EXAMPLE INTEGRATED PROPOSAL

Ecological Soil Community Management for Enhanced Nutrient Cycling in Organic Sweet Cherry Orchards

Submitted to the Integrated Organic Program

This example integrated proposal can be used as a model for applicants submitting to the Integrated, Research, Education, and Extension Competitive Grants Program (Section 406) or those programs soliciting integrated projects in the National Research Initiative (NRI) Competitive Grants Program.

***Note: For proposals submitted to the NRI, please designate if project is integrated in the first sentence of the Project Summary.**

EXAMPLE INTEGRATED PROPOSAL

UNITED STATES DEPARTMENT OF AGRICULTURE
COOPERATIVE STATE RESEARCH, EDUCATION, AND EXTENSION SERVICE

OMB Approved 0524-0039

Project Director(s) (PD):

[redacted]

Project Title:
Ecological Soil Community Management for Enhanced Nutrient Cycling in Organic Sweet Cherry Orchards

Key Words: nematodes, soil microbe function, orchard fertility, *Prunus avium*, microbial dynamics, nitrogen

PROPOSAL TYPE

For National Research Initiative Competitive Grants Program Proposals Only

[X] Standard Research Proposal
[ ] Conference
[ ] AREA Award
[ ] Postdoctoral
[ ] New Investigator
Strengthening:
[ ] Career Enhancement
[ ] Equipment
[ ] Seed Grant
[ ] Standard Strengthening

For Higher Education Program Proposals Only:

Need Area: ____________

Discipline: ____________

The goal of the following proposal is to identify those ecological soil community management strategies which synchronize soil nutrient availability with tree demand in order to improve long-term farm health, fruit quality, and production by using existing resources in an economic and environmentally beneficent way. Thus it responds directly to the research needs identified by growers, researchers, and extension personnel, as well as directly addresses the first OREI and the second ORG program goals.

A two-tiered approach is used as expressed by these objectives:

a) a comparison of the biological and economic effects of two different methods of organic fertility management during orchard establishment and early production;

b) an investigation of mature orchards to evaluate the use of soil community structure as a indicator of the effects of significantly different management practices on orchard health, fruit quality, and productivity.

Findings from this research are to be distributed via several mechanisms: through grower associations, extension service, web pages, field days, farm tours, a workshop, and publications in relevant newsletters, magazines, and journals. A third objective is to use a survey to assess the effectiveness of the different dissemination methods employed and the impact of the research on fertility management practices in orchards of [redacted] By responding to research needs as identified by the tree fruit community and by directly involving growers, university researchers, and extension agents in the research and distribution of its findings, this proposal integrates research, education, and extension.

4. Response to previous review- none

5. Project Description

a. Introduction

Goal

The long-term goal of this research effort is to identify those ecological soil community management strategies which synchronize soil nutrient availability with tree demand in order to improve long-term farm health, fruit quality, and production by using existing resources in an economic and environmentally beneficent way.

Relevant Body of Knowledge

Over application of nitrogen (N) in orchard systems has been a common practice (Sanchez et al. 1995, Weinbaum et al. 1992). Nutritional demands of trees are more complex than previously assumed and change as trees mature. For example, young trees require only 5-10kg/ha of nitrogen (N) while mature trees require a minimum of 45-50 kg/ha (unpublished data). In order to achieve fruit quality and production goals, tree vigor must be managed within the goals for different stages of tree development. In young trees, growth to develop good tree structure must be promoted but excessive vigor must be avoided to prevent delaying future production, loss of winter hardiness, and increased disease susceptibility. As orchards begin to bear fruit, vigor and yield must be balanced and nutrient availability timed to promote fruit set and development. Mature trees must be rejuvenated by replacing branches with new growth.

Therefore, nutrient supply must be synchronized with tree demand to avoid under/oversupply while meeting tree needs. Management of timing of N availability to the roots is critical to insure that the above mentioned goals will be met. Typically, N applications have been made in winter, but practices are changing to making applications in the late winter or early spring. However, a misconception still exists that this application will reach floral buds and assist in early vegetative growth in the spring. Cherry trees, being harvested in June/July have different fertilization needs than fall-producing fruit trees such as apples and pears. Only N that is mobilized from senescing leaves in the fall and stored in perennial tissues over the winter is available in the subsequent spring for budbreak, flower development and fruitlet growth (Sanchez et al. 1995). N applied postharvest is partitioned to the roots and only available in spring after budbreak in the next growing season.

Organic growers, even though they do not use mineralized fertilizers, are struggling with these situations, too. While the aim of organic orchard management is to satisfy tree nutrient demands ecologically, little information is available in this area, leaving many organic orchardists no other avenue but to simply substitute synthetic inputs (especially fertilizers) with rapid-release forms of approved, pelletized fertilizers made of various fish and poultry byproducts.

An alternative approach to fertility management relies on soil communities to meet tree nutrient demand. Soil microbial biomass, for example, plays a central role in the efficient recycling of nutrients from organic litter and converts nutrients from organic to plant available, mineralized forms (Coleman and Crossley 1996). More than 90% of all nutrients pass through the microbial biomass to higher trophic levels (Kennedy 1995). Moreover, the composition, activity, and biomass of the soil communities is significantly influenced by management practices (Forge et al. 2003, Neher 1999). For example, bacteria rapidly decompose leafy organic amendments, while woody, high C:N ratio material is decomposed primarily by fungi (Killham 1994). Changes in soil biodiversity have also been associated with N mineralization and availability (Setala 2002, De Ruiter et al. 1993). Soil community enrichment has been correlated with leaf phosphorous content (Forge et al. 2003). Different application techniques of organic amendments also influence the microbial composition (Neher 1995). Leaving plant residue on the surface selects for fungi while incorporating prunings and crop residue into the soil of the alleys will shift the balance towards bacteria (Hendrix et al. 1986, Holland and Coleman 1987). Additionally, Ferris et al. (2004) showed that orchard floor management is significantly influenced by soil moisture content which in turn affects soil community structure and decomposition pathways. Alternative orchard floor management practices also influence N leaching rates. Research on use of sods as nitrogen catch crops in peacan orchards showed a reduction in nitrate losses in orchards planted with sod (Weidenfeld et al. 1999). This was confirmed by Merwin et al (1996) who found that nitrate losses in apple orchards were minimized when trees were mulched or a sod was maintained.

Soil has a high diversity of microorganisms (estimated around 1 x 10^4/g soil) (Dobrovol'skaya et al 2001), but only a small part of these microorganisms (estimated around 1%) can be studied with classic culture-dependent techniques. Recent development and refinement of techniques in molecular biology allow a new approach to the study of the ecology of soil microbial communities and their response to disturbances. These new techniques look at total DNA or RNA extracted from a soil sample, amplifying functional genes or sequences of interest via the polymerase chain reaction, then sequencing it and comparing it to sequences of known organisms or generating community "fingerprints" representing the overall diversity of organisms (Calvo and Garcia-Gil 2004, Yuan et al. 2005, Hartmann et al. 2005).

Inherent in this new approach is an assumption of functional redundancy among soil organisms, though the extent of this overlap is not known. Some argue that microbial diversity is crucial to determining ecosystem level function, such as cycling of nutrients (Fitter 2005). Others contend that shifts in microbial community organization are irrelevant to overall ecosystem processes, because functions such as nutrient cycling are performed by a large variety of organisms (Nannipieri et al. 2003). Recent studies indicated that soils with higher diversity are more stable and show greater resistance to and faster recovery from disturbance, but not in all cases (Nannipieri et al. 2003).

However, only few studies have examined the relationship between orchard management practices and soil microbial communities (Oved et al. 2001, Goh et al. 2001, Rutto 2002). In an attempt to characterize soil communities and their response to management practices, and ultimately, their effects on tree health, recent studies have focused on the faunal component of soil communities and their relationship to N-mineralization rates (Postma-Blaauw et al. 2005, Ferris et al. 2001, Bongers and Ferris 1999).

Nematodes are excellent candidates as indicators for soil communities for the following reasons. Nematode feeding affects growth and metabolic activities of microbes and alters the microbial community. By changing the microbial community, nematode regulate decomposition and nutrient mineralization rates (Postma-Blaauw et al. 2005, Sohlenius et al. 1988). Due to their longer life cycle and higher trophic position in the food chain (relative to soil microbes), nematodes serves as integrators of physical, chemical, and biological characteristics (Neher 2001). Further, they are abundant in soil and the composition of their populations reflects substrate quality, organic inputs, and both natural an cultural disturbances (Yeats 2003, Ferris and Matute 2003) Thus, nematode diversity can be used as an indicator of soil community structure (Ferris et al. 1999) by calculating indices of enrichment and structure. The enrichment index (EI) is a measure of the relative abundance of enrichment opportunists and reflects the turnover of microbial biomass and nutrients. The structural index (SI) is a measure of the complexity of the nematode community. It is an indicator of functional diversity and stability of soil processes. By graphing the EI vs. SI, a graphic representation of the condition of the soil food web is obtained. The channel index (CI) indicates the turn over rate from the faster bacterial to the slower fungal pathways (Ferris and Matute 2003). Such a faunal profile can be used to describe the soil community and its ability to cycle nutrients (Ferris et al. 2001) and, when correlated with data about management practices, tree performance, and fruit quality, will provide the necessary information for the ecological management of tree nutrient demand.

By combining the information gained from faunal indices and with data obtained by molecular analysis, a new, more in-depth view of soil communities and their response to management practices can be obtained. Additionally, important information of the usefulness of either approach to the researcher/orchardist can be obtained.

Recently Completed Significant Activities

Research of key personnel currently in progress or recently completed focused on N uptake and partitioning in orchard systems, and the effects of alternative orchard floor management systems for improving soil quality and optimizing N uptake efficiency [redacted], N-cycling among microbes in natural systems [redacted], the population dynamics of nematodes in crop systems [redacted], the costs and returns of organic vs. conventional pear production, and the cost of alternative water management in sweet cherries [redacted].

Fertilizer-N uptake and its effect by alternative orchard floor management practices were studied in two experimental apple orchards. Percent N derived from fertilizer (NDFF) was significantly lower in the whole tree, leaves, new wood, old wood, spurs and roots of trees from compost than from unamended plots ($p<0.05$). NDFF also tended to be lower in trees from bark mulch treated plots than control plots, although differences were not always significant. The vetch/barley amendment resulted in NDFF similar to non-amended plots. There were no significant differences between the total N of trees from non-amended and compost plots. Trees from compost-treated plots appear to be acquiring N from sources other than fertilizer.

To study N partitioning in cherry trees, ammonium sulfate, labeled with the stable ^{15}N isotope, was applied to the soil at four timings; rapid shoot growth/spring (10 May), pre-harvest (15 June), post-harvest (3 Aug); and pre-leaf fall (3 Oct). Four trees were excavated at the end of the growing season, prior to leaf fall, and another set of four after a second growing season. Trees were excavated and partitioned into fruit, current season's growth, numerous wood components, spurs, roots, and leaves and analyzed for total N and ^{15}N content. In October, whole tree total N was 2.4, 2.4, 1.9 and 2.0 kg per tree for spring, pre-harvest, post-harvest and pre-leaf fall applications, respectively.

The respective amounts of fertilizer N was 0.30, 0.16, 0.09, and 0.06 kg/tree. N derived from the fertilizer (NDFF) was 13%, 7%, 5%, and 3% and uptake efficiency also declined 21%, 11%, 6%, and 4% for the different timings. After the second growing season, NDFF and uptake efficiency were not different between the timings and had a mean of 14% and 26%, respectively.

Research on N cycling involved two experiments. The first study investigated N cycling microorganisms along natural transitions in vegetation using a transect analysis. Objectives were to: (i) Determine links between vegetation type and microbial communities and processes, (ii) examine the spatial variability along meadow-to-forest transects, (iii) correlate microbial community structure and ecosystem functioning, and (iv) identify key and potentially novel nitrifying and denitrifying bacteria. At the same location, a reciprocal soil core transplant study was set up with the objectives to: (i) test the extent to which microbial parameters respond to rapid changes in vegetation and (ii) determine how quickly these responses occur. These experiments determined that nitrification and denitrification varied in soils developed under different vegetation and that this corresponded to different communities of ammonia-oxidizing and denitrifying bacteria (Mintie et al., 2003; Rich et al., 2003). These trends were also observed in the reciprocal transfer study, and after two years there was evidence that some N cycling processes were responding to the transfers and that generally this response occurred more quickly than changes in the composition of ammonia-oxidizer and denitrifier communities (Bottomley et al., 2004; Boyle et al., in revision).

Currently, three different investigations on the population biology and management of nematodes in potato cropping systems are underway: a study of population dynamics of Columbia root-knot nematode (CRKN) of potato in three different climatic regions in an attempt to develop a generally applicable model based on soil degree-days to predict population behavior for strategic timing of non-fumigant nematicide applications; an attempt to design a cropping system that utilize high acreage demand host crops with less demand alternative non-host crops and green manure cover crops to reduce populations of CRKN with reduced use of nematicides; and an investigation of the use of compost tea, mycorrhizae, and liquid fish fertilizer in organic potato production.

An analysis of the costs and returns of organic v. conventional d'Anjou pear production in the Hood River Valley in 1992, and a ten-year comparison of organic and conventional d'Anjou pear production in the Hood River Valley of Oregon (1992 to 2001) showed that the gross and net returns for organic d'Anjou pear production were much higher in the early 1990's with higher premiums for organically grown fruit. In recent year's those premiums have been reduced to the point that total production expenses exceed gross revenues. The cost to grow pears increased by 24% for the organic growers and only 9% for conventional growers. This can be explained by higher cost spray programs, increased fuel costs, and machine usage. In the long-run, price premiums for organically grown fruit must increase to help offset the increased costs of production per unit or there will be no economic advantages to organic pear production. Alternatively, costs of production must be reduced or efficiencies increased to remain competitive.

The up-front costs to establish conventional sweet cherries with fabric row cover to reduce herbicide costs and conserve soil moisture were $2,300 per acre higher than standard industry practices. The first commercial cherry harvest began in Year 3 of the experiment with the fabric cover producing larger cherries and higher yields than standard practices. The total revenues for Year 3 exceeded the annual costs for the fabric covered trees and began paying back the previous year's establishment costs. The revenues for cherry trees farmed with standard practices did not exceed annual costs in Year three.

Estimates of Economic Magnitude and Relevance to Stakeholders

Economic returns for sweet cherries are high, making sweet cherry production one of the more lucrative fruit tree products. Consequently, acreage in production, total yields, and farm cash receipts increased over the last 20 years and continue to do so. For example, in 1980 sweet cherries were valued at $135 million in U.S. farm cash receipts. This increased to $327 million in 2000. Sweet cherries were the 8th most valuable fruit and nut tree crop that year. Additionally, the U.S. is the world's second largest sweet cherry producer in terms of yield (230,380 tons) (NASS 2003).

Sweet cherry production is concentrated in the Pacific Northwest states of Washington, Oregon, and Californian which grow 85% of the total U.S. production. The lead producer is the state of Washington with 40-45% of the total US yield (Hinman and Watson 2003, Smith and Kupferman 2003), followed by Oregon with 22.4% of the national market (Anonymous 1999). In 2001, sweet cherries were the 9th most lucrative of the Washington agricultural commodities, with a gross value estimate of $130 to $180 million. Packed boxes and processed products produced sales of $215 million (Smith and Kupferman 2003).

Data for the state of Washington exemplify the rapid expansion for sweet cherry production in recent years. Rate of apple removal and replant with cherries increased during the 90's. As of 2002, new cherry orchards were being added in Washington at a rate of 1,000 to 2,000 acres per year (Smith and Kupferman 2003). Bearing acreage increased from 14,000 acres in 1992 to 22,000 acres in 2001 (Hinman and Watson 2004). Production, in turn, is expected to increase from an average of 78,000 tons per year (1996 to 2000) toward a predicted yield of 140,000 tons before 2008 (Smith and Kupferman 2003). The value to the grower is between $4,000 to $14,000 per acre with costs per acre ranging from $6,800-$8,300. Fruit quality, especially size, is the major determinant of price; large fruit bringing up to $.50 more per pound than small fruit (Hinman and Watson 2003, Smith and Kupferman 2003).

Following the same trend, organic sweet cherry orchard acreage in Washington state increased from 185 in 1998 to 513 in 2003 (Granatstein and Kirby 2002). However, there are considerable barriers to growers transitioning to organic practices. They are faced with higher labor, managerial, and certification costs; loss of production during the period of transition; risk of adopting unfamiliar management practices; and a lack of information specific to the organic system, and especially organic sweet cherries production practices. Unfortunately, apple and pear growers are not able to recoup these added expenses as they receive little or no premium for their organic product (ERS 2002, Hinman and Watson 2003). Organic sweet cherries still command a premium.

This makes research into management practices which provide specific information on the effects of organic fertility practices and their influence on fruit quality and overall farm health an important priority for the organic grower (please refer to stakeholder involvement). Research results are anticipated to provide necessary information about two important areas influencing profitability: reduced production costs due to the maintenance of optimal fertility and increasing product value by insuring optimal fruit quality.

Role of Stakeholders in Problem Identification and Implementation of Results

An important means of problem identification is through an analysis of grower contacts fielded by the [redacted] Extension Service over the last three years. A review of such contacts showed that 20-50 were regarding soil quality management. Soil quality and fertility management were also a concern of many of the growers who asked questions during extension service workshops and field days. These events are usually well attended (approximately 50 persons per event). Furthermore, a presentation at the Pacific Northwest Fruit School Short Course in 2003 about the timing of N applications had over 200 participants.

Input was also obtained via grower meetings and conferences. The project PD attends a monthly meeting of Oregon Tilth producers. Participants agreed that more research was needed on practices to enhance the ecological biodiversity of orchard systems. An informal focus group, which convened in 2003 during the 2nd National Organic Tree Fruit conference to discuss current sweet cherry management practices and knowledge gaps in these practices, came to a similar conclusion. It was agreed that further research on the relationship between soil biological health, nutrition, and orchard floor management was one of the top priorities.

The project is advised by the Soil Health In Fruit Trees Systems (SHIFTS) group which contains numerous stakeholders, research and extension personnel, and other practitioners. The panel is charged with the following tasks: advise on tree row and alleyway management and plant selection; design learning activities; provide mechanism for information dissemination; assist in estimating costs of production for commercial, alternatively-managed, and organic orchards using unconventional orchard floor management strategies; alternative pest management strategies.

Stakeholders will participate in the distribution of research results. The [redacted] Extension Service's workshops, field days, and web pages from different organizations will be used as means to disseminate information. Grower associations offer another venue to reach growers directly, through their newsletters and presentations at the meetings of these associations. The national research and extension community will be reached through publications in relevant magazines and refereed journals as well as through websites. Further, it is planned to measure the impact of this research through a survey instrument to document the range of adoption of new soil and fertility practices and their influences on overall orchard health and also evaluate effectiveness of different dissemination venues.

b. Objectives

Since nutrient cycling and availability are controlled by soil communities, and since tree performance is dependent on proper nutrition, we hypothesize that soil community structure can be used as an indicator of soil health and to select those management practices which foster high production of quality fruit through the maintenance of soil and tree health. Specifically, we aim to identify those soil community management strategies which synchronize soil nutrient availability with tree demand. Thus our research is guided by following objectives:

1. Compare the effects of two different methods of organic soil and fertility management on soil community structure, nutrient availability, productivity, tree health, and profitability during orchard establishment;
2. Determine if soil community structure can be used as an indicator of the effects of widely different management practices on soil health and orchard productivity in mature orchards.
3. Assess effectiveness of dissemination methods and impact of changes in management practices resulting from research findings.

c. Methods

Study Design

Due to the different nutrient needs of young vs. mature trees and due to the current expansion of acreage in production, growers need information regarding orchard fertility and health in two areas: establishment of new orchards and management of existing orchards. These information needs are reflected in a two-tiered study design. The first part is an analysis of the effects of two organic treatments on trees, soils, and profitability during orchard establishment (objective 1), the second part focuses on mature orchards and tests the hypothesis that soil community structure can be used as an indicator of the effects of three different management systems (conventional, alternative, and organic) on trees, soils, and profitability (objective 2). It is anticipated that research results will not only enable growers to better understand nutrient cycling in cherry orchards, but also provide practical guidance on how to change current management practices. To measure the impact of this research on the cherry growing industry, a survey will be conducted after completion of the research (objective 3). This survey will also be used to evaluate the effectiveness of the dissemination venues of different research results employed during the life of the project.

Under Objective 1

1. Rationale, Techniques, Methods, and Feasibility

RATIONALE

Two different organic fertility management practices have been selected for comparison. The first treatment, Input Substitution (IS), is commonly used, especially during transition from conventional to organic management. IS utilizes non-chemical and approved chemical means of weed control, and pest and pathogen-management measures. Commercially available, organic, pelletized, rapid-release N fertilizers are often used which, however, have little effect on long-term soil health and fertility. The second treatment, Sustainable Fertility Management (SFM), is an alternative approach. It is based on an ecological understanding of the whole orchard system with the aim to foster long-term soil fertility by utilizing soil biological cycles to manage nutrient availability and health, and by optimizing on-farm resources.

For each treatment, an array of tree data will be collected which will provide details on tree growth and health (disease incidence, mortality, vigor, etc.), floral precocity, and in the third year, yield and fruit quality. This information will be correlated to data obtained for leaf-N, soil-N, resident concentration of nitrate, and soil moisture to describe an overall orchard situation.

To further understand the interrelationship of the above with the below ground orchard system in each treatment, different data of the soil community will also be collected. Three aspects of soil community structure, namely, faunal composition, functional specificity of soil microbes, and microbial activity will be studied to gain an in-depth, differentiated understanding of the effects of management practices on soil communities. Faunal composition has been used to obtain an integrated view on soil communities and their ability to cycle nutrients (refer to the introduction for details). However, such an analysis does not provide any information on the amount and importance of functional specificity of the microbial community. In order to assess how well faunal profiles work as a tool for management, additional data will be collected on the microbial community itself. Three functional subgroups of the soil community will be investigated: a) ammonia-oxidizing bacteria (AOB) which control the rate-limiting step in the process of N cycling; b) denitrifiers which are responsible for N loss of plant-available N; and c) arbuscular mycorrhizae (AM) which scavenge nitrogen for their symbiotic tree hosts. New molecular methods allow us to gain information on these groups. Real-time-RFLP, a combination of real-time PCR and t-RFLP, will quantify these subgroups as well as give a "fingerprint," that is information on the total richness and relative abundance of the groups members (Yu et al. 2005).This is especially important for AOB and AM fungi, since they are monophyletic and have been, in general, particularly difficult to detect by culture-dependent methods (Calvo and Garcia-Gil 2004), but are well suited to molecular analysis (Purkhold et al. 2000). Quantification of the total fungal and total bacterial populations will also be obtained using real-time-PCR. In addition, information on the catabolic diversity of heterotrophic bacteria will be generated by using the BIOLOG method. While BIOLOG has all the biases inherent to any culture-dependent technique, it has been selected because it is relatively fast and inexpensive and can yield information of the functional diversity of the soil heterotrophic bacteria (Li et al. 2004).Lastly, microbial activity will be measured to gain important information on the soil communities' ability to digest C sources.

Economic data will be collected to compare the impact of each type of treatment on profitability.

TECHNIQUES/METHODS

Research Design- This research will be conducted on two certified organic, experimental orchards planted in the spring of 2005. [redacted] These orchards are under two models of organic fertility management: Input Substitution (IS) and Sustainable Fertility Management (SFM). Each treatment will be replicated four times at each site in a completely randomized design for a total of eight plots. Each plot contains 32 'Regina' sweet cherry trees on Gisela 6 rootstock planted at a 3.0m x 5.5m spacing. 'Sandra Rose', 'Skeena', and 'Sylvia' trees are planted as pollinizer cultivars.

Fertility Management- Fertility will be managed in response to soil conditions and tree demand (Table 1). No fertilizer application is planned for the first year in the IS treatment and alleyway vegetation will not be blown into tree rows under the SFM treatment, as it is anticipated from existing soil data that sufficient nutrients are available for tree growth. Soil data from the first year (please refer for details below under Soil Sampling) will be used to determine management practices for the second year, and data from the second year will be used to decide on options for the third year.

The IS treatment will use registered materials such as pelletized fertilizers. These are sources of quickly available N that do not add significant organic matter to the soil. For weed control, a geotextile landscape cloth will be installed after planting in spring of 2005.

The SFM treatment will use green manures, which will be mown and (if indicated by soil data) blown into the tree rows, compost, and/or organic mulches. The rapid decomposition of labile C and N in the green manure will provide N to the trees in the spring. Other tree row amendments will build soil organic matter and provide a source of slowly available nutrients and an energy source for soil microbes. The type of green manure/cover crop will vary based on changing N demands (as established from previous research) as the trees mature and resident nutrient availability. When the trees are young, grasses will be the primary alleyway crop planted. As trees age and their nutrient requirements increase, N-fixing cover crops will be planted and compost added to meet the tree's demands. The Soil Health In Fruit Trees Systems (SHIFTS) advisory group will provide guidance on the management of the orchard floor with respect to the choice of types of green manures, and organic amendments to be used.

To control weeds and to immobilize N in the very fertile orchard soils, a 10cm thick layer of a high C compost and/or composted bark mulch will be applied to plots after planting.

Data Collection

A) <u>Tree Data: Disease Incidence, Growth, Precocity, Yield, Fruit Quality and Leaf N</u>

Data will be collected from the interior six trees of each plot. Visual disease assessments, focusing on bacterial canker and powdery mildew, will be performed annually in mid-summer. Beginning in 2005, at the end of each season, trunk circumference will be measured at 30 cm above soil line to provide a measure of tree growth. Starting in the 3rd year, yield and fruit quality (size, color, firmness, stem pull force, °brix, and pH) of bearing trees will be determined (Pickworth et al). Information on leaf N will be available from a concurrent study funded by the Organic Farming Research Foundation (please refer to attached letter for details.) In brief, at 2 weeks past bloom or ~15 April, pre-harvest or ~15 June, mid-summer or 15 August and 15 October of each season, 20 leaves from current season's growth will be collected, dried, and weighed (Table 2). Dried leaves will be analyzed for NH_4^+-N, NO_3^--N, and total Kjeldahl N by the Central Analytical Laboratory [redacted]

B) <u>Soil Data</u>

Soil-N, resident NO_3^-, and Soil Moisture- Soil samples will be taken at 2 weeks past bloom or ~15 April, pre-harvest or ~15 June, mid-summer or 15 August and 15 October of each growing season beginning in 2005 (Table 2). Samples will be composites of eight cores (2.5 cm) and will be taken from the tree row (between the center six trees of each plot) and from the alley in each plot at a depth of 30 cm. Samples will be collected in plastic bags and stored in a cooler until transport to the laboratory. Composite samples will be passed through a coarse sieve, hand-mixed and sub-sampled. The number of soil cores per sample will be adjusted to provide sufficient soil for all the analysis if needed.

Soil sub-samples will be used to determine N mineralization by using aerobic incubation as described by Keeney and Bremner (1966). A 50 g portion of the composite sample for each plot will be used for soil N (NO3-, NH4+, and total Kjeldahl N), organic C, and organic matter analysis by the Central Analytical Laboratory. To calculate net ammonification, net nitrification, and net mineralization, initial $NH4^{+}$-N, $NO3^{-}$-N, and Nmin-N concentrations from non-incubated samples (day 0) will be subtracted from $NH4^{+}$-N, $NO3^{-}$-N, and Nmin-N concentrations after 7 days. This information on soil N will be available from a concurrent study funded by the Organic Farming Research Foundation (please refer to attached letter for details.) Mineral-N will be extracted using KCl and submitted to the Central Analytical Laboratory for mineral (NH_4^+-N and NO_3^--N) analysis.

Eight suction cup lysimeters at 90cm depth and two capacitance probes at 15, 30, and 60cm will be installed per plot as soon as funding becomes available following the protocols outlined by Brandi-Dohrn et al. (1996). After a two month establishment period, leachate will be collected on a monthly basis and submitted to the Central Analytical Laboratory for determination of resident nitrate concentrations. These data will be used to estimate potential nitrate losses on a per area basis. Capacitance probes will be used to assess soil moisture content.

Nematode Composition- Nematode analysis will be carried out in the Nematode Testing Laboratory [redacted]. Nematodes will be extracted from a 100g soil sub-sample by Cobb's sieving and decanting followed by sugar-flotation as described by Ingham (1994). The total number of nematodes in each sample will be counted under a stereomicroscope at 50X. The first 100 nematodes observed will be mounted on glass slides and classified to genus under a compound microscope at 400X. The density of each genus will be entered and nematode community indices calculated within spreadsheet templates distributed at the "Computation of Nematode Community Indices" workshop held at the Society of Nematologists Meeting in Estes Park, CO on August 2, 2004. Maturity indices, Channel Index (CI), Enrichment Index (EI), Structure Index (SI) and Shannon and Simpson Diversity Indices will be calculated for each sample.

Data will be summarized into abundance of bacterivore, fungivore, omnivore-predator, and plant-parasitic trophic groups according to Yeats et al. (1993). Genera will be assigned colonizer-persister values according to their life-history strategy (Bongers 1999). Enrichment index (EI), an indicator of resources available to the soil community and the response of primary decomposers to the resources, will be calculated from data on relative abundance of genera with differing c-p rankings in different trophic levels (Ferris et al. 2001). The same data can be used to calculate the structure index (SI), an indicator of complexity and number of trophic linkages within the soil community (Ferris et al. 2001). These two indices can be used to graphically represent the condition of the soil food web in a faunal profile (Ferris et al. 2001). In addition, a Channel Index (CI) based on weighted abundance of fungal feeders will be calculated as an indicator of the decomposition pathways active in the soil system. A high CI indicates activity of slow fungal decomposition pathways while low CI indicates more rapid bacterial decomposition pathways are dominant (Ferris et al. 2001).

Microbial Community Characteristics- A subsample from each soil sample will be analyzed. Real-time-RFLP, a combination of first performing real-time PCR and then T-RFLP, will allow quantification of each subgroup by using primers and probes specific to the functional gene of each of the subgroups.

Analysis of ammonia oxidizing bacteria (AOB) uses the ammonium monooxygenase (*amoA*) functional gene, which codes for the alpha subunit of ammonia monooxygenase, the enzyme that controls the rate limiting step of the ammonia oxidation (Yuan et al. 2005, Hartman et al. 2005). The protocol for real-time PCR as outlined by Okano et al. (2004) will be applied using the following primers and probes targeting the alfa-Proteobacter *amo*A sequence: the A189 forward primer labeled with 6-FAM fluorescent dye, the amoA-2R' reverse primer, and the A337 probe labeled with 6-carboxyfuorescein and 6- carboxytetramethyl rhodamine (Okano et al 2004) and then followed by implementing the methods of Mintie et al. (2003) for the subsequent T-RFLP. As in the Mintie et al. study, two sets of T-RFLP profiles will be generated using three different restriction enzymes to minimize coincidental matches in the size of fragments from unrelated organisms. The same protocols will be followed for the other two groups, however, different primers will be used in response to the characteristics of each group. Effective probes have not yet been designed for these due to the high polymorphism between different taxonomic units representing these groups. Rather than using a probe, SybrGreen™, a marker which fluoresces intensely when bound to any double-stranded DNA, will be used as the detection system for real-time PCR quantification (Henry et al. 2004, Stubner 2004, Stubner 2002). A crucial step in the denitrification process, the conversion of soluble nitrite to gaseous nitrous oxide, is catalyzed by the nitrite reductase enzyme, found widely within the bacterial domain (Bothe et al. 2000). This enzyme is available in two functionally identical forms, a copper-dependent form and a cytochrome cd1 form, coded for by the functional genes nirK and nirS respectively. Primers targeting nirK (nirK1F and nirK5R - Yoshie et al. 2004) will be used. The primer set, NS31 and AM1, specific to the Glomeromycota (arbuscular mycorrhizal fungi) will be used (Johnson et al. 2003).

To quantify total fugal and total bacterial populations, realtime PCR will be performed using universal fungal primers nu-SSU-0817 and nu-SSU-1536 (Edel-Hermann et al. 2004, Anderson et al. 2003) and universal eubacterial promers 8F 6-FAM and 1392R (LaMontagne et al. 2002).

Within 48 hr of soil collection, samples will be assessed using BIOLOG EcoPlate plates (standard 96 well plates with 3 repetitions each of 31 dried substrates plus a control). In this method, as described by Crecchio et al. (2004), microorganisms are extracted from the soil samples. Serial dilutions of the extract will be used to inoculate each of the wells. The plates will then be incubated for 5 days at 30°C. Color development of the redox indicator dye will be read every 24 hr on a microplate reader. The activity in response to the different sole carbon sources as represented by the pattern and intensity of color change is treated as a community-level physiological profile. Samples then will be compared by principle component analysis.

Microbial Activity- On each soil sampling date, soil respiration (CO_2 efflux) will be measured. Three PVC collars will be inserted 2 cm into the soil of each plot with at least a 2 cm of collar remaining above the soil surface. Collars will remain in the plots unless the soil is cultivated. If the area is to be cultivated, collars will be reinserted at least 24hr before soil respiration measurements are made. If a thick layer of amendment is applied to the soil, collars will be inserted both in the amendment and below it at soil level. Measurements will be made using a Licor-6200 infrared gas analyzer with a Licor-1000 soil chamber.

C. Economic Analysis

This project will also include an analysis of the up-front cash costs to implement treatments, annual cash costs and returns, present value of the net projected returns, and the rate of return on investment. Partial and enterprise budgets will be used for these calculations. Labor hours, production inputs, and materials and supplies that change between treatments will be tracked and analyzed on an annual basis. Fruit collected from data trees will be analyzed for total yield of fruit harvested, fruit size distribution, and cullage. These data will give a commercial packout for grower returns and information growers can use to compare against their own production systems.

FEASIBILITY

Both treatments of objective one are well within the expertise and capacity of staff at the experimental orchards as past experience indicates. The Central Analytical Laboratory, the Central Services Laboratory, and the Nematode Testing Laboratory [redacted] also have a long track record in analyzing soil samples and collecting the desired data (please refer to Facilities and Equipment for details). Each Project Director is a recognized expert in his/her field (please refer to CVs for details).

2. Timeline

Timelines for fertility management and data collection activities are provided in Tables 1-2.

3. Evaluation of Extension/Education Activities

Evaluation of research result dissemination activities is part of objective three and discussed below.

4. Stakeholder Involvement

The research design reflects grower concerns by focusing on the effects of current management strategies on soil communities and to compare those practices with a new and more ecological, farm-based approach to soil community management (Please refer to the introduction for more details.)

Table 1: Fertility Management Timeline for Objective 1

	2006[z]		2007		2008	
Month	**IS[y]**	**SFM[x]**	**IS**	**SFM**	**IS**	**SFM**
October-March		Use previous year's soil and tree nutrient data to develop nutrient management plan for coming year		Use previous year's soil and tree nutrient data to develop nutrient management plan for coming year		Use previous year's soil and tree nutrient data to develop nutrient management plan for coming year
April	Apply fertilizer (~5kg actual N/ha)	Manage tree row for nutrient supply or sequestration	Apply fertilizer (~10kg actual N/ha)	Manage tree row for nutrient supply or sequestration	Apply fertilizer (~20kg actual N/ha)	Manage tree row for nutrient supply or sequestration
June	No action	Mow in alleys		Mow and blow cover crop		Mow and blow cover crop
July					Apply pre-harvest fertilizer (~10kg actual N/ha)	
September		Sow cover crop		Sow cover crop		Sow cover crop

[z]It is anticipated that sufficient N is available for small trees. To avoid oversupply of N, no additional N sources will be used in 2005 ant the alleyway will be managed to reduce N availability within the tree row.
[y]IS=Input Substitution
[x]SFM=Sustainable Fertility Management
Milestones: Fertilizer application for the IS treatment, organic tree row amendments and green manure management (seeding, mowing, mulching, etc.) for the SFM.

Verifiable Indicators: Management plans for the upcoming year.

Table 2: Annual Tree and Soil Data Sampling Timeline for Objective 1

Month	2006-2008
October (autumn)	trunk circumference, soil data samples[z,y], soil moisture, (leachate sample[x])
November	leachate sample, soil moisture
December	leachate sample, soil moisture
January	leachate sample, soil moisture
February	leachate sample, soil moisture
March	soil data samples, leachate sample, soil moisture
April (bloom)	soil data samples, leaf sample, leachate sample, soil moisture
May	leachate sample, soil moisture
June (pre-harvest)	soil data samples, leaf sample, leachate sample, soil moisture
July	leachate sample, soil moisture, disease inspection, (yield)
August (mid-summer)	soil data samples, leaf sample, leachate sample, soil moisture
September	leachate sample, soil moisture

[z]soil data: collect samples for soil-N, resident NO_3^-, nematode composition, microbial community characteristics, and microbial activity.
[y]Leaf, soil, and leachate N sample analysis will be paid from matching funds.
[y]Lysimeters will be installed by November 2005

Milestones: Soil data samples taken in April, June, August and October. Plant disease evaluation completed in summer. Monthly leachate and soil moisture samples obtained.

Verifiable Indicators: Summarized data will be summarized in annual reports.

5. Anticipated Results and Expected Outcomes

We hypothesize that sustainable fertility management practices will result in:

- optimization of tree nutrient supply,
- consistent levels of yield of fruit of high quality will be assured,
- disease incidence will be reduced,
- soil fertility will be improved,
- cost of production will be reduced, resulting in a higher profitability for the grower.

The following indicators will be used to determine if anticipated results have materialized: yield, fruit quality, rate of disease incidence, levels of soil- and tree-N, cost of production, profitability.

Under Objective 2

1. Rationale, Techniques, Methods, and Feasibility

RATIONALE- While it is known that soil community structure responds to management actions (please refer to introduction for details), it is not known if it can be used by orchardists or extension agents to diagnose orchard/soil health. To investigate this possibility, orchards and soils which experience very different management systems need to be compared.

TECHNIQUES, METHODS

Research Design- Mature, commercial orchards of cooperating growers representing three different approaches to orchard management (conventional, alternative, and organic) will be surveyed to determine orchard age, soil type, management practices, and costs.

Data Collection- Nine orchards (for details please refer to Cooperation and Institutional Units Involved) will be sampled each fall when differences in soil community are most likely to be observed (Neher 1999). In each orchard, three soil samples each will be taken within the tree row and three within the alleyway. Each soil sample will be a composite of eight cores. Samples will be processed and analyzed for soil-N, nematode composition, and microbial community characteristics as described under objective 1. The timeline is shown in Table 3.

In addition, growers have agreed to provide information on orchard age, soil type, management practices, historic yield, fruit quality, and management costs. These data will be analyzed using methods described under objective one.

Table 3: Sampling Timeline for Objective 2

Month	2006-2008
September	Collect samples for nematode composition and microbial community characteristics
October	Historic data from cooperating orchard managers

Milestones: Soil samples taken, data collected from orchardists.

Verifiable Indicators: summarized data will be reported in annual reports.

FEASIBILITY

Grower interest in this research is high as evidenced by nearly $40,000 in-kind contributions (See Matching). Growers will gain valuable information about the state of their orchards and soils, and will readily supply the required data.

2. Timeline

Timelines for activities a provided in Table 3.

3. Evaluation of Extension/Education Activities

Evaluation of research result dissemination activities is part of objective three and discussed below.

4. Stakeholder Involvement

Growers participate directly by providing information on management practices and allowing sampling of their orchards as part of the field survey of mature orchards and through the Soil Health In Fruit Trees Systems (SHIFTS) advisory group (please refer to Cooperation and Institutional Units involved for a listing of members and description of responsibilities).

5. Anticipated Results/Expected Outcomes

A better understanding of the effects of different management practices on soil fertility and soil community structure will be gained. We hope that soil community structure can be used to characterize soil health, diagnose soil problems and to propose remedial actions.

Indicators of successful use of soil community structure are:

- characterization of soil health,
- number of orchards advised on soil problems,
- numbers of problems corrected due to advise obtained.

Under Objective 3

1. Rationale, Techniques, Methods, and Feasibility

RATIONALE

A two-pronged approach will be used to gauge effectiveness of dissemination methods and adoption success. Preliminary results and ideas generated from this research will be disseminated through a large variety of venues, namely, a combination of extension and grower meetings, academic society meetings, trade newsletters and journals, and scientific journals, and the web. Data will be collected to find the most effective venue.

In order to evaluate the importance of this research to organic cherry production, the most effective dissemination method in the industry at-large, the degree of change among cherry orchardists, and the nature of (if any) barriers to adoption, a post-research survey will be conducted.

TECHNIQUES/METHODS

Dissemination Strategy- Advantage will be taken of annual tree fruit meetings and field days or tours in Wasco County, Hood River, and the Willamette Valley and academic society meetings to present initial results and research updates (refer to Table 4 for details and timeline).

Table 4: Dissemination Timeline (Objective 3)

<table>
<tr><th>Month</th><th>2006</th><th>2007</th><th>2008</th></tr>
<tr><td>January</td><td></td><td colspan="2">Wasco County Winter Meeting
Hood River Annual Winter Meeting</td></tr>
<tr><td>March</td><td>Annual Report of the Organic Farmers Research Foundation</td><td></td><td></td></tr>
<tr><td>April</td><td colspan="3">Research Update for the OR Sweet Cherry Commission at LB</td></tr>
<tr><td>May</td><td colspan="3">Wasco County Annual Pre-harvest Tour</td></tr>
<tr><td>June</td><td></td><td>4th National Organic Tree Fruit Symposium</td><td></td></tr>
<tr><td>July</td><td colspan="3">Hood River Field Day, Willamette Valley Stone Fruit Tour
Annual Meeting of the American Society for Horticultural Science</td></tr>
<tr><td>October</td><td></td><td></td><td>Workshop:
"Rich soils: Harnessing soil microbial activity for profitability"</td></tr>
<tr><td>November</td><td colspan="3">Annual Meeting of the Oregon Sweet Cherry Commission
Annual Meeting of the Soil Science Society of America
Annual Meeting of Oregon Tilth</td></tr>
<tr><td>December</td><td colspan="3">Research updates in publications</td></tr>
</table>

Milestones: Posters, abstracts, presentations given for practitioners and at scientific meetings
Verifiable Indicators: Numbers of presentations given at meetings will be reported in annual reports

A combined effort is planned for the Wasco County winter meetings of 2007 and 2008. Members of the SHIFTS advisory group who are cooperating orchardists will report on their experiences with orchard floor management practices and how changes in community diversity have affected orchard profitability. This will be followed by a presentation by one of the researchers containing an interpretive analysis based on research results and growers' experiences.

For 2008, at the end of this project, to give an in-depth presentation of this research, a field workshop titled 'Rich Soils: Harnessing microbial activity for orchard profitability' is being planned. The focus of the workshop will be on how orchard floor management tools can be used to increase soil health and profitability. Cooperating researchers and growers will present results and experiences that will be published in *In Good Tilth*, the newsletter of Oregon Tilth and similar publications in Washington State. In addition, results and growers experiences will be the subjects of articles in trade journals such as *The Capital Press, Good Fruit Grower,* and *Western Fruit Grower.*

Researchers will submit abstracts for presentations at academic meetings such as the annual American Society for Horticultural Science and Soil Science Society of America. Articles will be submitted for publication in academic journals such as *The Journal of the American Society for Horticultural Science, Soil Science Society of America Journal, Applied Soil Ecology,* and *Agriculture Ecosystems & Environment.*

In addition, updates will be posted on the following websites: MCAREC website **oregonstate.edu/dept/mcarec**, Wasco County website **www.co.wasco.or.us**, and the OSU Department of Horticulture website **oregonstate.edu/dept/hort**.

Evaluation Strategy- Interaction with growers at meetings and responses to written materials or the web (letters, phone calls, emails) will be collected and analyzed to gauge grower interest in this research and relative dissemination success of each method (i.e. meetings, field days, workshops, web, newsletters, and other publications). In addition, information on effectiveness of dissemination venues will be collected with the survey instrument discussed below. The timeline is given in Table 5.

Table 5: Evaluation of Effectiveness of Dissemination Venues (Objective 3)	
Task	**Date of Completion**
Summarize and analyze grower contacts for 1st year	30 Dec 2006
Summarize and analyze grower contacts for 2nd year	30 Dec 2007
Summarize and analyze grower contacts for project	30 Oct 2008
Milestones: each of the tasks identified above. **Verifiable Indicators:** data on grower participation in dissemination events will be presented in annual reports.	

Survey Design- The Soil Health In Fruit Tree Systems (SHIFTS) advisory group will participate in the development of the questions, the initial testing, and distribution of the final survey. The following information will be collected: size of farming operation; current acreage in production; planned expansion (if any); type of farming system currently used; planned changes in farming operations (if any); reasons for these changes; venue of obtaining research results (outreach activities, publications, meetings, web, word-of-mouth); changes implemented due to research results (if any); reasons for changing/not changing; and further information needs. The following channels will be used (others may be added later on the advise of SHIFTS): to attendees at meetings, field days, and workshops (see dissemination timeline); to the members of the following growers organizations such as: Oregon Tilth, Washington Tilth, Oregon Sweet Cherry Commission,; Colorado Organic Crop Management Association and placed on the web. The timeline is given in Table 6.

Table 6: Survey Timeline (Objective 3)	
Task	**Date of Completion (2008)**
Development of survey questions	1 August
Initial Testing	1 September
Distribution	1 October
Deadline for Returns	15 October
Analysis of Returns	1 December
Publication of Results	15 January 2009
Milestones: Each of the tasks identified above. **Verifiable Indicators:** Number of surveys distributed and returned, publication of results	

FEASIBILITY

The Project Director [redacted] has 18 years of extension experience and has worked collaboratively with extension faculty who are professional survey designers.

2. <u>Timelines for Proposed Research, Education, and Extension Activities</u>

Tables 5-6 contain timelines and propose milestones and indicators (see above).

3. <u>Evaluation of Extension/Education Activities</u>

The evaluation of extension, and/or education activities is part of this objective and discussed under the techniques/methods above.

4. <u>Stakeholder Involvement</u>

Stakeholders will also participate in the dissemination of research results, in the evaluation of dissemination strategies, and the evaluation of degree of change in orchard management practices as described under objective three above.

5. <u>Anticipated Results/Expected Outcomes</u>

It is anticipated that the comparison of widely different dissemination venues will result in a better understanding of how best to reach organic growers. This information will be made available to extension agents and other professionals advising to organic growers. It is anticipated that this will result in improved collaboration between organic growers and professional advisers, ultimately benefiting both parties. It is further hoped that the survey instrument will yield valuable information on the penetration of research result in the industry, rate of management change, and provide crucial information for future research.

Two sets of indicators will be used. To measures the effectiveness of dissemination venues, the number of growers reached by each venue will be recorded. To measures the relevance of research results to growers, the following indicators will be used: 1) number of growers who changed management practices, 2) number of requests for information on new management techniques by non-participating growers, 3) number of soil problems diagnosed among participating growers, and 4) number of remedial actions implemented among participating growers.

Data will be collected at the end of each year and at the end of the project and reported in annual and final reports as well as in articles and presentations as outlined above (Tables 4-6).

d. Cooperation and Institutional Units Involved

The proposed research is an interdisciplinary, collaborative effort between [redacted] and cherry growers [redacted], spearheaded by the [redacted] Department of Horticulture. Providing expertise in nematode analysis, soil science, and agricultural economics are key personnel from the Department of Botany and Plant Pathology, the Department of Crop and Soil Science, and the Mid-Columbia Agricultural Research and Extension Center, respectively. This proposal builds on funding received from the Organic Farming Research Foundation, the Agricultural Research Foundation and the Oregon Sweet Cherry Commission (please refer to Matching) for the establishment of experimental orchards and the analysis of soil nutrients. Matching and in-kind funds cover plot maintenance charges on the research farms, and on-farm grower trials.

The project is advised by the Soil Health In Fruit Tree Systems (SHIFTS) [redacted] tasks; advise on tree row and alleyway management and plant selection; design learning activities; provide mechanism for information dissemination; assist in estimating costs of production for commercial, non-traditional, and organic orchards using alternative orchard floor management strategies and pest management strategies.

To date, five growers have agreed to participate in the research covered [redacted] growers who integrate alternative with conventional management practices. In each orchard, conventional and alternatively farmed areas will be sampled. The [redacted] SHIFTS, extension contacts, grower meetings, and field days with the aim of sampling 10 orchards each fall.

Each grower has agreed to grant access to their orchards for soil sampling and to provide historic data on management practices and costs of these practices. Their participation, as well as that of the SHIFTS members, is voluntary and, therefore, they will not receive any enumeration for their efforts.

e. Facilities and Equipment

Mid-Columbia Agricultural Research and Extension Center- MCAREC is a branch of the [redacted] Agricultural Experiment Station of [redacted] College of Agricultural Sciences and is located two miles south of Hood River. Facilities are located on 56 acres and include offices, laboratories, greenhouses, an insectary, conventional and controlled atmosphere storage facilities, three on-site residences, and specialized environmental field cages. The Center performs research for about 24,000 acres of fruit in the Mid-Columbia region of which 40% is cherry.

Lewis Brown Farm- The Department of Horticulture manages 110 acres of this experimental farm (of 225 in total) with the following facilities; field plots with access to water and power, a field laboratory, a cold room, an office building, a weather station, and standard farm equipment.

Central Analytical Laboratory (CAL)- The CAL in the Department of Crop and Soil Science, provides chemical analysis of plant tissues, soil extracts, water mixtures, biosolids, and geologic material digests. It employs the following instrumentation: a Perkin Elmer Optima 3000DV, two Perkin Elmer atomic absorption spectrometers, a Leco CNS-2000 Macro Analyzer, a Alpkem Flow Solution, a Alpkem RFA 300, and a Waters Capillary Ion Analysis System.

Central Services Laboratory (CSL)- The CSL offers services in genotyping and fragment analysis; DNA sequencing; and biocomputing and bioinformatics. It uses both ABI 3100 capillary and ABI 377 Prism DNA sequencers to resolve and analyze fluorescently labeled DNA fragments for genotyping applications. ABI Genescan® software is used to size fragments based on internal lane standard. Further analysis with Genotyper® software can be used for microsatellite analysis, AFLP analysis, gene expression profiling, mutation detection, and mutation screening. The lab operates an ABI 3730 capillary sequence machine for DNA sequencing, with set-up of chain-termination reactions, robotic analysis on an ABI 3730, and electronic delivery of sequence data.

Nematode Testing Laboratory- The Nematode Testing Laboratory is capable to conduct 100 Baermann funnel extractions and uses a Damon/IES CU-500 Centrifuge; operates microscopy rooms with Zeiss SR and Olympus SZ60 stereomicroscopes, as well as Olympus BHB-001and Leitz LaborLux compound microscopes. All microscopes have photo tubes for photo documentation of specimens.

Equipment- The following pieces of equipment are being requested: 64 suction cup lysimeters for leachate collection to determine resident nitrate concentratons and 48 capacitance probes to measure soil moisture. Both resident nitrate concentrations and soil moisture are important physical parameters to determined the influences on soil-N and soil communities (please refer to introduction for details.) The suction cup lysimeters are a relatively inexpensive tool but accurate and precise in comparison to other lysimeters, yet allows for repeated sampling, requires less soil disturbance during installation, can be operated both under saturated and unsaturated conditions (which both occur regularly in OR soils), and provides an estimate of the resident nitrate concentrations. The capacitance probes also allow rapid and accurate measurement of soil moisture content once the soils pressure release curves have been generated.