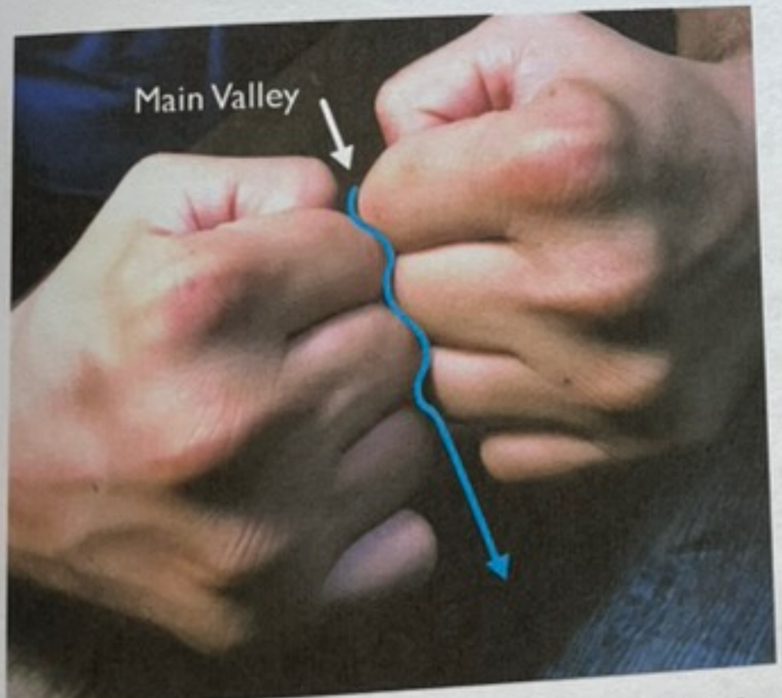
The knuckles themselves represent "hills" or "crests" along the main ridge.

The low spot between knuckles (hills!) are "saddles."

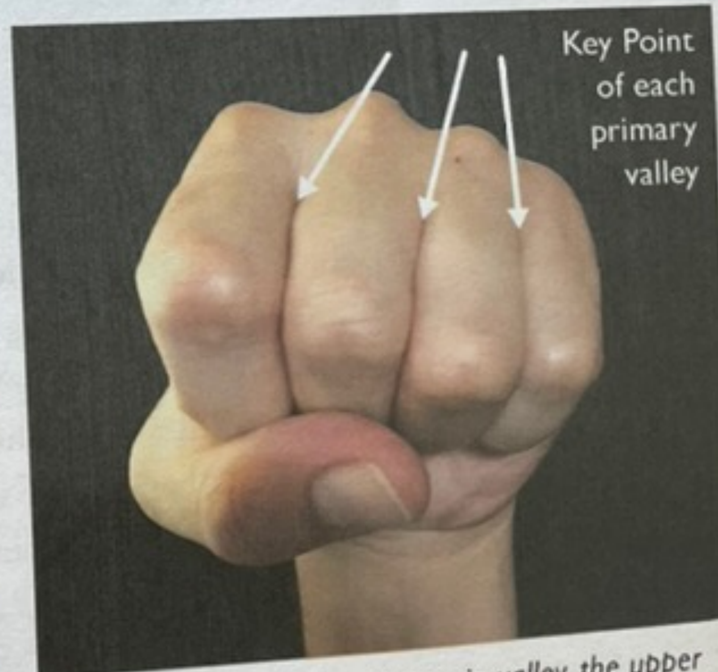
The keypoints of each primary valley are usually at different elevations from one another. Knowing how this landform geometry works is what will allow us to easily design gravity-flow irrigation and livestock watering systems on the land.



A Keyline is the contour line of a valley that is centered at the keypoint and goes along the sides of the valley only until the valley walls turn outward. This is the first reference line in Keyline Design.



Two primary ridge forms coming together create a "main valley" at the bottom. Water from each hand migrates toward the main valley.



Traveling upwards from the main valley, the upper terminus of a primary valley (the point where the space between your fingers becomes the fleshy web of skin) is the "keypoint" of that primary valley.

2.Slope

$$\frac{\text{Rise}}{\text{Run}} = \text{Slope} = \frac{1}{10} = 10\%$$

Ideally no more than 10% for keyline projects

3. Runoff

Off the Contour #10 – A Modern Approach

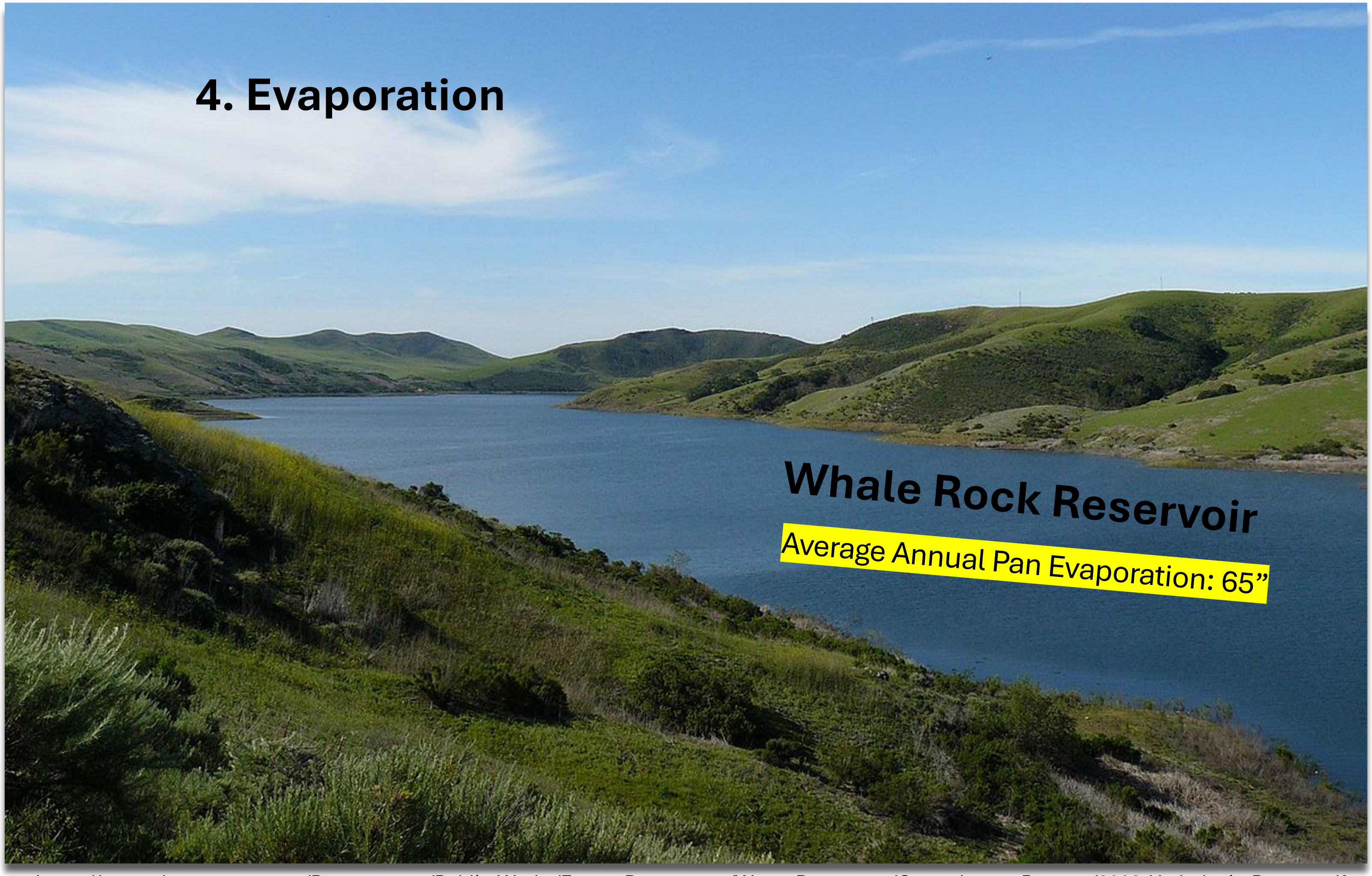
to Keyline Design for your Property Part I

Traceland Rehydration System

Average Annual Rainfall	Total Annual Evaporation	Clay Pans, Inelastic Clay or Shale
18-30 in	50 to 70 in	7.5 – 12.5 %

Table 1 – RUNOFF FROM CATCHMENTS[i]

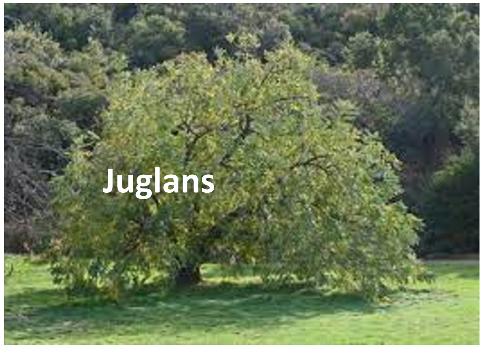
			Runoff as a % of average annual rainfall (Y)			
Average annual rainfall (R) (mm)	*Total annual evaporation (mm)*	*Reliability (years out of 10)*	*Shallow sand or loam soils (%)*	*Sandy clays (%)*	*Elastic clays (%)*	*Clay pans, inelastic clays or shales (%)*
> 1100		*8*	*10 to 15*	*10 to 15*	*15 to 20*	*15 to 25*
		9	*6.5 to 10*	*6.5 to 10*	*10 to 13*	*10 to 16.5*
901 to 1100		*8*	*10 to 12.5*	*10 to 15*	*12.5 to 20*	*15 to 20*
		9	*6.5 to 8*	*6.5 to 10*	*8 to 13*	*10 to 13*
501 to 900	*less than 1300*	*8*	*7.5 to 10*	*7.5 to 15*	*7.5 to 15*	*10 to 15*
		9	*5 to 6.5*	*5 to 10*	*5 to 10*	*6.5 to 10*
	1300 to 1800	*8*	*5 to 7.5*	*5 to 12.5*	*5 to 10*	*10 to 15*
		9	*3 to 5*	*3 to 8*	*3 to 6.5*	*6.5 to 10*
401 to 500	*1300 to 1800*	*8*	*2.5 to 5*	*5 to 10*	*2.5 to 5 7*	*7.5 to 12.5*

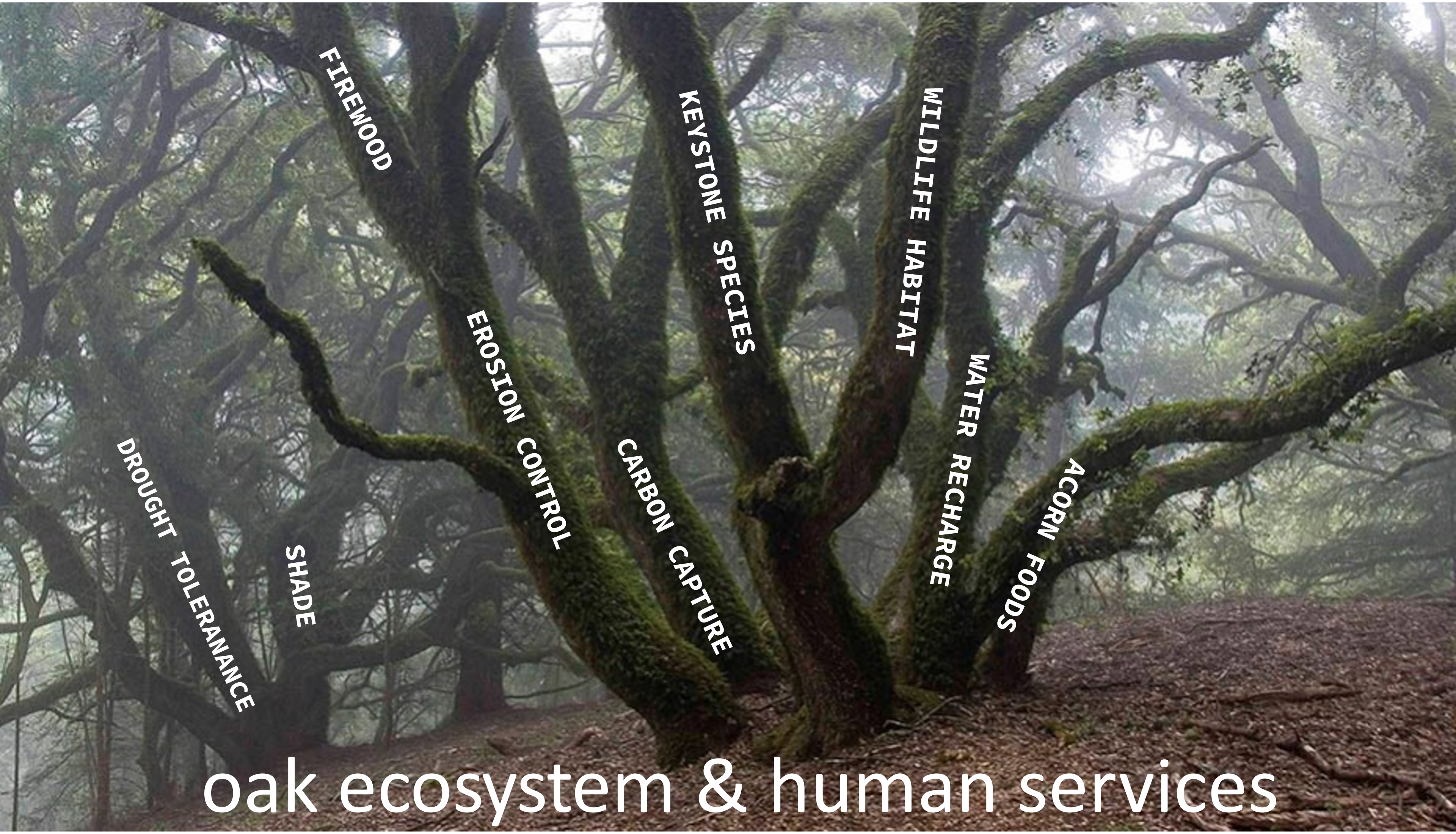


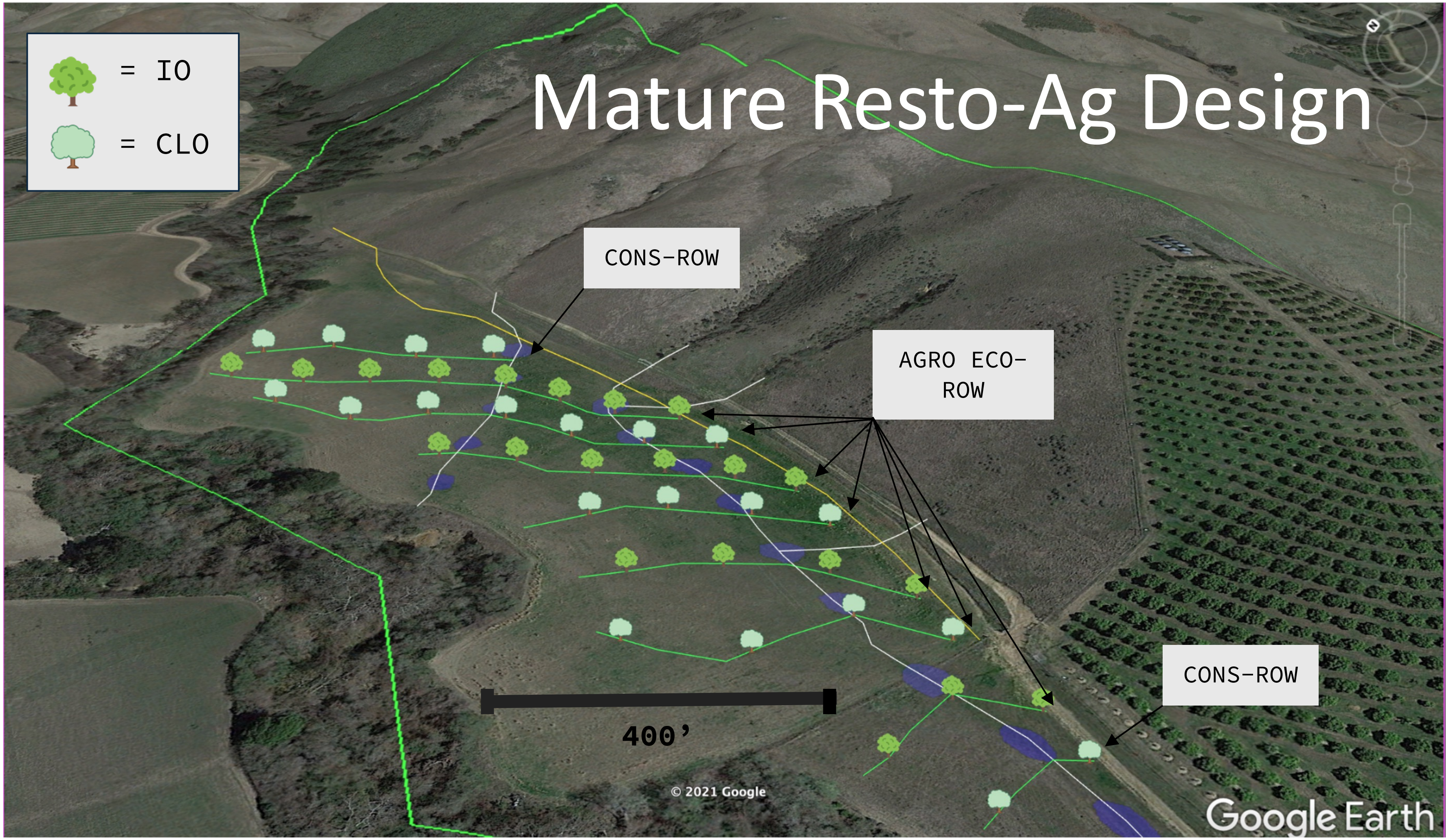
https://www.slocounty.ca.gov/Departments/Public-Works/Forms-Documents/Water-Resources/Groundwater-Reports/2002-Hydrologic-Report.pdf

Restoration Agriculture

Identify Biome → COAST LIVE OAK SAVANNA → Interesting Edible Genera:




FIREWOOD
KEYSTONE SPECIES
WILDLIFE HABITAT
EROSION CONTROL
WATER RECHARGE
CARBON CAPTURE
ACORN FOODS
DROUGHT TOLERANANCE
SHADE
oak ecosystem & human services



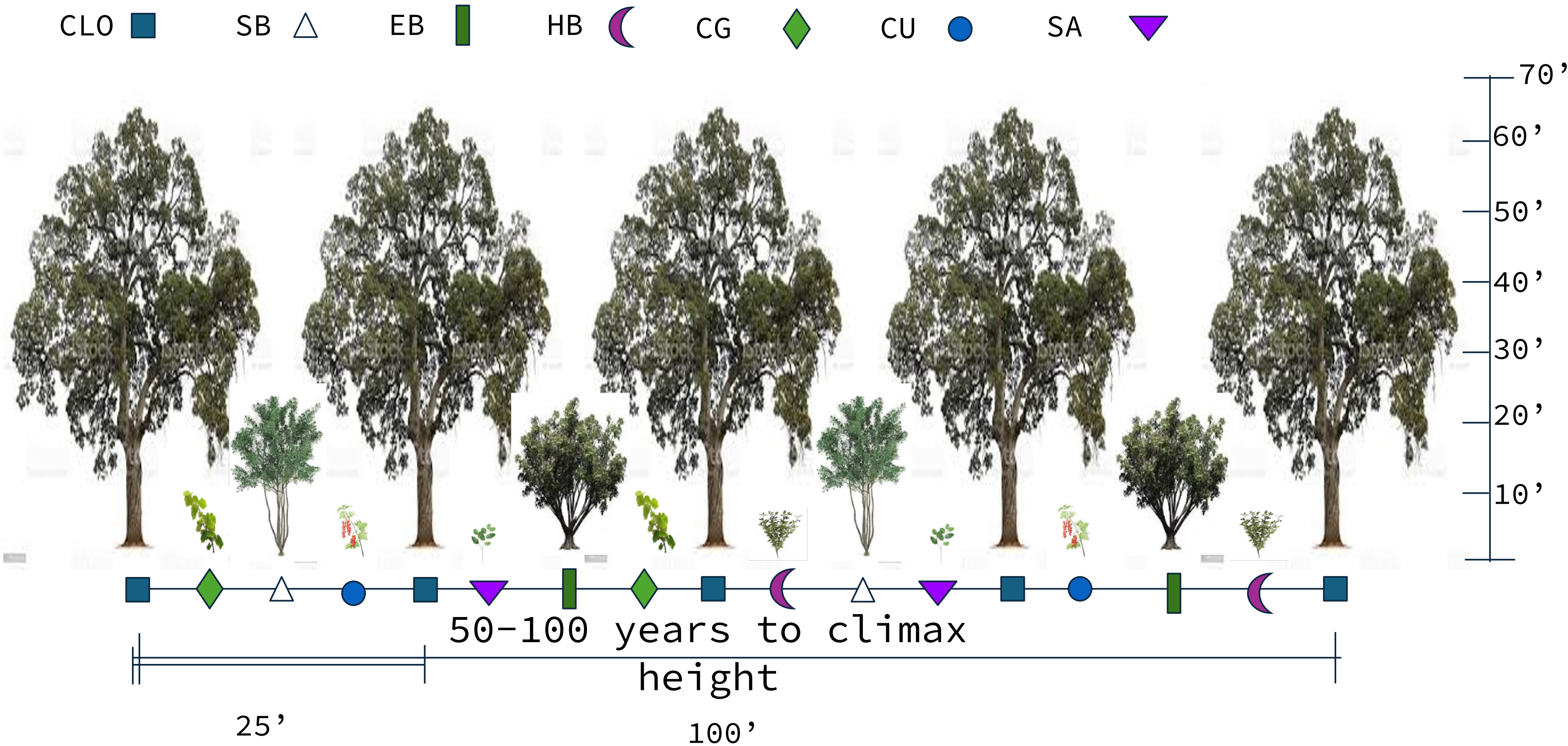
Mature Resto-Ag Design
= IO
= CLO
CONS-ROW
AGRO ECO-ROW
CONS-ROW
400'
© 2021 Google
Google Earth

PLANT SPECIES LIST

Common Name	Scientific Name	Code
Coast Live Oak	Quercus agrifolia	CLO
Golden Chinquapin	Chrysolepis chrysophylla	CC
Black Walnut	Juglans hindsii	BW
Salal	Gaultheria shallon	SA
Huckleberry	Vaccinium ovatum	HB
Currant	Ribes speciosum	CU
Blue Elderberry	Sambucus cerulea	EB
California Wild Grape	Vitis californica	CG
Service Berry	Amelanchier utahensis	SB

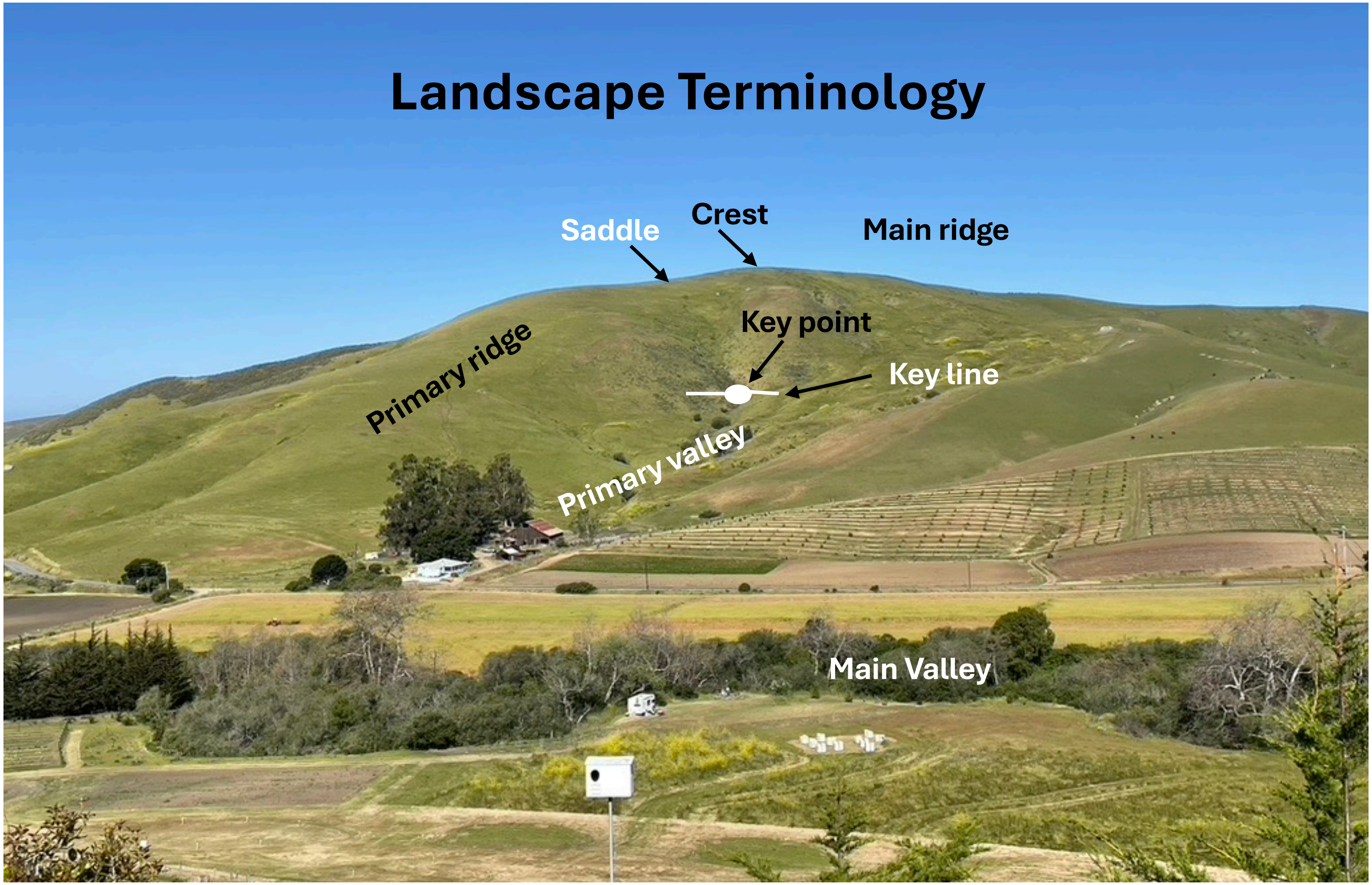
Conservation Row

Legend




Native Food and Pollinator Hedgerow

Field Trip



Landscape Terminology
Saddle
Crest
Main ridge
Key point
Key line
Primary ridge
Primary valley
Main Valley

Rehydrating Toro Creek with Sustainable Agriculture: Traceland Farm Demonstration Project

Project Objectives:

Objective 1: Water management accounting

Objective 2: Expand Ag to Flats, Restore Habitat, Earthworks

Objective 3: Reduce erosion and arrest stream bank collapse

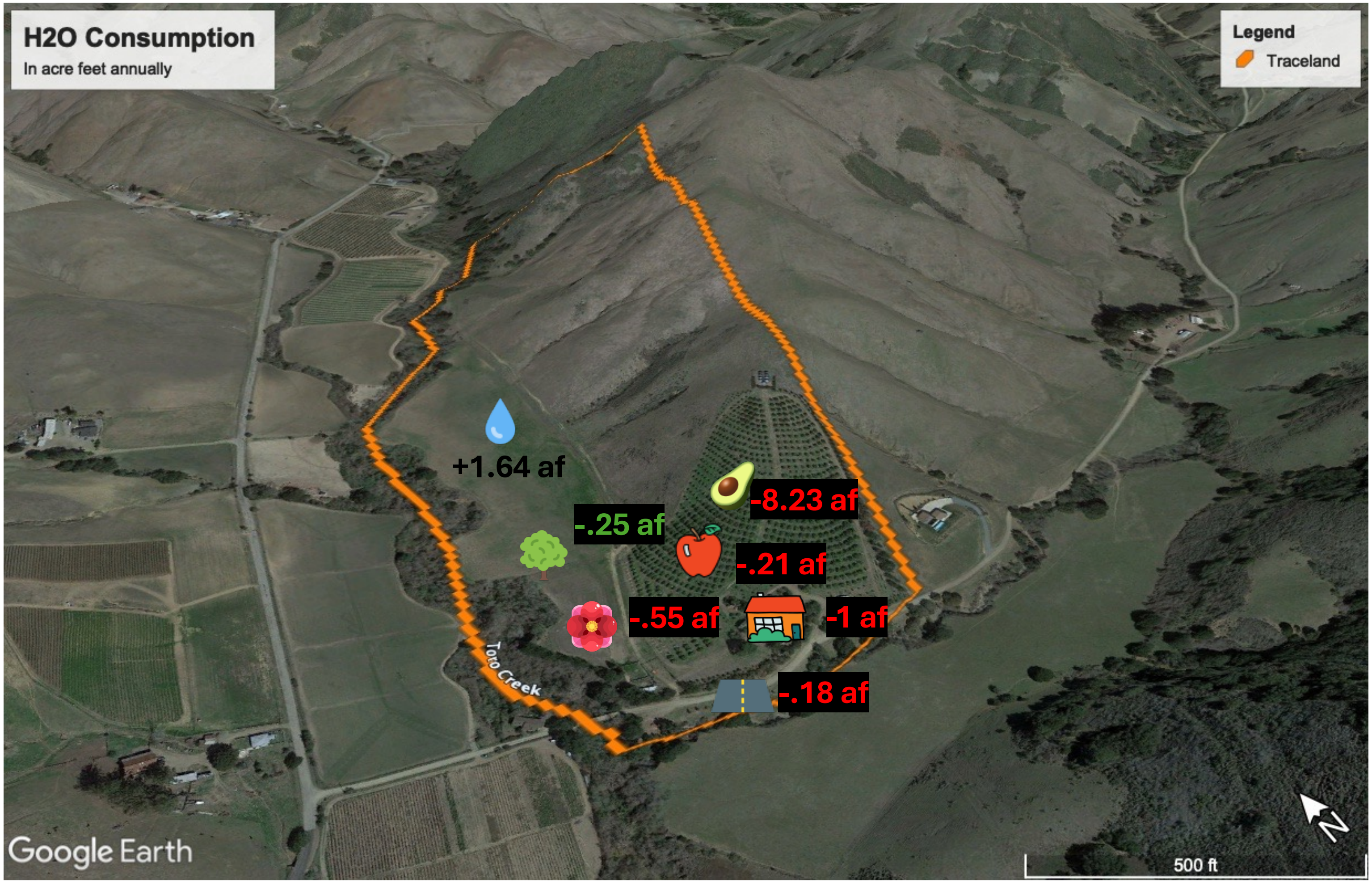
Objective 4: Capture 500k gal of storm water runoff

Objective 5: Bio-sequester CO_2 from planting 143 trees

Objective 6: Research and Develop Acorn food production

Western SARE
Sustainable Agriculture Research & Education

Objective 1: Water management accounting



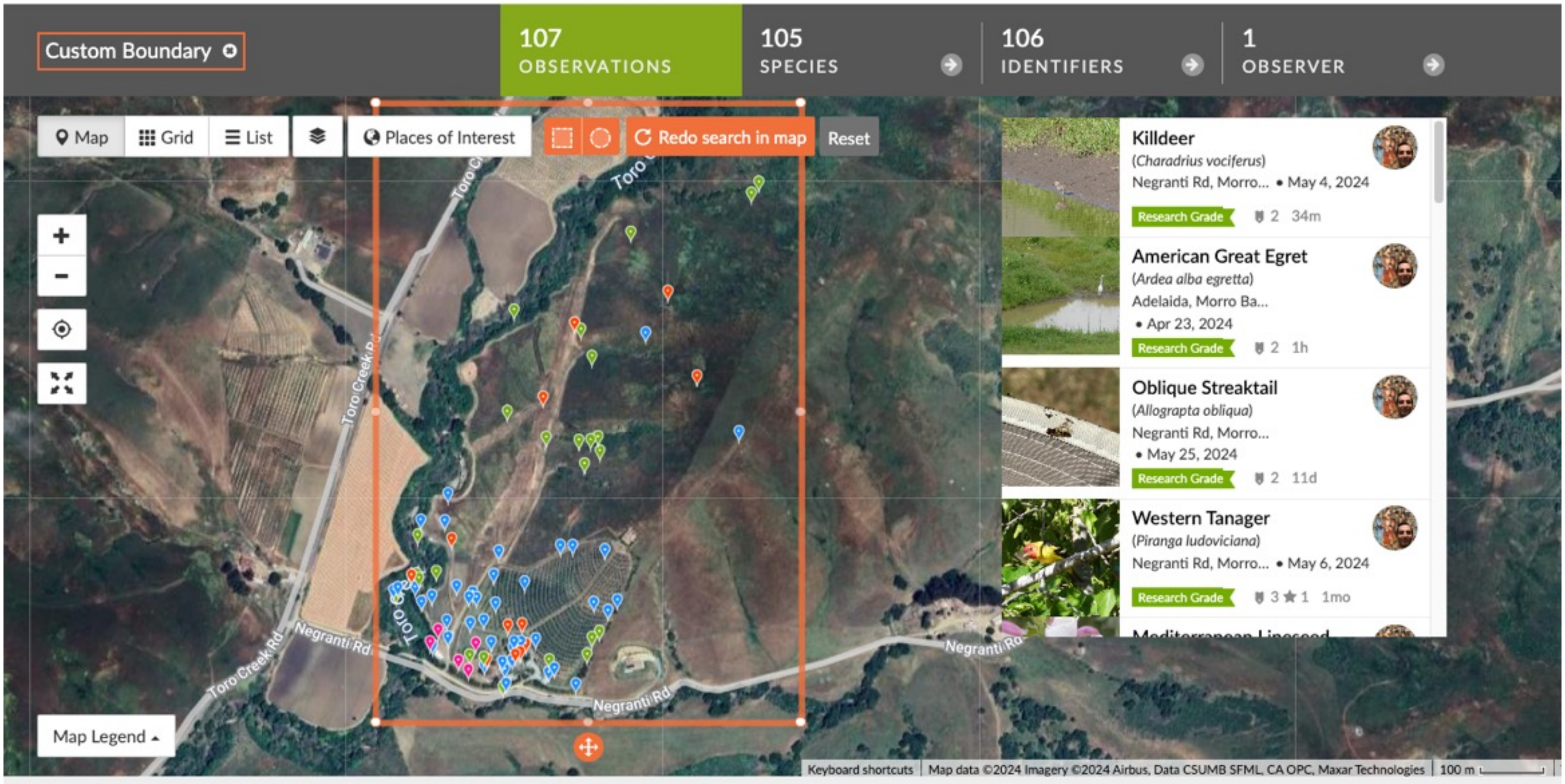
Avocados, sub-tropicals & road water **-8.41** + Homestead & gardens **-1.21** + Flowers & rowcrops **-.55** + Restoration plantings **-.25** + Recharge **+1.64** = **- 8.53 af**

Water Consumption

Zone	Description	Trees / Plants	Emitter Type	Hours per Week	Total Weekly (in gallons)	Annual Total (9 mo)	Acre Feet
Avocados	8.5 acre Hass Avocado Orchard w. some pollinator Etinger / Zutano	850	12 gal sprinklers and 2 gal emitters	6	68000.00	2631600.00	8.10
Sapotes	1 acre Vernon Sapotes	71	2 gal (x2) drippers	6	710.00	27477.00	0.08
Coffee	3 rows of arabica coffee in upper avocados	48	7 gal sprinklers	1	336.00	13003.20	0.04
Passion Fruit and Limes	Trellised Fredricks Passionfruit, Assorted Exotic Lime and Passiflora	19	2 gal (x2) drippers	6	76.00	2941.20	0.01
Nursery	Oak, Walnut and Assorted Drought Tolerant Fruit Trees	100s of seedlings	Hose	1	25.00	967.50	0.00
Home Orchard	Assorted Citrus, Pomme and Stone Fruit Trees	50	10 gal sprinklers on	1.5	750.00	29025.00	0.09
Homestead	California avg. annual consumption	n/a	n/a	n/a	n/a	n/a	1.00
Home Gardens	Herbs, flowers and vegetables, landscape	50 plants	Emitters and Sprinklers	2	1000.00	38700.00	0.12
Flowers	Ranunculus, Dhalias, Marigolds	2,000 linear ft	1g x 1ft	3	3000.00	116100.00	0.36
Asparagus	Purple and Green	800 linear ft	1g x 1ft	2	1600.00	61920.00	0.19
Road Water	Dust Abatement	18 Nozzles	3 gal per minute	24min	1500.00	58050.00	0.18
Restoration Plantings (Remove water after 3 years)	Riparian Buffers and hedgerows	400	2 gal emitters and 12 gal sprinklers	n/a	2100.00	81270.00	0.25
						3061053.90	**10.42**

Objective 2: Expand Ag to Flats, Restore Habitat, Earthworks

Biological Baseline



Objective 3: Reduce Erosion and Arrest Stream Bank Collapse

Objective 4: Capture 500k gal of Stormwater

325,000 gal = 1 acre foot
27,030 gal = 1 acre inch

Rehydration System Dimensions

RUN-OFF CALC

42 acres x **18”** = annual average **precipitation: Total:** 20,475,000 gal

10% run off rate (Table 1 from Run-off Catchments Regrarians)

2,475,000 gallons of runoff annually in a typical year of precipitation

SEDIMENT BASINS

12 basins

50’ x 30’ x 2’ = 3,000 ft^3 x 7.5g = 20,000 gal x 12 basins = 240,000 gal

1 Redwood Basin
100’ x 40’ x 2.5’ = 10,000 ft^3 x 7.5g = 75,000g

1 Flower Basin
100’ x 30’ x 2’ = 6,000 ft^3 x 7.5g = 40,000 gal

BERMS + SWALES

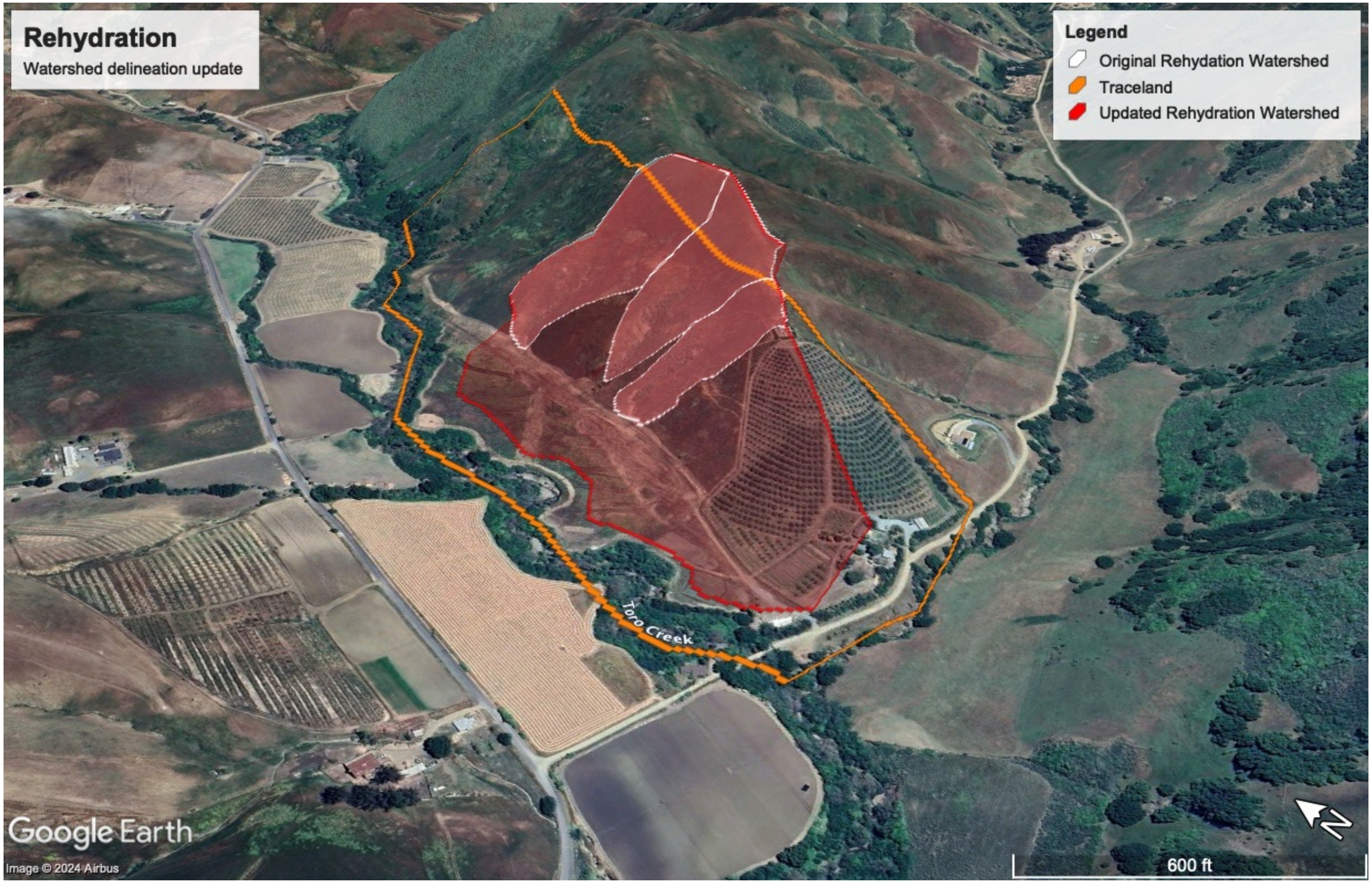
9 B+S

3000’ total x $8ft^2$ =

$24,000ft^3$ x 7.5g = 180,000 gal


30’
100
’

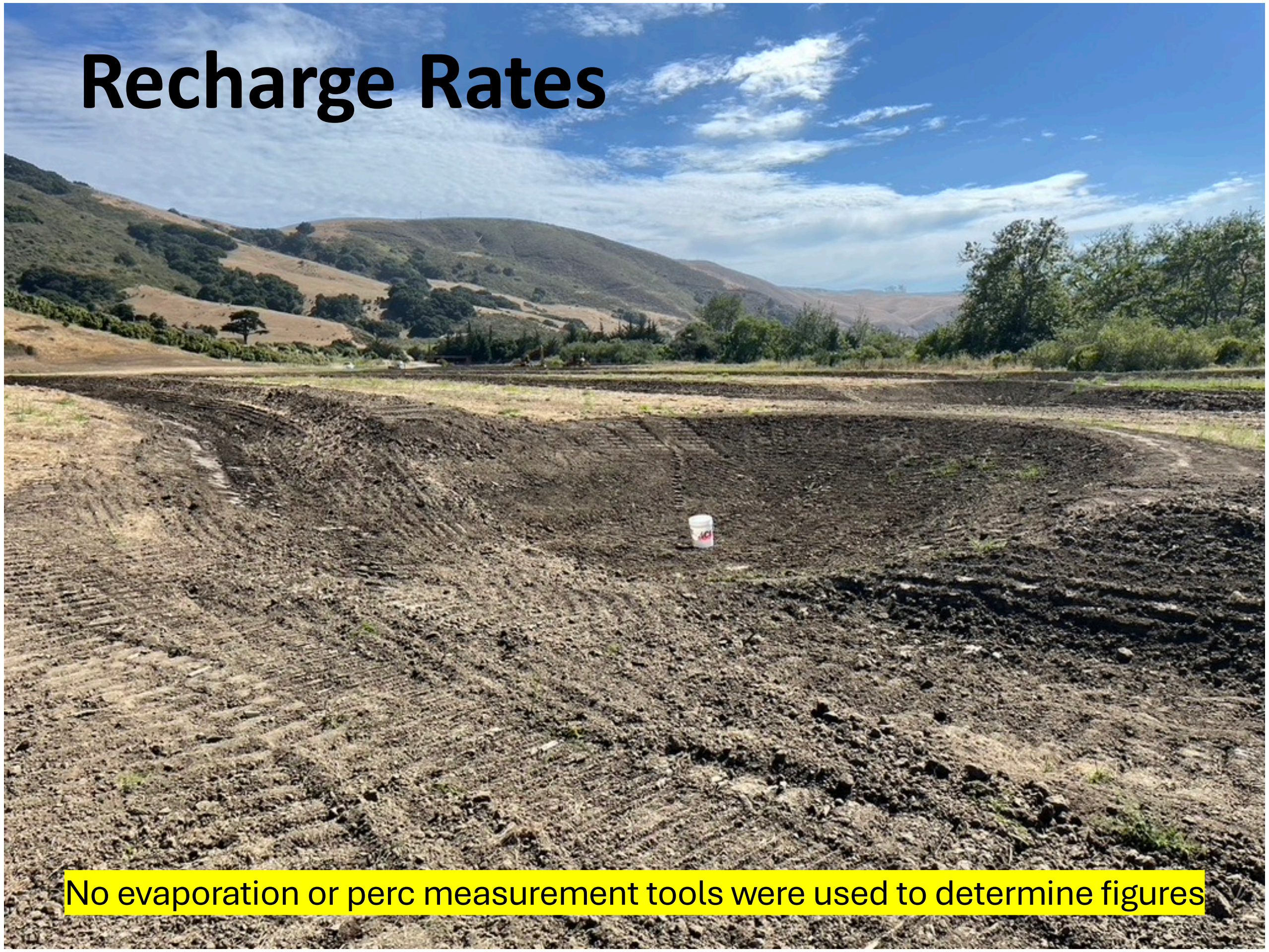

2’
7’



21 acres

to

42 acres



Sediment Basins

50,000 ft^2 of infiltration surface

Nearby Perc Test:

1” of perc in 80 min

Infiltration

50,000ft^2 x .082 (1 inch) =
4,100 ft^3 x 7.5 gal
=30,750gal per 80 min

From Field Observation:

The basin water surface is lowering roughly 1” per day

24hrs x 60min / into 80 minutes
80 minutes is 5-6 % of 24hrs

5-6% of rate perc test

Objective 5: Bio-sequester CO_2 Planting 143 trees

CUFR TREE
CARBON CALCULATOR

Carbon Accounting

1 Gallon of Diesel = 22lbs CO_2 or 10 kilos CO_2

2 Bulldozers/ Excavators / Paddle Scraper / Box Scraper at aprox 400 gallons per day x 18 days of earthworks = 7,200 gallons x 22lbs =

158,400 lbs of CO_2 or 72,000 kilos CO_2

Mature 80-year-old
Native = 22,674.6 Kg CO_2
Foreign = 13,548 Kg CO_2

1 oak tree stores 1 ton after 20 years

Minimum of 72, 20-year-old Oaks: Native, Native adjacent, Foreign

CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of Forestry and Fire Protection

20 year Timeline

Tree and Building Data entry			
Enter Tree data below one tree at a time, then record results			
Data name	Data entry	Units	Description
Species code and scientific name	QUAG (Quercus agrifolia)		coast live oak
Age (years)	20	Age (years)	12.3 in DBH & 31.6 ft high

Total CO_2 Stored	Above ground biomass
	(dry weight)
(kg/tree)	(kg/tree)
1134.0	482.0
(lb/tree)	(lb/tree)
2,500.1	1,062.7

Roughly 1 ton per Tree

Tree and Building Data entry			
Enter Tree data below one tree at a time, then record results			
Data name	Data entry	Units	Description
Species code and scientific name	QUIL2 (Quercus ilex)		roble negro
Age (years)	20	Age (years)	13.3 in DBH & 33.1 ft high

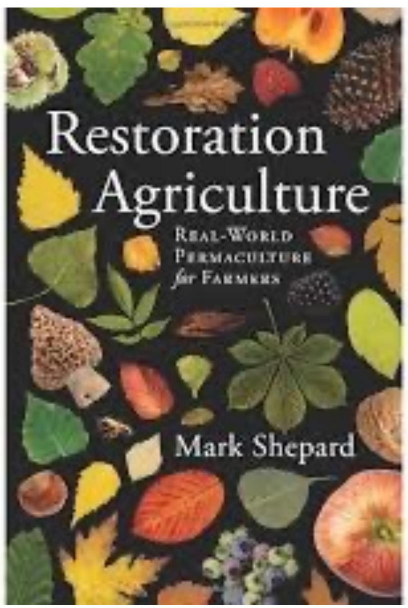
Total CO_2 Stored	Above ground biomass
	(dry weight)
(kg/tree)	(kg/tree)
998.6	424.5
(lb/tree)	(lb/tree)
2,201.6	935.8

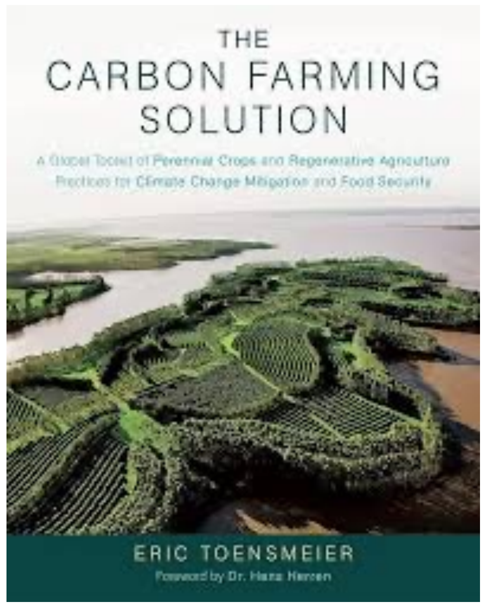
Objective 6: Research and Develop Acorn food production

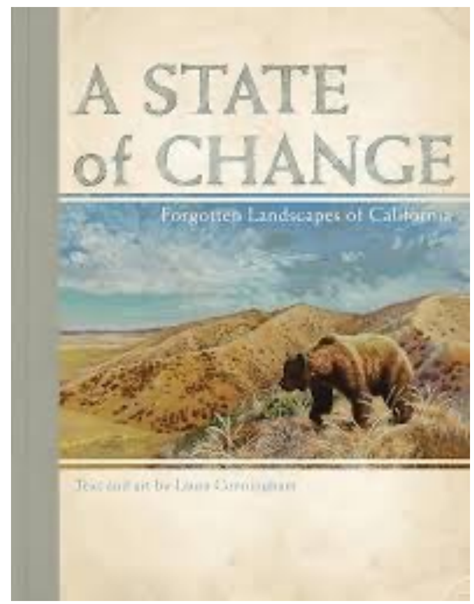

July 2017

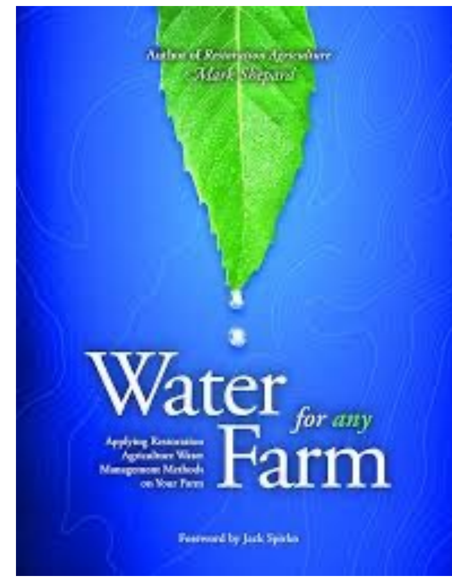

March 2024

References


Restoration Agriculture
Real-World Permaculture for Farmers
Mark Shepard


THE
CARBON FARMING
SOLUTION
A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security
ERIC TOENSMEIER
Foreword by Dr. Hans Herren


A STATE
of CHANGE
Forgotten Landscapes of California


Mark Shepard
Water
for any
Farm

Extras

Before & After 2” rain 3/24/24


2023-24
Winter Rains
Did not spill


2nd Flower Bed


Rehydration System
Black = Basins
White = Swales
Red = Ravines

CUFR Tree Carbon Calculator

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80 year Timeline

Tree and Building Data entry			
Enter Tree data below one tree at a time, then record results			
Data name	Data entry	Units	Description
Species code and scientific name	**QUAG (Quercus agrifolia)**		coast live oak
Age (years)	**80**	Age (years)	45.6 in DBH & 49.6 ft high

Total CO_2 Stored	Above ground biomass (dry weight)
(kg/tree)	(kg/tree)
22674.6	**9638.2**
(lb/tree)	(lb/tree)
49,988.8	21,248.7

Tree and Building Data entry			
Enter Tree data below one tree at a time, then record results			
Data name	Data entry	Units	Description
Species code and scientific name	**QUIL2 (Quercus ilex)**		roble negro
Age (years)	**80**	Age (years)	31.5 in DBH & 66.7 ft high

Total CO_2 Stored	Above ground biomass (dry weight)
(kg/tree)	(kg/tree)
10054.2	**4273.7**
(lb/tree)	(lb/tree)
22,165.7	9,421.9