Discipline: Agriculture	Sub-discipline: Sustainable Agriculture
General Course Title: **Exploring Sustainability in Agriculture**	Min. Units: **3-4 Semester**
	Proposed Suffix: **L**

Course Description:
An introduction to the study of natural resource sustainability in agriculture designed for use on college farms and intended to integrate the study of theoretical aspects of agricultural sustainability with field-based laboratory exercises and participatory learning of sustainable agriculture practices. Laboratory Required.

Required Prerequisites or Co-Requisites[1]

Advisories/Recommended Preparation[2]

Course Objectives: *At the conclusion of this course, the student should be able to:*

- Explain the origins of agriculture and how pre-historic agricultural land uses influenced the long-term productivity of agro-ecosystems
- Describe the development and dissemination of modern agricultural technologies and land use practices
- Detail the extent of agricultural land use today and how trends in human population growth have and may continue to place additional demands upon agricultural ecosystems
- Explain the agroecoystem, environmental quality and human health risks associated with the technologies and land use practices common in modern US agriculture
- Define and describe the basic structural organization and processes of natural and agricultural ecosystems
- Explain the differences and similarities of several types of sustainable agriculture
- Describe the basic principles and strategies that may be used in the design and management of more sustainable farming systems
- Define the environmental and social indicators of sustainability in food and agricultural systems
- Describe basic plant anatomy and physiology as it relates to crop production
- Demonstrate a introductory command of soil science terminology and ability to assess the physical, chemical and biological properties of soils as they relate to soil quality in agricultural systems
- Articulate the goals of sustainable soil fertility management and develop a soil fertility management plan
- Define the major components of a sustainable soil fertility management plan and the functional role of each as it relates to soil fertility and pest management
- Describe the role of cover crops in sustainable agriculture and demonstrate an ability to select appropriate cover crop species for a given area and estimate the nitrogen contribution of a given cover crop
- Explain the basic principles of crop rotation and demonstrate the ability to develop a simple crop rotation plan
- Define the role of soil testing in sustainable agriculture and demonstrate an ability to take a representative soil sample, interpret laboratory analyses, and develop a simple nutrient budget
- Describe the role of conservation tillage in sustainable agricultural systems
- Demonstrate the ability to prepare soils using garden-scale sustainable tillage techniques
- Describe the role of organic matter and compost in sustainable agriculture and explain the key factors involved in successful aerobic, high temperature composting
- Demonstrate an ability to successfully build, monitor and manage compost piles and

[1] Prerequisite or co-requisite course need to be validated at the CCC level in accordance with Title 5 regulations; co-requisites for CCCs are the linked courses that must be taken at the same time as the primary or target course.

[2] Advisories or recommended preparation will not require validation but are recommendations to be considered by the student prior to enrolling.

assess compost quality and maturity
- Explain the potential advantage or disadvantage of each soil fertility management practice with regards to environmental quality and the sustainability of agroecosystems
- Explain the major design and management strategies used to increase sustainability in animal husbandry systems
- Explain the major preventative strategies for select arthropods, weeds, plant pathogens and vertebrate pests in sustainable farming systems
- Demonstrate basic pest monitoring, sampling, identification skills and an ability to determine control action thresholds and least-toxic treatment options for pest arthropods, weeds and plant pathogens
- Demonstrate a command of basic irrigation concepts and terminology and an ability to develop irrigation schedules using qualitative and quantitative methods
- Explain the principle biodiversity conservation concerns in agriculture and describe strategies for biodiversity conservation in agriculture
- Explain the major social and economic obstacles to the adoption of more sustainable farming practices
- Describe growth and development in the sustainable and organic food industry, nationally and internationally

Course Content:

Social and Environmental Sciences

1. The History and Development of Agriculture:
    a. The origins of agriculture
    b. Pre-historic agricultural land use and environmental impacts
    c. Cultures with sustainable forms of agriculture
    d. The development and dissemination of modern agricultural technologies and land u practices
    e. The extent of state, national, and global agricultural land use
    f. Human population growth, anticipated demands upon agricultural ecosystems and need for sustainable agricultural systems

2. Environmental Quality and Human Health Issues in Modern Agriculture:
    a. Agricultural nutrients and environmental quality
        1) The basic role of fertilizers in plant nutrition
        2) The production of synthetic fertilizer
        3) Synthetic fertilizer use trends: state, national, international
        4) Production benefits of synthetically compounded fertilizers
        5) Effects of synthetic fertilizers on the soil biological community and soil qu
        6) Effects of high nutrient inputs on insect and pathogen pest populations (M et al. 1997)
        7) Synthetic fertilizer and its application: Timing and the potential for crop u and nutrient loss
        8) Environmental quality impacts and risks of nutrient pollution
        9) Human health risks associated with fertilizer pollution
        10) Energy use in the formulation of synthetic fertilizers

Exploring Sustainability in Agriculture
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    b. Synthetic pest control agents
        1) Synthetic pesticides and how they function
        2) Trends in crop losses and types of loss due to pest damage
        3) Advantages of synthetic pesticide use
        4) Trends in pesticide use: California, US, international

5) Agro-ecosystem impacts from pesticides
6) Mechanisms for human and environmental exposure to pesticides: Drift, r leaching, and occupational exposure
7) Known environmental impacts and risks of pesticides
8) Known and potential human health risks of pesticide exposure
9) Energy use in the production of synthetic pest control agents

c. Tillage:
1) The role of tillage in agricultural systems
2) Soil quality impacts of intensive tillage
3) Environmental impacts of intensive tillage: Carbon loss, effects of erosion downstream or downwind ecosystems
4) Energy use in mechanical tillage

d. Water use:
1) Water requirements in agriculture
2) Types of water application in agriculture: Rain-fed vs. irrigated systems
3) Water diversion and impacts to wild ecosystems
4) Water diversion and habitat enhancement in Ca rice agroecosystems
5) Irrigation and soil salinity
6) Irrigation efficiency and nutrient losses

e. Monoculture production systems:
1) Definition and examples of monoculture production systems
2) Production advantages of monoculture production systems
3) Monocultures and the loss of crop and agroecosystem biodiversity
4) Monocultures, agroecosystem biodiversity and the internal regulation of p populations
5) Monocultures and pesticide dependence

f. Genetically engineered organisms in agriculture:
1) Genetic engineering/transgenic organisms defined and technology describ
2) Potential advantages of genetically engineered organisms in agriculture
3) Environmental quality risks of transgenic organisms
4) Agroecosystem risks of transgenic organisms
5) Human health risks of transgenic organisms

g. Confined feeding operations (CFO):
1) Definition and description of CFO
2) Advantages of confined animal production systems
3) Nutrient concentration and pollution in CFO
4) Effects on animal health and behavior
5) CFOs, odors and impacts to surrounding communities
6) Energy use and nutrient efficiency in CFO-based animal agriculture

h. Energy use in agriculture:
1) Energy use in the formation of agricultural inputs
2) Energy use in tillage and irrigation
3) Energy use in national and international transportation of food products
4) Energy use in food processing, packaging, refrigeration
5) The environmental impacts of energy use in agriculture

Exploring Sustainability in Agriculture
(Content Continued)

i. Impacts to wild biodiversity
1) The extent of habitat loss due to conversion to agriculture
2) Impacts to wild species from exposure to agricultural chemicals
3) Impacts to wild species due to water diversion
4) Impacts to wild species due to erosion and sediment runoff
5) Pest management of large mammalian predators

3. Exploring Sustainability in Agriculture:
    a. Native ecosystems
        1) Ecosystem structure and organization
        2) Ecosystem processes and functions
    b. Agricultural ecosystems
        1) Agro-ecosystem structure and organization
        2) Agro-ecosystem processes and functions
    c. Defining sustainable agriculture
        1) Popular definitions of sustainable agriculture
        2) The debate over the definition of sustainable agricultural
    d. Forms of sustainable agriculture
        1) Traditional agriculture
        2) Agroecology
        3) Certified Organic Agriculture
        4) Integrated Pest Management (IPM) and low input agriculture
    e. Principles and strategies for designing and management of sustainable farming sys
    f. Comparisons of the environmental performance of alternative, certified organic an conventional agricultural production systems
    g. Ecological indicators of agricultural sustainability
    h. Social and economic sustainability in the food and agriculture system
        1) Community food security
        2) Economic viability of small-scale agriculture
        3) Economic viability of regional food systems
        4) Quality of life for farmers
        5) Equitable living and working conditions for agricultural workers
    i. The environmental and social values implicit in sustainable agriculture

Plant Science

4. Basic Plant Anatomy and Physiology
    a. Basic anatomy of cultivated plants
    b. Photosynthesis and respiration
    c. Water and nutrient uptake
    d. Plant growth stages and nutrient demands of cultivated plants
    e. The plant growth environment and plant growth responses

Exploring Sustainability in Agriculture
(Content Continued)

Soil Science

5. Soil Quality and Sustainable Agriculture:
    a. Physical Properties of Soils:
        1) Soil constituents
        2) Major soil physical properties
        3) The influence of soil physical properties on soil quality, fertility, plant heal and the resistance and resilience of crop plants to pests and pathogens
        4) Soil management strategies for the maintenance of desirable soil physical properties
    b. Chemical Properties of Soils:
        1) Essential macro- and micro- plant nutrients
        2) Nutrient cycling in agricultural soils

3) Benchmarks of soil chemistry/fertility
4) Soil management for the development and maintenance of optimal nutrie levels and cycling of nutrients
5) Soil fertility, plant health and the resistance and resilience of crop plants t pests and pathogens
6) Nutrient deficiencies and symptoms

c. Biological Properties of Soils:
1) The soil food web
2) The role of soil organisms in nutrient cycling
3) Soil biological diversity and pest and disease prevention
4) Biological indicators of soil quality
5) Soil management strategies used in maintaining optimal soil biological properties

Crop Science

6. Soil Fertility Management And Sustainable Farming Systems
a. Goals and strategies of sustainable soil fertility management
1) Management of soil organic matter for soil quality/fertility
2) Maintain crop productivity and crop quality
3) Prevent pests and disease causing organisms through soil fertility, crop rotation and biodiversity of farming system
4) Reduce dependence on off-farm soil fertility inputs through biological nitr fixation and efficient use of off-farm inputs
5) Reduce environmental pollution from agriculture through efficient use of v and nutrient inputs

b. Components of a sustainable soil fertility management program
1) Cover cropping
a. The role of cover cropping in sustainable agriculture
b. Selecting and using cover crops
c. Estimating the nitrogen contribution of cover crops
2) Crop rotation
a. Principles of crop rotation
b. Developing simple crop rotation plans

Exploring Sustainability in Agriculture
(Content Continued)

3) Soil testing and nutrient management
a. The role of soil testing and amending
b. Taking representative soil samples
c. Interpreting laboratory analyses
d. Developing simple nutrient budgets
4) Conservation tillage and cultivation
a. The role of tillage in agriculture
b. Preparing soils using sustainable tillage techniques
5) Compost
a. The role of organic matter and compost in sustainable agricu
b. Key factors involved in successful aerobic, high temperature composting
c. Building and monitoring compost piles
d. Assessing compost quality and maturity
6) Supplemental fertility

a. The role of supplemental fertility in sustainable agriculture
b. Tools and techniques of supplemental fertilizing

7) Advantage and disadvantage of alternative soil fertility management prac

Animal Science

7. Sustainable Livestock-Based Agricultural Systems
   a. Ecological principles and agroecology of livestock production systems
      1) Ecosystem structures
      2) Interdependence of biotic and abiotic components
      3) Nutrient cycling
   b. Role of livestock in farming systems
      1) History of livestock in farming systems global, national, local
      2) Breeds and their characteristics
      3) Animal health and forage quality in temperate, tropical and intermediate climates
      4) Food and nutrition
      5) Human, animal and environmental well being in animal agriculture
      6) Economical, social, political, cultural justifications for animal husbandry
      7) Systems productivity potentials without and with livestock
      8) Environmentally sound livestock management practices
      9) Biodiversity conservation in range management
      10) Case studies in sustainable animal agriculture
   c. Management for sustainable livestock production
      1) Management objectives: What is being managed and why?
      2) Definitions, productivity and management option for grasslands, pasturel rangelands and croplands
      3) Systems combinations and their management
      4) Sustainable vs. conventional livestock production systems
      5) Assessing pasture and soil resources for utilization and impact*
   d. National Organic Program (NOP) standards for livestock production

Exploring Sustainability in Agriculture
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Pest Management

8. Pest Management and Sustainable Farming Systems
   a. Arthropod Pest Management:
      1) IPM and IPM management strategies
      2) Preventative pest management strategies*
      3) Arthropod monitoring*
      4) Identification of arthropod pests and beneficial insects*
      5) Damage assessment and determining control action thresholds*
      6) National Organic Program standards for pest control materials
      7) Tools and techniques for active management of arthropod pests
   b. Weed Management:
      1) Preventative weed management strategies
      2) Weed identification*
      3) Weeds as indicators of soil conditions*
      4) Weed monitoring
      5) Determining control action thresholds for weeds*

6) National Organic Program (NOP) accepted management measures
7) Cultivation tools and techniques for weed management*

c. Pathogen Management:
1) Preventative plant pathogen management strategies
2) Monitoring for plant pathogens*
3) Identification of plant pathogens*
4) Damage assessment and defining control action thresholds*
5) NOP accepted control measures*

d. Vertebrate Pest Management*
1) Preventative management
2) Damage assessment and determining control action thresholds
3) Tools and techniques for vertebrate pest management*
4) National Organic Program (NOP) accepted management measures

Natural Resources Management

9. Irrigation and Sustainable Farming Systems:
a. The role of irrigation in arid and semi-arid farming systems
b. The movement and cycling of water in agriculture systems
c. Tools and techniques for the efficient delivery of irrigation water

10. Biodiversity Conservation and Sustainable Agriculture
a. Biodiversity conservation concerns in agriculture
b. Agro-biodiversity conservation: Conservation of genetic diversity of crop and livest varieties
c. Wild biodiversity conservation:
1) Production practices
2) On-farm habitat enhancement
3) Landscape ecology and planning

Exploring Sustainability in Agriculture
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Conclusion

11. The Adoption of Sustainable Farming Practices: Obstacles and Directions for Change
a. Human population growth and diet
b. Consumers accustomed to historically low US food prices
c. Consumer awareness of externalized costs of production and the demand for sustainable food and fiber products
d. Federal and State agricultural labor standards
e. Abundance of labor and the US labor market
f. The organization of the agricultural labor force
g. Federal and state regulation of synthetic pesticide and fertilizer use
h. Federal and stated technical and financial support encouraging the adoption of sustainable farming practices
i. Federal and state financial support for natural and social science research into sustainable farming systems
j. The shortcomings of federal standards for certified organic agriculture

12. The Growth and Development of the Sustainable Agriculture and the Organic Food Indust
a. Development and growth of the sustainable and organic foods industry

1) National
2) International

b. Case studies in small- and large-scale sustainable and organic agriculture

Laboratory Activities: Individual Laboratory Activities are designed to support course objectives.

Laboratory 1: Assessing Soil Physical Properties and Soil Quality in Agroecosystems

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 2.1: An Introduction to Soil Physical Properties. http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes suggested preparations and materials; demonstration outlines; suggested field exercised; and handouts for hands-on and experiential learning of soils and soil physical properties*.

    - Demonstration and Exercise 1: Soil Texture Determination
    - Demonstration and Exercise 2: Soil Profile Examination
    - Supplemental Demonstrations of Soil Physical Properties

2. Gliessman, S.R. 2000. Investigation #5: Soil Property Analysis. Field and Laboratory Exercises in Agroecology. Lewis Publishers. Washington, DC. *Includes background information, synopses, learning objectives, procedures, material and preparations and sheets for assessing a variety of soil properties of soil samples from several different agroecosystems and investigating how the observed soil properties are kinked to differences in management history.*

3. Weil, R.R. 2005. Laboratory Manual for Introductory Soil Science. 7 ed. Kendall/Hunt, Dubuque, IO. 212p. *A comprehensive manual for conducting field and laboratory exer examining the physical, chemical and biological properties of soils. See exercises 1-9.*

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Laboratory 2: Assessing Chemical Properties of Soils, Soil Quality and Agroecosystem Health

1. Weil, R.R. 2005. Laboratory Manual for Introductory Soil Science. 7 ed. Kendall/Hunt, Dubuque, IO. 212p. *A comprehensive manual for conducting field and laboratory exercises examining the physical, chemical and biological properties of soils. See exercises 1-9.*

Laboratory 3: Assessing Biological Properties of Soils, Soil Quality and Agroecosystem Health

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 2.3: An Introduction to Soil Biology and Ecology http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes suggested preparations and materials; demonstration outlines; suggested field exercised; and handouts for hands-on and experiential learning of soil biology, ecology and soil qualit assessments and nutrient cycling. *Note: It is suggested that the above exercises be conducted in different farming systems (or soils historically receiving different manage inputs) in order to compare and contrast soil quality differences due to farming techni*

used.

- Demonstration and Exercise 1: Organic Matter Decomposition in Litter Bags
- Demonstration and Exercise 2: Soil Respiration
- Demonstration and Exercise 3: Earthworm Populations
- Demonstration and Exercise 4: Soil Arthropods

2. Gliessman, S.R. 2000. Investigation # 12: Census of Soil Surface Fauna. Field and Laboratory Exercises in Agroecology. Lewis Publishers. Washington, DC. *Includes background information, synopses, learning objectives, procedures, material and preparations and data sheets for assessing soil surface fauna diversity and abundance an indicator of agroecosystem management*

3. Weil, R.R. 2005. Laboratory Manual for Introductory Soil Science. 7 ed. Kendall/Hunt, Dubuque, IO. 212p. *A comprehensive manual for conducting field and laboratory exercises examining the physical, chemical and biological properties of soils. See exercises 11-14.*

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Laboratory 4: Cover Crops in Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.6: Selecting and Using Cover Crops http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes demonstration ou and suggested field exercise for discussing the biology and and role of cover crops in agriculture including estimating the nitrogen contribution of cover crops.*

    - Demonstration 1: Introduction to the Biology and Role of Cover Crops in Susta Agriculture *(link)*
    - Demonstration 2 and Exercise 1: How to Estimate the Nitrogen Contribution of Cover Crop

Introduction to the Biology and Role of Cover Crops in Sustainable Agriculture

In this exercise instructors take a group of students out into the College farm fields/gardens to discuss the following information on the biology of cover crops and the role of cover crops in sustainable farming systems. Upon return to the classroom, instructor and invited guest(s) discuss the rationale behind the use of various types of cover crops in different farming

systems. Techniques, equipment and costs and benefits should be discussed.

A. Small Group Field Walk: The roles of cover crops in sustainable agriculture

- Nitrogen Fixation
- The Biology of N-fixation: The process of biological nitrogen fixation and the potential nitrogen contribution of cover crops
- A brief overview of nitrogen as one essential nutrient that may be a limiting factor in crop growth
- Erosion control during rains and or winds
- Carbon fixation/organic matter production
- Soil structural improvements
- Soil aggregate formation resulting from the absence of disturbance and the organic matter additions
- Influence of root systems on soil including both tap and fibrous rooted cover crops
- Beneficial Insect Attraction
- Weed Suppression:
- Light competition with weed species
- Allelopathy and the chemical suppression of germination and growth of weed species
- Nutrient Cycling
- Nutrient retention and of prevention of nitrate leaching by non-nitrogen fixing cover crops (e.g. – grasses)
- Phosphorous cycling by cover crops in the Fabaceae
- Crop Rotation and Disease Suppression: Interrupting pest/pathogen and the crop host patterns
- Demonstration of cover crop incorporation:
- Timing: Cover crop development and soil moisture

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

- Mowing techniques
- Tillage techniques

B. Discussion and Questions and Answers: How cover crops are used in different locations and why

1. What species of cover crops are planted and why
2. When are they planted?
3. How much seed is used, where is the seed obtained and how much does it cost (time and money)?
4. When are the cover crops incorporated (or harvested) and why at this stage of development?
5. What is the process and what are the tools and techniques used in harvesting and incorporating cover crops efficiently at this scale?
6. The other cover crops that are used at the farm:
    a. Summer cover crops: Species used, rationale, techniques and advantages and disadvantages
    b. Cover crop treatments in orchards: Species used, rationale, techniques and advantages and disadvantages

Laboratory 5: Crop Rotation in Sustainable Agriculture

1. Van Horn, Mark. 2004. UC Davis Student Farm Crop Rotation Exercise.

Includes a demonstration outline for field-based discussion of the history and ratio of crop rotation of a given farming operation and a hands-on small group exercise students involving the development of simple crop rotation and soil fertility plans f hypothetical production systems.

- Demonstration 1: Examining Crop Rotation History and Rationale
- Exercise 1: UC Davis Crop Rotation Exercise

Crop Rotation Exercise

Adapted from the UC Davis Student Farm Crop Rotation Exercise

Introduction:
In the following hand-on exercise, students are asked to develop a simple 3-year crop rotation for one or more of the sample production scenarios listed below. (Instructors are encouraged to develop regionally appropriate scenarios based on local agriculture or student interest.) Students are asked to work in small groups of 2-4 students in developing the hypothetical crop rotation and soil amendment plans and presenting them along with their rationale to the other students and instructors who provide critical feedback.

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(Laboratory Activities Continued)

Preparations and Materials: For the Instructor
Following an introductory lecture /discussion and field trip on crop rotation (see resources below) organize students into small groups (2-3) and assign the following exercise. Provide students with 30 min. to develop a hypothetical crop rotation plan. After 30 min. reconvene as one large group and ask that each of the small groups present their chosen scenario and their rationale for chosen crop rotation and soil amendment plan. 5 min. are given to each small group presentation with 5 additional min. for feedback and discussion with other students and instructors. *Note: When including the soil fertility component (see #4 below), students will need to be provided with sample soil nutrient levels (see sample figures following first 4 production scenarios below).*

Preparation time: 15 min.
Exercise time: 1.5 hours
Materials:
- Photocopies of crop rotation exercise
- Pens/pencils
- Chalkboard/whiteboard

Student Assignment:
Select one or more of the sample production scenarios below and develop a 3-year crop rotation. You will have 30 min. to define your crop rotation plan and 5 min. to present your decisions to the rest of the class. For each crop rotation plan please address the following topics:
1. The amount of land in each cash crop each season
2. The amount of land in cover crop each season
3. The specific crop rotation sequences your group recommends (use chart template below) and your reasoning behind your choices.
4. Soil fertility: Optional

i. Identify specific cover crops to be used and when in rotation
ii. Define compost use: Please specify timing of application, application rate and why used.
iii. Define soil amendment use. Please specify which amendments used, application rates and timing of application.

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Example of simple crop rotation:

Field	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
A	Corn	Legume cc	Tomato	Grass cc	Bean	Legume cc
B	Tomato	Grass cc	Bean	Legume cc	Corn	Legume cc
C	Bean	Legume cc	Corn	Legume cc	Tomato	Grass cc

Field	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**

Production scenarios

- 3 Acres total. Each year grow: 1 A: Sweet Corn, 1/2 A ea. of: Tomatoes, Bell Peppers, Lettuce, Broccoli, Carrots. (60 ppm P, 250 ppm K, 200 ppm Mg)
- 3 .5 Acres total. Each year grow: 1/2 A ea of Green Beans, Winter Squash, Melons, Hot Peppers, Lettuce, Spinach, Beets. (100 ppm P, 200 ppm K, 1100 ppm Mg)
- 3 Acres total. Each year grow: 1/2 A ea of Tomatoes, Eggplant, Potatoes, Summer Squash, Cucumbers, Long Beans (50 ppm P, 70 ppm K, 90 ppm Mg)
- 500 acres total: Irrigation District ditch water only (April - October only). 100 Acres each of: Field Corn Melons Tomatoes Winter Squash Rice. (60 ppm P, 250 ppm K, 200 ppm Mg)
- 3.5 Acres total. Each year grow: 1 A of Sweet Corn; 1/2 A ea. of: Tomatoes, Potatoes, Lettuce, Broccoli, Carrots, Collards

- 3 Acres total. Each year grow: 1 A: Sweet Corn, 1/2 A ea. of: Tomatoes, Bell Peppers, Lettuce, Broccoli, Carrots
- 3 .5 Acres total. Each year grow: 1/2 A ea of Green Beans, Winter Squash, Melons, Hot Peppers, Lettuce, Spinach, Beets
- 4 Acres total. Each year grow: 1/2 A ea of Lettuce, Swiss Chard, Carrots, Beets, Broccoli, Cauliflower, Onions, Potatoes
- 4 Acres total. Each year grow: 1/2 A ea of Sweet Corn, Tomatoes, Eggplant, Peppers, Summer Squash, Cucumbers, Long Beans
- 500 acres total near Woodland, Ca. Yolo Irrigation District (ditch water; April - October only) 100 Acres each of: Sweet Corn Melons Tomatoes Winter Squash Rice
- 3.5 Acres total with well water Each year grow: 1 A: Sweet Corn, 1/2 A ea. of: Tomatoes, Potatoes, Lettuce, Broccoli, Carrots, Collards

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

General Guidelines for Crop Rotation:

- Since plants that are closely related often share pests, have similar cultural practices and similar nutrient needs, rotate between crops that are not related botanically. A good general rule is to rotate between families: Poaceae (grasses like wheat, oats and corn), Brassicaceae (mustard and broccoli family crops), Solanaceae (tomatoes, potatoes, peppers, eggplant), Cucurbitaceae (cucumbers, squash, melons), Fabaceae (legumes—peas, vetch, beans), Compositae (lettuce), Amaryllidaceae (onions, garlic, leeks), Chenopodiaceae (spinach, beets and chard), Apiaceae (carrots, parsnips, parsley, cilantro, fennel, dill).
- Do not rotate to crops that share diseases or other pests (even if not botanically related).
- Longer rotations (longer time periods before repeating same or similar/related crop) are better than shorter rotations. Also, specific information on survival of pests in soil can help determine appropriate length of a rotation.
- Rotate between crops that have different root growth patterns and depths.
- Rotate between crops that do not make the same demands on soil for nutrients - heavy feeders such as corn should be preceded by legumes and followed by a light feeding crop such as beets or carrots.
- Cover crops should be a part of the rotation. Remember to consider effects on diseases, weeds and other pests when growing a cover crop to improve the soil. Rotate cover crops, not just cash crops.
- Some weeds are particularly adapted to row crops, some to small grains and solid planted cover crop, and some to hay and pasture crops. Rotating these three types of crops greatly restricts annual weeds.

Resources:

- Altieri, Miguel A., (ed). 1995. Chapter 11: Crop Rotation and Minimum Tillage. *Agroecology: The Science of Sustainable Agriculture.* Boulder, CO: Westview Press. *Provides a concise overview of the impacts of crop rotation and reduced tillage on soil quality and pest and diseases.*
- Colemann, Eliot. 1995. The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener. Chelsea Green Publishing Co. White River Junction, VT. *An overview of intensive organic production methods on a small scale. Good*

section on crop rotation planning.

- Karlen, D.L., G.E. Varvel, D.G. Bullock and R.M. Cruse. 1994. Crop rotations for the 21st century. Advances in Agronomy. 53:1-45. *Provides a summary of the agronomic advantages of crop rotations including crop rotation effects on yields, soil quality, pests and diseases.*
- Magdoff, F. and H. Van Es. 2000. Building Soils for Better Crops. Second Edition. Sustainable Agriculture Network, Handbook Series Book 4. Sustainable Agriculture Network. National Agricultural Library. Beltsville, MD 20705-2351. www.sare.org . *An introductory overview of organic management of soil fertility covering the basics of soil organic matter, physical and chemical properties of soil, ecological soil and crop management. Practical and accessible information.*
- Miles, Albie and Brown, Martha. 2005. Teaching Direct Marketing and Small Farm Viability: Resources for Instructors. Unit 4.6: CSA Crop Rotation and Soil Fertility. *Contains lecture notes on the principles and practices of crop rotation and appendices containing A/V materials and sample crop rotations.* Available online: http://zzyx.ucsc.edu/casfs/index.html.

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

- Sustainable Agriculture Network. 1998. Managing Cover Crops Profitably. Second Edition. Handbook Series Book 3. Sustainable Agriculture Network. National Agricultural Library. Beltsville, MD 20705-2351. www.sare.org. *Very useful information on the characteristics, costs seeding rate and management of different cover crop species.*
- Van Horn, Mark. 2003. UC Davis Crop Rotation Lecture. UC Davis Student Farm. *Lecture notes for an introductory discussion of crop rotation.*

Laboratory 6: Soil Analysis, Nutrient Budgeting and Soil Amending in Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.11: Reading and Interpreting Soil Tests. http://zzyx.ucsc.edu/casfs/training/manual/contents.html. Includes lecture notes, de lecture notes for student, suggested field demonstrations, and multiple laboratory exe for hands-on and experiential learning of how to take soils samples, read and interpre results, develop nutrient budgets and amendment plans.

    - Demonstration and Exercise 1: Taking representative soil samples
    - Demonstration and Exercise 2: Reading and interpreting a soil analysis Report
    - Demonstration and Exercise 3: Nitrogen budgeting
    - Demonstration and Exercise 4: Field observations: Plant growth and soil fertilit

2. Weil, R.R. 2005. Laboratory Manual for Introductory Soil Science. 7 ed. Kendall/Hunt, Dubuque, IO. 212p. *A comprehensive manual for conducting field and laboratory exer examining the physical, chemical and biological properties of soils. See exercises 18 a 19.*

Laboratory 7: Soil Tillage and Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for

Instructors. UC CASFS. Unit 1.2: Garden and Field Tillage and Cultivation http://zzyx.ucsc.edu/casfs/training/manual/contents.html. Includes lecture notes, suggested field demonstrations, suggested preparations and materials for field demonstrations; demonstration outlines; suggested field exercises for students; illustrations for hands-on and experiential learning of garden and field-scale tillage an cultivation.

- Demonstration and Exercise 1: Garden-scale tillage
- Demonstration 2: Mechanical tillage

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Laboratory 8: Principles and Practices of Compost Production and Use

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.7: Making and Using Compost. http://zzyx.ucsc.edu/casfs/training/manual/contents.html. Includes lecture notes, suggested field demonstrations, suggested preparations and materials for field demonstrations; demonstration outlines; suggested field exercises for students for ha on and experiential learning of garden and field-scale compost production, assessmen use.

    - Demonstration 1: Garden-scale compost production
    - Demonstration 2: Field-scale compost production

Laboratory 9: Integrated Pest Management (IPM) in Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.8: Arthropod Pest Management. http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes field demonstrati suggested preparations and materials and demonstration outlines for hands-on and experiential learning of arthropod monitoring, sampling, identification skills and treatn strategies used in integrated pest management.*

    - Demonstration 1: Pest monitoring, sampling , identification and management options
    - Demonstration 2: Field observations (for field trips)**Laboratory 10: Weed Bio and Weed Management In Sustainable Agriculture**

1. Gliessman, S.R. 2000. Investigation # 10: Management History and the Weed Seed B Field and Laboratory Exercises in Agroecology. Lewis Publishers. Washington, DC. *Incl background information, synopses, learning objectives, procedures, material and preparations and data sheets for identifying weeds and making inferences about the e of management activities on weed populations.*

2. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for

Instructors. UC CASFS. Unit 1.10: Managing Weeds http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes field demonstratio suggested preparations and materials and demonstration outlines for hands-on and experiential learning of weed identification and non-chemical weed management on a garden and field-scale.*

- Demonstration 1: Mechanical weed management
- Demonstration 2: Hand weed management
- Demonstration 3: Weed identification

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Laboratory 10: Plant Pathogen Management in Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.9: Managing Plant Pathogens http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes field demonstrati suggested preparations and materials and demonstration outlines for hands-on and experiential learning of plant pathogen identification and treatment options.*

    - Demonstration 1: Disease identification

Laboratory 11: Vertebrate Pest Management in Sustainable Agriculture

1. Baefsky, Michael; Davidson, Nita; Messenger, Belinda; Welsh, Angelica. 2004. Curricula for School IPM Workshops: Curriculum for Burrowing Rodents. California Department of Pesticide Regulation (CDPR).

    Contains an extensive listing of instructional resource for use in teaching IPM for burrowing rodents. Includes reference texts, lecture notes, and methods and materials field demonstrations. Available online through CDPR: http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/training/main.cfm?crumbs_list=1,39

Laboratory 12: Water Conservation Irrigation Practices for Sustainable Agriculture

1. Miles and Brown (eds.) 2003. Teaching Organic Gardening and Farming Resources for Instructors. UC CASFS. Unit 1.5: Irrigation – Principles and Practices http://zzyx.ucsc.edu/casfs/training/manual/contents.html. *Includes field demonstrations, suggested preparations and materials, demonstration outlines, exercises and other resources for use in hands-on and experiential learning of efficient field and garden scale irrigation.*

    - Demonstration 1: Field-scale irrigation
    - Demonstration 2: Garden-scale irrigation

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Laboratory 13: Animal Husbandry Practices in Sustainable Agriculture: Methods for

Inventorying Pasture/range for Estimating Stocking Capacity and Grazing Impacts

1. Mufandaedza, Oneas T. 2004. Methods for Inventorying Pasture/range for Estimating Stocking Capacity and Grazing Impacts. Central Carolina community College. *Includes field demonstrations, suggested preparations and materials, demonstration outlines, exercises and other resources for use in hands-on and experiential learning of pasture assessment through the identification of forage and weed species; estimating plant species composition; estimating ground cover and biomass; assessment of over- and under-utilization of common grasses and legumes in a pastures; recognize misuse (under-/over-grazing) of pastureland/grassland/rangeland.* (Note: Recommended Reading - Cosgrove, Dannis; Dan Undersander and Maurice Davis (1996) . Determining Pasture Condition - Pasture Condition Scoring. Wisconsin County Extension , Wisconsin Cooperative Extension Pub A3667.)

2. Sullivan, Preston 2001. Assessing the Pasture Soil Resource. ATTRA--National Sustainable Agriculture Information Service. *This 9 page technical note provides methods to determine biological activity of pasture soils and practical tips on improving the usefulness of typical soil and plant samples. The soil biology sampling methods are easy to learn, and utilize commonly available tools found around any farm. Once these biological assessments are made, more insight into the many benefits of nutrient cycling become apparent. Methods for using soil and plant samples strategically are also covered.* Available online through ATTRA*:* http://www.attra.ncat.org/livestock.html

Laboratory 14: Assessing the Sustainability of Local Farming Systems and the Influenc Market Forces on Agricultural Practices

1. Gliessman, S.R. 2000. *Investigation #23: Farmer Interview.* Field and Laboratory Exercises in Agroecology. Lewis Publishers. Washington, DC. *Includes background information, synopses, learning objectives, procedures, material and preparations, suggested areas to investigate, interview questions, and suggested discussion topics*
   for interviewing growers to learn about farmers' practices, knowledge, motivations goals and challenges. Serves to assist students in examining the sustainability of various production systems and the constraints placed upon growers in the adoption of sustainable farming practices.
   - Farmer Interview

2. Gliessman, S.R. 2000. *Investigation #24: Local Food Market Analysis.* Field and Labor Exercises in Agroecology. Lewis Publishers. Washington, DC. *Includes background information, synopses, learning objectives, procedures, material and preparations and sheets for investigating local retail produce sites in determining availability, source an of fresh produce. This information is then used to construct an image of the student's food market and how market forces may influence agricultural practices.*

- Local Food Market Analysis

Exploring Sustainability in Agriculture
(Laboratory Activities Continued)

Notes:

* Indicates use of college farm resources for laboratory exercise and/or skill development.

Bold headings indicate future active link to annotated resources sections.

Note: The materials associated with the *'Exploring Sustainability in Agriculture'* course, including course outline, course description and the annotated instructional resources listing contained wit this binder are also available online from the Center for Agroecology and Sustainable Food Syste http://zzyx.ucsc.edu/casfs/. Please see the Resources section for more information, acknowledgements, and the printed annotated instructional resources.

Methods of Evaluation: Lecture	Methods of Evaluation: Laboratory
Comprehensive Quizzes and Exams	Laboratory Skill Validation by Observation
Written Critical Thinking Scenarios	Laboratory Projects and Reports
Problem Analysis and Solution	Laboratory Research Projects and Reports
Research and Term Papers	Laboratory Skill Practicum Exams

Typical Textbooks, Manuals, or Other Support Materials
PowerPoint presentations
See Resource section for books, publications, and online resources.

Statewide Articulation: Transfers as lower division elective

FDRG Lead Signature: Date:

Mark E. Bender, PhD CSU Stanislaus

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