Irrigation of Agricultural Crops in California

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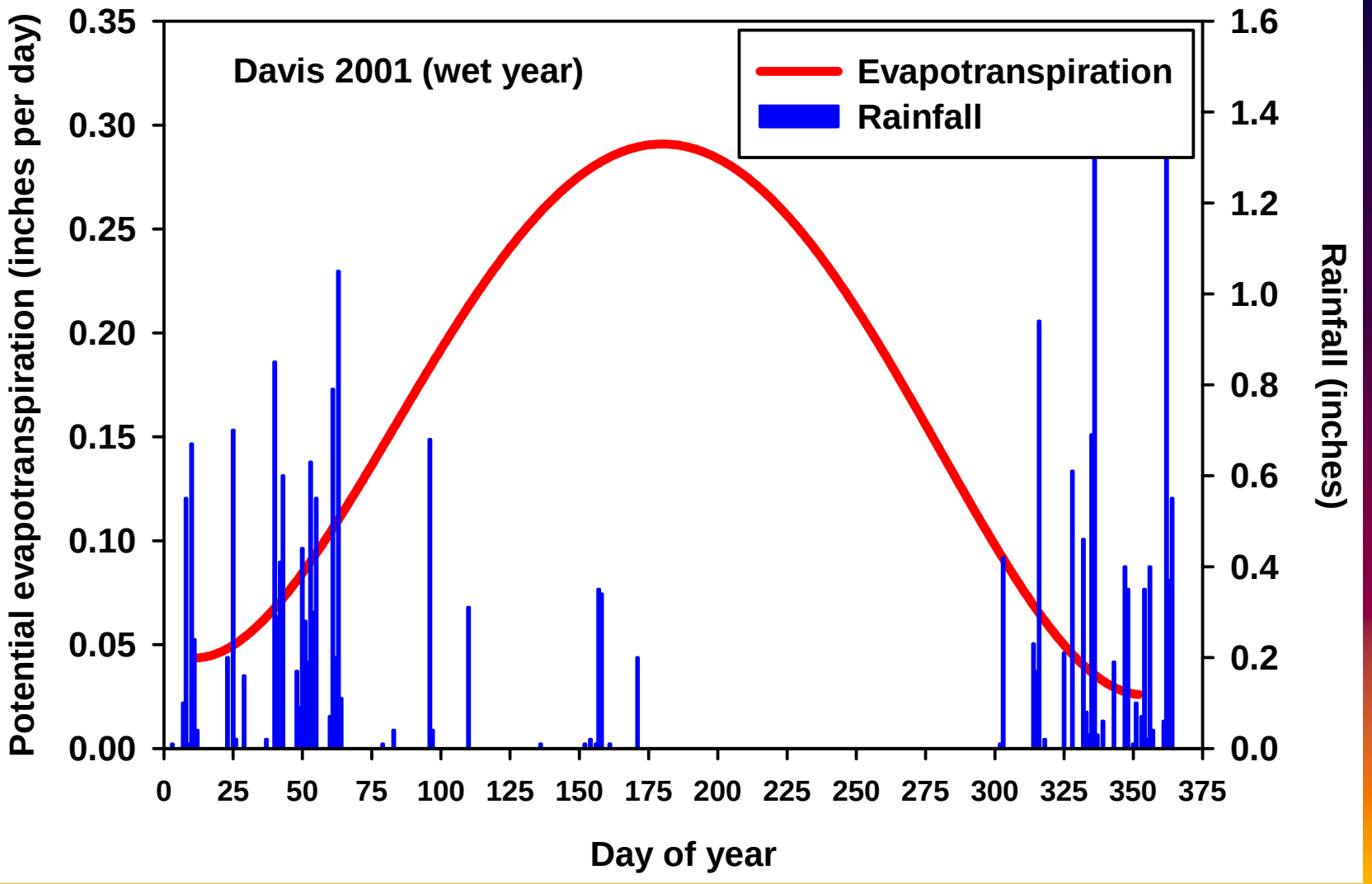
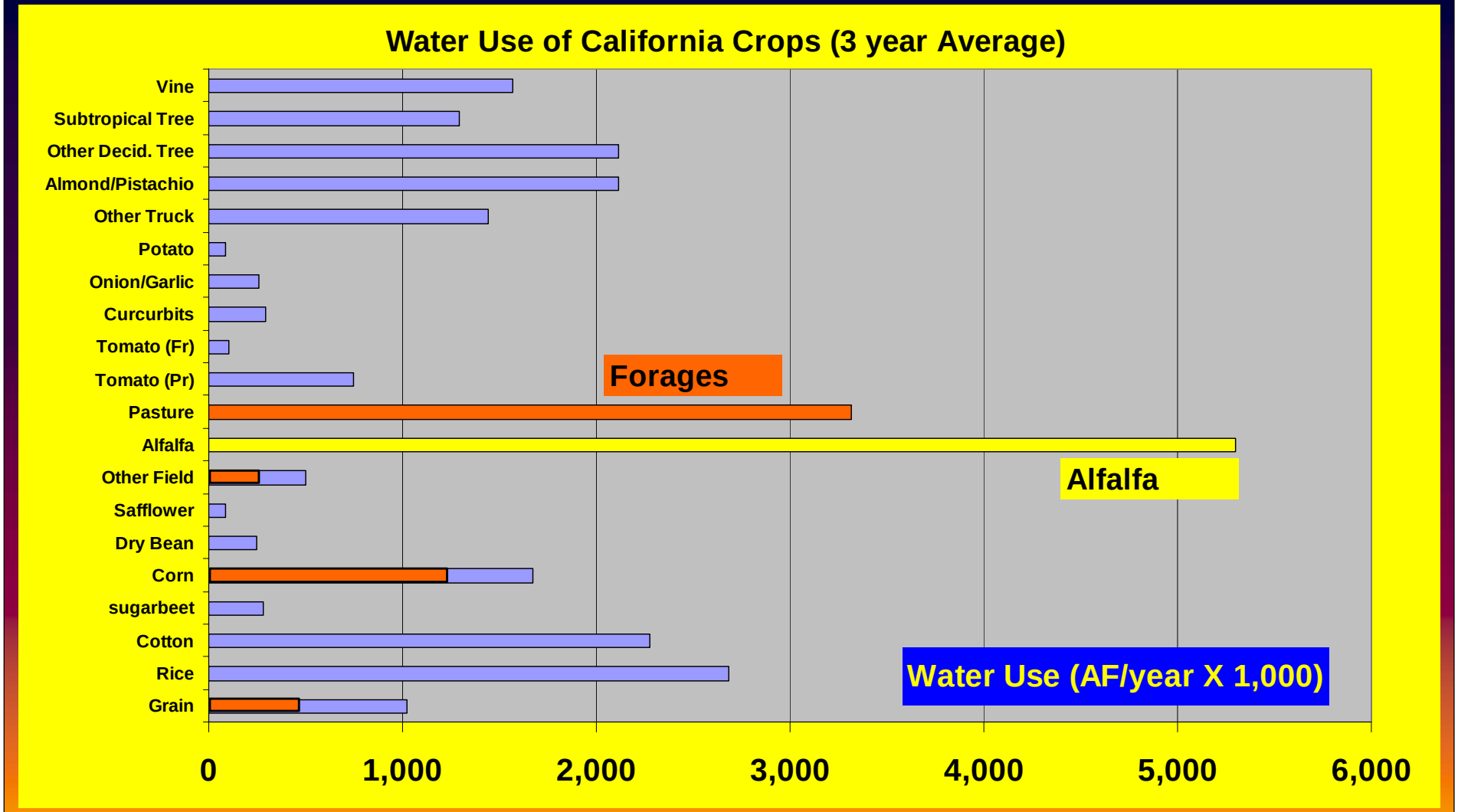
What percentage of California's water is used by agriculture?

- 80 %: based on the developed water supply
- 52 %: based on the total water supply of a dry year
- 29 %: based on the total water supply of a wet year

Why irrigate?



Water Use of California Crops



How much water does agriculture need?

What is evapotranspiration (ET)?

- Evapotranspiration: crop water use
  - Water evaporation from plant leaves (transpiration)
  - Water evaporation from soil surface
  - More than 95% of the water uptake by plants is evaporated
- Factors
  - Climate: solar radiation, temperature, humidity, wind
  - Plant: crop type, stage of growth, health
  - Soil moisture content

Units of evapotranspiration (ET)

- Volume of water
  - One acre-inch = 27,160 gallons
  - One acre-foot = 325,900 gallons
- Depth of water (inches, feet, cm, mm)
  - Standardized water use (independent of field size)
  - One inch of water = 1 acre-inch per acre = 27,160 gallons per acre

Measuring evapotranspiration (ET)

- Difficult and expensive to measure
- Methods
  - Lysimeter – very expensive, restricted to ag field stations
  - Meteorological methods – moderately expensive, portable
  - Soil moisture measurements – inexpensive, can be inaccurate
- California Irrigation Management Information System (CIMIS)
  - Network of weather stations Installed and maintained by the University of California and California Department of Water Resources
  - Weather data used to calculate a reference crop ET (ET of grass or alfalfa)
  - Crop coefficients (Kc) used to relate reference crop ET to actual crop ET
  - ET = Kc x Reference crop ET

Lysimeter

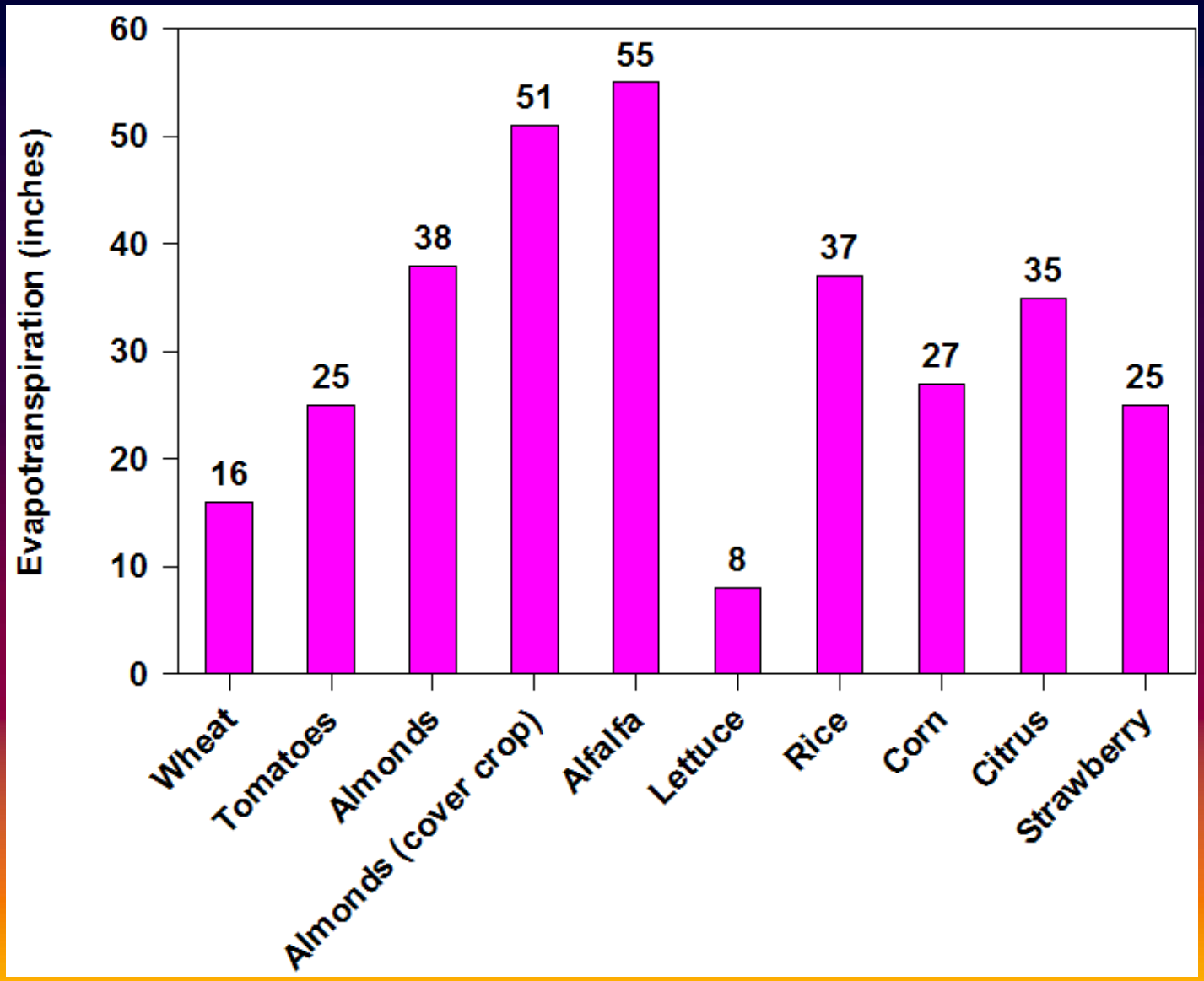
Meteorological Methods

Soil moisture measurements

CIMIS weather station – data and complex equations are used to calculate a reference crop ET

Crop ET = crop coefficient x reference crop ET

Evapotranspiration of selected crops




Alfalfa

Where do dairy products come from?

- Dairy products: ice cream, cheese, milk, yogurt, butter
- Dairy cows produce the milk used to make these products
- Dairy cows eat about 70% of the alfalfa produced in California

Alfalfa

- Products: ice cream, milk, cheese, yogurt, butter
- Seasonal ET of alfalfa = 55 inches of water = 55 acre-inches per acre = 1,500,000 gallons per acre
- 160 acres: ET = 160 acres x 1,500,000 gallons per acre = 240,000,000 gallons of water per year (does not included irrigation system inefficiencies)
- Are we wasting water growing alfalfa?

Grain

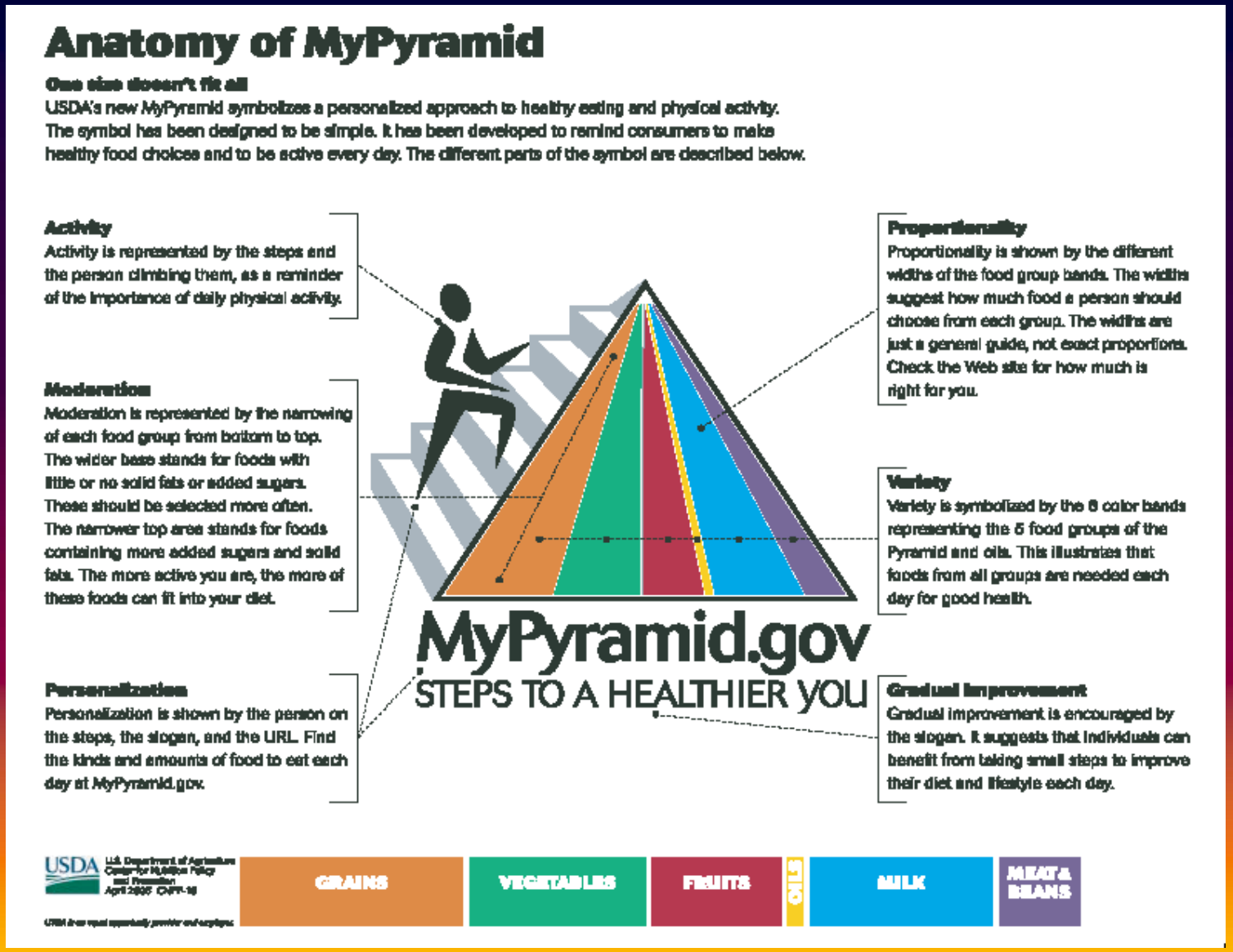
- Products: bread products, rice, cereal, chicken, eggs, steak
- Seasonal ET of wheat = 16 inches of water = 16 acre-inches per acre = 435,000 gallons per acre
- 160 acres: ET = 160 acres x 435,000 gallons per acre = **69,600,000** gallons of water per year (does not included irrigation system inefficiencies)

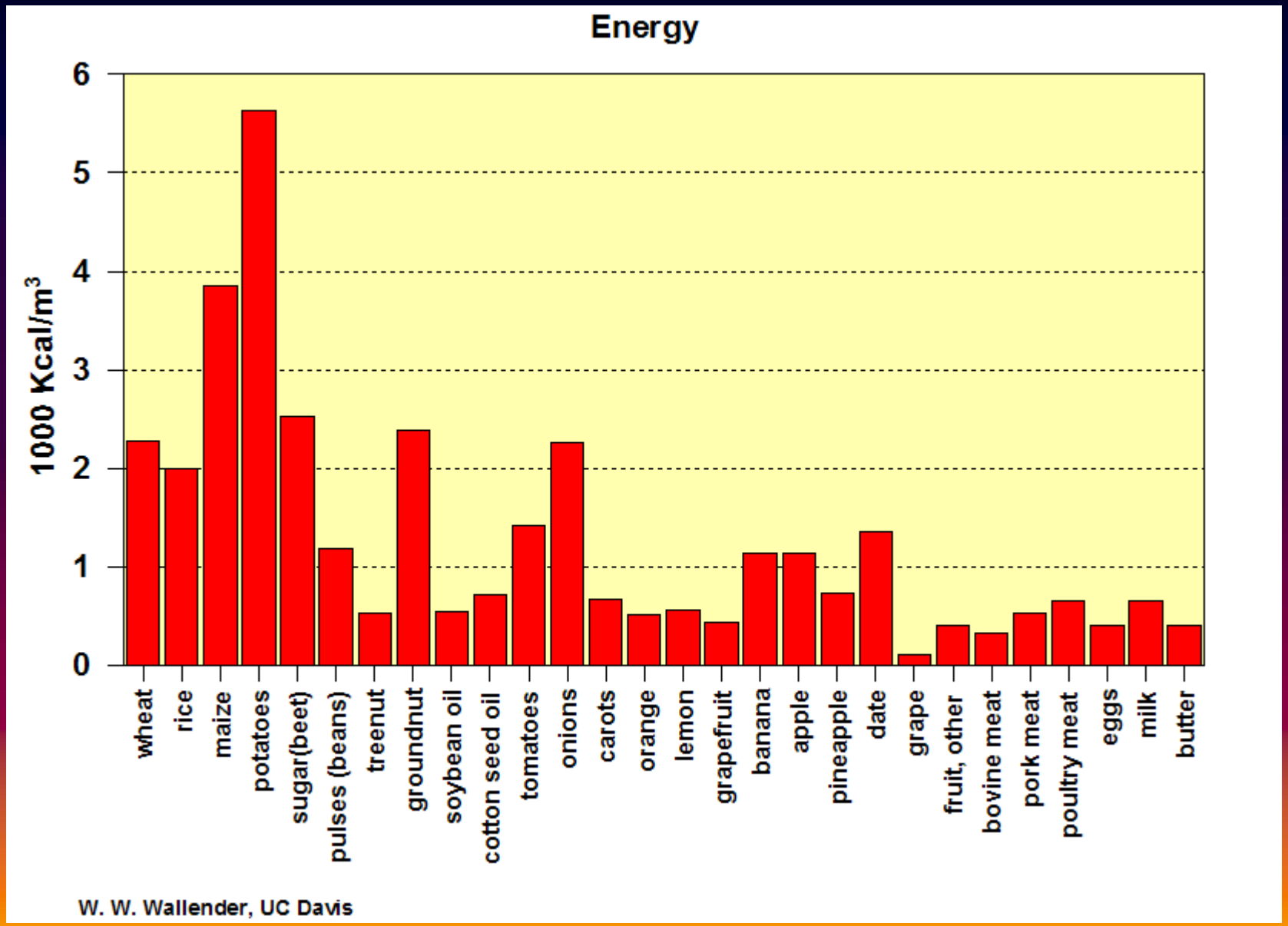
What crops should be grown in California?

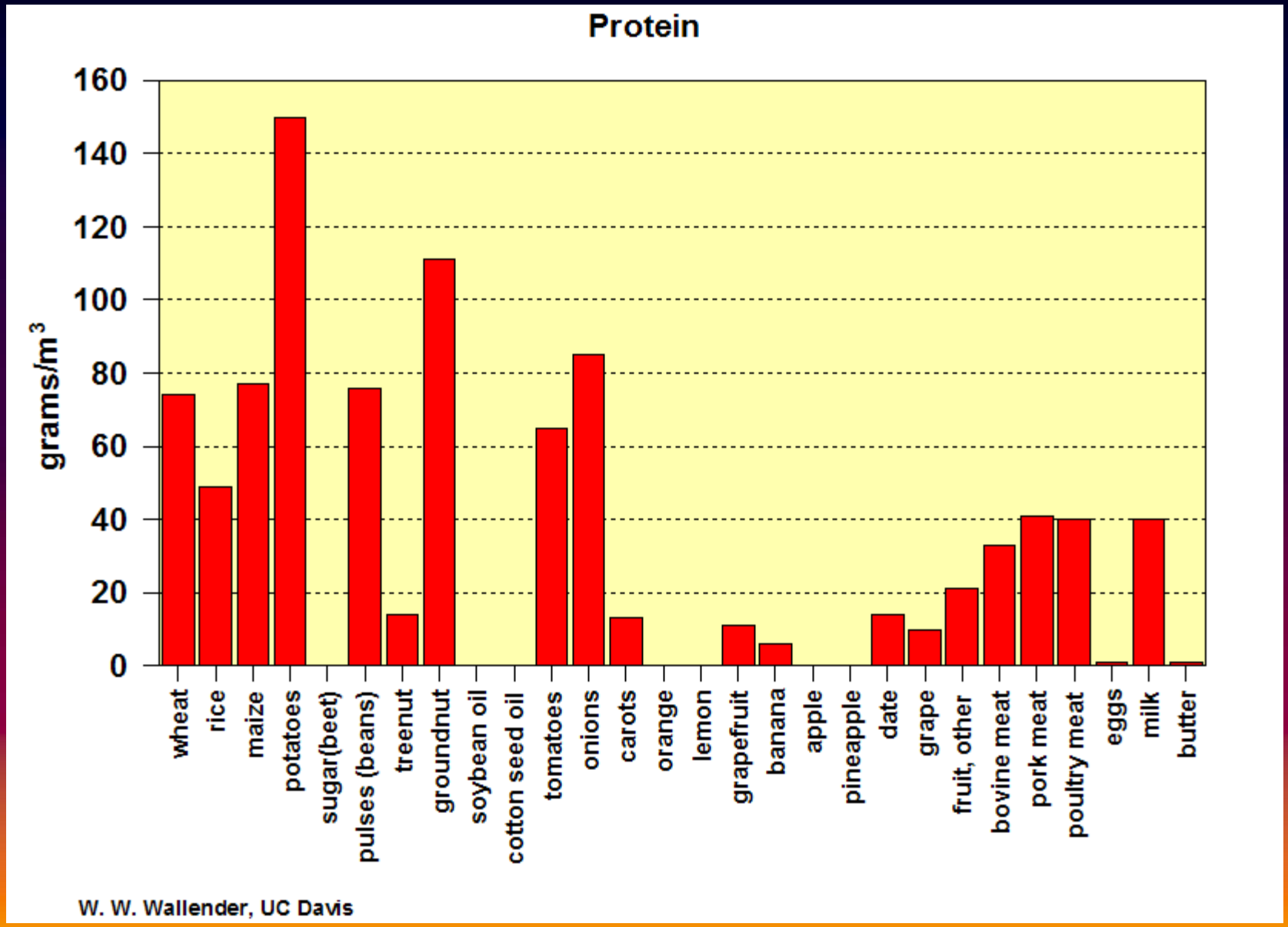
Maximize dollar returns?

- Only high cash value crops should be grown
  - Tree crops
  - Vegetable crops
  - Tomatoes
- Low cash value crops should not be grown
  - Wheat
  - Corn
  - Cotton
  - Alfalfa?

Maximize human health?




Energy
1000 Kcal/m3
0
1
2
3
4
5
6
wheat
rice
maize
potatoes
sugar(beet)
pulses (beans)
treenut
groundnut
soybean oil
cotton seed oil
tomatoes
onions
carots
orange
lemon
grapefruit
banana
apple
pineapple
date
grape
fruit, other
bovine meat
pork meat
poultry meat
eggs
milk
butter
W. W. Wallender, UC Davis


Protein
grams/m3
160
140
120
100
80
60
40
20
0
wheat
rice
maize
potatoes
sugar(beet)
pulses (beans)
treenut
groundnut
soybean oil
cotton seed oil
tomatoes
onions
carots
orange
lemon
grapefruit
banana
apple
pineapple
date
grape
fruit, other
bovine meat
pork meat
poultry meat
eggs
milk
butter
W. W. Wallender, UC Davis

The situation

- Agriculture cannot compete economically with the urban/industrial sector for water.
  - Uses a large amount of water per unit of production
  - We do not pay very much for the agricultural products
- Regardless of the economics, if we want food we will have to pay the price in terms of water and land for producing the agricultural products used to produce our food. There is no other choice if we want food!
- Lower-cash value crops provide a major part of our diet

Irrigation methods in California

Irrigation efficiency

- **Definition: ratio of water beneficially used to amount applied**
- **Beneficial uses**
  - **ET – major use**
  - **Salinity control**
  - **Frost protection**
  - **Drip system maintenance**
- **Losses affecting the irrigation efficiency**
  - **Surface runoff – water that runs off the lower end of gravity irrigated fields**
  - **Deep percolation – water that percolates through the soil below the root zone**
  - **Evaporation**
- **Different numbers for farm, irrigation district, regional irrigation efficiencies**

Furrow irrigation (gravity)

Flood or border irrigation (gravity)

Wheel-line sprinkle system

Hand-move sprinkle system

Portable solid-set sprinkler system

Center-pivot sprinkler system – inappropriate for many California soils

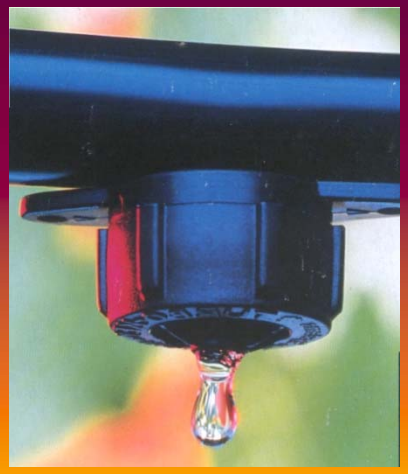
Linear-move sprinkler system

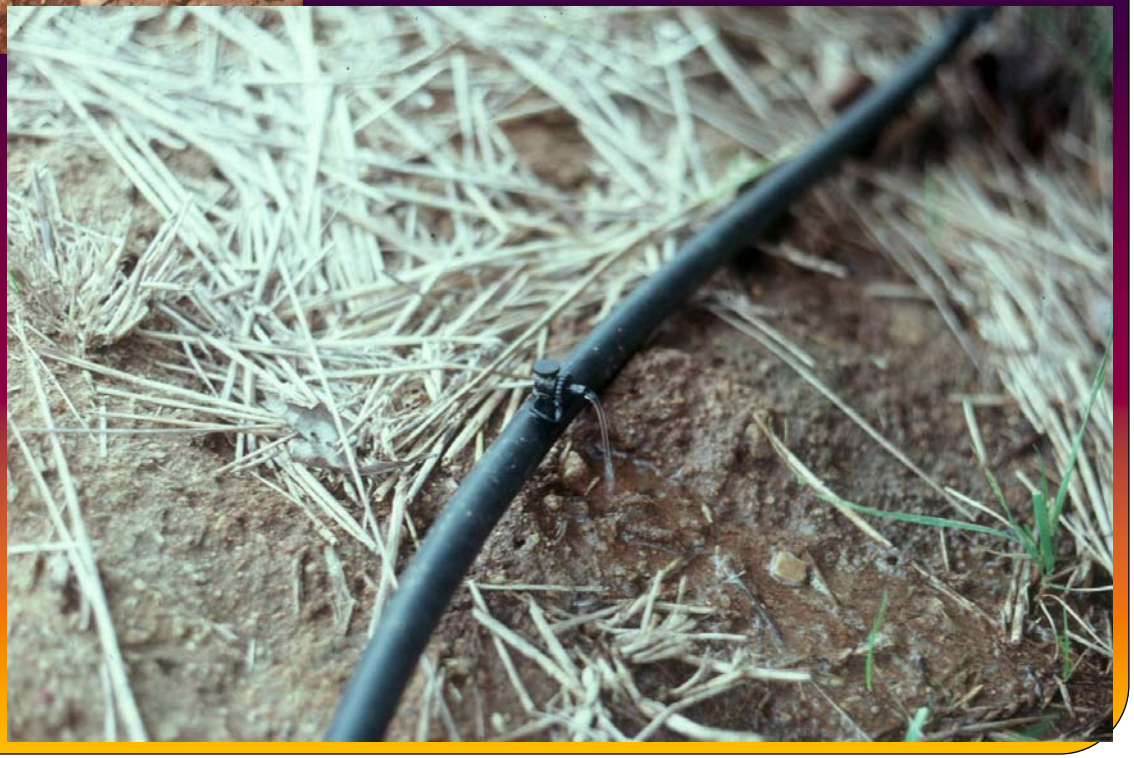
Microsprinklers – tree crops

Microsprinkler

Drip irrigation – vineyards, tree crops

Drip emitter





Drip irrigation – row crops

Surface drip irrigation

Subsurface drip irrigation

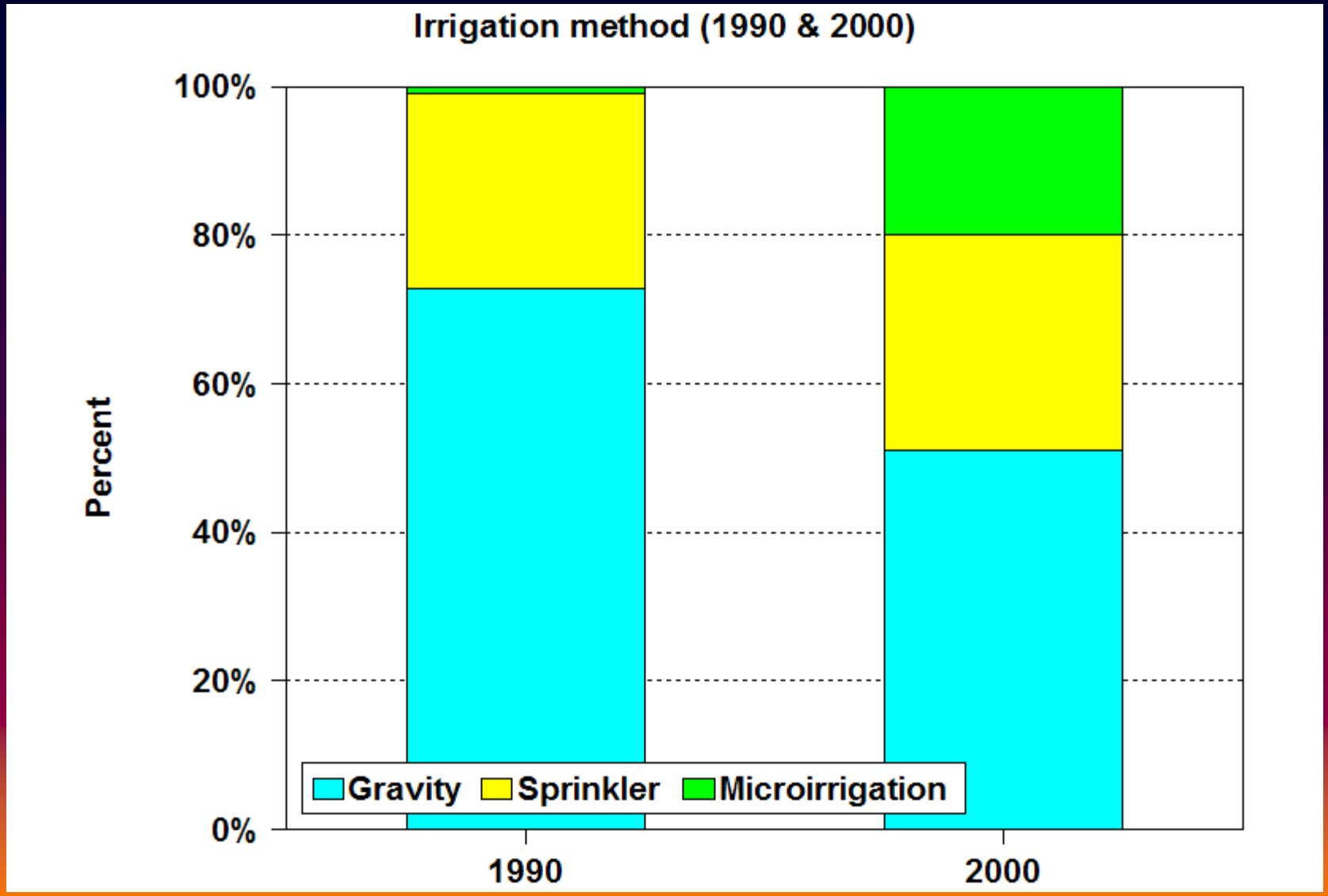
Drip tape

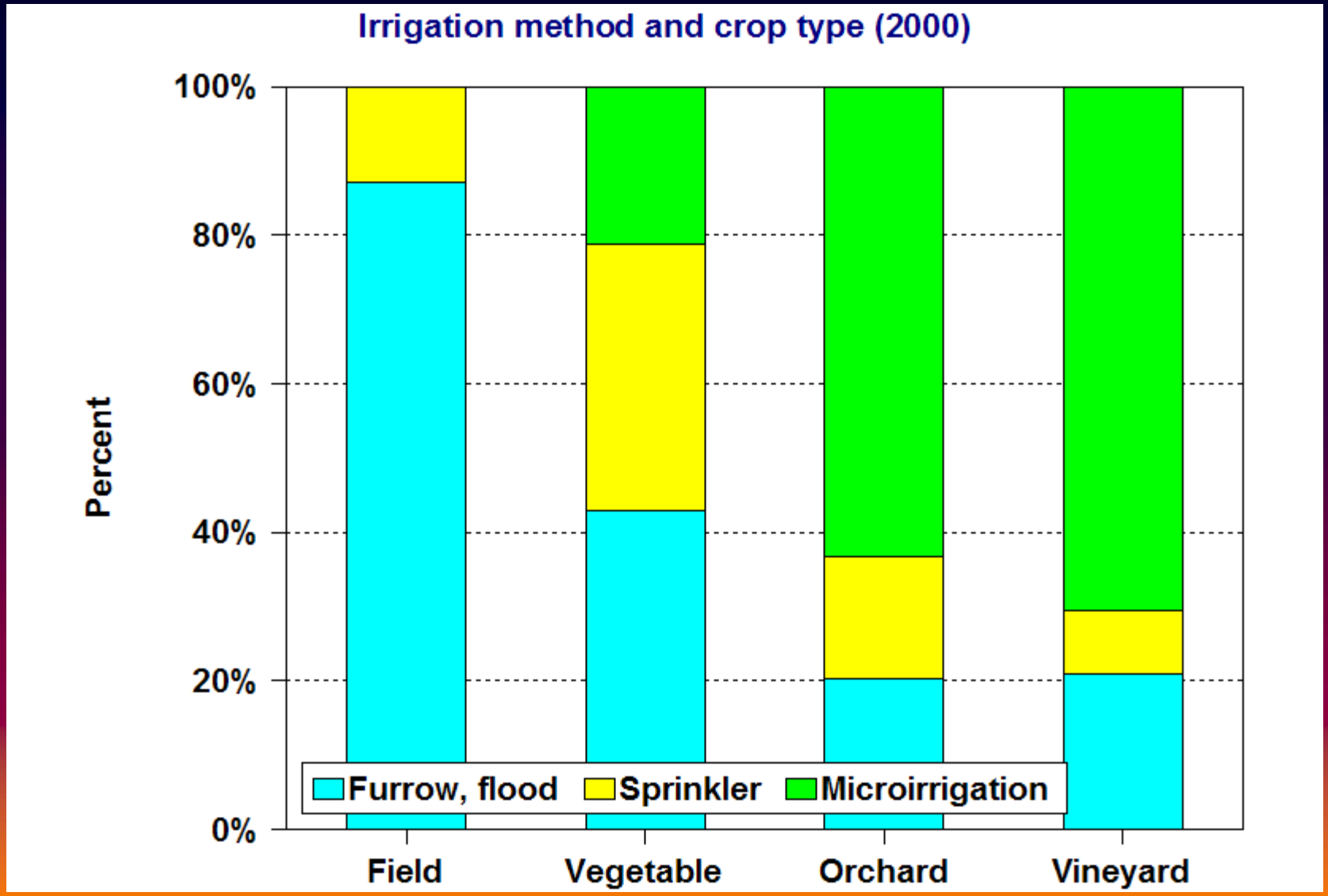
Which irrigation method is the best?

- Gravity irrigation
  - Low capital cost
  - Low labor cost to operate
  - Difficult to manage efficiently – trial and error approach
  - Surface runoff can cause water quality problems
- Sprinkler irrigation
  - Moderate capital cost
  - Low to moderate labor costs to operate
  - Easy to manage
  - Efficiency limited by wind effects
- Microirrigation
  - High capital costs (up to $1,000 per acre)
  - Precise application of water throughout a field
  - Moderate labor costs
  - Easy to manage
  - Highly susceptible to emitter clogging

Maximum potential irrigation efficiencies

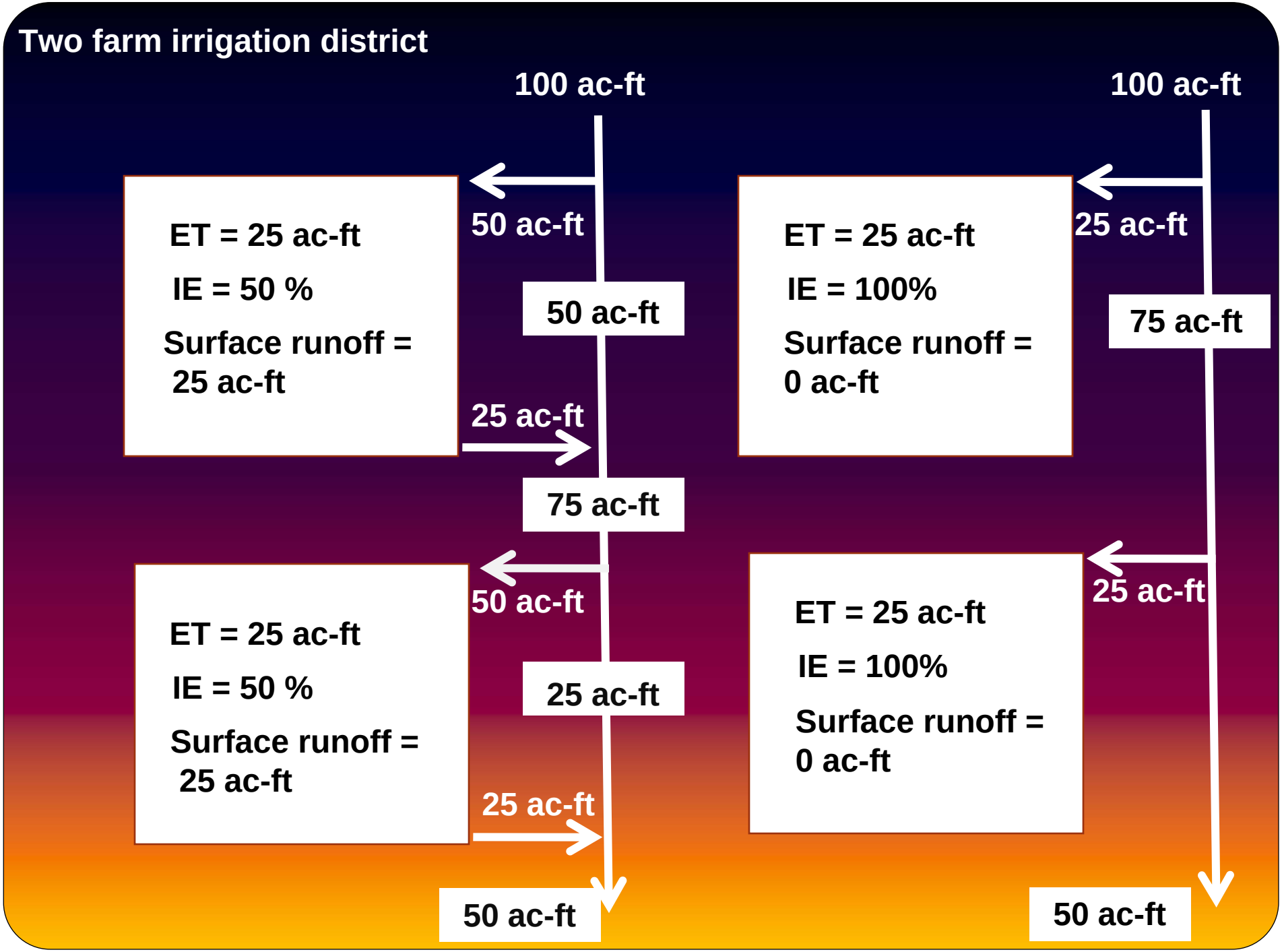
Irrigation method	Irrigation efficiency (%)
Gravity (furrow, flood)	70-85
Sprinkle	
Hand-move, wheel-line, solid set	70-80 (low wind)
Center pivot, linear-move	80-90
Microirrigation	80-90


Irrigation method (1990 & 2000)
100%
80%
60%
40%
20%
0%
Percent
Gravity
Sprinkler
Microirrigation
1990
2000


Irrigation method and crop type (2000)
Percent
100%
80%
60%
40%
20%
0%
Furrow, flood
Sprinkler
Microirrigation
Field
Vegetable
Orchard
Vineyard

Will increasing the farm irrigation efficiency save water that can be used elsewhere?

- Numerous studies have attempted to answer this question
  - Many researchers are not very familiar with irrigated agriculture
  - Some ignore reality
  - Questionable assumptions, results, and conclusions
- Problem – losses from one farm frequently are used by downstream water users
  - Difficult to track where the water goes
  - Little or no real water savings


Two farm irrigation district
100 ac-ft
50 ac-ft
ET = 25 ac-ft
IE = 50 %
Surface runoff = 25 ac-ft
50 ac-ft
25 ac-ft
75 ac-ft
50 ac-ft
ET = 25 ac-ft
IE = 50 %
Surface runoff = 25 ac-ft
25 ac-ft
25 ac-ft
50 ac-ft
100 ac-ft
25 ac-ft
ET = 25 ac-ft
IE = 100%
Surface runoff = 0 ac-ft
75 ac-ft
25 ac-ft
ET = 25 ac-ft
IE = 100%
Surface runoff = 0 ac-ft
50 ac-ft

Estimates of potential water savings from increased irrigation efficiency

- University of California study – 843,000 acre-feet
  - University , state and federal agencies, irrigation districts, grower organizations
  - Considered reuse of water
  - Estimate based on amount of water not reused downstream
- Consultant study – at least 4.400,000 acre-feet
  - Did not consider reuse of water
- Improved water quality may be the primary benefit of increased irrigation efficiency rather than water savings – reduced surface runoff (sediments, pesticides, nutrients)

Where will the water come from?

- No more dams for water storage
- Water conservation from increased irrigation efficiency?
- Removal of agricultural land from production – most likely source of water for satisfying the increased urban/industrial and environmental water demands
  - DWR water transfer program
  - MWD program of removing alfalfa fields from production on a rotating basis in the Palo Verde Valley – water is transferred to the LA area
- Deficit irrigation of agricultural fields
  - Regulated deficit irrigation – trees and vine crops (UC Davis)
  - Mid-summer deficit irrigation - alfalfa (UC Davis)
- Reduced urban/industrial and environmental demands

Summary

- Agriculture is California's largest user of water.
- It takes a lot of water to produce a crop.
- The price that society has to pay for food is the water and land required to produce the crops needed for food. There is no other choice.
- It is unlikely that increasing irrigation efficiency will have a large impact in supplying the predicted future water needs of the urban/industrial and environmental sectors.
- Agricultural land will need to be removed from production to supply the needed water.

Have a good day!