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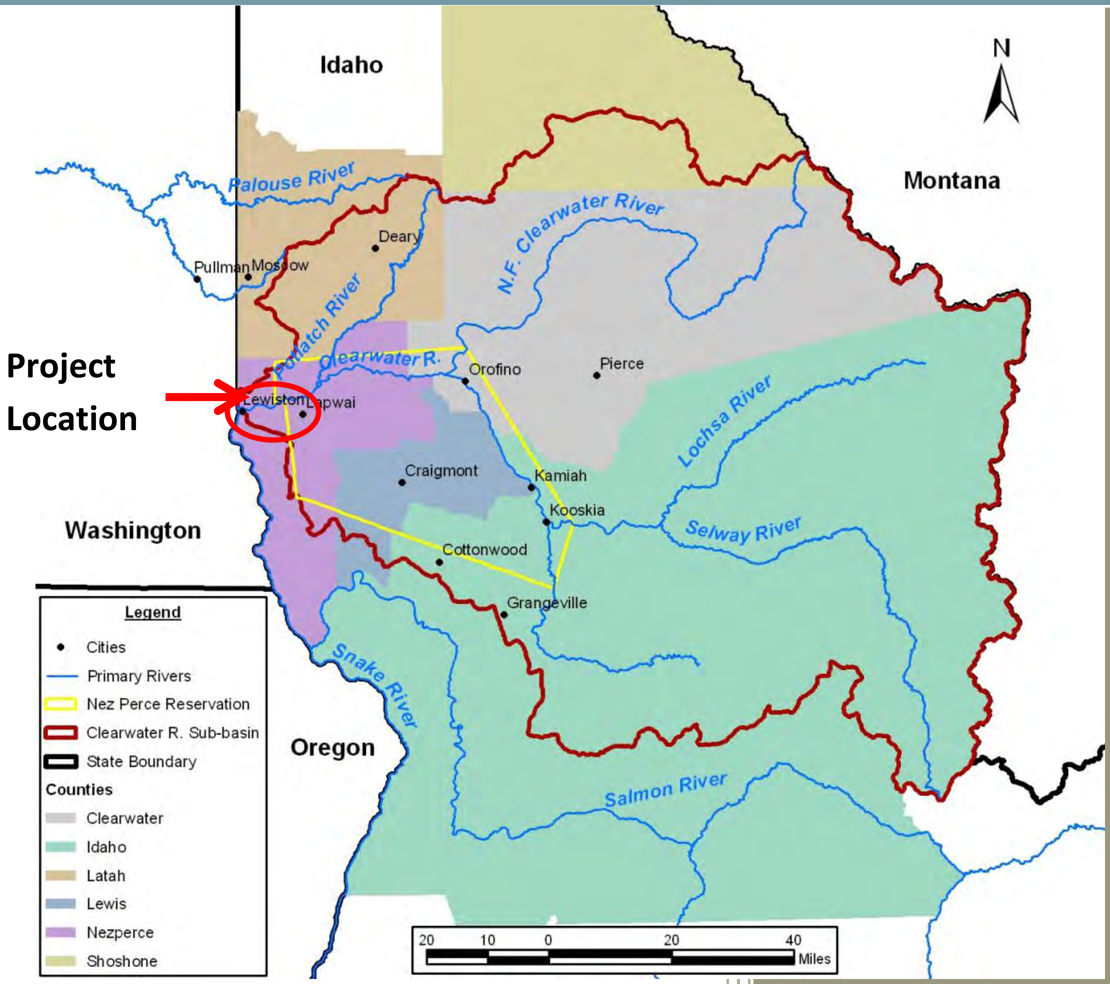
Nez Perce County Lower River Tributaries Appendix 2 Regional Sediment and Nutrient Load Reduction Practices



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1706010305 (TenMile Canyon),
170603061307 (Lindsay Creek),
1706013061308 (Hidden Canyon),
170603061308 (unnamed tributary)

Nez Perce Soil and Water Conservation District

Nez Perce County Lower River Tributaries Appendix 2 Regional Sediment and Nutrient Load Reduction Practices

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NEZ PERCE
SOIL & WATER CONSERVATION DISTRICT

Appendix 2 – Regional Sediment and Nutrient Load Reduction Practices

Hydrologic, Hydraulic and Erosion Analysis of Lewiston-Nez Perce County Watersheds for the National Water Quality Initiative

NEZ PERCE
SOIL & WATER CONSERVATION DISTRICT

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1. Introduction

Exceptional climate and topography make soil erosion control on the Palouse extraordinarily challenging. Special research programs have been necessary to understand the causes and countermeasures for soil erosion in this region, which hosts some of the most productive farmland in the world. For the NWQI project, it is important to understand the main findings of these long-term research programs to know which conservation practices will most effectively reduce sediment loads in the NWQI watersheds.

Recent published reviews highlight the effectiveness of conservation practices in the dryland farming region of the Pacific Northwest. Perhaps the most important point from these reviews is that there is a sustained trend towards conservation practices that well established and known to reduce erosion and sediment yield in watersheds similar to the Lewiston-Nez Perce County NWQI watersheds. Many of the practices are voluntarily adopted by growers for sound agronomic reasons. For the NWQI project, this means that focused technical and financial assistance can likely expedite the trend and successfully reduce sediment yield to levels that meets water quality goals.

2. Sediment Load Reduction Practices

The literature of soil conservation in the interior Pacific Northwest is extensive and overlapping. Only a few of the more recent reviews are highlighted.

2.1 STEEP - Solutions to Environmental and Economic Problems

Kok, Papendick and Saxton (2009) describe how the science, technology, and outreach of the tri-state STEEP program enabled large reductions in soil loss on Pacific Northwest wheatlands. This article is an update of the STEEP achievements covered in the book on conservation farming by Michalson, Papendick, & Carlson (1999) cited elsewhere in this report. The Lewiston-Nez Perce County NWQI watersheds are located mostly within the high (19.7 to 22.0 inches per year) and intermediate (15.7 to 18.1 inches per year) precipitation zones identified in the STEEP research.

The main point of the article is that implementation of improved conservation technology and farming systems have reduced average soil loss on the Palouse since the 1970's from 20 ton/ac/yr to 5 ton/ac/yr or less. The core strategy has been to replace conventional moldboard plow tillage with reduced-tillage (conservation-tillage) and no-till methods. The changeover is justified based on both grower economics and soil loss reduction. Research surveys conducted by STEEP in 1976, 1990, and 2002 showed that adoption of conservation practices was closely related to grower economics and attitudes about newer soil conservation technology. This underscores the need for effective and accessible technical assistance and educational outreach.

The systems approach of the STEEP program has addressed essential aspects of wheatland farming including fertilizer application, seeding systems, integrated pest management, rhizoctonia disease control wheat disease reduction, wheat varieties, residue management, conservation planning, and conservation practice adoption. Below are several of the advances given as evidence of substantial progress towards to wider conservation practice adoption.

2.1.1 Conservation Tillage

Surveys show that conservation tillage is now standard practice on most farms in the inland Northwest. Conservation tillage uses fewer passes of implements causing substantially less soil disturbance, increasing surface residual, and increasing soil erosion resistance. Conservation tillage benefits soil health. After several years of conservation tillage, some growers transition to a no-till seeding method because of improved soil tilth. Though herbicide applications are extra operations in both the one and two pass conservation tillage systems, these operations do not disturb the soil or surface residues, thus are more erosion resistant.

2.2 Increased No-Till

Surveys also show that use of no-till is increasing. No-till (direct seeding) innovations, along with outreach education and improved implements have removed some of the concerns growers had about the limitations of no-till. The main reasons cited are lower and more variable yields, too much surface residue, lack of knowledge, and the cost of switching to no-till from conventional farming. The STEEP experience suggests that better educational outreach, further technological improvements, lower equipment costs, and reduced energy costs should encourage further adoption of no-till methods.

A problem that may slow adoption of no-till methods in the NWQI watersheds is too much residue where winter wheat yields are high (> 100 bu/ac) because it interferes with certain types of no-till implements. The authors cited this as a need for further research.

A major accomplishment of the STEEP education program was the organization of the Pacific Northwest Direct Seed Association (PNDSA)[1], a grower-based organization of some 300 members dedicated to increasing the use of economical conservation tillage and no-till farming systems.

2.2.1 Undercutter Methods

Cooperators in the SEEP program developed the undercutter method of dryland farming which uses a minimum till, broad-sweep implement for primary spring tillage. This implement causes little surface soil disturbance and leaves significant standing residue for erosion control throughout the fallow period. They found no agronomic disadvantages when switching from conventional tillage fallow to the undercutter method and it was more profitable due to less energy cost.

2.2.2 Fallow Reduction

Approximately 13 percent of the cropland in the high precipitation zone was fallowed in the 1970s. By the 1990s,

[1] https://www.directseed.org/

the amount of fallow had reduced to about 6 percent, then further decreased to near zero in 2005. In the intermediate precipitation zone, fallowed cropland was about 24 percent in the 1970s and 1990s and reduced to about 20 percent in 2005. There has also been a shift from tillage fallow to more erosion resistant chemical fallow over the past 20 years.

2.2.3 Crop Rotations

The review noted a change from rotations of almost exclusively winter wheat, peas, and fallow with conventional tillage in the 1970's to more variable three-year or longer rotations of winter wheat, spring barley, peas, or legumes with conservation tillage. Some of the rotations no longer include fallow.

2.2.4 Proven Erosion Reduction

Soil erosion in the Palouse and surrounding areas has decreased during the past 30 years, especially in the past 10 years (before 2009), as adoption of conservation practices increased. The authors observed more residue on winter wheat fields and rougher surfaces because of limited or no tillage compared with clean tilled seedbeds of the 1970s. Deposits in road ditches had decreased and rills and gullies were less evident because of conservation tillage. Soil erosion modeling with RUSLE2 by the authors confirmed the reduction in soil loss.

2.2.5 PNW Conservation Tillage Handbook

The online PNW Conservation Tillage Handbook[2] is a product of the STEEP project. It is a source of practical research results and guidance developed during the STEEP project. It addresses many aspects of conservation tillage on the Palouse.

2 https://pnwsteep.cw.wsu.edu/pnw-conservation-tillage-handbook/

2.3 Advances in Dryland Farming in the Inland Pacific Northwest

The STEEP project was defunded by Congress in 2011. The recent Washington State University Extension publication, *Dryland Farming in the Inland Pacific Northwest* (Yorgey & Kruger, 2017) is an extensive update and summary of research and guidance for modern-day practices of dryland farming on the Palouse and surrounding areas. While there is overlap with the earlier STEEP review (Kok, Papendick, & Saxton, 2009), this publication increases focus on farm sustainability and lessening of climate impacts. Key findings of a few of the most relevant chapters that pertain to soil erosion reduction are highlighted below.

This extension publication defines crop zones somewhat differently than the STEEP publications. High precipitation zones roughly equate to Annual Crop agroecological class (AEC), the Annual Crop-Fallow Transition class is about the same as the STEEP intermediate precipitation zone and the Grain-Fallow class is for areas of lower precipitation. A map in the publication shows that the Lewiston-Nez Perce County NWQI watersheds are in the Annual Crop-Fallow Transition AEC.

2.3.1 Conservation Tillage Systems

The key points made by the authors of this chapter are (Bista, Machado, Ghimire, & Georgine Yorgey, 2017):

- Conventional tillage-based cropping systems deplete soil organic matter (SOM), increase soil erosion, and threaten sustainable crop production.

- Conservation tillage systems have been increasingly adopted by growers in the inland PNW to conserve soil fertility and SOM, reduce soil erosion, and improve sustainability of dryland cropping systems in the region.
- Adoption of conservation tillage systems is dependent on considerations such as agroecological class, crop rotations, equipment, residue management, soil fertility management, support systems, and economics.

The Natural Resource Conservation Service (NRCS) and the Conservation Technology Information Center (CTIC) define conservation systems as crop management systems that leave at least 30% of crop residue on the soil surface after planting, to reduce soil erosion by water.

In the Annual Crop-Fallow Transition AEC, crops are grown in two out of every three years. Rotations generally incorporate winter wheat, a spring cereal or legume, and fallow. The more intensive cropping reduces the potential for soil erosion compared to the Grain-Fallow AEC. The increased diversity of the three-year rotation also reduces weeds and disease. The spring crops usually grown in rotation with winter wheat are spring barley, spring wheat, pea, lentil, chickpea, canola, and condiment mustard.

The three types of conservation tillage systems and one other tillage system are defined by CTIC:

Ridge Tillage

Ridge tillage eliminates full-width tillage. The soil is left undisturbed from harvest to planting except for strips up to one-third of the row width. Planting is completed on the ridge and usually involves removal of the top of the ridge. Equipment for such tillage often includes sweeps, disk openers, coulters, or row cleaners.

Mulch Tillage

Mulch tillage is designated as full-width tillage that disturbs the entire soil surface, and it is done prior to and/or during planting. Equipment used for this type of tillage includes chisel, disks, field cultivator, sweeps, or blades and harrows.

No-Till/Chemical Fallow

No-till/chemical fallow leaves the soil undisturbed from harvesting to planting. In the inland PNW, no-till is commonly described as direct seeding. Direct seeding eliminates full-width tillage for seedbed preparation. Planting, seeding, or drilling is done using hoe drills. Weeds are controlled with herbicides. There are several sub-systems including low-disturbance direct seeding, high-disturbance direct seeding, and one-pass and two-pass direct seed systems. Direct seed was found to be highly effective in controlling runoff and soil erosion compared with inversion tillage systems.

Reduced Tillage

Reduced tillage is a type of full-width tillage that disturbs the entire soil surface, leaving 15% to 30% of residue cover after planting.

Other Tillage Systems

Other conservation tillage practices in the inland PNW include minimum tillage, delayed minimum tillage, undercutter fallow, chisel, discs, and sweep tillage systems. The undercutter method of fallow management uses wide V-blade sweep implements that slice beneath the soil surface and deliver nitrogen during primary spring tillage. In the summer, one or two non-inversion rod-weeding operations control weeds.

Adoption of Conservation Tillage

The number of farmers using conservation tillage systems is increasing as experience grows and practices are promoted by fuel savings and government programs. A recent survey of wheat growers from 33 different counties in Washington, Idaho, and Oregon showed that nearly 70% of the growers were using no-till or another form of conservation tillage in 2012–2013.

Recent studies suggest that sufficiently high yield and greater farm profitability are possible with conservation tillage compared to conventional tillage. In eastern Washington, conservation tillage practices such as minimum tillage and delayed minimum tillage were found to be more profitable as they reduced fuel and farm labor expenses compared to conventional tillage winter wheat-fallow. A survey of 47 farmers in the inland PNW showed equivalent winter wheat grain yields and profitability with undercutter systems as compared to conventional tillage fallow systems.

Soil Erosion Reduction

Wind and water erosion are major factors affecting the sustainability of the cereal-producing regions of the inland PNW. Wind erosion mostly affects areas of lower precipitation but should not be discounted in the Lewiston-Nez Perce County NWQI watersheds. Water erosion is caused by a combination of factors including winter precipitation with a high potential for falling on frozen soils, steep topography, and crop management systems that leave the soil with low surface residue. Planting winter wheat in early September in bare soil following intensive tillage causes up to two-thirds of annual soil erosion across the inland PNW.

Residue Management

Researchers generally agree that 30% residue coverage (approximately 1,000 lb/acre residue) is adequate to control both wind and water erosion in flat fields, but coverage requirements increase to as much as 60% in sloped fields under a conservation tillage system. The NRCS Conservation Plan currently requires at least 30% of last year's crop residue on the soil at planting for a conservation tillage system. For best water and wind erosion control, surface residue should be spread as uniformly as possible.

In the Annual Crop-Fallow Transition AEC, no-till that leaves residue on the soil surface provides significant benefits in soil water storage over conventional tillage. In the topography of the Palouse, no-till retains more soil water with less spatial variation of snow depth at all topographic locations compared with conventional tillage. Standing crop residue, such as wheat and sunflower stubble, is more effective not only in reducing wind speed and evaporation but also in increasing snow catch than chopped residue.

Rotational Diversification and Intensification

Crop rotations and crop intensification are discussed in a separate chapter in the extension publication. When feasible, crop intensification and diversification to reduce fallow can be used to increase biomass and soil carbon sequestration while increasing soil and water conservation benefits. Examples of crop intensification include replacing winter wheat-summer fallow with summer fallow-winter pea-winter wheat, or by replacing summer fallow by short-season, spring-planted crops such as spring wheat, barley, canola, sunflower, and others to make a winter wheat-spring crop - summer fallow rotation in the Transition AEC.

Much of the Transition AEC is cropped in the 2-year WW-F sequence. In areas with sufficient moisture, an intensified 3-year rotation is possible, typically winter wheat - spring grain – fallow or, less commonly, winter wheat - spring broadleaf – fallow. Tilled fallow is common, especially in the drier areas, to maintain seed zone moisture and control weeds, but most growers in the Transition AEC have adopted some form of reduced tillage, or no-till.

Diversification and intensification strategies have potential in the Transition AEC. No-till, flex cropping, and practices such as integrating tall cereals, harvesting with a stripper header, or undercutter tillage fallow increase the potential for intensification of traditional rotations. Some producers have had success with 4- and 5-year crop sequences integrating no-till winter and spring cereals, spring pea, winter pea, canola, and camelina with 12–14" precipitation. Grain legumes can improve soil N status and reduce N leaching.

Researchers are evaluating the potential for a 3-year WW-Camelina-F rotation to replace traditional 2-year WW-F rotations; good yields have been achieved by replacing fallow with camelina following winter wheat. The taproot of camelina can efficiently extract subsoil water and nitrogen.

Precision Agriculture

Precision agriculture is the management of farm and field-scale variability to achieve improved crop yield, grain quality, and nitrogen use efficiency by more accurately matching crop needs with specific input requirements (4 Rs). Precision agriculture technology enables variable application rates of nitrogen fertilizer across fields to match crop needs and increase nitrogen use efficiency. Greater nitrogen use efficiency reduces the potential for nitrogen to leach to groundwater (Section 3).

Surveys show that the proportion of farmers using GPS guidance increased markedly between 2011 (47%) and 2012 (66%). In 2012, over one-third of respondents reported having and using variable fertilizer applicator and yield monitoring technology. Few producers reported having precision agriculture technology and not using it, but more than two-thirds of respondents did not have technology for spatial soil mapping, aerial crop imagery, variable seeding equipment, and precision agriculture software. Barriers are the cost of the equipment and steep learning curves.

2.4 Evaluation of Sediment Yield Reduction for the Lower Snake River

Researchers from the University of Idaho and Washington State University evaluated sediment yield reduction potential on agricultural watersheds for a U.S. Army Corps of Engineers (USACE) study of sedimentation the lower Snake River reservoirs (Boll, et al., 2010). The report is marked draft but was issued by USACE in 2014 as part of an environmental impact statement (EIS) for the Lower Snake River Programmatic Sediment Management Plan.

The study estimates soil erosion and sediment yield of the main watersheds of the lower Snake River including the Clearwater River basin using a RUSLE-GIS approach. The study used C-factors that ranged from 0.015 to 0.039 for reduced till and 0.008 for no-till in the intermediate precipitation zone based (2005) based on the analysis by Kok et al. (2009). The adopted practice factor, P, was 0.91 to represent contour tillage. The average rill and interrill erosion rate based on the RUSLE-GIS modeling for the Clearwater River basin was 4.1 ton/ac/yr.

Sediment yield was computed by the sediment delivery ratio (SDR) method based on the Vanoni relationship (1975). The SDR for the 2,319 square mile Clearwater River basin was 0.041. The report acknowledges that the large watershed areas in the study were beyond the range of the data that Vanoni used to develop the SDR relationship.

The study modeled the effectiveness of conservation practices to reduce erosion and sediment yield. Practices identified as having good potential to reduce erosion from cropland were:

- Conversion of conventional tillage to reduce or mulch till,
- Wider adoption of no-till methods,
- Installation of gully plugs in high precipitation zones,
- Grass buffer strips along streams,
- Conversion of erodible land to CRP.

Effectiveness of the practices ranged from 37 percent to 89 percent removal depending on type of practice and tillage (Table 13 in the report).

The authors concluded that "…the conversion to reduced tillage and no-tillage practices alone is very effective at reducing the delivery of sediment to streams. Installation of buffer strips, conversion to CRP, and, to a lesser extent, installation of gully plugs all take land out of production and therefore would not be as attractive an option for regional farmers without economic incentives."

2.5 CEAP - Conservation Effects Assessment Project

The USDA Conservation Effects Assessment Project (CEAP) is a multi-agency effort to quantify the environmental effects of conservation practices and program[3]. Project findings are are likely the most current guidance for selection and implementation of conservation practices. Assessments in CEAP are carried out at national, regional and watershed scales on cropland, grazing lands, wetlands and for wildlife. Watershed assessment reports were prepared for agricultural basins throughout the country. Below is a summary of the main findings of the assessment for the Pacific Northwest.

2.5.1 Erosion Estimate

The CEAP erosion modeling for the Pacific Northwest (CEAP, 2014) found that sheet and rill erosion on cropped acres in the Lower Snake River Basin, including the Clearwater River and Salmon River, averaged about 0.14 ton per acre per year (ton/ac/yr). Total sediment loss at the edge of field, including ephemeral gully erosion averaged 2.22 ton/ac/yr. Wind erosion on cropland averaged 0.51 ton/ac/yr. Highly erodible land comprises about 83 percent of the cropland.

2.5.2 Adoption of Conservation Practices

Structural practices for controlling water erosion were in place on 33 percent of all cropped acres in the region, including 40 percent of highly erodible

[3] https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/

land. Fifty-nine percent of cropped acres meet criteria for mulch till, and 21 percent meet criteria for no-till. Ninety-two percent of cropped acres have structural or tillage and residue management practices, or both. Farmers met criteria for good nitrogen management—appropriate rate, timing, and method of application—on 44 percent of the cropped acres and good phosphorus management on 43 percent.

The study found that only about 3 percent of the cropped acres in the region have a high level of need for additional conservation treatment. About 70 percent of the cropped acres in the region had a moderate level of need for additional conservation treatment.

A farmer survey conducted during the years 2003–06 found that use of conservation practices can vary year to year depending on economic and environmental factors, including changes in crop rotations in response to market conditions, year-to-year changes in weather factors affecting tillage, irrigation, and nutrient management, and conservation program funding levels and program rules.

2.5.3 Residue and Tillage Management Practices

The CEAP study found that overall, 80 percent of cropped acres in the Pacific Northwest Basin meet the tillage intensity rating for either no-till or mulch till[4]. The amount of crop residue was not used to determine no-till or mulch till.

About 21 percent of the cropped acres met the criteria for no-till, and 59 percent met the tillage intensity criteria

[4] The distinction between no-till and mulch-till depends on Soil Tillage Intensity Rating (STIR).

for mulch till. About 11 percent of cropped acres do not meet criteria for mulch till or no-till but have reduced tillage on some crops in the rotation. Only 10 percent of the acres are conventionally tilled for all crops in the rotation. About 67 percent of the cropped acres are classified as having a moderate level of treatment. Most of these acres meet tillage intensity for no-till or mulch till but are losing soil organic carbon.

2.5.4 Conservation Crop Rotation

The CEAP study for the Pacific Northwest Basin found that nearly all crop rotations meet NRCS criteria for conservation crop rotations (NRCS practice code 328). This practice consists of growing different crops in a planned rotation to manage nutrient and pesticide inputs, enhance soil quality, or reduce soil erosion. Including a legume, hay, or close grown crop in the rotation can have a pronounced effect on long-term average field losses of sediment and nutrients, as well as enhancement of soil quality. In the Pacific Northwest Basin, only 6 percent of cropped acres are in continuous row cropping.

2.5.5 Cover Crops

Cover crops are planted when the principal crops are not growing. Cover crops reduce soil erosion and utilize excess nutrients remaining in the soil from the preceding crop, thereby reducing nutrient leaching and minimizing the amount of soluble nutrients in runoff during the non-crop growing season. The CEAP study found that in the Pacific Northwest Basin, cover crops were not commonly used as a conservation practice during the period covered by the farmer survey (2003–06).

2.5.6 Nutrient Management Practices

Nitrogen and phosphorus are essential inputs to profitable crop production. Farmers apply these nutrients to the land as commercial fertilizers and manure to promote plant growth and increase crop yields. Nutrients not taken up by crops are lost to the environment, which can contribute to offsite water quality problems. The CEAP study listed four basic nutrient management criteria for application of commercial fertilizers and manure[5].

1. Apply nutrients at the appropriate rate based on soil and plant tissue analyses and realistic yield goals.

2. Apply the appropriate form of fertilizer and organic material with compositions and characteristics that resist nutrient losses from the agricultural management zone.

3. Apply at the appropriate time to supply nutrients to the crop when the plants have the most active uptake and biomass production and avoid times when adverse weather conditions can result in large losses of nutrients from the agricultural management zone.

4. Apply using the appropriate application method that provides nutrients to the plants for rapid, efficient uptake and reduces the exposure of nutrient material to forces of wind and water.

Depending on the field characteristics, these nutrient management techniques can be coupled with other conservation practices such as

[5] These criteria are also referred to as 4R nutrient stewardship—right source, right rate, right time, and right place.

conservation crop rotations, cover crops, residue management practices, and structural practices to minimize the potential for nutrient losses.

2.5.7 Conservation Cover Establishment

Establishing long-term cover of grass, forbs, or trees on a site provides the maximum protection against soil erosion. Conservation cover establishment is often used on cropland with soils that are vulnerable to erosion or leaching. The practice is also effective for sites that are adjacent to waterways, ponds, and lakes. Because these covers do not require annual applications of fertilizer and pesticides, this long-term conserving cover practice greatly reduces the loss of nitrogen and phosphorus from the site, and nearly eliminates pesticide loss. Because conservation covers are not harvested, they generate organic material that decomposes and increases soil organic carbon.

According to the CEAP study, as of 2003 about 2.3 million in the Pacific Northwest Basin. Approximately 73 percent of the cropland acres enrolled in the CRP in the Pacific Northwest Basin are classified as highly erodible land. About 67 percent of the CRP land is planted to introduced grasses and 21 percent to native grasses. An additional 11 percent has plantings specifically to support wildlife and about 1 percent is planted to trees.

2.5.8 Structural Conservation Practices

The Conservation Effects Assessment Project (CEAP) study (2014) identifies structural conservation practices that are known to work in the inland Pacific Northwest. The practices can be divided in three categories, overland flow control, concentrated flow control practices, and edge-of-field buffering and filtering practices. In the CEAP study, about 33 percent of the cropped acres in the Pacific Northwest Basin are treated with one or more water erosion control structural practices. The treated percentage for highly erodible land acres is slightly higher—40 percent.

Only about 3 percent of cropped acres in the region had a high level of treatment (combination of edge-of-field buffering or filtering and at least one in-field structural practice). About 7 percent have a moderately high level of treatment for structural practices. About 67 percent of the acres had a low treatment level for structural practices, which indicates no structural practices for water erosion control.

Overland Flow Control

NRCS practice standards for overland flow control include

- Terraces,
- Contour farming,
- Strip cropping,
- In-field vegetative barriers,
- Field borders.

In the CEAP study, overland flow practices were found on about 22 percent of the cropped acres in the region, including 27 percent of the highly erodible land.

Concentrated Flow Control Practices

Concentrated flow control practices are designed to prevent the development of gullies along flow paths within the field. NRCS practice standards for concentrated flow control practices include

- Grassed waterways,
- Grade stabilization structures,

- Diversions,
- Water and sediment control basins.

About 12 percent of the cropped acres in the CEAP study had one or more of these practices, including 17 percent of the highly erodible land. About 54 percent of cropped acres in the inland Pacific Northwest are highly erodible land (HEL).

Edge-of-field Buffering and Filtering practices

Edge-of-field buffering and filtering practices, consisting of grasses, shrubs, and/or trees, are designed to capture the surface sediment that was not avoided or mitigated by the in-field practices. Filter strips can also intercept shallow ground water and utilize nitrogen lost from cropland. NRCS practice standards for edge-of-field mitigation practices include:

- Edge-of-field filter strips,
- Riparian herbaceous buffers,
- Riparian forest buffers.

CRP's buffer practices are included in this category. Edge-of-field buffering and filtering practices are in use on about 6 percent of all cropped acres in the region.

3. Nutrient Load Reduction Practices

A quantitative analysis of the sources of excess nutrients in surface and groundwater is not feasible at the scale of this NWQI assessment and may not be possible even at scale of individual farm fields in complex Palouse topography (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017). The main point from this review is that nutrient load reduction practices are specific to individual fields and operations– efficient soil fertility management for wheatland in the interior Pacific Northwest depends on many cropland and economic variables that vary from year to year.

The following guidance is mostly from Chapter 6 Soil Fertility Management in *Advances in Dryland Farming in the Inland Pacific Northwest* (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017). The authors summarized key findings for soil fertility management in the region:

- Climate, weather, topography, and soil drive wheat productivity and soil fertility management strategies in the inland PNW.
- Variable landscapes and rainfall gradients affect crop fertilizer accessibility, nutrient use efficiencies, and crop growth. Inland PNW producers can achieve the best growing conditions for wheat by tailoring management strategies to their specific field and within-field locations.
- Practices that maximize nitrogen use efficiency include fertilizer placement, fertilizer source, timing of application, and rates that match crop needs.

- Over-use of fertilizers can result in harmful effects on air, water, and soil quality and negatively affect a producer's bottom line. Appropriate management strategies and regular soil testing can reduce nutrient loss and improve overall farm gains.
- Conserving soil water is imperative in dryland agricultural regions since available soil water directly drives wheat yields and nutrient availability. Increased water stress is likely underpredicted climate scenarios. Management strategies that buildup soil organic matter and improve soil health can buffer against crop nutrient and water loss.

The authors stress that managing soil nutrients is more than simply knowing how much fertilizer a crop needs to grow. It is a process that requires controlling a variety of fertility sources over time in complex and dynamic cycles. The challenge is to meet the overall need of the crop, applying nutrients at peak crop demand while continuing to sustain healthy soils and associated natural resources.

3.1 Nitrogen Loss and Load Reduction

Nitrogen applied in fertilizer to cropland in the NWQI watersheds is lost by Nitrate-N leaching, volatilization, and soil erosion. Leaching is the pathway that most impacts surface water and groundwater and is a major pathway of N loss in wheat-based cropping systems in the inland PNW (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017). Leaching potential is increased when soils are wet. Leaching potential is reduced by maintaining good soil health and by matching crop N needs with soil type, N supply, and timing of application.

3.1.1 Nitrogen Sources and Requirements

In the NWQI watersheds, nitrogen (N) is the nutrient that producers supply in the largest quantities each year in wheat-based cropping systems due to the high demand of N by cereal crops. The largest sources of N are commercial fertilizers and incorporating legumes into the rotation. Conceptually, applying nutrients with organic fertilizer sources (manure) is possible, though not evident in the NWQI watersheds. Fertilizer recommendations for winter wheat in the NWQI project area are published by the University of Idaho Extension (Mahler, 2015).

3.1.2 Strategies for Reducing Nitrogen Load

Below are the main strategies for reducing nitrogen loads to surface and groundwater (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017).

Precision Agriculture

Variable application of nitrogen is possible with precision agricultural methods and remote sensing. The technology is rapidly evolving, offering producers more opportunities to increase nitrogen use efficiency (NUE) by using site-specific management.

Fertilizer Timing and Placement

Splitting N fertilizer applications between fall and spring allows producers to conservatively apply smaller amounts of N early in the growing season and then adjust rates and add additional fertilizer in the spring if the precipitation outlook is favorable for high wheat yields. Split (fall-spring) applications of N fertilizer are recommended in areas receiving approximately 21 inches of annual precipitation. Higher precipitation areas might benefit from spring applications only. It may not be advantageous to split

N applications in drier areas where leaching is less of a concern.

Wheat Cultivars

Modern wheat cultivars can have increased vigor and increased stress tolerance, as well as improved efficiencies for taking up water and nutrients.

Crop Rotations

A more continuous crop cover can improve NUE by increasing WUE while maintaining soil health. Nitrogen use efficiency can also increase when wheat follows legumes rather than when following fallow or continuous wheat.

3.2 Sulfur Loss and Load Reduction

Sulfur (S) is the second most deficient nutrient in crops after nitrogen (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017). Sulfur can leach below the root zone when soils are saturated but appears not to cause a water quality problem in the NWQI watersheds. Sulfur loads to surface water, if any, would be reduced proportionally by practices implemented to limit nitrogen and phosphorus loads.

3.3 Phosphorus Loss and Load Reduction

Phosphorus is the third most frequently deficient nutrient in the inland PNW (Borrelli, Maaz, William Pan, Carter, & Haiying Tao, 2017). Phosphorus released to surface water contributes to eutrophication (Thomann & Mueller, 1987). Phosphorus is absorbed to soil particles and does not readily leach. Phosphorus is absorbed to soil particles and enters surface water primarily through soil erosion. Conservation practices that reduce soil erosion will also reduce phosphorus loads to surface water.

Phosphorus is usually not seen as a threat to groundwater quality, but once the capacity of a soil to adsorb phosphorus is exceeded, the excess will move more freely with water, either directly to a stream, or downward to an aquifer (Domagalski & Johnson, 2012). Long-term over-application of manure and chemical fertilizer can cause phosphorus to leach into groundwater. Unfertilized riparian zones can intercept and limit the transport of orthophosphate to streams (Domagalski & Johnson, 2012).

3.4 Other Nutrient Loads

Other nutrients and soil amendments such as potassium, chloride, and micronutrients are not known to cause water quality problems in the NWQI watersheds.

3.5 Nutrient Management of Animal Feeding Operations

There are small livestock feeding operations along the main streams in the Lewiston-Nez Perce County NWQI watersheds. It is unknown how much these operations contribute to nutrient and bacterial loads to surface water (IDEQ, 2001; IDEQ, 2010).

3.6 Nutrient Management Plans

NRCS Conservation Practice Standard 590 – Nutrient Management[6] outlines the process of preparing nutrient management plans for cropland and livestock operations. The State of Idaho

[6] https://www.nrcs.usda.gov/wps/portal/nrcs/detail full/national/technical/cp/ncps/?cid=nrcs143_026849

Department of Agriculture[7] also provides guidance for developing nutrient management plans.

[7] https://agri.idaho.gov/main/animals/environmental-nutrient-management/

4. Stream Bank Stabilization Practices

The principles and practices of stream bank stabilization appropriate for the NWQI watersheds are documented in existing NRCS publications. The primary references that would be used to develop bank treatments are listed below.

1. Federal Stream Corridor Restoration Handbook (FISRWG, 1998)
2. Stream Restoration Design (National Engineering Handbook 654)[8].
3. Streambank Soil Bioengineering Field Guide for Low Precipitation Areas (Hoag & Fripp, 2002).
4. Stream Visual Assessment Protocol Version 2 (NRCS, 2009).

[8] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/manage/restoration/?cid=stelprdb1044707

5. Erosion Control for Rural Construction and Development

Erosion control practices for land-disturbing construction activities and rural development are documented in existing local, state, and federal publications. The primary references appropriate for the NWQI watersheds are listed below.

1. Idaho Catalog of Storm Water Best Management Practices (Idaho DEQ, 2020).
2. Erosion Control and Treatment Selection Guide (USFS, 2006)
3. Conservation Practices for Protecting and Enhancing Soil and Water Resources in Growing and Changing Communities (NRCS, 2008).
4. Others…

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