The challenges presently facing agriculture in Washington State reflect global concerns about food production, climate change, soil and water protection, farm profitability, and rural communities. Local concerns include soil erosion and sedimentation of waterways in the Palouse region, pesticide drift in the Columbia Basin, and degradation of water resources by livestock and forestry activities in western Washington. Loss of farmland to urbanization and other commercial uses is dramatically changing the structure of agriculture within the state. State researchers are studying groundwater contamination from agriculture to determine its extent and seriousness.

Many farmers are actively seeking alternative practices to improve their stewardship of agricultural resources while maintaining profitability. Sustainable agriculture provides a conceptual framework and key principles to guide future development of farming practices and systems that will protect water quality, other natural resources, and quality of life.

Four faces of Washington agriculture.

What Is Sustainable Agriculture?
Sustainable agriculture is a long-term goal, not a specific set of farming practices. The verb sustain means to support adequately, completely, and by implication, indefinitely. A sustainable agriculture must balance the following outcomes.

- Conserve and enhance resources (soil, water, air, minerals, etc.) both on and off the farm.
- Maintain or improve profits.
- Provide safe, abundant, and high quality food and fiber.
- Improve the vitality of rural communities.
- Be socially acceptable

Given infinite resources, almost any form of agriculture could be sustainable. However, we have a declining agricultural land base, a limited fresh water supply, a diminishing fossil energy supply, and a growing population. These constraints force us to find ways of sustaining the resources needed for future farming.

Sustainable agriculture is a relative term. It will take shape differently in each diverse crop/product/climate area of Washington State. Many current farm practices suppress, simplify, or replace biological processes sometimes incurring greater production and environmental costs. Sustainable farming strategies that can enhance biological processes include conservation tillage, diverse crop rotations, improved manure management, increased use of perennial crops, mixed crop/livestock operations, and integrated pest management. These approaches also can reduce the need for some of the current production inputs and can protect the environment and farm profits.

Sustainable agriculture as a concept can encompass other terms that describe approaches to more environmentally sound farming, including alternative, ecological, regenerative, low-input, biological, and organic agriculture. For example, both sustainable agriculture and organic farming encourage rebuilding soil organic matter, but organic farming prohibits the use of synthetic fertilizer, while sustainable agriculture does not.

The term low input refers to reducing purchased, external, or nonrenewable inputs. Low input does not mean "do-nothing" while magically maintaining crop productivity. Farmers successful in reducing purchased inputs such as chemical pesticides may intensively scout fields for pests, release biological controls, and apply botanical pesticides more frequently. This approach requires a greater knowledge of the biological relationships present in farming systems.

Sustainable implies accounting for all costs associated with the food-fiber system both to society and to growers. Milk, wheat, beef, or apple prices do not currently include all the costs associated with production, such as cleaning contaminated water, disposal of food processing and packaging wastes, effects on human health, or decline of rural communities. Farmers incur costs of soil erosion through reduced soil productivity and lost nutrients. Short-term profit from farming is essential. But long run costs, such as groundwater contamination and soil erosion, have been ignored in determining what is profitable today. We need to develop knowledge of long-term impacts, both on and off the farm, to guide farming decisions in shaping a sustainable agriculture.

**Sustainable Agriculture and Groundwater Quality**

Modern agriculture relies heavily on purchased petrochemicals to produce abundant
food and fiber supplies. These include pesticides, fertilizers and fuel. Some are potential contaminants that can move to surface or groundwater. Preventive strategies are essential since cleanup of contaminated groundwater is a difficult long-term task. Groundwater contamination from agriculture often affects farmers directly, because virtually all rural residents rely on well water. In 1990, researchers with the Washington State Department of Ecology (Ecology) found that 22% of the wells tested in Whatcom, Franklin, and Yakima counties had nitrate concentrations above the 10 ppm drinking water standard. The detection of low concentrations of pesticides, mostly fumigants no longer used, serves as a warning for potential problems in the future.

Sustainable agriculture offers three general strategies to protect water quality. **Improved efficiency** includes increased nitrogen fertilizer efficiency and improved pesticide application methods. **Substitution of inputs** includes using biological controls instead of pesticides or using legumes instead of nitrogen fertilizer. **Agroecosystem design** includes approaches such as intercropping and agroforestry, which increase biological self-reliance and decrease production inputs and negative environmental impacts. Integrated Pest Management draws on all three strategies to reduce pesticide use.

For example, Washington State University extension specialists and researchers use a computer program to predict codling moth growth stages (Fig. 1). At the same time they trap moths to determine if pest levels are high enough to warrant control. Early results show up to a 50% reduction in codling moth insecticide use on apples. Washington State University researchers and extension workers have imported and released natural predators to control the Russian wheat aphid, a widespread pest in cereal crops. Biological control of noxious weeds offers hope for a long-term reduction in herbicide treatment on thousands of infested noncrop acres. In western Washington, three released insects—a moth that eats foliage, a beetle that eats roots, and a fly that attacks flowers—are successfully controlling tansy ragwort.

---

**The calendar Is a poor predictor of when to spray.**

Spraying for coding moth, the most serious apple pest, is typically scheduled by the calendar. Poor spray timing reduces pesticide effectiveness, and can result in extra applications in some years. Workers at the Washington State University Wenatchee Tree Fruit Research and Extension Center determined how air temperature affects insect growth. From this, they developed a model to predict the most effective time to spray. The charts compare the calendar method with the model for accuracy in predicting when to apply the first coding moth spray. Positive numbers indicate the method was earlier than observed first entry. Negative numbers mean it was later, and a zero indicates an exact prediction.

The model predicted from 2 days too late to 2 days too early. The calendar method was up to 18 days early. Accuracy is the difference (in days) between the predicted timing and the observed first larval entry in the field (ideal spray timing). The predictive model and other tools being developed for Integrated Pest Management in apples can help reduce total pesticide use.
Sustainable Farming Strategies

No prescriptions or detailed guidelines make or judge whether a farm is "sustainable," in contrast to the specific standards for organic farm certification. However, a number of underlying principles and practices apply (Fig. 2). The principles include:

- increasing biological diversity
- recycling nutrients and waste products
- protecting and restoring natural resources
- accounting for all costs and benefits of farm practices (including social and environmental costs)
- using information-intensive and site-specific management
- implementing complementary social and farm policy structures to encourage these principles.

Research results and farmer experience both indicate the positive effects of these principles at work. The whole result of a set of improved practices often is greater than the sum of its parts, or the expected result of each practice. For example, agricultural economists at Washington State University found that dryland farmers in the annual cropping zone of eastern Washington can reduce soil erosion, disease incidence, and herbicide inputs by switching from a wheat/pea rotation to a wheat/barley/pea rotation. This can translate into 10-15% higher wheat yields, and increased net returns.
Agriculture relies on intensive use of information in farm management. A knowledgeable grower can substitute timing for certain production inputs. Intensive pest monitoring, coupled with knowledge of pest economic thresholds, can often reduce pesticide use. Site-specific information, developed from on-farm testing, can be far more valuable than general, average, or regional research data. Specific actions are available and reliable.

**Actions to consider:**

- Test soil regularly for nutrient and moisture availability.
- Analyze plant tissue for adequate fertility and feed quality.
- Choose crop type, variety, and planting geometry to reduce pest problems.
- Manage different soils in a field with appropriate levels of fertilizer, herbicides, water, tillage, etc. (Table 1).
- Scout fields intensively to determine if weed, insect, or disease problems have reached economic thresholds before using pesticides.
- When available, choose agrichemicals that match soil type and are less likely to leach.
- Select the timing of pest control measures based on crop or pest stage.
- Schedule irrigation based on crop requirements to reduce water use, agrichemical leaching potential, power use, and costs.
- Use records to set attainable yield goals and to adjust production inputs accordingly.
- Evaluate the economics of alternative management strategies such as new crops and rotations.
Manage Fertilizer according to soils, not fields.

Individual fields on eastern Washington dryland wheat farms often have highly variable soils and productivity, yet uniform management (fertilizer, tillage, etc.) over the whole field is normal. David Mulla (WSU) and Max Hammond (CENEX) compared a variable fertilizer rate based on soil test results with a uniform rate in side by side field length strips at two farm sites. The variable rate was more profitable and supplied adequate crop nutrients, leaving less to potentially move to ground or surface water.

<table>
<thead>
<tr>
<th>Fertilizer application</th>
<th>Wheat yield (bu/acre)</th>
<th>Net benefit of variable rate ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>St. John site</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>63.5</td>
<td></td>
</tr>
<tr>
<td>Uniform</td>
<td>61.7</td>
<td>$11.20</td>
</tr>
<tr>
<td><strong>Colfax site</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>57.7</td>
<td></td>
</tr>
<tr>
<td>Uniform</td>
<td>53.7</td>
<td>$31.77</td>
</tr>
</tbody>
</table>

Table 1. Comparison of variable versus uniform fertilizer application.

(Source: *STEEP Conservation Farming Update*, Spring 1989, p. 7-11. Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID)

**Increasing Biological Diversity**

In recent times, agriculture has shifted to specialization in an attempt to increase production efficiency and lower unit production costs. Often the result is crop monoculture or livestock confinement, either of which can increase severity of production problems. A key strategy for sustainability is to increase biological diversity. In annual cropping systems, longer, more diverse crop rotations are beneficial. In perennial forage systems, shorter rotation cycles may maintain production, improve nutrient cycling, and reduce weed problems. In orchards or berry production cover crops can provide benefits similar to rotation. Perennial and annual crops can blend into an overall cropping system, such as alfalfa, corn, and potatoes. Benefits include a decrease in disease, weed, and insect pests; improved soil structure; and lower fertilizer inputs.

Genetic diversity is a critical resource. Well adapted, more competitive, and disease and insect resistant crop varieties lower production inputs and costs. Mixed crop and livestock enterprises can use forages and crop residues effectively. In addition, proper manure management can improve soil condition while protecting ground water quality.

**Actions to consider:**
• Include different crop families in rotations (Table 2).
• Maintain a broad genetic base in crops and livestock for disease and insect resistance.
• Use more competitive crops and varieties to suppress weeds.
• Plant varietal mixtures or multiline varieties.
• Use intercropping (e.g., corn and alfalfa).
• Use pest-specific control measures to minimize impacts on beneficial species (e.g., Bacillus thuringiensis (BT) for cabbage loopers).

---

**Green manure crops help control nematodes in potatoes.**

Crop rotation can help control soil-borne diseases and pests that build up when their host crop is grown frequently. Researchers at Washington State University Prosser Irrigated Agriculture Research and Extension Center are testing green manures for rotation with potatoes. These crops help suppress Columbia root-knot nematodes and may replace chemical soil fumigation. All the treatments led to similar potato yields, but nematode infection was lowered by sudangrass and spring-incorporated winter rapeseed to levels similar to chemical fumigants.

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>Potato yield (ton / acre)</th>
<th>Infection index*</th>
<th>Percent culls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow</td>
<td>20.0 a</td>
<td>5.16 a</td>
<td>97 a</td>
</tr>
<tr>
<td>Wheat</td>
<td>19.0 a</td>
<td>4.46 a</td>
<td>82 a</td>
</tr>
<tr>
<td>Sudangrass</td>
<td>20.1 a</td>
<td>1.50 cd</td>
<td>24 bc</td>
</tr>
<tr>
<td>Rapeseed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall incorporated</td>
<td>19.8 a</td>
<td>2.54 bc</td>
<td>50 b</td>
</tr>
<tr>
<td>Spring incorporated</td>
<td>18.6 a</td>
<td>1.00 de</td>
<td>17 bc</td>
</tr>
<tr>
<td>Mocap fumigant</td>
<td>25.0 a</td>
<td>1.29 cde</td>
<td>20 bc</td>
</tr>
<tr>
<td>Telone II fumigant</td>
<td>23.7 a</td>
<td>0.13 e</td>
<td>1 c</td>
</tr>
</tbody>
</table>

Means in each column followed by the same letter are not significantly different (p<0.05)

*Infection index: 0-6, with 0 = no nematode and 6 = >100 infections per tuber

**Table 2. Effects of green manure crops on potatoes.**

(Source: G.S. Santo, H. Mojtahedi, A.N. Hang, and J.H. Wilson, WSU Prosser IAREC).

---

**Protecting and Restoring Natural Resources**

Farming practices often lead to a significant depletion of natural resources, such as by
soil erosion or fossil fuel use. Sustainable agriculture emphasizes farming practices and systems that conserve or replenish natural resources. For example, conservation tillage, a broad set of practices, can dramatically reduce soil erosion, rebuild soil organic matter, and conserve tractor fuel.

**Actions to consider:**

- Use a soil survey to match soil resources with farm enterprise choices and minimize environmental problems.
- Practice conservation tillage, including reduced tillage, no-till, and strip-cropping.
- Use cover crops (Fig. 3) to protect and improve soil quality and to increase beneficial insect habitat.
- Plant windbreaks to reduce erosion potential and conserve moisture.
- Choose appropriate machinery size to conserve fuel and properly schedule operations to avoid soil compaction.
- Implement stream buffers and livestock fencing to protect water quality and streambank habitat.
- Replace diesel fuel with farm-produced oilseed fuels.
- Use intensive rotational grazing to reduce forage harvest costs and to improve perennial ground cover.

---

**Cover crops can replace tillage in raspberries.**

Perennial trees and vines are often cultivated between rows to control weeds. Over time, this can impair the soil due to compaction, erosion, loss of organic matter, and breakdown of soil structure. Researchers compared four potential cover crops to a rototilled check in red raspberries, and all provided adequate weed control. Other potential benefits from cover crops include nitrogen fixation (from legumes) and habitat diversity for beneficial insects.

![Fig. 3. Effect of groundcover on raspberry yield.](image)

Bars with the same letter are not significantly different. (Source: Stan Freyman, Agriculture Canada, reported by Charles Brun, *Pacific Northwest*)
Improved Nutrient Cycling

Plant and animal nutrients are largely recycled in native systems. Agriculture often disrupts this cycle by eliminating perennial vegetation, removing nutrients in harvested crops, and increasing soil erosion. The structure of the food system compounds the problem by concentrating farm nutrients in cities, where they are dumped into landfills or waterways for disposal. Interest in returning these nutrients to farmland is growing as waste treatment and disposal costs increase.

**Actions to consider:**

- Recycle organic nutrients such as manure, compost, or clean sewage sludge to supply crop nutrient needs.
- Conserve nutrients with cover crops and green manures.
- Base crop fertilizer needs on attainable yield and quality goals, crop nutrient removal, nitrogen credits, and soil testing.
- Apply fertilizer with proper timing and placement to maximize plant use and minimize leaching losses.
- Alternate deep and shallow rooted crops to minimize nutrient leaching.

Farming for Profit and Stewardship

Farming practices can be profitable, environmentally sound, and beneficial to the region. Yet many tradeoffs remain in choosing management options. For example, adopting mechanical weed control to minimize herbicide use and potential groundwater contamination can lead to greater soil erosion, a major threat to long-term sustainability. Legumes in dry areas can substitute for fertilizer nitrogen, but at the cost of precious water for the following grain crop. Nitrogen can leach from fertilizer, manure, and legume sources if growers do not consider proper application timing and nitrogen credits. As these tradeoffs are recognized, farmers, researchers, extension and industry need a greater degree of teamwork to resolve them.

On-farm testing is one promising strategy for site-specific improvement of sustainability on both large and small farms. Farmers can run properly designed and managed on-farm tests with their own equipment, and generate reliable site-specific results. They can evaluate both standard practices and unproven new methods on the farm. Cooperative Extension can help plan and evaluate such tests.

Groups of farmers are already showing how to reduce off-site impacts and improve profits. The Practical Farmers of Iowa group is nationally recognized for developing and disseminating profitable management practices through on-farm testing that reduce groundwater contamination. Similar groups are becoming active in Washington state.

Sustainable agriculture is not a cure-all and is not a particularly new concept in the Northwest. The term permanent agriculture was used in the early 1900s. Many similar concerns were expressed during the 1930s Dust Bowl era. But problem-solving in agriculture has often been narrow in focus, as the solution of one concern frequently
created new difficulties. Sustainable agriculture stresses problem solving in a broader context, with new partnerships across academic disciplines, among all sectors of agriculture, and between urban and rural populations. It emphasizes a greater role for knowledge and use of biological processes on the farm than in the past several decades.

Innovative farmers are discovering ways to make profit and stewardship compatible. Researchers, extension, and private industry are providing key new technologies and information. Consumers can influence change through buying habits, food prices, and policy pressures. Government policies must be supportive of the needed changes. Ultimately, society as a whole must become more ecologically sensitive for a sustainable agriculture to be possible. Agriculture has a unique opportunity to provide a lead role in creating a sustainable society.

Additional Resource


ATTRA (Appropriate Technology Transfer for Rural Areas), P.O. Box 3657, Fayetteville, AR 72702. (800) 346-9 l40. A free information service.


Rodale Institute. The New Farm. A bi-monthly popular magazine on farming alternatives and innovations. Emmaus, PA.
Washington State University and AERO. Sustainable Farming Quarterly. A quarterly newsletter on sustainable agriculture in dryland farming areas. Helena, MT.

Contact the WSU Cooperative Extension office in your county for more information.

Acknowledgments

Partial funding for publications in this series on Groundwater Protection was obtained through U.S. Environmental Protection Agency nonpoint source pollution grants administered by the Washington State Department Of Ecology.

By David M. Granatstein, M.S., Washington State University Project Coordinator for the Northwest Dryland Cereal/ Legume LISA Project; and Baird C. Miller, Ph.D., WSU Extension Dryland Cropping Systems Agronomist.

The authors acknowledge the contributions of Christopher F. Feise, Ph.D., Washington State University Extension Western Washington Water Quality Coordinator and Groundwater Fact Sheet Project Coordinator, WSU—Puyallup Research and Extension Center; John H. Pedersen, Ph.D., P.E., Consulting Technical Editor and retired manager of the Midwest Plan Service, Iowa State University, Ames, IA; and Ronald E. Hermanson, Ph.D., P.E., WSU Extension Agricultural Engineer and Water Quality Project Leader, WSU—Pullman.

Issued by Washington State University Cooperative Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Cooperative Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, color, gender, national origin, religion, age, disability, and sexual orientation. Evidence of noncompliance may be reported through your local Cooperative Extension office. Trade names have been used to simplify information. No endorsement is intended. Published September 1991. A. Subject Code 371.