SOILS, CLIMATE AND NATIVE AMERICAN CULTURE in NORTHERN CALIFORNIA

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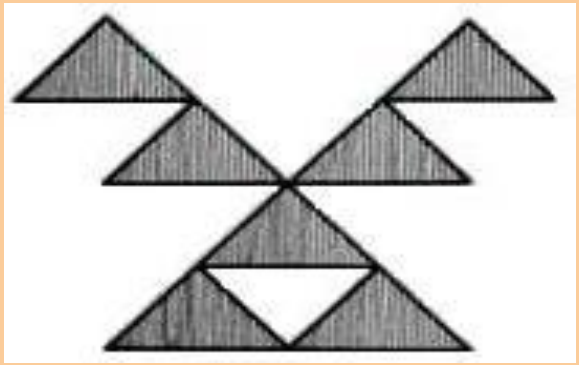
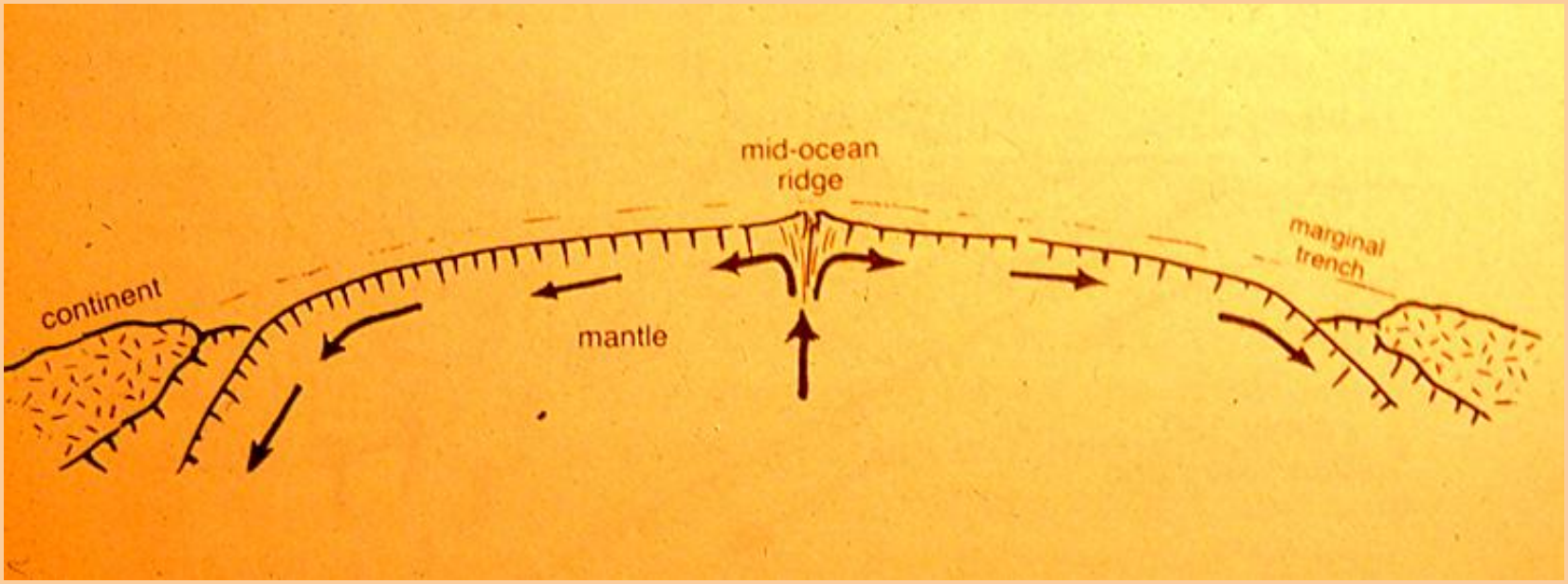


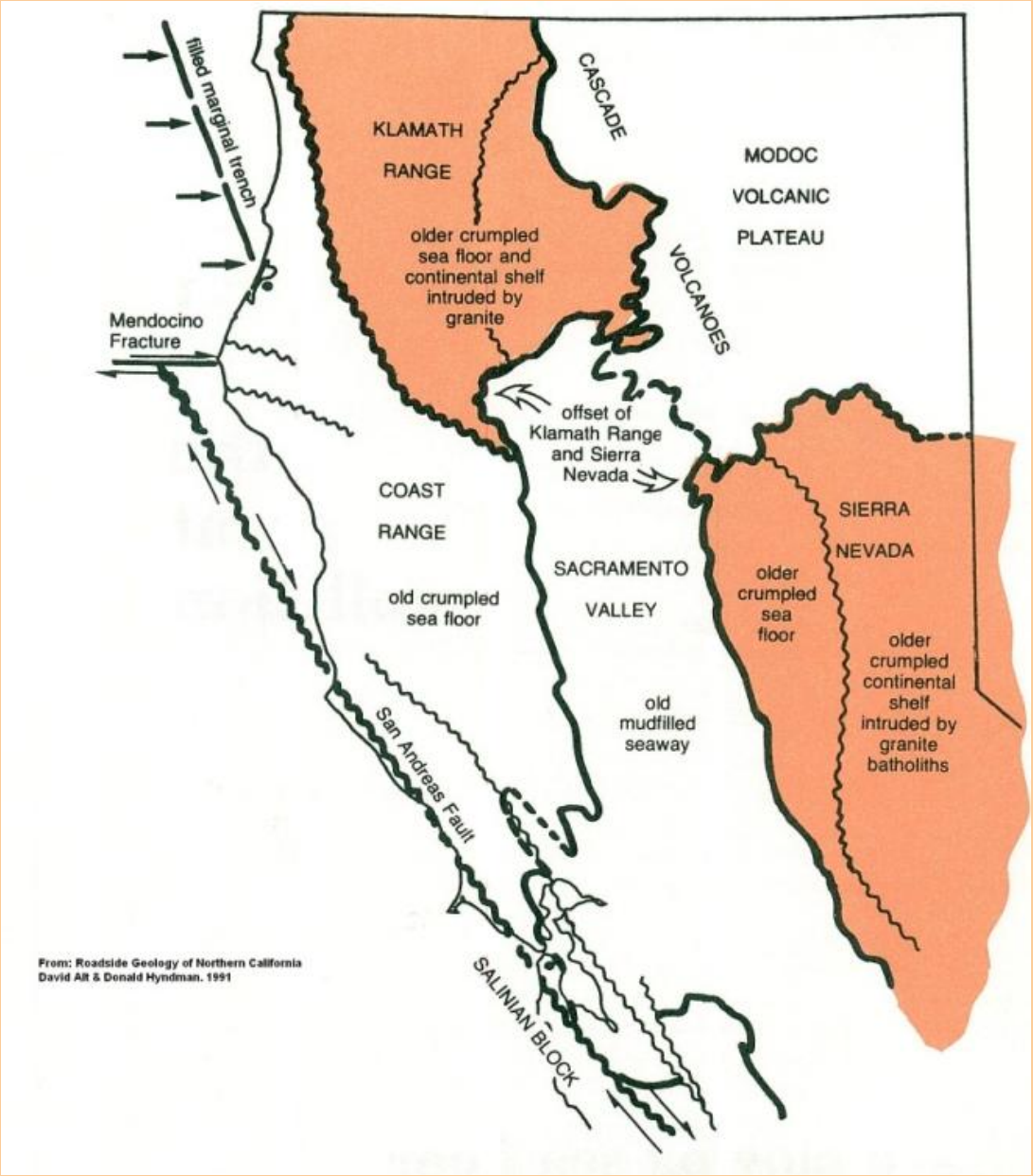
CALIFORNIA GEOLOGY – Mid-ocean ridges form new ocean floor from molten volcanic basalt. At the edges of the sea floor is the oldest rock. This moves continents apart (continental drift) and forces the sea floor under the continent – forming coastal ranges and uplifted mountains



VOLCANIC ACTIVITY

- When molten rock erupts on the surface volcanoes are formed (Mt Konocti in Clear Lake) = Igneous rock
- When rock is weathered and deposited elsewhere it is Sedimentary rock
- If rock is changed by heat and pressure it is Metaphoric rock
- All three are present in northern California

Northern California Can Be Divided into Sierra, Franciscan & Valley sequences



The San Andreas fault divides a plate moving north along the California coast. There are granite (igneous) rocks along our coast that once were near Santa Barbara

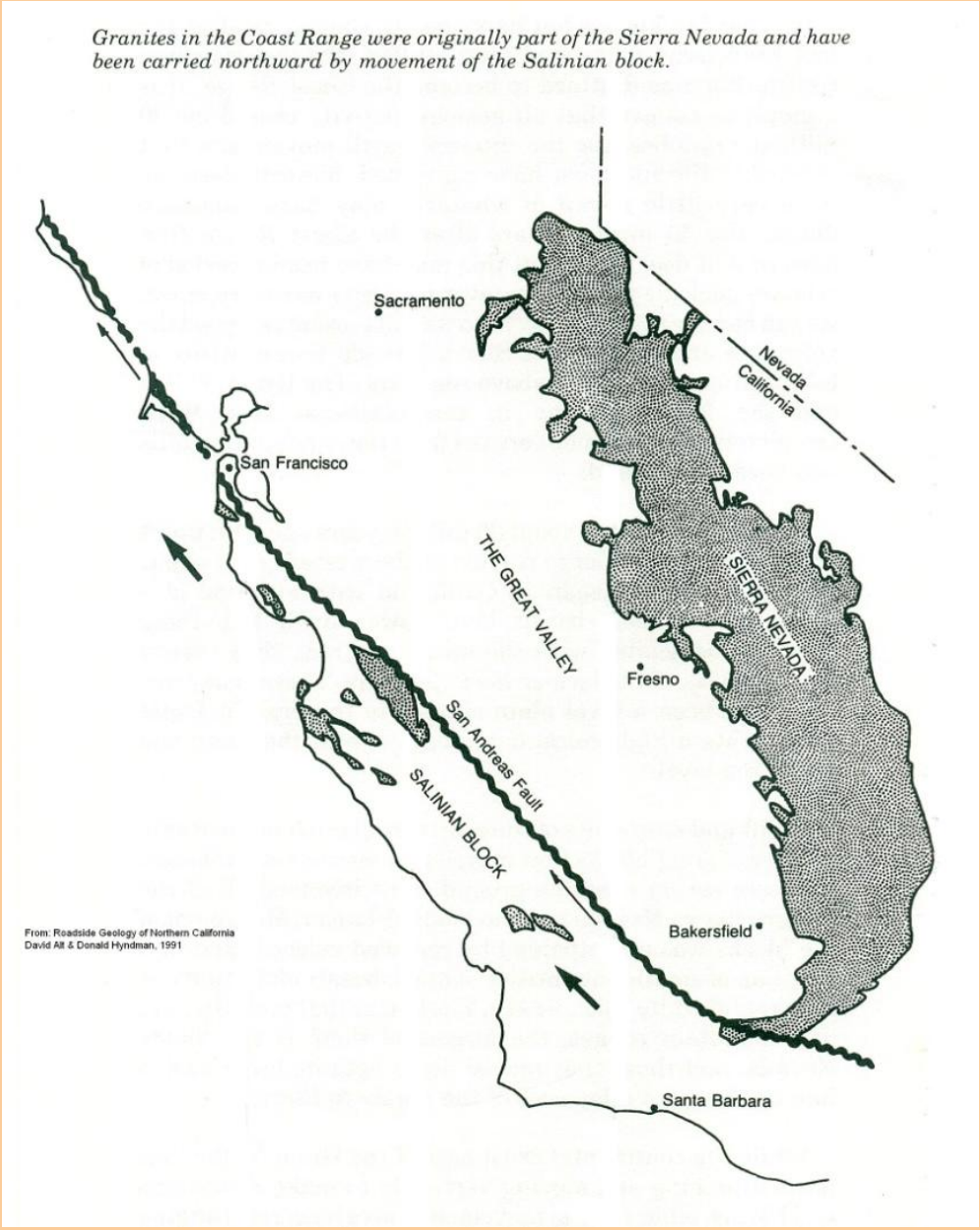
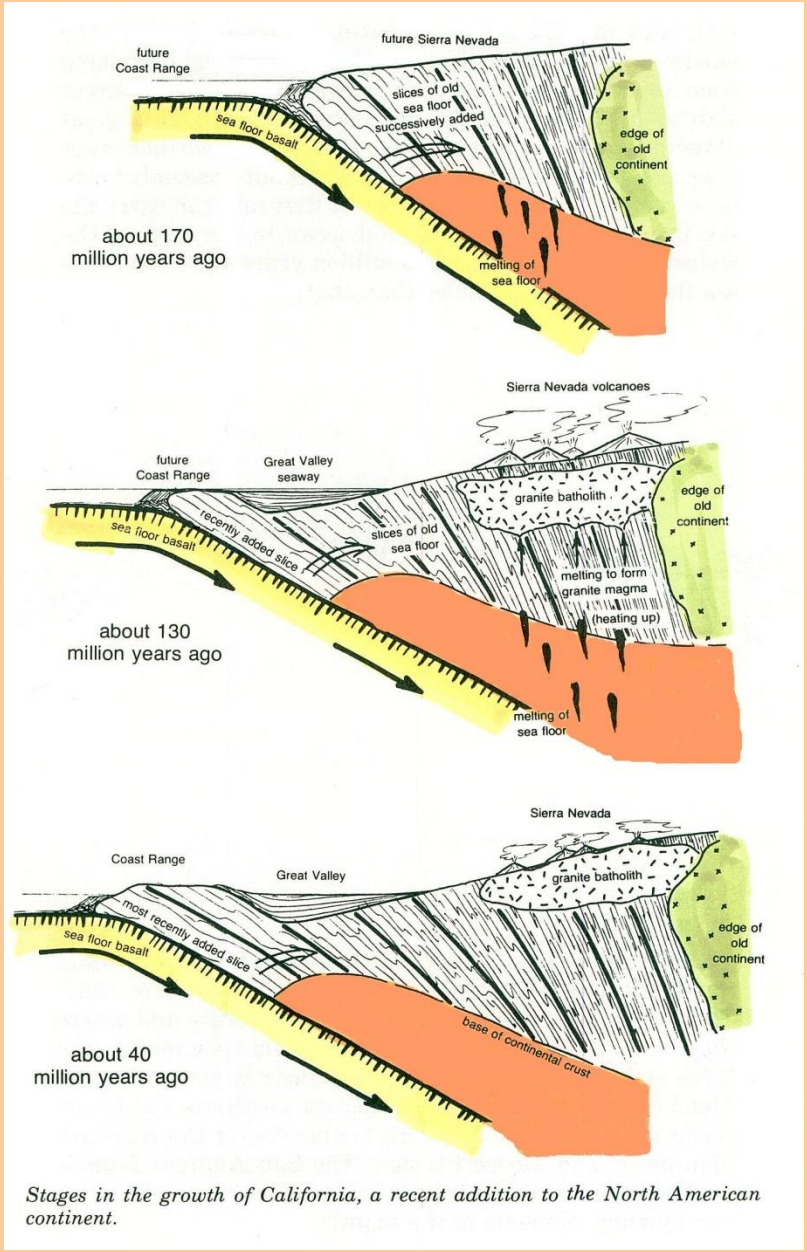


Plate Tectonics – this process has continued for about 200 million years, resulting in the formation of the Sierra and coastal mountain ranges (Franciscan formation).



Stages in the growth of California, a recent addition to the North American continent.

From: Roadside Geology of Northern California
David Alt & Donald Hyndman

Formation of Marine Terraces

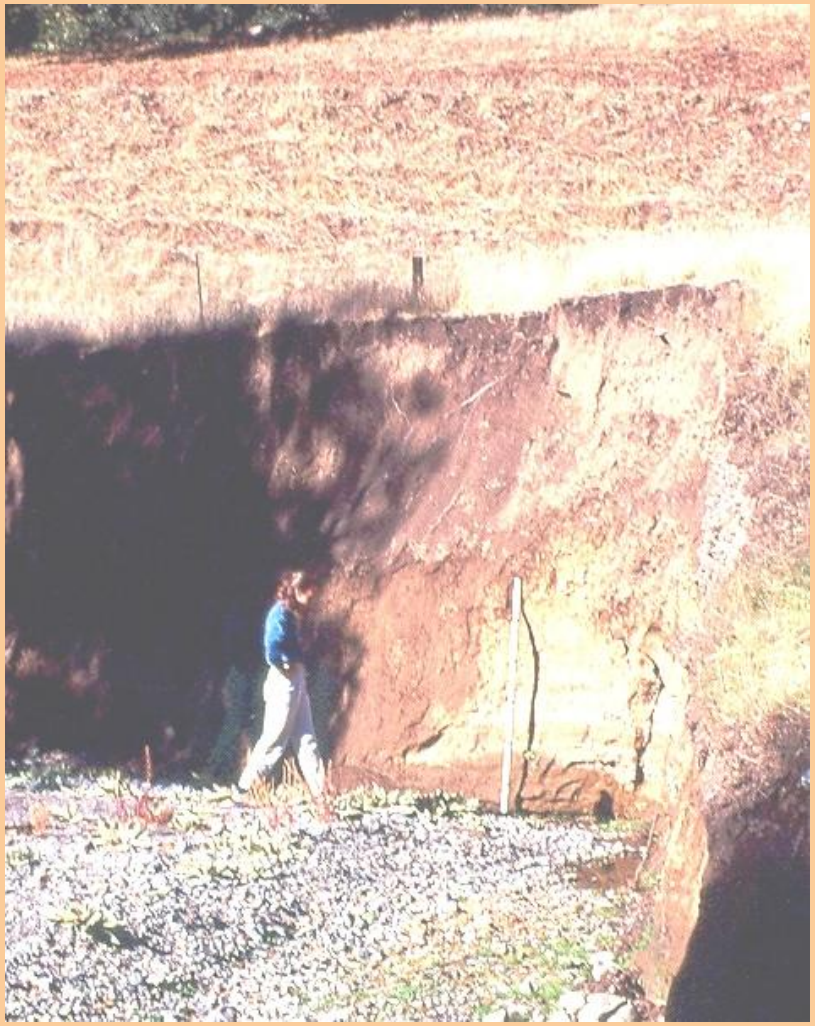
- The uplifting of the coastal land forms results in terraces near shore. These are very productive resource areas: food, salt, shells
- Ancient terraces provided sites with mild seasonal climate due to proximity to the sea
- Erosion of near shore terraces provided habitats for replenishment of living resources

NORTH COAST SOIL TYPES

- North coast soils are derived from 3 main types of rock/parent materials:
  - Franciscan , sediments scraped from the sea bed and raised
  - Serpentine soils, from magma deep within the earth forced to the surface
  - Volcanic soils, where basalt and other igneous rocks have surfaced
  - All have been leached for thousands of years

DEFINITION of SOIL

- The top layer of the earth's surface, consisting of rock and mineral particles mixed with organic matter
- The soil is the upper weathering layer of the solid earth crust.



CLIMATE EFFECTS on SOILS

- Soils are created and moved by wind, rain, flowing water, heat, freezing & biological activity
- Amount of rainfall and when it occurs is a very important factor in soil formation
- Man's effects (acidification, organic matter depletion, fertilization, cover cropping) can speed up soil processes

DEFINITION OF SOIL DEVELOPMENT

- Soil formation is parent material, climate, vegetation, and organic matter working over time

Basic soil science:
What is happening here?

Typical River

Green River

Clear River

Rainfall dissolves salts, which are delivered to streams, rivers and eventually lakes & oceans. The salts are composed of (in order): bicarbonates, calcium, silicon, sulfate, chloride, sodium, magnesium, potassium. These are the bottom of the food pyramid for sea life.

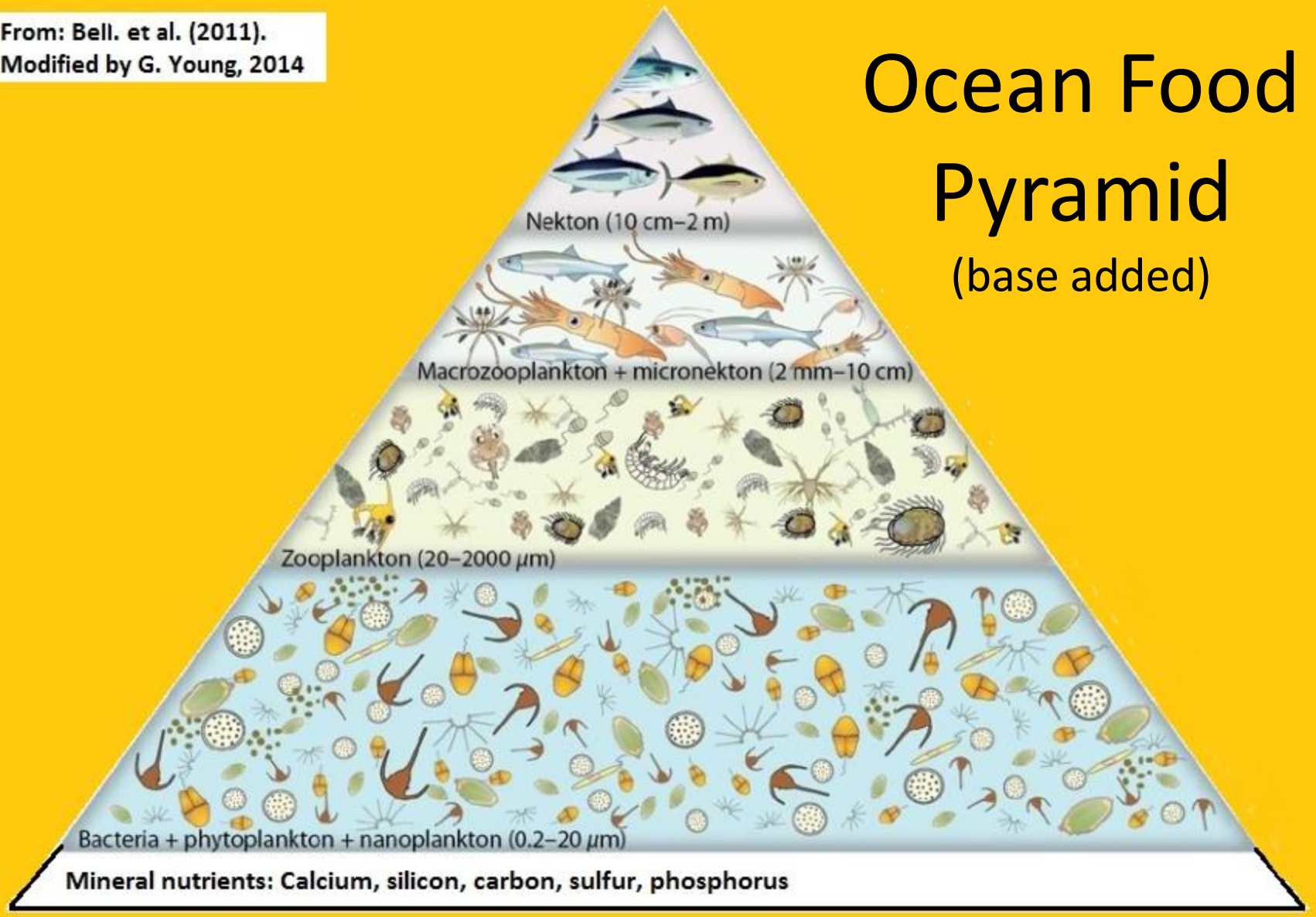
COMPARISON BETWEEN OCEAN WATER AND RIVER WATER

Chemical Constituent	Percentage of Total Salt Content	
	Ocean Water	River Water
Silica (SiO_2)	—	14.51
Iron (Fe)	—	0.74
Calcium (Ca)	1.19	16.62
Magnesium (Mg)	3.72	4.54
Sodium (Na)	30.53	6.98
Potassium (K)	1.11	2.55
Bicarbonate (HCO_3)	0.42	31.90
Sulfate (SO_4)	7.67	12.41
Chloride (Cl)	55.16	8.64
Nitrate (NO_3)	—	1.11
Bromide (Br)	0.20	—
TOTAL	100.00	100.00

From: Bell. et al. (2011).
Modified by G. Young, 2014

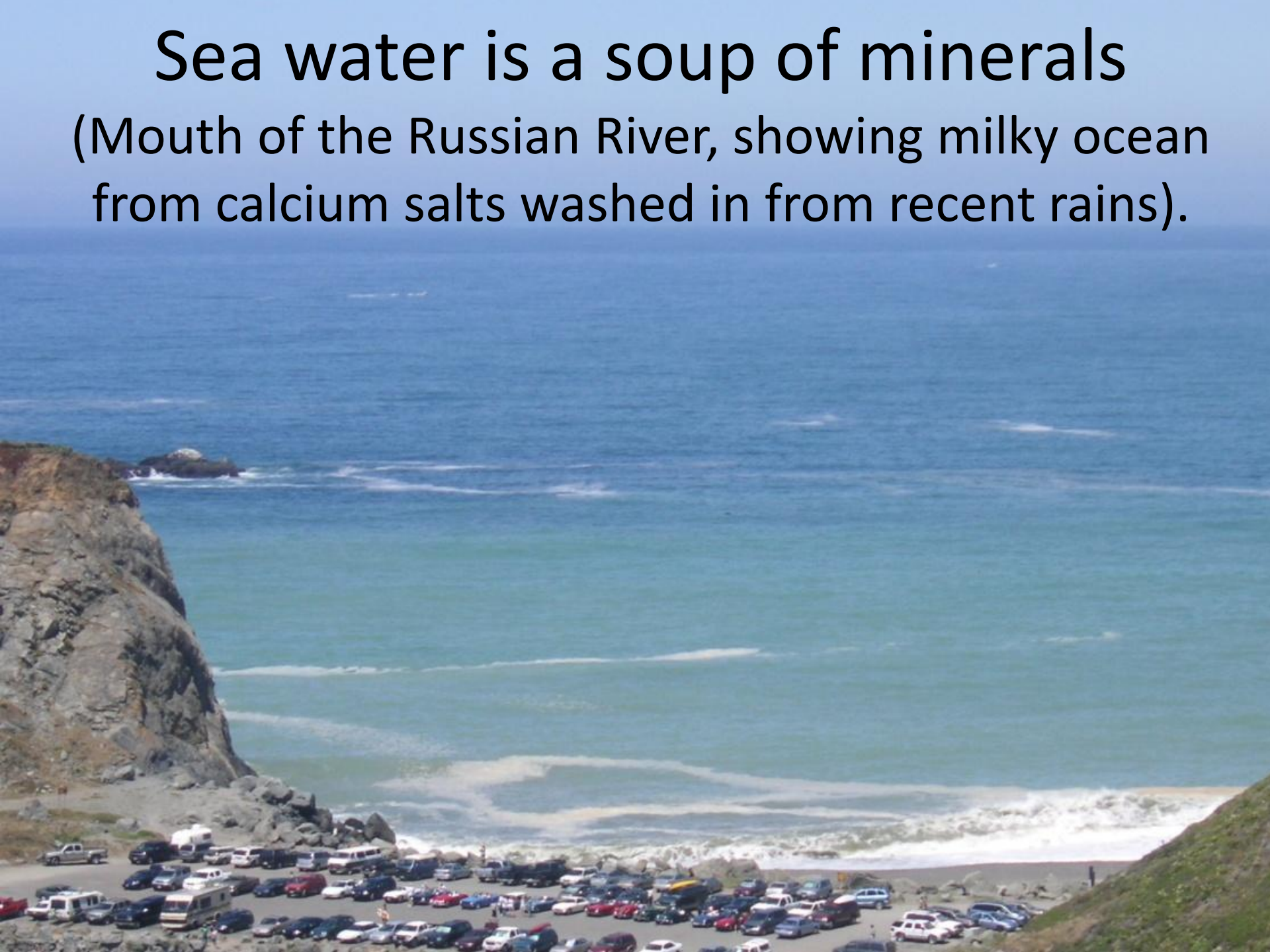
Ocean Food Pyramid

(base added)



Sea water is a soup of minerals

(Mouth of the Russian River, showing milky ocean from calcium salts washed in from recent rains).



Remaining after nutrients are removed? - mostly salt (sodium chloride).

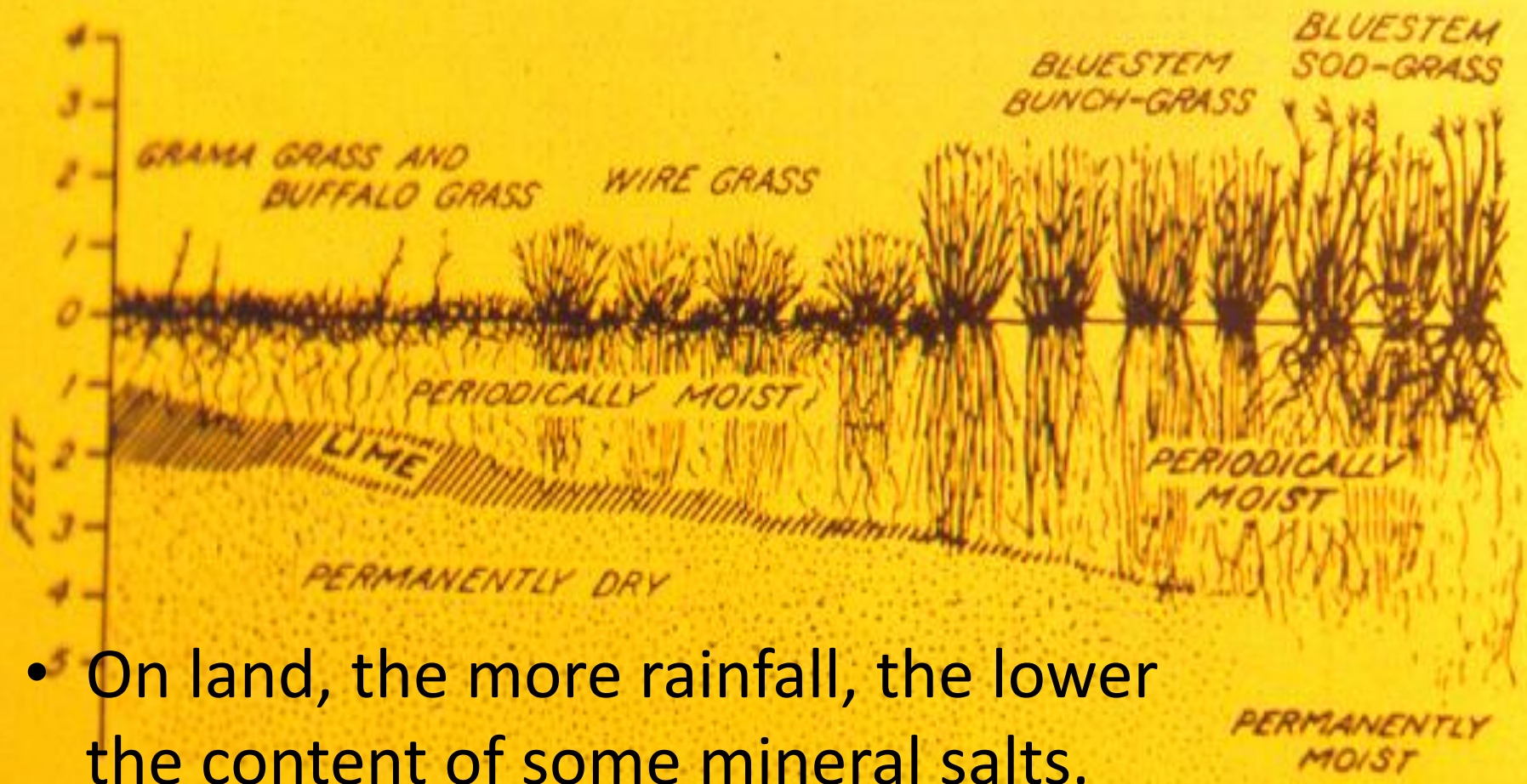
- Organisms (from plankton to shellfish to fish) take up the carbon, silicon and calcium for their skeletons. They incorporate nitrogen, sulfur and phosphorus into protein, fats, and carbohydrates.

PRINCIPAL CONSTITUENTS OF SEAWATER

Chemical Constituent	Content (parts per thousand)
Calcium (Ca)	0.419
Magnesium (Mg)	1.304
Sodium (Na)	10.710
Potassium (K)	0.390
Bicarbonate (HCO_3)	0.146
Sulfate (SO_4)	2.690
Chloride (Cl)	19.350
Bromide (Br)	0.070
Total dissolved solids (salinity)	35.079

The following minerals are found in old lake or ocean deposits:

- Calcium carbonate (limestone)
- Sodium chloride (salt)
- Magnesium sulfate (Epsom's salt)
- Trace elements (boron, iron, etc.)



- On land, the more rainfall, the lower the content of some mineral salts.

Fig. 2.6

Relationship between vegetative growth and moisture supply along a west to east transect to the Great Plains. (From Shantz.[23])

Mineral salts are leached in this order:

sodium; calcium; magnesium; potassium

- High rainfall (>15 inches in 6 months) soils have low sodium & calcium. Even higher rainfall results in losses of magnesium and potassium
- Medium rainfall soils have rich reserves of minerals and are generally most productive
- Low rainfall (<10 inches/year) soils have high salt contents

What Do Dams do?

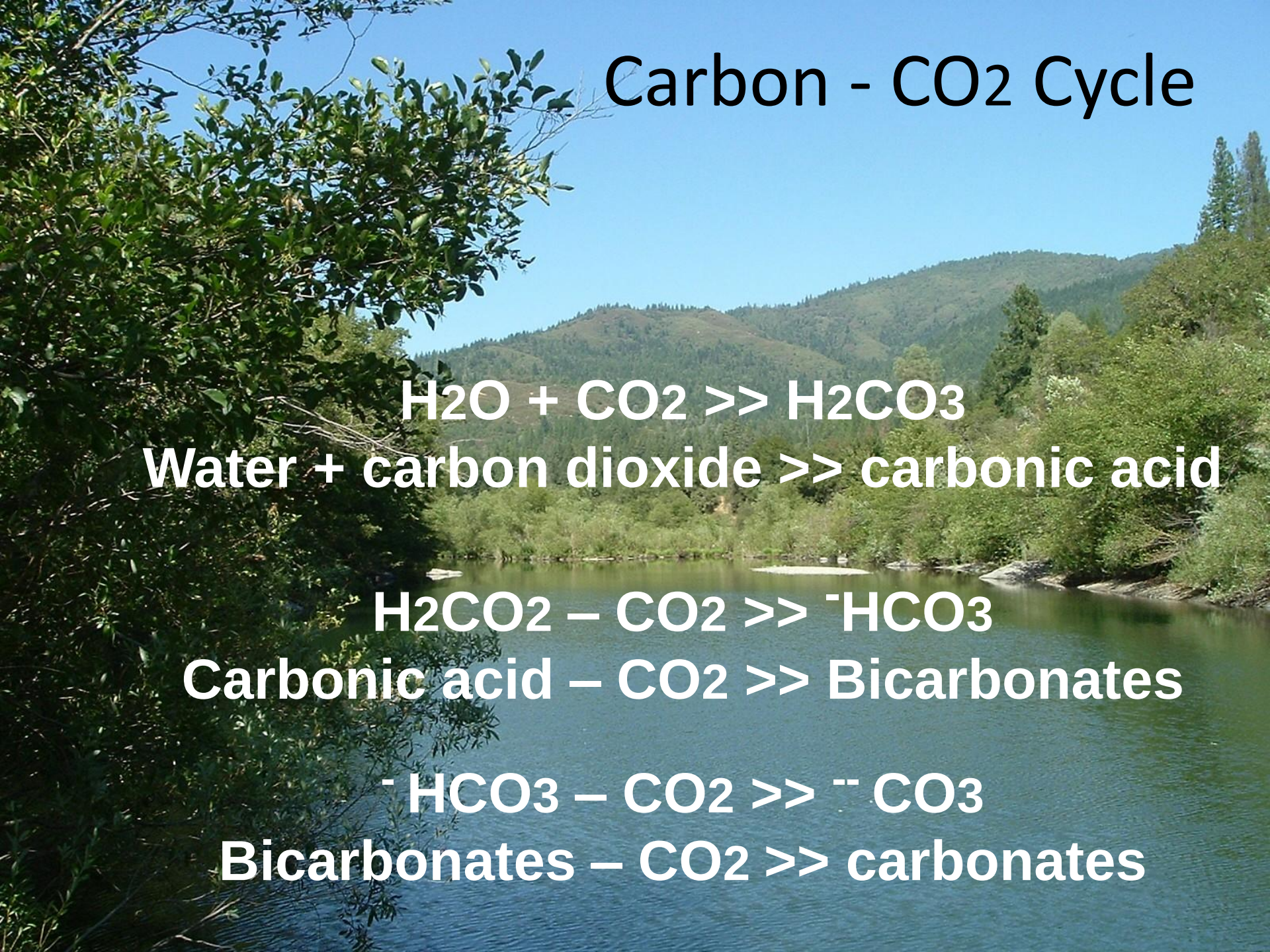
- (Besides blocking fish passage, reallocating water supplies & changing natural cycles?)

Effects of Dams & Reservoirs 1

- Rainfall picks up CO_2 from the air >> carbonic acid (H_2CO_3).
- Water picks up more CO_2 from air and soil organic matter when coming off igneous rocks (basalt, granite) and forest soils
- This natural acid dissolves minerals in soils, resulting in bicarbonates of Ca, Mg, K, Na.
- Under natural conditions these salts are deposited in rivers, floodplains, lakes & oceans

Effects of Dams & Reservoirs 2

- As water sits in lakes, oceans & rivers, CO_2 evaporates. Bicarbonates (HCO_3^-), then carbonates (CO_3^{--}) form from carbonic acid as CO_2 leaves the system
- This results in carbonates of Ca, Mg, K, Na, which can deposit as salts or remain in solution
- This results in high pH problems and nutritional imbalances in irrigated land. High pH is the symptom, not the cause of the problems



Carbon - CO_2 Cycle

$H_2O + CO_2 >> H_2CO_3$

Water + carbon dioxide >> carbonic acid

$H_2CO_2 – CO_2 >> {}^{-}HCO_3$

Carbonic acid – CO_2 >> Bicarbonates

$^{-}HCO_3 – CO_2 >> {}^{--}CO_3$

Bicarbonates – CO_2 >> carbonates

The following common salts/minerals are deposited in bodies of water and soils:

- Calcium carbonate, magnesium carbonate, potassium carbonate, sodium carbonate
- Also chlorides of Ca, Mg, K, Na
- When rivers are dammed and desert areas irrigated, the salts of carbonates can result in problems with crops. Modern remedies usually involve acidification with chemicals. This generally results in very good yields for many years – but not forever.
- Civilizations have risen and fallen during this process.

The carbon dioxide in the soil solution makes it a potent solvent for calcium compounds; thus calcium is leached out lf the soil as calcium bicarbonate and soil acidity is increased. Large amounts of calcium and sodium have been carried into the oceans. Sea water is salty from the accumulation of sodium salts; it would be milky from the accumulation of calcium salts if most of the calcium had not been removed from the water and built into the shells of marine animals to be deposited on the ocean bottom (Sprague, H. 1964. Pg. 65).

Sustainable Agriculture

- Systems that use sustainable methods follow natural cycles when feasible.
- This builds soil organic matter (SOM) through cover cropping and compost amendment.

Sustainable Agriculture

- SOM produces carbonic acid naturally, which helps dissolve minerals & keep them available to plants. CO_2 can also be added to irrigation water.
- High rainfall/acid soils often are <u>lacking</u> in calcium and magnesium carbonates (limestone & dolomite) and other minerals

Climate effects on soil formation & productivity

Appendix I

CLIMATE and SOIL FORMATION

FOREST	PRAIRIE/GRASSLAND	DESERT
HIGH RAINFALL: 20+ "	MEDIUM RAINFALL: 10 - 15 "	LOW RAINFALL: 0 - 5 "
PRECIPITATION > EVAPORATION	BALANCED PRECIP / EVAPORATION	EVAPORATION > PRECIPITATION
HI O.M. ACCUMULATION - Trees	O. M. ACCUMULATION - Roots	LOW O.M. ACCUMULATION
LEACHING OF MINERALS - Na, Ca, Mg, P_2O_5		ABUNDANCE OF NUTRIENTS - Ca, Mg, K, P_2O_5, excess salts
<< INCREASING ACIDITY	MEDIUM RANGE pH 7-8	INCREASING ALKALINITY >>
BICARBONATE (HCO_3) PRODUCTION	LOW ACIDITY - DISSOLVES NUTRIENTS	CARBONATE (CO_3) ACCUMULATION
CARBOHYDRATES - Wood, fruits	PROTEIN - forages, grains, legumes	PROTEIN w/ irrigation & salt leaching
SUPPORTS FEWER ANIMALS	HIGH ANIMAL PRODUCTION	LOW NATIVE ANIMAL PRODUCTION
NEEDS: Limestone; often major nutrients	Needs: Maintain fertility & organic matter	NEEDS: Water, O.M., leaching of excess salts, often micronutrients
UNDER DESTRUCTION	WELL DEVELOPED	UNDER CONSTRUCTION

By Gregg Young, from Albrecht (1975)

Native Americans in the plains and Central Valley followed elk, buffalo, deer, and antelopes from southern to the northern regions as the seasons changed. The wetter desert and prairie/grassland areas were the most productive.

To grow or produce highest amounts of protein (animal, seeds, nuts) the soils need the missing minerals in high rainfall areas. This is called re-mineralization.

Limestone and potash applied to north coast soil

Did Native Americans know this?

- They managed natural resources on a sustainable level.
- They used natural forces: fire, weather & vegetation to manage resources to their advantage.
- They generally recognized when resources were becoming scarce, and moved to new areas, limited harvests, or changed practices.
- Among the techniques of traditional resource management: burning, irrigating, pruning, sowing, tilling, and transplanting

From: Anderson, K. (2006). Tending the Wild – Native American Knowledge and the Management of California's Natural Resources

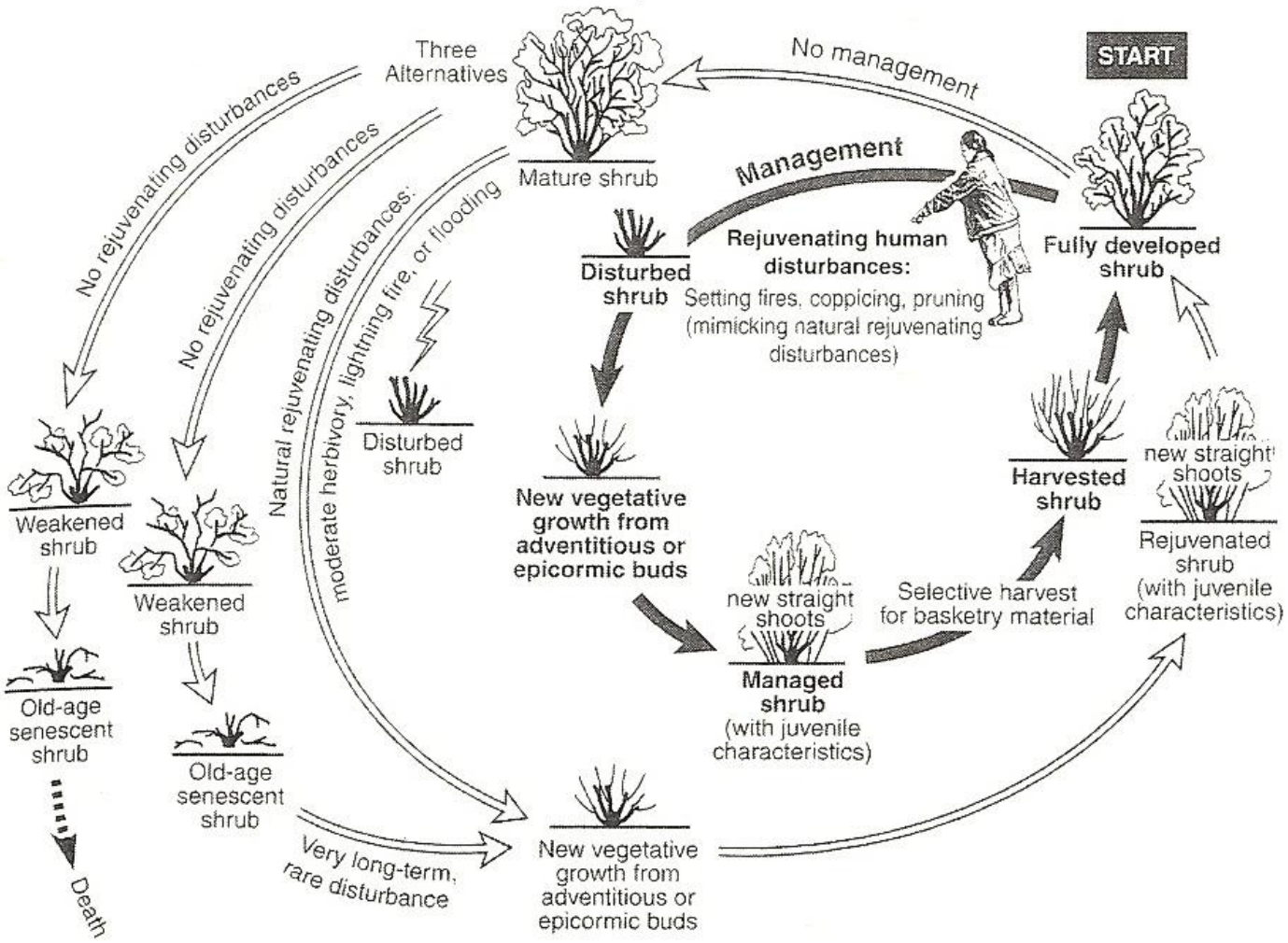
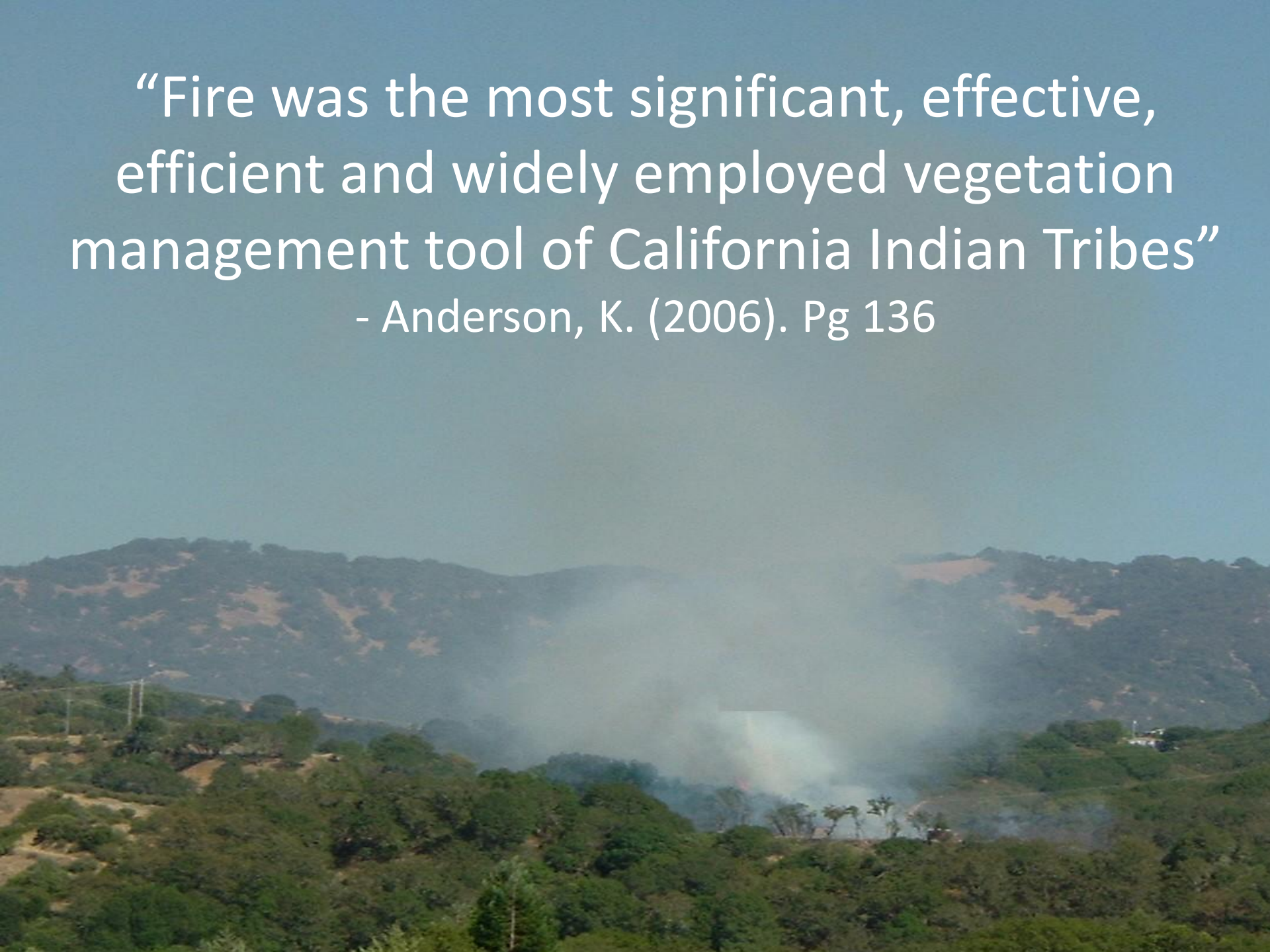


Figure 31. Coppice shrub system: a conceptual model for indigenous management of shrubs. Management techniques mimic natural disturbances such as flooding and lightning fires and can be applied over long periods to manage shrubs in situ. In the absence of disturbance the shrub's life span may be shortened, and it quickly becomes unsuitable for basketry material.



"Fire was the most significant, effective, efficient and widely employed vegetation management tool of California Indian Tribes"

- Anderson, K. (2006). Pg 136

Burning entire watersheds creates tons of ash; some of this is delivered to bodies of water in pulses during large rain events

EFFECTS of FIRE

- Reduces organic matter to its mineral constituents (calcium, potassium, magnesium, phosphorus, sodium, sulfur, micronutrients)
- Eliminates pests, diseases and unwanted plants
- Stimulates growth of perennial plants and forages
- Stimulates nitrogen fixing bacteria (free-living and nodule/legume)
- Improves game productivity and protein production
- Thins understory of forests, resulting in larger, faster growing trees & shrubs

What's in Wood Ash? (% by Weight)

Element	Pine	Aspen	Poplar	R. Oak	W. Oak	W. Oak Bark	D. F. Bark
Calcium	29.05	21.17	25.67	36.58	31.35	36.14	34.26
Potassium	16.24	11.25	7.93	6.08	10.25	0.97	2.78
Magnesium	7.03	3.55	9.09	5.20	7.57	0.34	0.37
Sulfur	1.07	0.70	1.02	1.80	1.21	0.40	0.52
Phosphorus	0.84	1.18	0.95	1.56	0.56	0.08	0.51
Manganese	4.04	0.14	0.45	1.49	0.14	0.16	0.37
Zinc	0.36	0.34	0.04	0.22	0.08	0.05	0.07
Iron	0.58	0.26	0.32	n.d.	0.09	0.01	0.26
Aluminum	0.47	0.14	0.35	0.68	<0.03	<0.03	0.59
Sodium	0.06	0.06	2.30	0.08	<0.06	<0.06	<0.06
Silicon	n. d.	0.11	n. d.	n. d.	0.13	0.12	0.24
Boron	0.06	0.05	0.05I	0.08	0.04	0.007	0.07
Copper	0.04	0.03	0.03	0.07	0.02	<0.002	0.02

What's in the Ash from an Acre of Chaparral? (in pounds/acre)

Element	Red shank	Chamise	Ceanothus	Black sage	TOTAL (+ misc)
Calcium	52	48	78	12	211
Nitrogen	33	24	50	8	121
Potassium	30	18	33	21	102
Magnesium	6	3	5	2	17
Phosphorus	4	2	2	2	10
Sodium	3	1	2	1	8

Thinning of Forests will occur:

- By Humans OR
- By Fire OR
- By Pests, Diseases

(We get to choose)

"Epidemics" such as *Phytophthora* and others are a natural part of forest cycles; these will increase if we continue to exclude fire from the system.

RESOURCES 1

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RESOURCES 2

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