	Sustainable Agriculture		Unit E	Sustainable Crop Production
ESSENTIAL STANDARD:	**5.00**	**20%**		**Sustainable Crop Production**
Objective:	*5.01*	*3%*	*C2*	Compare important horticultural and agronomic crop systems in North Carolina.

A. According to the North Carolina Department of Agriculture and Consumer Sciences:
   a. Crops were 37.2% of Farm Cash Receipts in NC in 2012
   b. Crops added $4,552,241 to the NC Economy
   c. The top 5 counties for crop production in terms of cash receipts are Sampson, Mecklenberg, Johnston, Wayne, and Wilson. * Crop production includes field crops, horticultural crops, and fruit and vegetable crops.
   d. The top 5 crops in terms of cash receipts for NC in 2012 are: Tobacco (6.4%), Greenhouse/Nursery/Floriculture/Christmas Trees (6.1%), Soybeans (%6), Corn (5.2%), Vegetable/Fruit/Nut (5.1%)
   e. Soybeans have the highest acreage planted of all agronomic crops in NC
   f. Soybeans also had the highest total value of all field crops in 2011

B. According to the North Carolina Department of Agriculture and Consumer Sciences:
   a. Crops are a major contributor to agricultural receipts for the state.
   b. Crops added a great economic value to the state
   c. Crop production includes field crops, horticultural crops, and fruit and vegetable crops.
   d. The top crops in terms of cash receipts for NC usually consist of: Tobacco, Greenhouse/Nursery/Floriculture/Christmas Trees, Soybeans, Corn, Vegetable/Fruit/Nut
   e. Soybeans usually have the highest acreage planted of all agronomic crops in NC
      i. North Carolina holds ranks highest among the 50 states in the production of:
         1. Sweet Potatoes
         2. Tobacco.
         3. Christmas Trees
         4. Cucumbers
         5. Strawberries
         6. Tomatoes
         7. Bell Peppers
         8. Greenhouse/Nursery Crops
         9. Peanuts
         10. Squash
      ii. Check the NCDA for current statistics to enrich your student's knowledge of North Carolina crop production

C. Farm Size Statistics:
   a. Farms in North Carolina - 50,000+
   b. Land in Farms - 8,500,000 acres +
   c. Average size of Farm - 170 acres +
   d. Farm Real Estate Value per Acre - $4,000 +
   e. Realized Net Farm Income - $3,336,952,000 ++
   f. Net Income per Farm - $45,532 ++

    g. Value of Agricultural Exports - $2,743,800,000 +++
       +2012 Estimates, ++2007 Census of Agriculture +++ ERS

D. Vertically Integrated
    a. A single entity owns multiple steps in the production system.
    b. Example: A farmer owns a seed company, field corn production system, mill, and pig farm that uses the corn that was produced.

E. Industrialization
    a. Increased specialization and mechanization. Breaks down a multistep process into individual steps and specialization.
    b. Example: Farmers might grow a single crop without having a diverse system because the equipment required for each crop is so specialized.

F. Diversified Crop Production
    a. Farmers grow multiple crops with different growing cycles.
    b. Allows farmers a more stable income since one crop is a lower percentage of total income.

	Sustainable Agriculture		Unit E	Sustainable Crop Production
ESSENTIAL STANDARD:	**5.00**	**20%**		**Sustainable Crop Production**
Objective:	*5.02*	*5%*	*C2*	Understand tools and techniques needed to cultivate horticultural and agronomic crops.

A. Crop production methods have been developed to meet the goals of sustainability.

a. Crop Rotation, No-Till, High Tunnels, Intercropping, and Permaculture are a few techniques that help accomplish these goals.

i. Crop Rotation: Technique where crops are moved sequentially to different fields or plots each year, preventing the same crop from being grown on the same land multiple years in a row.

ii. Typically rotation is done by family since many plants in the same family are susceptible to the same diseases and pests. Some common crop families are listed below.

1. For example in four fields there would be a crop from a different family in each field each year. If peas were planted in field 1 in 2014, then it should be 2018 before you plant any member of the pea family back in that field.

Family Latin Name	**Family Common Name**	**Crops in Family**	**Common Pests**
Poaceae	Grass Family	Corn, Wheat, Barley, Oats, Sorghum, Fescue, Rice, Sugar Cane	Grey Leaf Spot
Fabaceae	Pea Family OR Legumes	Black-eyed Pea, Snap Bean, Pinto Bean, Peanuts, Soybeans, Alfalfa, Clover	Fusarium Root Rot
Brassiceae	Mustard Family	Cabbage, Broccoli, Cauliflower, Kohlrabi, Kale, Brussels Sprouts, Turnips, Radish, Collards, Rutabaga	Club Root (Fungal Disease)
Solanaceae	Nightshade Family	Tomato, Pepper, Potato, Eggplant, Tobacco	Tomato Bacterial Canker, Verticillium Wilt
Cucurbitaceae	Cucurbits	Cucumber, Melons, Squash, Pumpkins	Powdery Mildew, Viruses, Rot
Chenopodiaceae	Goosefoot Family	Spinach, Beets, Chard	Viruses, Leaf Spot, Downy Mildew
Convulvaceae	Morning Glory Family	Sweet Potatoes	Rots, Feathery Mottle Virus, Fusarium Wilt

Malvaceae	Mallow Family	Cotton, Okra	Root Knot Nematode, Verticillium Wilt, Root Rot

a. Advantages:
    i. Increased yields
    ii. Decreased need for pesticides and fertilizers
    iii. Growing diverse crops reduces the risk for yield losses during crop disease outbreaks or drought years.
    iv. Improved soil health

b. Intercropping: Growing two or more crops simultaneously in the same space.
    i. Examples:
        1. Growing both broccoli and radishes in the same field. Planting the fast maturing radishes in between the rows of broccoli means you will be able to harvest the radishes from the middle row before the roots and leaves of the broccoli crowd the radish plants.
        2. Historically growing corn, beans, and squash together was done by the Native Americans. Commonly called the "three sisters".
    ii. Types of intercropping: Row intercropping, strip intercropping, mixed intercropping, relay intercropping, and trap crops.
        1. Row Intercropping: Growing two or more crops at once in the same row.
        2. Strip Intercropping: Growing two or more crops in a section of fields large enough to allow for production machines to enter and small enough to ensure crop interaction
        3. Mixed Intercropping: Growing the crops with no defined rows.
        4. Relay Intercropping: Planting the second crop in as the first crop is maturing, but is not yet harvested.
        5. Trap Crops: Plants used to draw pests away from more valuable crops
            a. Can be done by planting a more preferred crop to attract pests or by planting the same crop at two different times so that the pest is drawn to the one in the preferred stage of development.
            b. Example would be Pepper 'Purple flash'. This ornamental pepper is often referred to as a bumper and the flowers lure insects like thrips away from others.
            c. Example would be marigold. The leaves of the marigold can be used to lure pests away. Thrips and spider mite feast on marigolds and not the crop in production.
        6. Considerations:
            a. Make sure seeding densities are adjusted to provide for the additional plantings. If you plant both crops at usual seeding rates neither will have optimal production because they are overcrowded.
            b. Typically done with two plants from the same family especially if crop rotation is also desired.
            c. Need to consider growth habits, row spacing, and maturation rates to ensure that both crops have adequate sunlight, rain, and nutrients while also ensuring maximum yields.
            d. Can also plant non-crop plants for pollinator attraction or beneficial insect attraction.
        7. Advantages:
            a. Increased yields
            b. Decrease need for fertilizer and pesticides

        c. Attract beneficial organisms
        d. Lower financial risk because of increased diversity of crops

c. No Till Farming: Land is no longer tilled, instead the residue of the crop is left after harvest and acts as a mulch over the soil.

    i. Historically, farmers began tilling to warm the soil, aerate it, and make it ready for planting.

    ii. Now it is known that tilling leaves the soil vulnerable to wind and water erosion.
        1. Tilling is one of the leading causes of land degradation in agriculture.
        2. No-Till is feasible on a large scale today because of herbicide availability and the development of specialized equipment to seed through the crop residue
        3. Conservation tillage: which is defined by the USDA as any type of tillage that maintains at least 30% of the soil surface is covered after planting.
        4. Conservation tillage, including no-till, is credited for the 43% decline in cropland erosion from wind and water from 1982-2003

    iii. Advantages:
        1. Increased soil health
        2. Soil Protection from erosion
        3. Increased soil microorganism populations and diversity
        4. Increased organic matter in soil
        5. Water Conservation
            a. Limits runoff of fertilizers and other chemicals by increasing water infiltration
            b. Decreased evaporation off the soil surface (decreased watering needs)
        6. Reduces fuel and labor costs.
            a. Requires the least number of passes over a field in a tractor (%50-80 less fuel and %30-50 less labor)
        7. Helps support local wildlife species

    iv. Considerations:
        1. Since there is this layer of crop residue, practitioners need to use specially designed seeders at planting to cut through the residue.
        2. Equipment is costly
        3. Relies more heavily on herbicides and may increase occurrence of herbicide-resistant weeds
        4. Different weeds, diseases, and pests may be more prevalent
        5. Slow germination
        6. Reduced yields

d. Permaculture: A way to design agriculture production systems that mimics the relationships found in natural ecosystems.

    i. Principles include:
        1. Catch and store energy
        2. Produce no waste. Tries to use waste as an input back into the system
        3. Integrate instead of segregate: In natural ecosystems there is no separation between plants of different types and animals
        4. Use and value diversity
        5. Use Edges and Value the Marginal: Often on the borders between two systems there is the opportunity for productivity

    ii. Examples:
        1. Harvesting Rainwater: Prevents erosion and reduces reliance on irrigation water
        2. Stack Functions: Companion planting/intercropping
        3. Make a Plant Guild: Combine different size plants such as large fruit trees planted with smaller fruit trees under those and berry bushes under those, and a strawberry groundcover all. This planting system corresponds with forest ecosystems

e. High tunnels: simple plastic-covered steel structures that derive heat from the sun and are typically high enough to stand up in.
    i. Crops are grown in the soil underneath the structure, not in pots or hydroponically like typical greenhouse production.
    ii. Used to grow salad greens, spinach, tomatoes, cucumbers, basil, cut flowers, berries, etc.
    iii. Types of High Tunnels
        1. Quonset or Hoop-house:
            a. Most common type
            b. Rounded steel arches make up the structure usually spaced 4 ft apart down the length of the bay.
            c. 12-40ft wide. Typically 30ft.
            d. Can have rounded walls to the ground or can have 4-6ft straight sidewalls. This allows taller plants to be grown in the area near the walls.
            e. Rounded roofline doesn't shed snow as well as Gothic style structures so the spacing of the arches at the appropriate interval for snowfalls in the growing area is critical.
        2. Gothic
            a. Have peaked roofs and straight sides.
            b. Steeper roofs and taller houses shed snow better and allow for more stable temperatures in the warmer months
            c. May require additional bracing for the wind because of height
        3. Multi-bay tunnels
            a. Several spans of arches connected by gutters where their roofs meet
            b. Cover larger acreages
            c. Larger than other houses allowing for tractor traffic and growing fruit trees under their cover
            d. Not well braced and not meant to withstand the winds and snow loads of other types of houses
        4. Caterpillars or low tunnels
            a. Lower than other houses. Caterpillars 5-6' and low tunnels 1.5-2'
            b. More temporary in nature
            c. Not able to withstand much snow or wind pressure
            d. Low tunnels are used within high tunnels to increase the winter protection for sensitive crops or outside to provide moderate temporary protection.
    iv. Advantages:
        1. Extend growing season
        2. Protects crops from frost, temperature fluctuations, precipitation, and wind
        3. Allow for intense production
        4. Better utilize labor by providing work in bad weather and offering the possibility of year-round employment with the extended seasons.
        5. Yields higher quality and quantity of crop
        6. Fewer pesticides used
    v. Disadvantages
        1. Cost
        2. Maintenance and Repair
        3. Irrigation must be supplied under the plastic
        4. Microclimate can act as a greenhouse and particular attention must be paid to not overheating plants.

	Sustainable Agriculture		Unit E	Sustainable Crop Production
ESSENTIAL STANDARD:	**5.00**	**20%**		**Sustainable Crop Production**
Objective:	*5.03*	*12%*	*C3*	Apply methods of sustainable crop production.

A. Common steps in crop production systems:
   a. Soil Preparation
      i. Farmer makes decisions on tillage, irrigation, and rotation prior to preparing soil.
         1. Tillage of the soil maybe necessary
         2. Using a rototiller for a space might be needed, however, never till in a garden when the soil is wet
      ii. Reduce the amount of weeds
         1. Solarization- cover an area with clear plastic and use the radiant energy of the sun to kill weeds
         2. Use goats for entire removal of a crop
         3. Cover a space with cardboard and a layer of mulch to suffocate the weeds
         4. Use an herbicide as a last result
      iii. Be sure that the structure and overall health of the soil is fair
         1. Complete a soil test and implement results (allow enough time for tests, results and implementation- best to start the opposite season you plan to plant)
         2. Plant cover crops a season before and incorporate the material back into the soil
         3. To increase pore spaces, plant something like a "Tiller Radish."
            a. This deep rooted radish tills down into the soil. When removed it has acted like an aerator and added pore spaces. It increases water permeability and infiltration.
            b. This is also known as a Daikon radish.
         4. Add compost and organic materials
         5. Never add just sand to clay to change the texture. This practice may lead to creating a brick-like structure that is difficult to grow crops.
   b. Planting
      i. Depends on the crop being grown.
      ii. Use high tunnel
      iii. Conserve space- grow vertically (cucumbers and beans and peas should be trellised)
      iv. Reduce the amount of waste and trash. Recycle or reuse pots. Be sure to sterilize the containers before planting another crop.
      v. Plant crops according to the right time of year.
      vi. Pay attention to the size of the plants (when mature). Watermelons take up a great deal of space. Grow vertically or allow enough space to grow.
      vii. Refer to one or both of the following:
         1. http://www.wqseeds.com/documents/WQVegPlantGuide-revised.pdf
         2. https://content.ces.ncsu.edu/central-north-carolina-planting-calendar-for-annual-vegetables-fruits-and-herbs

   c. Nutrient Management
      i. Should consider soil test results
      ii. Test compost or manure for nutrient content before application

iii. Observe plants for potential signs of nutrient deficiencies and toxicities. Common deficiency or toxicity symptoms include:
    1. Yellowing of young or mature leaves
    2. Foliar stunting
    3. Resetting of leaves
    4. Leaf drop
    5. Wilting
    6. Pale flowers and fruit
    7. Small fruit
    8. Tips of leaves browing
    9. Purpling of leaves
    10. Interveinal chlorosis
iv. Using city water to irrigate may cause problems with plants and toxicities due to excessive chlorine and fluoride
v. Applications of organic fertilizers can increase nutrient content, however, organic material (especially purchased commercially) is often low in nutrient analysis
    1. Blood meal, however, is 12-0-0 and can be used to fertilize and supply higher quantities of nitrogen
    2. Epsom salts has a great deal of calcium and magnesium and can be applied in solution
    3. Beware of using homemade composts and manures. If not composted correctly, these can contain too much of a nutrient and lead to plant burning.

d. Pest Management
    i. Integrated Pest Management
        1. Scouting and Identification of pest
        2. Biological controls- other organisms used to control (cats for vermin, goats for weeds, parasitic wasps for tomato hornworms and ladybugs for aphids)
        3. Cultural controls- using resistant cultivars, traps, trap crops, handpicking/removal of bugs or diseases or weeds
        4. Chemical controls- organic and synthetic pesticides
        5. Natural barriers- row of holly trees, water, mountains
        6. Quarantining- remove or sequester infested crop from the rest of the healthy plants
    ii. Select appropriate pesticides
        1. Pay particular attention to mouthparts of insects and life cycles
            a. Piercing sucking, chewing, rasping, siphoning
            b. Common insect problems in a vegetable garden include: tomato hornworms, beetles, grubs, caterpillars, mealybugs, thrips, spidermites,
            c. Additional pests can include vermin (woodchucks, mice, squirrels, moles), birds, deer, raccoons, opossum

e. Irrigation
    i. Select appropriate irrigation system
        1. Contour-levee
        2. Trickle
        3. Sprinkler
    ii. Minimize water use

f. Drainage
    i. Determine the grade or slope of the land
    ii. Monitor for puddling or flooding after irrigation or rainfall
    iii. Change slope or add drain tiles
    iv. Change the characteristics of the land to move water to a lower site or retaining pond

g. Harvest
    i. Always use best practices (Good Agricultural Practices are a guide) that will ensure safety of all parties and the crop being harvested
    ii. Harvest in the morning, if possible

iii. Harvest when ripe, if the produce is to be consumed immediately
iv. Wear gloves, tie hair back, wash hands
v. Do not place crop on the ground once harvested, place into clean gathering devices
vi. Remove plants at harvest date specified for determined need (a tomato could be harvested green, breaking color, or at full maturity- depending on the objective of that grower)
vii. Do not allow the crops to remain in the garden once harvested. Take to a packing house or allow to cool (latent heat is stored in the fruit from the sun and causes faster decay)
viii. If crops were not harvested in time, do not allow the crops to sit and decay in the fields. Remove and take to a compost pile or harvest for animal feed when appropriate.

h. Post-harvest
    i. It is imperative to cool crops as soon as they are harvested. Cooling the crops reduces spoilage (caused from various pathogens and physiological changes) and retards further ripening. This will extend the shelf life of the crop.
    ii. Take the harvest to the proper cooling and cleaning facility
    iii. Products may need to be rinsed (sometimes several times) with cool, clean and sanitized water (the produce should not be warmer than the rinsing water, as this may act as a vacuum agent and pull the water into the fruit)
    iv. Some vegetables, like cucurbits, may have a wax sealant applied to the fruit
    v. Pack the product if necessary to into the appropriate containers (bags, plastic clamshells, paper or cardboard materials)
    vi. Each crop has its own set of parameters for extending shelf-life. These include proper storage temperatures and humidity. Additional factors can include the reduction or addition of carbon dioxide, ethylene gas and other factors