SOIL HEALTH and DROUGHT

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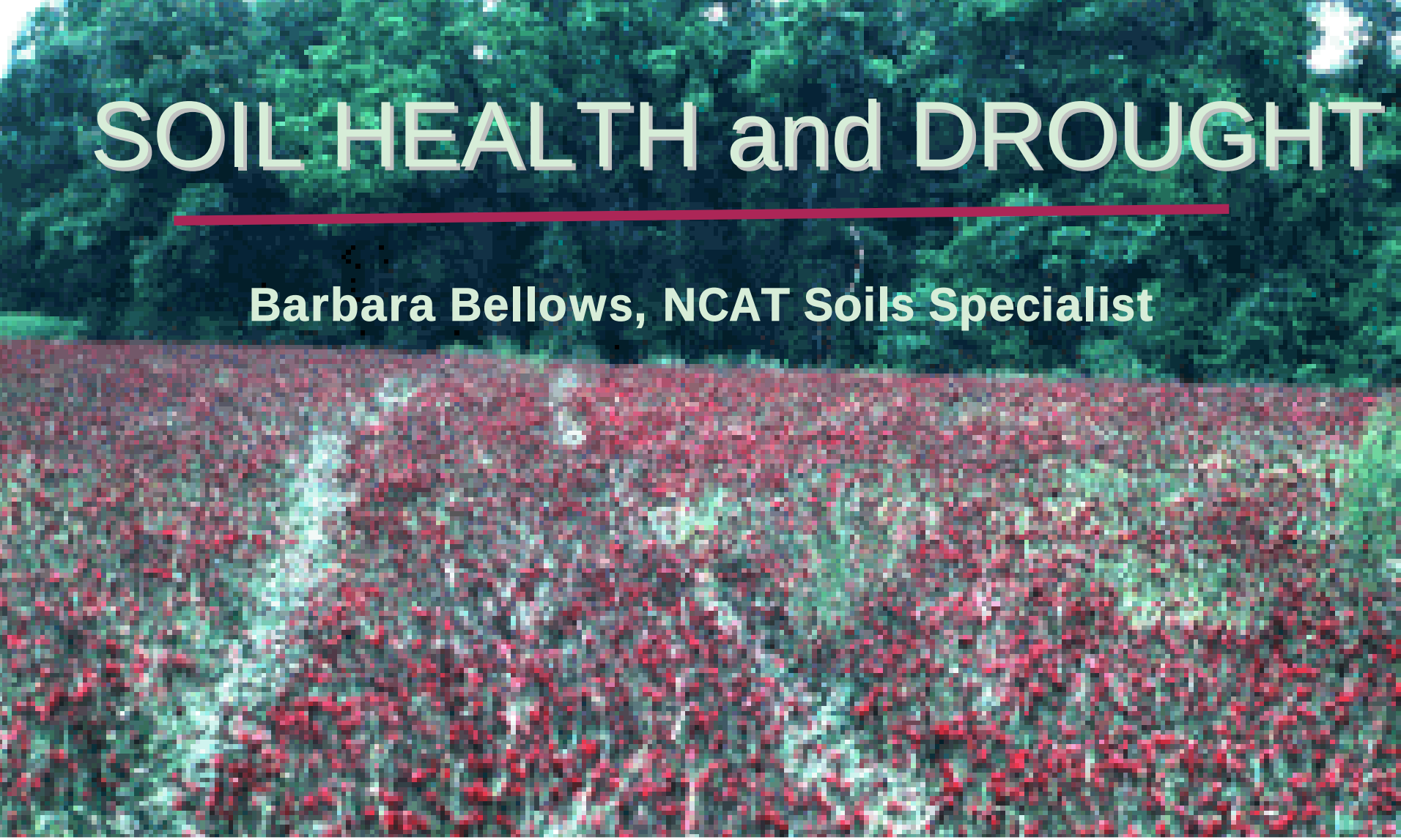

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Soil Health: Nature and Management

- **Nature and soil characteristics**
  - Local geology and climate determines soil type
  - Soil type determines natural water- and nutrient-holding capabilities
- **Land management practices**
  - Can decrease or enhance soil nutrient- and water-holding capabilities
  - These management changes may not be apparent for several years

Natural Soil Characteristics

- **Soil texture**
  - Soil mineralogy: sand, loam, clay, muck
  - Particle size
- **Soil profile**
  - Soil depth
  - Subsoil characteristics
- **Soil slope**

Soil Texture and Water

Water / Soil	Absorbs water	Holds water	Drains water
Sandy soil	Good	Poor	Good
Clay soil	Poor	Good	Poor
Loam soil	Good	Good	Good
Muck soil	Excessive	Excessive	Poor

Soil Profile and Water

- **Characteristics of deep topsoils**
  - Absorb and hold water and nutrients
  - Promote thick root growth able to reach water
- **Subsoil characteristics**
  - Clay, hard rock, or compacted subsoils restrict water entry and movement → low water absorption
  - Gravelly or cracked rock subsoils allow excessive water to flow through the soil profile → low water holding

Soil Slope and Water

- **Water absorption**
  - Limited by water flow on steep slopes
  - Limited by thin topsoils on steep slopes
- **Water retention**
  - Conservation practices slow water flow downslope
  - Conservation practices protect topsoil, enhancing soil's water-holding capacity

Soil Water Conservation

- **Cropping practices**
  - Rotations with perennial grasses
  - Adds organic matter to soil
  - Minimum tillage
  - Cover cropping
- **Grazing practices**
  - Managed rotational grazing
  - Riparian area protection

Cropping Practices for Healthy Soils

- **Add manure and crop residues to soil**
  - Promotes growth of soil organisms
  - Builds soil organic matter
  - Enhances soil aggregation and tilth
- **Use cover crops, minimum tillage, and mulches**
  - Protects against erosion and runoff
  - Minimizes water loss through evaporation

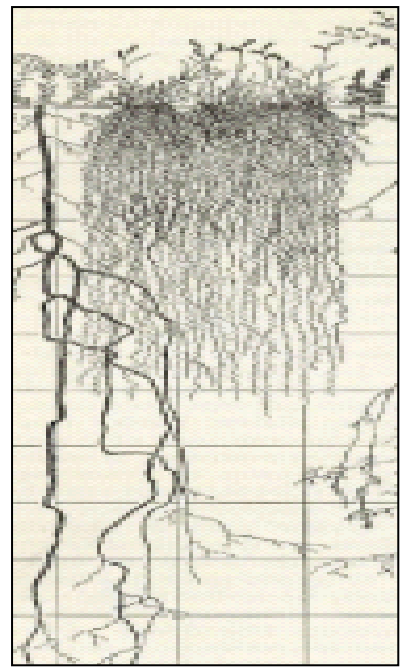
Soil Organic Matter and Soil Organisms

- **Soil organisms decompose organic matter and build soil humus**
  - Increase nutrient availabillity
  - Increase water-holding capacity
- **Soil organisms build soil tilth**
  - Insect and earthworm burrows make soil porous
  - Fungi and bacteria build soil aggregates
  - Mycorrhizae enhance plant uptake of water and nutrients and create soil aggregates

Mycorrhizae

Aggregated Soils

- **Enhance water availability**
  - Decreased soil crust formation, resulting in better water absorption
  - Increased water storage throughout the soil profile
  - Decreased leaching and evaporation
- **Enhance plant water uptake**
  - Facilitates soil water and nutrient movement
  - Facilitate root growth through soil profile



Practices to Protect Soil Life

Earthworm burrow

- **Use minimum tillage**
  - Soil cover moderates temperature and protects against water loss by evaporation
  - Does not disrupt the habitat of soil organisms
- **Add manure and crop residues to land to provide soil organisms with food and favorable growing conditions**
- **Minimize or eliminate use of synthetic chemicals to protect soil biological health**

Soil Health Indicators

- Moderate to high organic matter
- Even distribution of nutrients
- Good water infiltration
- Minimal soil erosion
- Deep crop root growth

- Active populations of soil insects, earthworms, and microbes

Residues for Water Conservation

- **Surface residues conserve soil organic matter**
  - Feed soil organisms that build aggregates
  - Cool soil and slow organic matter decomposition

- **Soil cover facilitates water infiltration**
  - Cushions against raindrop impact and crust formation
  - Protects soil against runoff and erosion
- **Soil cover decreases water evaporation**

Windbreaks to Reduce Evaporation

- Hot winds blowing across soils and plants increases evapo-transpiration
- Tree shelter belts reduce winds and evaporation potential
- Choose windbreak trees that
  - Use water efficiently
  - Create minimum shade
  - Provide habitat for beneficial organisms

Stubble to Increase Snow Infiltration

- **Effective in arid areas with winter snows**
- **To capture snowfall, cut stubble at alternating heights, perpendicular to the wind**
  - **Acts as windbreak to collect snow within fields**
  - **Residue cover facilitates infiltration of snowmelt**
  - **Increases the amount of moisture available to soils in the field**

Plant According to Water Needs

- **Plants have critical periods of water need**
  - Leafy vegetables need water throughout the growing period
  - Root, tuber, and bulb crops need water when roots are enlarging
  - Fruit and seed crops need water at flowering and at fruit or seed set
- **When possible, plant crops so their critical periods of water need coincide with times of normally wet weather**

Plant to Enhance Water Availability

- **Time planting to avoid known dry periods**
  - Use fall-seeded crops that overwinter and take advantage of spring moisture
  - Time planting to harvest before dry periods
  - Plant short-season crops that produce yields before onset of dry periods

- **Time planting to correspond with know wet periods, such as spring or mid-summer rains**

Conserve Moisture During Planting

- **To conserve moisture during planting**
  - Till shallowly to minimize moisture loss
  - Plant seeds deeper, where soil is moist
  - Pack seed following drilling to close soil

Use Drought Resistant Crops

- **Early-maturing, low water-use crops**
  - Barley
  - Oats
  - Peas
  - Lentils

- **When moisture is favorable, harvest crops for sale**
- **If drought reduces crop yields or quality, graze these crops to recover some of their value**

Rotate to Build Soil Quality

- **Rotate between annual and perennial crops**
  - Deep rooted perennials can get water and nutrients that have moved out reach of annual plant roots
  - Fine roots of perennial grasses build soil aggregation and tilth
- **Rotate cropping and grazing land**
  - Aids soil recovery from compaction
  - May decrease weed competition

Avoid Water Competition Between Rotated Crops

- **Choose appropriate cover crops and crop rotations**
  - Know each crop's water needs
  - Match with soil moisture availability

- **Determine best time to cut or kill cover crops**
  - Limiting cover crop growth reduces water depletion
  - Extending cover crop growth produces more residues while decreasing the potential for soil erosion and water loss through evaporation

Control Weeds to Conserve Moisture Availability

- **Weeds compete with crops for soil moisture**
- **Wide spacing between plants provides roots with more area to obtain moisture from soil, but wide spacing**
  - **Reduces moisture-conserving canopy**
  - **Can increase weed competition**

Weed Control Practices

- **Organic weed control**
  - Crop rotations and cover crops decrease weed pressure over time
  - Flaming, acetic acid, corn gluten meal
- **Herbicides for weed control**
  - Often used in minimum tillage – "chem till"
  - Preplant herbicides dry out soil
  - Soil-applied herbicides need moist soil to be effective
- **Harm to soil organisms and soil tilth is usually *less* from herbicides than from tillage**

Tillage and Compaction

- **Tillage and heavy equipment use compacts soils**
  - Tilling or driving equipment on wet soils compresses them and forms clods
  - Repeated plowing at the same depth forms plow pans

- **Tillage degrades soil aggregates**
  - Disrupts soil organisms that form aggregates
  - Allows heat to breaks down organic gels and glues

Tillage and Moisture Loss

- **Tillage increases moisture loss by evaporation**
  - Exposes moist soil to drying forces of sun and wind
  - Reduces residues that protect against evaporation
- **Soil moisture loss increases with tillage passes and tillage depth**
  - Most moisture is lost on the first pass, with approximately 1/3 to ½ inch additional loss with each tillage pass
  - Deeper tillage increases moisture loss

Tillage Equipment and Evaporation

As tillage decreases residue cover, it increases water evaporation from soil

Minimum till

Undercutter (v-blade)

Rodweeder

Chisel with sweeps

Cultivator with harrow

Disc

Moldboard

Most residue cover / least evaporation

Least residue cover / most evaporation

Minimum Till Practices

- **Killed mulch**
  - Used with cover crops
  - Crop planted or transplanted into killed cover crop
- **Chem till**
  - Uses herbicides to kill weeds
  - Often involves use of GMO crops

Minimum Till Trade-Offs

- **Killed mulch**
  - Cover crop needs sufficient moisture and time for growth
  - Suitable for organic production
- **Chem-till**
  - Soil applied herbicides are less effective when soil is dry
  - Not suitable for organic production

- **All minimum tillage practices retain moisture, slowing soil warm-up in spring**

Killed-Mulch Tillage Tools

- Stalk pullers pull stalks, leaves residues
- Uprooter-shredder-mulchers uproot and shred stalks, then inject them into the soil
- Undercutters sever plants below crown, then flatten residues

- Roll-choppers flatten plants and cut stems perpendicularly
- Flail choppers shred stalks behind picker

Minimum Tillage Alternatives

- **Minimum till practices are not suitable for areas with cold and wet winters**

  - Surface mulches prevent wet soil from drying and warming in spring
  - Cool, wet soils cause seed rot and poor root growth

Zone or ridge tillage

  - Seeding zone tilled and raised
  - Allows the seed zone to warm up and dry out

Frost Tillage

- **Soil tilled in winter when frost is less than 4" deep (But these weather conditions may not occur every year.)**
- **Produces a rough soil surface**
  - **Encourages moisture infiltration**
  - **Reduces potential for soil compaction**
- **Early tillage allows for earlier spring planting**

Rangeland Health Indicators

- **Biological soil crusts**
  - Composed of bacteria, algae, and fungi
  - Enhance water infiltration and water-holding capacity of soils

- **Even distribution of vegetation, residues, and organic matter across the landscape**
- **Minimal soil surface loss or degradation**

Grazing Practices for Healthy Soils

- **Graze short-term on small paddocks**
  - Forces even grazing across paddocks
  - Results in an even distribution of plant residues and manure
  - Reduces bare spots and compaction from lounging

- **Rest paddocks between grazing periods**
  - Permits forage regrowth and enhances forage diversity
  - Allows soils to recover from compaction

Rotating for Forage Persistence

Grazing / Rest	Short term	Long term
Short term	Effective use of rapidly growing forages	Force use of unwanted forages
Long term	Minimum impact on young forage, slow growing forage, or wet soils	

Riparian Protection

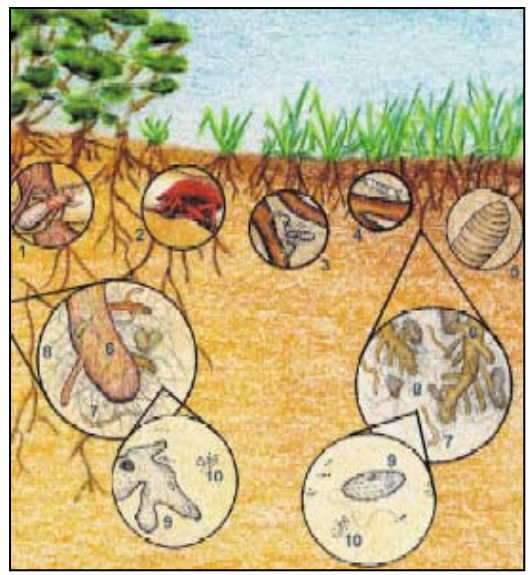
- **Exclude or limit animal access**
  - Designate water crossings
  - Provide alternative water systems
  - Place minerals, shade, and water away from streams
- **Protect vegetation on riparian soils**
  - Plant grass and trees
  - When upland vegetation is sparse, exclude animals from riparian areas to prevent overgrazing

Riparian Protection Benefits

- Enhances water recharge
- Reduces flooding by absorbing rainfall, then slowly releasing water into streams
- Protects water quality by limiting nutrient and pathogen movement into streams
- Protects plant and wildlife habitat

Summary

- **Manage your soils to reduce impacts of drought**
  - Return organic matter to the soil
  - Minimize soil compaction
  - Protect soil organisms
  - Protect against runoff and erosion



- **Reduce water loss from evaporation, runoff, and weed growth**

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