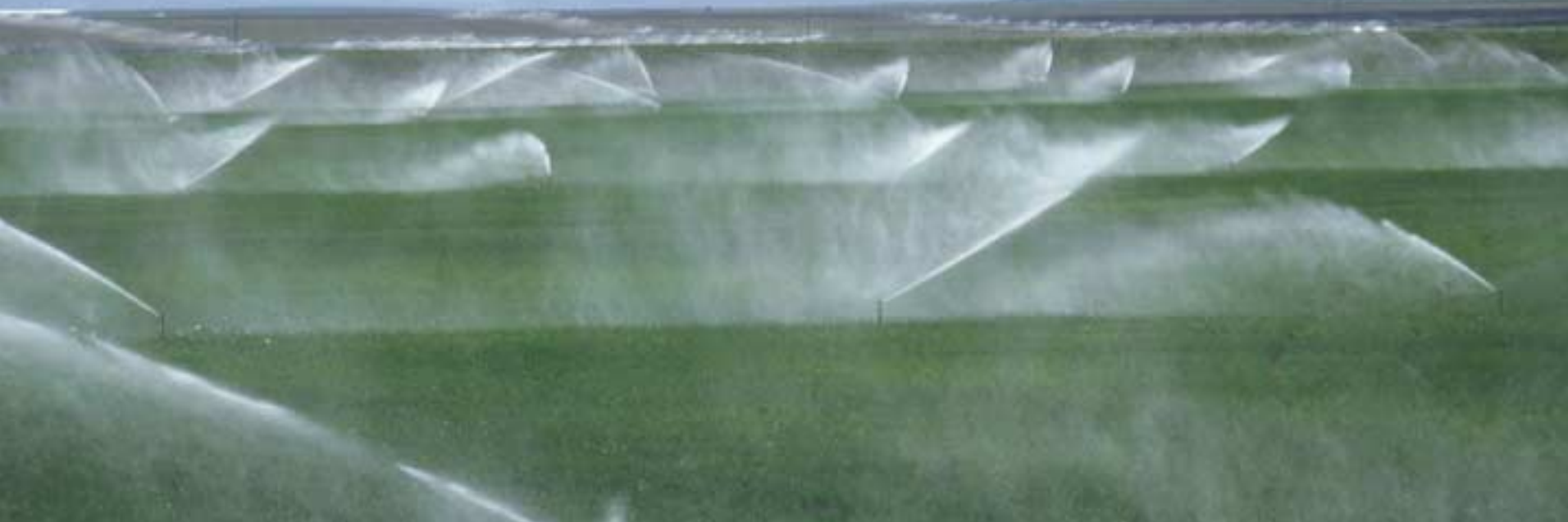


# IRRIGATION

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Barbara Bellows, NCAT Soils Specialist

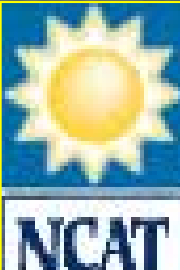


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# Sustainable Irrigation



**Irrigation** practices farmers can continue to use to produce agricultural products at reasonable cost while ensuring that irrigation and drainage do not degrade the quality of land, water, or other natural resources

# Un-sustainability of Irrigation

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- **Globally, 71% of withdrawn freshwater is used for irrigation**
- **Rivers dammed to collect irrigation water**
  - People living in areas behind the dams are displaced
  - Wildlife habitat destroyed
- **Irrigation depletes rivers and aquifers**
- **Irrigation degrades water, soil, and wildlife habitat**

# Access to Irrigation Water

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- **Government support of irrigation**
  - Historically, allowed crop production in areas where they would not thrive without irrigation
  - Greater water-use competition increasingly reduces water available to agriculture
- **Irrigation water availability**
  - Requires permit in many states
  - Permit process causes inequities among agricultural producers



# Irrigation and Water Rights

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- **Ground- and surface-water rights vary by state**
  - California: First person to claim owns rights to water
  - South Dakota: All water is the property of the state
- **Unresolved water rights / water use issues**
  - Who owns conserved water?
  - Water banking (storage and reserve)
  - Water pricing: urban vs. rural, large vs. small farms
  - Water futures (stock trading)

# Water Competition

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- **Supply problems**
  - Increased water demand for irrigation
  - Decreased availability of good-quality water
- **Economic problems**
  - Increased competition with urban water users
  - Water rationing
  - Increased cost of irrigation water
  - Water available but not sufficient or available only at the wrong time



# Competing Water Demands

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- **Agricultural use**
- **Residential use**
- **Industrial / commercial use**
  - Industry, bottled water
  - Tourism: hotels, fountains, golf courses, boating
- **Water levels for commercial shipping**
- **Water levels for wildlife / fish habitat**



# Future of Irrigation

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- **Water available for irrigation will decrease**
  - Increased demand for water quality, urban water use
  - Increased economic competition for water
  - Water use decisions will be at the watershed level
- **Global competition for agriculture products**
  - Affects prices of agricultural products
  - Determines profitability of irrigated crops
  - Favors larger, diversified farms



# Sustainable Irrigation

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- **Extract only the amount of water that can be replenished through recharge**
- **Apply water efficiently**
  - Minimize losses during delivery to site and application to crops
  - Apply only the amount of water the crop needs
- **Minimize downstream environmental damage**
  - Protect water quality to protect irrigation water
  - Isolate, reuse, or dispose of saline drainage water

# Limited Irrigation

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- **Reduce irrigated acreage**
  - Grow primarily crops that use less water
  - Manage soils to capture and hold precipitation
- **Reduce irrigation water applied**
  - Apply water as needed to obtain best economic returns
  - Delay irrigation until plants reach critical need for water
- **Water reuse**
  - Reuse irrigation water prior to discharge
  - Use municipal waste water for irrigation



# Limited Irrigation Management

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- **Limited irrigation provides the best economic returns rather than the highest yields**
- **Especially important where irrigation water is not sufficient to meet crop demands**
  - High competing demands for water
  - Ground and surface water reserves are being depleted
  - Quality of available irrigation water is being degraded



# Reduce Irrigated Acres

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- **Plant dryland crops that require less water**
- **Increase moisture-holding capacity of dryland soils**
  - Use mulches and cover cropping
  - Employ minimum tillage practices
  - Increase soil organic matter
- **Decrease evaporation by planting windbreaks**
- **Increase water-use efficiency on irrigated land, to obtain the same production on less land**



# Increase Irrigation Efficiency

- **Reduce seepage loss**
- **Reduce evaporation in fields**
- **Schedule irrigation based on soil moisture and plant needs**
- **Do not over-fertilize crops**
- **Control weeds that compete for water**
- **Time planting to take greatest advantage of natural precipitation**



# Efficiency of Irrigation Methods

- **Flood**                      **least efficient**
- **Furrow**
- **Sprinkler**
  - Center-pivot
  - Wheel line
- **Micro-irrigation**    **most efficient**
  - Trickle, drip, spray
  - Above ground, below ground



Wetting pattern of drip tape

# Flood Irrigation

- **Benefits**

- Good for small, irregularly-shaped fields
- Low cost if water is relatively cheap
- Flushes salts out of the soil



- **Requires flat fields so water does not pool**

- **Concerns**

- High water loss through evaporation and leaching
- Anaerobic environment promotes nitrogen loss



# Furrow Irrigation

- **Benefits**

- Good for small, irregularly- shaped fields
- Relatively inexpensive where water costs are low

- **Requires furrows designed to distribute water evenly**

- **Concerns**

- High water loss by leaching, seepage, and evaporation
- High potential for waterlogging and salinization



# Sprinkler Irrigation

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- **Benefits**

- More efficient than flood or furrow
- Good for medium to large fields
- Land can have a moderate slope



- **Concerns**

- Water loss through evaporation
- Wet leaves from irrigation favors foliar diseases
- White leaf spots if irrigation water has bicarbonates

# Micro-Irrigation: Trickle, Drip, or Spray

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- **Benefits**

- More than 90% efficient
- Can be used on hilly land
- Can use relatively saline water
- Programmable



- **Concerns**

- Expensive to install and maintain
  - Clogging of water emitters if water quality is poor
  - Can cause localized salinity at edge of wetting zone
-

# Drip Irrigation Maintenance

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<b>Clogging Problem</b>	<b>Maintenance Treatment</b>
Suspended materials	Filter water with 200 mesh filter
Chemical precipitation of bicarbonates and iron	Add acid to irrigation line
Biological growth	Add chlorine to irrigation line

**WARNING!!!**

**DO NOT MIX ACID AND CHLORINE IN SAME CONTAINER**

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# Irrigation Scheduling

- **Monitoring moisture availability**

- Crop stage of growth and vigor
- Air temperature and wind speed
- Rainfall or irrigation water applied
- Soil moisture

- **Calculations**

- Daily crop water use or evapo-transpiration
- Soil water balances and water available to plants



# Evapo-transpiration

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- **Evapo-transpiration is water evaporation from the soil and transpiration from plant leaves**
- **Factors affecting evapo-transpiration**
  - Climate: wind speed, temperature, humidity
  - Field aspect or solar exposure
  - Crop type
  - Stage of crop growth
  - Soil moisture
  - Soil cover



# Evapo-transpiration Estimations

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- **Evaporation pan**
  - Determine allowable water depletion for soil type and crop being grown
  - Set up pan with water in sun with the allowable soil water depletion level marked below initial water level
  - Irrigate when water evaporates to marked level
- **AgriMet Network for local and regional weather**
  - Provides evapo-transpiration measurements by station
  - <http://www.usbr.gov/gp/agrimet/>





# Water Availability

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- **Soil water-holding capacity**
  - Silt and clay provide good water holding capacity; clay restricts water infiltration and drainage
  - Organic matter increases water holding capacity
- **Plant available water**
  - Amount of water plants can use before starting to wilt
  - Affected by type of plant, stage of growth, rooting depth
  - Mulches that limit evaporation increase available water

# Soil Moisture

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- **Estimate water available to plants**
- **Measurement methods**
  - Tensiometers
  - Gypsum blocks
  - Lysimeters
  - Feel method
  - Soil probe
- **Assess moisture by rooting depth**



# Soil Moisture Estimation by Feel Method

## Descriptions are for sandy loam soils

Moisture content	Description
0–25%	Ball of soil is weak and grains break away quickly
25–50%	Soil ball is weak, but finger marks show
50–75%	Moist ball, dark color, light soil stain on fingers
75–100%	Moist soil ball, medium soil stain on fingers



# Plant Available Water

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- **The difference between the amount of water currently in the soil and the amount of water in the soil when the crop is at the wilting stage**
  - Determined by rooting depth of crop
  - Combines soil moisture and crop growth stage
- **At critical growth stages, less than 40–60% plant available water causes plant stress**
- **Estimates available through Agri-Met**
  - [http://www.usbr.gov/gp/agrimet/crop\\_about\\_charts.cfm](http://www.usbr.gov/gp/agrimet/crop_about_charts.cfm)

# Environmental Impacts of Irrigation

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- Depletes water from lakes, rivers, and aquifers
- Degrades and destroys wildlife habitat
- Degrades soil quality
- Degrades water quality
- Decreases agricultural productivity and profitability



# Freshwater Depletion

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- **Water use is greater than water recharge**
- **Excess surface water use depletes rivers, causing them not to reach the sea**
- **Excess ground water use causes**
  - Stream levels to drop within 30 years
  - Land subsidence
- **Limited snow pack during droughts decreases recharge and water availability**

# Irrigation Water Reuse

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- **Benefits**

- Increases irrigation water supply in district
- Decreases discharge of saline water into rivers

- **Reuse methods**

- Blend used, saline irrigation water with fresh water
- Use this water to irrigate salt-tolerant crops
- In next rotation, use fresh irrigation water to grow crops that are less salt-tolerant
- Repeat this rotation cycle



# Wildlife Habitat Degradation

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- **Dams disrupt animal movement and fish migration**
- **Sediments destroy fish and amphibian breeding areas**
- **Nutrients and toxins kill or disrupt growth of fish and other wildlife**



# Soil Quality Degradation

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- **Erosion during drainage of irrigation water**
  - Irrigation water removes topsoil
  - Sediments carry nutrients and other contaminants
- **Decreased nutrient availability**
  - Formation of alkaline soils
  - Imbalances of soil nutrients
- **Degradation of soil tilth**
  - Formation of saline crusts
  - Breakdown of soil aggregates



# Risk Conditions for Irrigation

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- **Characteristics of soils that pose a high risk of environmental degradation when irrigated**
  - Steep slope
  - Excessively slow or fast permeability
  - Shallow soils
  - Soils with a subsoil layer that restricts root growth
  - High water table
  - High saline or sodic soils



# Water Quality Degradation

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- **Irrigation degrades water quality through**
  - Discharge of excess or tail water into streams
  - Water erosion of sediments from irrigated fields
  - Leaching of contaminated water into aquifers
- **Agronomic impacts of degraded water quality**
  - Limits reuse for irrigation
  - Decreases crop yields
  - Can shorten the life of irrigation equipment

# Water Quality Concerns

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- **Salinity — total soluble salt**
- **Sodium — proportion of sodium to calcium and magnesium**
- **Alkalinity – carbonates and bicarbonates**
- **Specific ions: chloride, sulfate, boron, nitrate**
- **Nutrients and pesticides**
- **Plant pests, pathogens, and weeds**
- **Human pathogens**
- **Industrial contaminants, such as petroleum**

# Soil Salinity

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- **Most common in arid areas with poorly-drained soils**
  - Soil minerals include easily-dissolved salts
  - Risk increased by the over-application of irrigation water and water logging
- **Salinization problems**
  - Crop yields decreased by 25-30%
  - Salt loading of rivers receiving irrigation discharges



# Causes of Soil Salinity

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- **Waterlogging of soils by poor water management**
  - Excessive application of irrigation water
  - Water seeps into fields during irrigation water delivery
- **Impacts of soil waterlogging**
  - Irrigation water dissolves and leaches salts downward
  - Excess irrigation water causes the water table to rise
- **Evaporation moves salts upward in soil profile**
  - Increased by high temperatures and bare soils
  - As water evaporates, it leaves behind dissolved salts

# Salinity Impacts on Crops

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- **Total soluble salt (Cl, NO<sub>3</sub>, Ca, Na)**
  - Measured by electrical conductivity (EC)
  - As EC increases, water availability decreases: <0.25 is excellent, >3.00 is unsuitable
  - Water with an EC of 1.15 dS/m contains 2000 pounds of salt per acre foot of water
- **Salinity reduces water availability to plants**
  - Plants can only transpire pure water
  - Water availability to plants directly related to yields



# Crop Salinity Tolerance

<b>Intolerant</b>	Most crops during germination. Strawberry, raspberry, bean, carrot
<b>Slightly tolerant</b>	Grapes, peach, pear, cherry, apple, pea, pepper, sweet corn, potato, lettuce, sunflower, clover
<b>Moderately tolerant to tolerant</b>	Spinach, cantaloupe, squash, tomato, cucumber, alfalfa, vetch, crested wheatgrass
<b>Very tolerant</b>	Asparagus, soybeans, oats, rye, wheat, sugar beets

# Salinity Management

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- **Leaching provides local, short-term benefits**
  - Moves salts in soil below the rooting zone of crops
  - Improves crop yields
  - Improves soil condition
- **Leaching causes long-term, regional problems**
  - Produces saline drainage water
  - If not captured and excluded, drainage water can contaminate streams, soils, and aquifers

# High Sodium or Sodic Soils

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- **High levels of sodium in soils causes flocculation or plugging of the soil pores**
- **Expressed as sodium adsorption ratio (SAR)**
  - Proportion of sodium to calcium + magnesium
  - SAR values: 1-9 are low, 18-25 are high
  - Clay soils are affected at lower SAR values than are more sandy soils
- **At the same SAR, highly saline water degrades soils less than water with low salinity**

# Sodium Management

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- **Add organic matter to enhance aggregate formation**
- **Use gypsum or calcium sulfate to reduce soil sodium levels**
  - Requires rainfall or sufficient irrigation water to leach calcium into the soil
  - Useful when sodium-affected soils occur in spots or inclusions (not across the entire landscape)
  - Improves soil structure by breaking down soil crusts

# Acidic Irrigation Water

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- **Irrigation water should have pH of 6.5 to 8.4**
- **Acidic irrigation water has a pH less than 6.5**
  - Decreases nutrient availability
  - Limits nitrogen-fixation by legumes
  - Can corrode irrigation systems
- **Treat by adding lime**
  - Where water is limited, make sure added lime is finely-ground to facilitate breakdown and function



# High pH Irrigation Water

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- **Alkalinity**
  - Caused by high concentration of carbonates and bicarbonates in soil and water
  - Forms white deposits on leaves and fruit when irrigation water is applied using overhead sprinklers
  - Depresses plant growth
- **High exchangeable sodium percentage**
  - Found in sodic soils
  - SAR values greater than 15 are associated with pH values above 8.5

# Summary

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- **Use management practices that increase the soil's ability to hold and retain water**
- **Manage irrigation according to soil moisture levels and crop needs**
- **Manage salinity and sodic soils to**
  - Enhance crop yields
  - Protect soil quality
  - Protect the environment



# Micro-Irrigation

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<http://www.dripworksusa.com/farm.html>



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