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Project Title

Long Term Research on Agricultural Systems: Crop Diversity and Input Level as Determinants of Function and Evolution of the Agroecosystem

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Budget Totals	Requested from SAREP	Matching
2/15/90-1/31/91:	$149,400	$115,800
2/1/91-1/31/92:		$199,000
2/1/92-1/31/93:		$234,500

Donald R. Nielsen

Summary

The performance of all agricultural systems is ultimately evaluated by inputs and outputs. These criteria are useful not only for calculations of profitability but also for assessing the environmental impact of the production system. This study isolates two critical variables, namely the diversity of crops in a rotation and the level and source of nitrogen inputs, to evaluate the performance of several standard field crop systems. The experiment is designed to determine the impact of these variables on resource use efficiency, identify the components of the system that cause changes in efficiencies through time, and provide explanations for the component changes. The study specifically contrasts efficiencies and outputs from systems where nutrient and water sources are endogenous versus exogenous. A team of 19 researchers with broad interdisciplinary expertise will provide a systems perspective for the implementation and evaluation. The Coordinator of the Long-Term Research on Agriculture Systems (LTRAS), a component of the UCD Sustainable Agriculture Program, will direct the study on a 300 acre facility for both research and education. The College has committed $500,000 in matching resources to this site over the next 4 years.

Objectives

This proposal represents the commitment of the College of Agriculture and Environmental Sciences at UC Davis to resolving important issues that confront California's agriculture, but require a long-term research approach. Our primary objective is to establish several permanent experiments on annual, perennial, and rangeland systems. The first long-term study will focus on annual field crop systems with the following goals:

1. to compare resource use efficiency, productivity, and economic return from cropping systems that differ in crop rotation and the degree of reliance on rainfall and nitrogen derived from legume N_2 fixation versus reliance on water supplied by irrigation and fertilizer nitrogen.

2. to determine the long-term effects of crop rotation and the level of input application on soil quality (defined in relation to measurable soil physical, chemical, and biological properties such as pest populations), and whether such changes influence resource use efficiency, productivity, profitability, and sustainability of the production system.

3. to determine how the degree of reliance on renewable resources, crop rotation, and changes in soil quality influence the movement of pollutants (e.g. nitrate and pesticides) below the root zone.

4. to identify and characterize the processes and mechanisms that control changes in soil quality and biological components of the agroecosystem that result from differences in crop rotation and level of input application.

5. to use these long-term experiments as an educational facility for undergraduate and graduate level courses that provide direct experience with field-level research on agricultural systems, and for extending information about the structure and function of crop production systems to growers, consumers, agricultural industries, and policy makers.

Procedures

Experimental Design and Field Operations

The initial experiment on field crop systems will be arranged as a confounded split-plot design, with three replicate blocks. Water input levels comprise mainplot treatments. Subplot treatments are combinations of nitrogen source and level, crop rotation, and rotation starting point. All subplot treatments are two-year rotations, and there are three cropping system treatments within each mainplot. This provides six replicates of each cropping system treatment--three each as opposite starting points in the two-year rotation (Appendix A).

Each treatment plot will be 65m x 60m (213' x 197' = 0.96 ac); each block will require about 20 acres including access roads and turn space for machinery. The entire experiment will need about 60 acres (Appendix B). All field operations will be conducted using full-size equipment. Winter crops will be planted on rolling beds and flood irrigated. Summer crops will be planted on beds and furrow irrigated. Pest management will not be a treatment variable because we anticipate that pest control methods will change dramatically over the duration of the experiment. Instead, state-of-the-art IPM guidelines will be followed and control measures taken as necessary in each cropping system treatment independently. Potential treatment effects on pest pressure will be manifested by more, or fewer, control actions and costs, or by yield differences. We intend to utilize improved pest management tools that minimize pesticide use as they become available. Monitoring of pest populations in relation to cropping system treatments will be conducted as component studies where appropriate.

Establishing the Experiment and Characterization of Initial Conditions

Before the experiment is established, a first-order soil map of the site will be made, and a rainfed, unfertilized barley covercrop will be grown, cut, and hay removed. Aerial infrared and regular photographs will be taken of the covercrop. If sufficient funding is available, the hydrology at the site will be characterized to establish the rate and direction of ground water flow and depth to the water table.

Based on the characterization of uniformity and hydrology, the experiment will be laid out, and infrastructure such as irrigation lines and weather station installed. An initial set of soil samples to 1.8m depth in intervals of 0-30, 30-60, 60-120, and 120-180cm will be taken in a krieged pattern from each plot. These will be archived for future reference after measurement of primary variables including total N and C, pH, and extractable levels of inorganic N, P, and K. For each plot, a composite soil sample for the sampled depths will be made from the multiple cores taken in the krieged pattern. A more detailed characterization of soil physical, chemical, and biological properties will be made on these composite samples which will be stored for future reference.

Management of Treatment Variables

For each cropping system, all field operations will be managed to optimize the efficiency of input utilization, whether inputs are from a renewable source or of external origin. Time of planting will be an important consideration in rainfed systems. In irrigated treatments, efficient water use will be facilitated by monitoring plant water potential and soil water depletion with a neutron probe to determine irrigation schedules. In systems that receive nitrogen fertilizer, the level, form, timing, and method of nitrogen application will be designed to achieve 95% of the average maximum yield without nitrogen limitation for each crop in the specified rotation and water input level. Legume nitrogen input from N_2 fixation also will be tailored to match the nitrogen demand of the following crop by manipulating the length of the growing period (i.e. planting date and plow-down) (Miller et al., 1989). Estimates of primary productivity, crop residue return, and water and nitrogen inputs for the various treatments are shown in Appendix C.

Core Measurements in the Experiment

A log will be kept of all field operations, labor, and machinery use. Crop yields will be determined from a complete harvest of the entire "unperturbed" area (45m x 60m) within each plot (Appendix B). Destructive sampling will be minimized in this area such that spatial variability of soil physical, chemical, and biological properties will be influenced solely by the imposed cropping system. A relatively small number of mature plants will be removed at harvest to estimate total aboveground dry matter, nutrient accumulation, and partitioning between harvested and vegetative organs that are regarded as residue. At two-year intervals, soil samples will be taken as described earlier to monitor changes over time in levels of soil nutrients, organic carbon, physical properties, and, where appropriate, biological components such as seed banks and pathogen and nematode populations.

Water budgets will be monitored by measuring rainfall, irrigation applications using inflow meters, and an electronic recording system to determine tailwater runoff (Hanson et al., 1988). Nitrogen budgets will be constructed from measurements of nitrogen removed in harvested fruit or grain, changes in soil nitrogen levels to 1.8m depth, and nitrogen inputs from rain, fertilizer, and legume N_2 fixation.

A "monitoring area" of 20m x 60m on one side of each treatment plot (Appendix B) will be reserved for more intensive monitoring activities and smaller subexperiments on important components of the main experiment. Initial component studies will focus on (i) more precise calibration of fertilizer-nitrogen requirements based on residual soil nitrogen levels and soil nitrogen mineralization potential, and (ii) prediction of N_2 fixation by the vetch covercrop in relation to planting date, initial soil nitrogen levels, duration of growth, accumulated heat units, and water supply. This information is needed to more efficiently utilize legume- and fertilizer-nitrogen inputs in the different cropping systems, and to generate response functions for the water and nitrogen variables in the experiment.

Objective 1: Comparison of Cropping Systems

"Common parameters" will be used to compare the performance of cropping systems that differ in component crops, rotation pattern, and input levels. Economic parameters such as net return provide one form of common measure. Measures of resource use efficiency also are useful indicators of performance in agricultural systems. Ratios of caloric yield per unit water input, protein yield per unit nitrogen (or water) input, energy output/input, and net return per unit water or nitrogen input are several relevant common parameters. Stability of yield and stability of the above common parameters also can be evaluated across cropping systems.

Statistical comparison of common parameters and yield are not straightforward in experiments that are confounded by different crop rotations. Several methods, however, have been proposed for analysis of rotation experiments (Yates, 1954), and these will be employed where appropriate. Likewise, separate analyses that include restricted subsets of comparable cropping system treatments can be made using standard analysis of variance techniques to isolate specific treatment effects. These subset analyses include effects of level and source of nitrogen in rainfed versus supplemental irrigation systems, legume-derived nitrogen versus fertilizer-nitrogen comparisons, and corn versus wheat as a summer or winter cereal rotation crop for processing tomato (Appendix A). Such comparisons can be made for any even-year interval (i.e. 2, 4, ..., 12 etc.) to allow evaluation of short- versus long-term effects, and the stability of performance parameters over time. Regression and multiple regression techniques will be used to identify the important soil properties and biological components that influence performance of the cropping systems, and to characterize the relationships among these determinants of performance.

Objective 2: Relationship Between Soil Quality and Performance

The range in recycled biomass and the source and level of water and nitrogen inputs (Appendix C), as well as the range in the intensity of management operations that accompany the various cropping system treatments are expected to result in large differences in soil properties that define soil quality. Monitoring treatment effects on soil, physical, chemical, and biological properties, and evaluating these changes with respect to the common performance parameters described earlier, will help identify soil properties that have the greatest impact on resource use efficiency and economic return from crop production systems in the Sacramento Valley. Trend analysis of these relationships over time will provide a test of the hypothesis that soil quality has a direct effect on output/input ratios and profit.

Objective 3: Movement of Water and Input Residuals Below the Root Zone
Objective 4: Mechanisms that Control Changes in the Resource Base on Which Agriculture Depends

Funding resources will not be adequate to begin these component studies at the outset of the experiment. We plan, however, to seek additional funding from commodity groups, agro-industry, and from university, state, and federal agencies once the experiment is established. The following projects are to become an integral part of the long term experiment.

1. The capability to monitor movement and fluxes of water and solutes (especially nitrate and pesticides) below the root zone, and to define the effects of crop rotation, source and level of nitrogen inputs, and water supply on the rate of leaching. Likewise, temporal and spatial variation of these fluxes are also an important issue. Actual methods used to accomplish these objectives will depend on the water table depth and funding level for this component project.

2. The experiment is designed to provide exciting opportunities for component studies to elucidate the mechanisms that govern cycling of organic carbon and nitrogen in Sacramento Valley soils. We anticipate projects that measure the rates of carbon and nitrogen exchange between the mineral soil matrix, microbes and microfauna, roots, and aboveground plant organs in systems that differ in quantity and quality of recycled crop residue and root biomass. The dynamics of these processes will be evaluated in relation to temporal variation in temperature and moisture, and as influenced by the cropping system. Effects on crop nutrient acquisition, rhizosphere ecology, and leaching of nutrients will also provide exciting research opportunities.

3. Cropping system treatments are expected to alter soil physical properties in different ways. There is interest and expertise among the project investigators to compare the effects of substituting legume-nitrogen (and associated organic carbon) for fertilizer-nitrogen on aggregate stability, water infiltration, and soil crust formation that limits seedling emergence. The relationships among soil organic carbon levels, chemical forms of organic carbon, microbial ecology, and soil physical properties must be defined to improve our understanding of how physical traits evolve over the short- and long-term under different cropping systems.

4. Biological components of the agroecosystem will also evolve differently in the various cropping systems. In the wheat-based systems, soil pathogens such as take-all disease and root and foot rots caused by Fusarium spp. are influenced by nitrogen and water inputs. Rotations are known to affect pathogenic fungi associated with straw (e.g. Septoria spp.). On tomato, Phytophthora root rot, and corky root caused by Pyrenochacta lycopersici and root knot nematode are likely to be sensitive to rotation and water regime. Weed seed banks represent the history of weed seed production on a field, and seed banks are the source of weeds in subsequent years. Weed populations, weed pressure, and the need for control measures will be sensitive to irrigation level, nitrogen supply, and crop rotation. Pests that are not highly migratory and plant tolerance of such pests (e.g. spider mites) are likely to be sensitive to the imposed cropping system treatments. While these examples illustrate possible candidates for research, providing details concerning implementation is premature. Selection of appropriate subjects and methods will be determined after examination of monitoring data on disease incidence, weed species and infestation levels, and insect populations. Pest management regimes will be specific for each cropping system treatment based on IPM guidelines that require monitoring and records of pest levels. These data will be used to target studies on biological components of major concern in the experiment.

Objective 5: Extension and Education

The initial experiment on field crop systems is designed to be a research and education "facility" within the Sustainable Agriculture Program at UC Davis. As the experiments progress, the facility will be used as a coordinating center for workshops and dissemination of information concerning long-term research on important issues in agriculture. An annual field day event, open to the agricultural community and public-at-large, will be jointly sponsored by A&ES and UC Cooperative Extension researchers involved in the project. It is not difficult to imagine these research plots becoming an important educational center that is open to the public for a first-hand look at agricultural systems and the exciting research that is conducted at a land grant university. Likewise, we will encourage faculty to utilize resources at the long-term experimental plots in their present courses, and to assist in the development of new undergraduate and graduate level courses on the structure, function, and evaluation of agricultural systems. The UCD Sustainable Agriculture Program is focusing on the revitalization of the Agricultural Ecology area of emphasis within the Ecology Graduate Group. A preproposal for a Training Grant to NSF from the group will use the LTRAS as a central training facility for agricultural research. This graduate program and the new undergraduate minor in Sustainable Agriculture will also be closely linked to the LTRAS for field courses and research opportunities.

Time Table

The experiment is designed with the intention that it will be a valuable research and education resource for many decades. The following time table represents only the major events of the initial start-up.

March 1990	-	final site selection
April to Sept 1990	-	first-order soil survey conducted, observation wells established, .hydrology studies initiated
October 1990	-	barley covercrop planted to assess soil uniformity
early March 1991	-	barley cut and removed, experiment laid out, initial soil samples taken, analyzed, and archived
	-	planting of cropping system treatments with entry point A summer crops
October 1991	-	first annual field day
Fall 1991	-	harvest of summer crops, planting of entry point A winter crops
Spring 1992	-	harvest or plow-down of winter crops, planting of entry point B summer crops
October 1992	-	second annual field day
Fall 1992	-	harvest of summer crops, planting of entry point B winter crops
Spring 1993	-	harvest of winter crops and end of first two-year rotation cycle, biennial reference soil samples taken, experiment continues as above.
October 1993	-	third annual field day, report of results from first two-year cycle, workshop held on long-term research on agricultural systems

Justification

California's agriculture is characterized by high productivity, intensive use of capital and inputs, and rapid adoption of new technologies. Field crops are the backbone of agriculture in the state; they dominate nearly 70% of the irrigated farmland in the Central Valley. The structure and function of these production systems are being questioned, however, as greater attention is focused on the effect of agriculture on the environment.

Use of water from irrigation and fertilizer-nitrogen are the primary factors responsible for the high yield levels that distinguish field crop production in California from rainfed systems elsewhere in the United States. Reliance on large inputs of these resources has been criticized: California has a rapidly increasing population but limited water supplies, and nitrate contamination of groundwater in crop production areas is attributed to leaching from applied fertilizer. At issue is whether the use of large external subsidies of water and nitrogen is economically and ecologically sustainable. It is likely that efficient use of water and nitrogen, and effects on the soil resource and groundwater will remain a crucial issue in the foreseeable future.

The proposed experiment is designed to compare water and nitrogen use efficiency, productivity, and profitability in cropping systems that differ in degree of reliance on external sources of these inputs (Appendix A and C). The fully-irrigated tomato-wheat and tomato-corn rotations are representative of many commercial farms in Central California. Tomato is a high value crop that is inefficient in uptake of nitrogen fertilizer (Hills et al., 1983) and has a high water requirement. Corn and wheat are staple food crops, and both are efficient in acquisition of fertilizer-nitrogen (Abashi et al., 1984). As a summer crop, corn produces greater biomass and grain yield and requires considerably more nitrogen and water inputs than wheat or tomato. The rainfed cropping systems provide a baseline reference of inherent productivity of the agroecosystem without exogenous water supply, and rainfed winter cereals have been the basis of agriculture in mediterranean areas since civilization began. Wheat-based cropping systems that receive irrigation only to supplement rainfall are an intermediate option between the fully-irrigated and rainfed systems. Within each water input level regime in the experiment, one of the cropping systems utilizes a winter legume covercrop to replace or reduce the nitrogen requirement of the cash crops.

Although water, nitrogen, and crop rotation are the state variables, the study provides a framework for examination of other crucial issues concerning the sustainability of agricultural systems. Large differences in expected outputs and inputs among cropping system treatments (Appendix C) are likely to cause significant differences in soil quality and pest populations (Daamen et al., 1989). These fundamental changes in the agroecosystem are likely to affect the need for pest control measures, leaching of pollutants below the root zone, input use efficiency, and profitability. The experimental plots are also of sufficient size to determine long-term effects of diverse management systems on spatial and temporal variability of important soil properties and biological components, and how such heterogeneity influences input use efficiency, the ability to control the fate of applied inputs, and economic return (e.g. Dinar et al., 1986).

Careful measurement of yield, and budgets for water, nitrogen, and production costs will allow comparisons of common performance parameters among cropping systems. Common parameters also provide a yardstick that will allow assessment of system performance in relation to the fundamental changes that occur in the agroecosystem due to crop rotation, level of input use, and associated field operations. A better understanding of cause and effects at a mechanistic level, and the impact of these effects on field-level performance is a requisite for developing improved cropping systems that are sustainable over the long-term.

The scale of this experiment, both in terms of size and life expectancy, raise special concerns that are not often associated with shorter duration field projects of smaller scale. Allocation of land and additional support from the Dean's Office (see Budget and Appendix D and E), and the $150,000 from UCSAREP will permit the establishment of the experiment and core measurements as described in the Procedures section. Component studies on Objectives 3 and 4, however, will require additional funding. We are optimistic that the existence of a well-structured, long-term experiment will provide a comparative advantage to researchers who seek funds for these studies. It is likely that funding levels in general for long-term research will increase. But given the broad based support within the college for the establishment of the proposed long-term experiment, and for the initiation of subsequent long-term studies on other agricultural systems, we are convinced that it will be possible to sustain funding for this exciting and crucial research effort at California's largest institution of agricultural research and education.

Education and Outreach

These activities were discussed under Objective 5 of the Procedures section, and expected dates for initial events are included in the Time Table.

Literature Cited

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Yates, F. 1954. The analysis of experiments containing different crop rotations. *Biometrics.* 10:324-346.

BUDGET (x 1000)

	1990-91			1991-92			1992-93		
	Requested Funds UCSAREP	Matching Funds		Requested Funds UCSAREP	Matching Funds		Requested Funds UCSAREP	Matching Funds	
		Amount	Source		Amount	Source		Amount	Source
Personnel:									
Coordinator (50%)		24.3	UCD		25.8	UCD		27.3	UCD
Benefits		5.6	UCD		5.9	UCD		6.3	UCD
Senior Supervisor of Agriculture (100%)[1]	18.6			19.7	19.7	UCD		41.7	UCD
Benefits	5.4			5.7	5.7	UCD		12.1	UCD
SRA II (100%)		33.8	UCD		35.8	UCD		38.0	UCD
Benefits		9.8	UCD		10.4	UCD		11.0	UCD
Lab Assistant I		17.3	UCD		18.4	UCD		19.5	UCD
Benefits		5.0	UCD		5.3	UCD		5.6	UCD
Land[2]		20.0	UCD		40.0	UCD		60.0	UCD
Supplies & Expenses:									
1st Order Soil Survey	15.0								
Irrigation Equipment	20.0				20.0	UCD			
Monitoring Wells	30.0								
Neutron Probes	8.0								
Weather Station	8.0								
Irrigation Water Measurement System	10.0								
Field Operating Expenses	9.0				12.0	UCD		13.0	UCD
	124.0	**115.8**		**25.4**	**199.0**			**234.5**	

[1]Begins July 1, 1990.
[2]Based on lease value for 100 acres, 1990-91; 200, 1991-92; 300, 1992-93.

Total Request: **$149,000**
Matching Funds: 1990-93 **$549,300**

Appendix A. The proposed experiment on field crops

Experimental Design: Confounded Split-Plot Design, arranged in replicate blocks

Mainplot treatments - water input level

Subplot treatments - N level/source, crop rotation, and rotation starting point

There will be a total of six replications of each water input level x N level/source-rotation treatment, three each as opposite starting points in the two-year rotation pattern that is common to all treatments. There will be three blocks, however, and thus each mainplot will contain six subplots, (i.e. 3 two-year rotation treatments x two rotation starting points). These subplots will be randomized within mainplots. If starting point (i.e. year) effects diminish over time relative to water input level and/or N level/source-rotation effects, it would then be possible to establish another three treatments at the subplot level.

Treatments:

Mainplots	**Subplots**	
1) rainfed	-- alternate yr wheat-fallow no N fertilizer	(**1A**) first yr wheat (**1B**) first yr fallow
	-- alternate yr wheat-fallow **sufficient N fertilizer**+	(**2A**) first yr wheat (**2B**) first yr fallow
	-- alternate yr wheat-**winter leg. cc**+, no N fertilizer	(**3A**) first yr wheat (**3B**) first yr winter leg. cc
2) **supplemental irrigation**+	-- alternate yr wheat-fallow no N fertilizer	(**4A**) first yr wheat (**4B**) first yr fallow
	-- alternate yr wheat-fallow sufficient N fertilizer	(**5A**) first yr wheat (**5B**) first yr fallow
	-- alternate yr. wheat-winter leg. cc, no N fertilizer	(**6A**) first yr wheat (**6B**) first yr winter leg. cc
3) **fully irrigated**+	-- alternate yr wheat-tomato sufficient N fertilizer	(**7A**) first yr wheat (**7B**) first yr tomato
	-- alternate yr. corn-tomato sufficient N fertilizer	(**8A**) first yr corn (**8B**) first yr tomato
	-- alternate yr corn-tomato no N fertilizer on corn but a winter leg. cc before corn (i.e. after tomato) and sufficientN fertilizer on tomato	(**9A**) first yr (wlcc) corn (**9B**) first yr tomato

Definitions

+**Sufficient N fertilizer**: Fertilizer nitrogen will be applied at a total season rate, form, and timing to achieve approximately 95% of the average maximum yield without nitrogen limitation for each crop species in the specified rotation-water input level treatment. Nitrogen rate will therefore be constant for each crop in each rotation-water input level treatment for the first years of the experiment, or until more precise N fertilization guidelines are developed. Rough estimates of the required N rates are shown in Table 1.

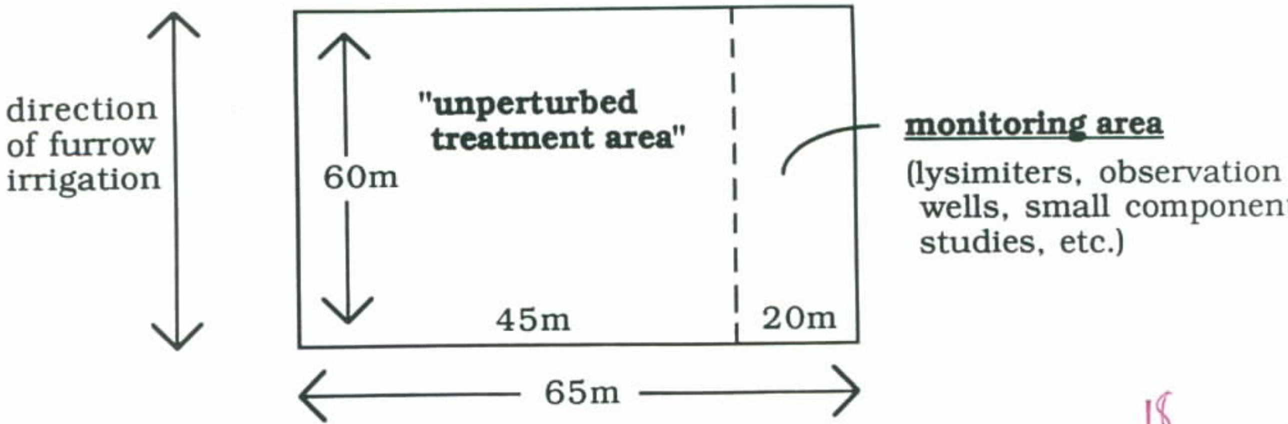
+**Winter legume covercrop**: This will likely be woolypod vetch (*Vicia dasycarpa*) since it performs well in both irrigated and rainfed conditions. It will be planted before the winter rains in the rainfed mainplot treatment (approx. first week in November), and in late September in the supplemental and fully irrigated mainplot treatments, with irrigation as needed to establish the stand and to prevent water stress during prolonged rainless periods.

+**Supplemental irrigation**: Irrigation applied only to supplement rainfall to these winter season crops such that yield is not limited by water stress. Expected quantities of applied irrigation water are shown in Table 1.

+**Fully irrigated** refers to the high water requirements of the summer-grown crops in the rotation, although care will be taken to optimize water use efficiency via irrigation timing and quantity without yield loss from water stress. Supplemental irrigation will be applied to the winter season crop species in the rotations as above.

Appendix B. Plot Size and Spatial Arrangement of Treatments

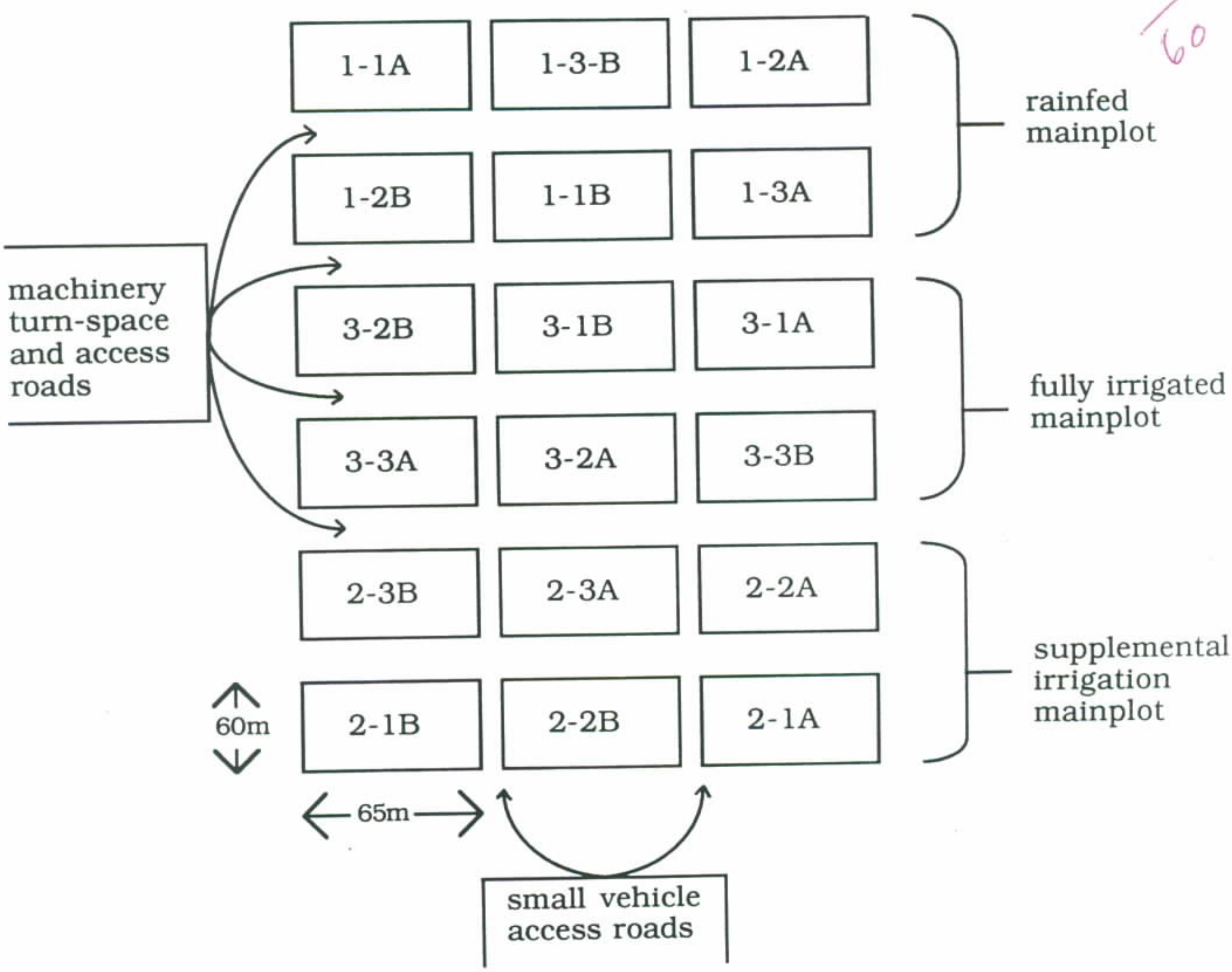
Individual treatment plot - 65m x 60m (213ft x 197ft = 0.96ac)



18
3
54
6
60
20
3

A complete block (one of three)

treatment numbers refer to designations in Appendix A.



Appendix C. Expected mean primary productivity and initial rough estimates of input requirements for treatments that differ in crop rotation patterns and the degree of reliance on renewable resources (i.e. rainfall and nitrogen derived from fixation of atmospheric N_2 by a winter legume) or resources of external origin (irrigation water and fertilizer-N).

Treatment			**Expected Primary Productivity (dry matter basis)**			**Expected Input Levels (first approximation)**			
						-------water-------		----------nitrogen--------	
water input level	2-year rotation	exogenous nitrogen source	harvested yield	recycled crop residue	recycled carbon	rain	irrigation++	fertilizer	N_2 fixation++
			---------------kg ha^{-1}---------------			-------m (depth)-------		---------kg ha^{-1}--------	
rainfed	wheat-	none	2500	3750	1650	0.43	-	-	-
	fallow		-	-	-	0.43	-	-	-
	2-year total		**2500**	**3750**	**1650**	**0.86**	-	-	-
rainfed	wheat-	fertilizer	3300	4950	2180	0.43	-	35	-
	fallow		-	-	-	0.43	-	-	-
	2-year total		**3300**	**4950**	**2180**	**0.86**	-	**35**	-
rainfed	wheat-	legume	3300	4950	2180	0.43	-	-	-
	wlcc+		-	2500	1050	0.43	-	-	35
	2-year total		**3300**	**7450**	**3130**	**0.86**	-	-	**35**
suppl. irrigation	wheat-	none	3000	4500	1980	0.43	0.40	-	-
	fallow		-	-	-	0.43	-	-	-
	2-year total		**3000**	**4500**	**1980**	**0.86**	**0.40**	-	-
suppl. irrigation	wheat-	fertilizer	6400	9600	4220	0.43	0.40	120	-
	fallow		-	-	-	0.43	-	-	-
	2-year total		**6400**	**9600**	**4220**	**0.86**	**0.40**	-	-
suppl. irrigation	wheat-	legume	6400	9600	4220	0.43	0.40	-	-
	wlcc		-	8000	3360	0.43	0.30	-	120
	2-year total		**6400**	**17600**	**7580**	**0.86**	**0.70**	-	**120**
fully irrigated	wheat-	fertilizer	6400	9600	4220	0.43	0.40	120	-
	tomato		4000	5000	2150	0.43	0.90	120	-
	2-year total		**10000**	**14600**	**6370**	**0.86**	**1.30**	**240**	-
fully irrigated	corn-	fertilizer	12000	15000	6600	0.43	1.00	220	-
	tomato		4000	5000	2150	0.43	0.90	120	-
	2-year total		**16000**	**20000**	**8750**	**0.86**	**1.90**	**340**	-
fully irrigated	corn-	legume	11000	13500	5940	0.43	1.00	-	-
	tomato-	fertilizer	4000	5000	2150	-	0.90	120	-
	wlcc		-	8500	3570	0.43	0.50	-	180
	2-year total		**15000**	**27000**	**11660**	**0.86**	**2.40**	**120**	**180**

+wlcc represents a winter legume covercrop, such as wollypod vetch, that is grown in the cool season from late September or October through late March or early April.

++Actual quantities of irrigation and N_2 fixation will vary somewhat from these expected average values depending on climatic variation.

DAVIS: COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION
OFFICE OF THE DEAN AND DIRECTOR OF PROGRAMS

November 13, 1989

KEN CASSMAN
TAG DEMMENT

RE: College Support for Long Term Research on Agricultural Systems (LTRAS)

The College enthusiastically supports your proposal to establish an LTRAS program, including long-term plot work at Davis, which may be funded in part by the UC Sustainable Agriculture Research and Education Program.

The College contribution to this program, first specified in my September 29, 1989 memo to Dr. Demment, includes:

* Release time (50%) for a Faculty Coordinator of the LTRAS.
* Funding (full-time) for a Staff Research Associate II to establish and prepare the field plot site.

These are in addition to the provisions made to the College's Sustainable Agriculture Program (SAP) office which include such items as funding for a seminar series which may benefit LTRAS personnel. Our establishment of the College SAP in 1988 reaffirms our commitment to sustainable agriculture research, and our willingness to redirect some resources to this new area in an era of steady-state funding.

I would also point out that the College's new strategic plan (Project 2000) includes focus on integrated management of the agroecosystem to sustain economic viability as one of three priority objectives in our food and fiber research mission.

Finally, this College recently made a successful bid for an Ecotoxicology program which includes a study of long-term transport and fate of agricultural chemicals in the agroecosystem. I feel certain that some of the faculty in the new Ecotoxicology program will conduct research at the LTRAS plots, joining the mainstream sustainable agriculture faculty in plant and animal science departments at UCD.

Please keep me apprised of your progress in establishing the LTRAS facility.

R.K. Webster

Robert K. Webster
Acting Dean

RKW/JNS:cp

cc: L. Vanderhoef
D. Nielsen
J. Seiber

APPENDIX D

14 November 1989

M. W. Demment
K. G. Cassman

Gentlemen:

I was pleased to hear of your plans to establish a campus-based program dealing with the subject: Long Term Research on Agricultural Systems (LTRAS), as part of the UCD Sustainable Agriculture Program.

I will commit the assignment of farmland owned by the University to the LTRAS program sufficient to conduct the proposed research. As the program matures, the land allocation will increase as needed to accommodate new research to a maximum of 300 acres. An example of appropriate acreage, which you are now exploring, is the Nelson Farm east of Woodland. Your plan to work in active partnership with the commercial firm now farming the land on lease from UC is quite acceptable.

If the Nelson Farm does not fulfill your needs, I will locate the acreage from other land assigned to this campus. I will work with Acting Dean Robert Webster and with you to see that your land needs for this new program are satisfied.

Sincerely,

Larry N. Vanderhoef

Larry N. Vanderhoef
Executive Vice Chancellor and
Acting Vice Chancellor for Research

:jms

cc: Chancellor Hullar
Vice Chancellor Sullivan
Acting Dean Webster

APPENDIX E