Northwest

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Description of the Region

The Northwest is a region of dramatic physical and environmental contrasts, ranging from high alpine ecosystems to moist lowland rainforests and high deserts. Land uses and opportunities for agroforestry vary accordingly. Proximity to the Pacific Ocean and elevation are the major climatic influences. Rain shadows lie east of the Cascade, Olympic, and Coast Ranges and, west of the mountains, heavy rainfall and moderate temperatures prevail (Hardesty and Lyon 1994).

Agriculture is important to the Northwest's economy, environment, and culture. Agriculture contributes 3 percent of the Northwest's gross domestic product, crop and pasturelands comprise about one-fourth of Northwest land area, and farming and ranching have been a way of life for generations. Wheat, potatoes, tree fruits, hazelnuts, vineyards, and more than 300 minor crops and also livestock grazing and confined animal feeding operations, such as beef and dairy, depend on adequate water and particular temperature ranges (Dalton et al. 2013). During the past century, the average annual temperature increased by 1.5 °F, with increases in some areas up to 4 °F. Changes in snowpack, streamflows, and forest cover are already evident (USGCRP 2009). Future climate change will likely continue to influence agriculture. The average annual temperature in the region is projected to increase by 3 to 10 °F by the end of the century (USGCRP 2009). Winter precipitation is projected to increase, but summer precipitation is projected to decrease, though precipitation projections are less certain than those related to temperature (USGCRP 2009). Pressures related to the rapidly growing population in this region would compound future climate change impacts.

Higher temperatures, changing streamflows, and increases in pests and disease threaten forests, agriculture, and fish populations in the Northwest (USGCRP 2009). Decreasing supplies of water for irrigation, increasing incidents of pest and disease attacks, and growing competition from weeds threaten Northwest agriculture, particularly the production of tree fruits, such as apples and wine grapes (USGCRP 2009). Human activities already threaten Northwest salmon populations and climate change impacts would add stress. Lower summer streamflows and warmer stream and ocean temperatures are less favorable for salmon and other cold-water fish species.

Agroforestry practices that integrate animal husbandry, crop rotations, and fallow periods have long been part of the heritage of North American peoples (Bishaw 2013; Davies 1994). In the Willamette Valley, Oregon, the Kalapuya managed oak savannas, vast woody huckleberry shrubs, and forests while also managing crops, including camas and wapato (Goodness 2011). Prescribed burning was a tool most Pacific Northwest tribal communities used to maintain and enhance prairie edges and oak woodland savannas for vegetation and wildlife management for various food and cultural resource products throughout western Washington and Oregon (Anderson 2007). The Pacific Northwest tribal communities also managed soil fertility.[2] They gathered food, medicine, and other supplies in a rotational basis for sustained harvests. This management process, enforced by tribal leaders (Anderson 2007; Goodness 2011),[3] was conducted by "skilled and knowledgeable applied ecologists who actively managed the land" (Bainbridge 1995: 147). Some of these management practices, collectively referred to as traditional ecological knowledge (TEK), are ongoing today. This regionally specific body of knowledge has tremendous potential for supporting sustainable agroforestry development in the Northwest.

The most common agroforestry practices in the Northwest region include silvopasture, riparian buffers, forest farming, mixed-practice agroforests, alley cropping, and windbreaks. Silvopasture is used primarily for economic production. Riparian buffers are implemented to address water pollution, create fish habitat, and control erosion. Forest farming is often used for producing mushrooms, floral greenery, and juniper berries. Agroforests use woody crops as part of whole-farm crop and income diversification systems. Windbreaks are used to protect high-value crops and animals. Each of these practices sometimes integrates bioenergy crops. These practices increase income and biological diversity in the region and protect against water and wind erosion (Bishaw 2013). In 1990, researchers surveyed nonindustrial private forest landowners in

[2] Petrie, M. [N.d.]. The land management practices of Coos, Lower Umpqua, and Siuslaw Indians. Term paper for RNG 477 agroforestry course. Corvallis, OR: Oregon State University.

[3] Petrie, M. ([N.d.]).

Washington State and found that 57 percent practiced agroforestry (Lawrence et al. 1992). Although many landowners in this region may not identify themselves as agroforesters or as practicing agroforestry, they are often engaged in practices that may be considered agroforestry.

Silvopasture

Silvopasture in the Northwest involves many forms, including grazing native understory vegetation in young commercial forests and woodlands, tree/livestock production in forested rangelands, and livestock/timber production in thinned, mid-rotation forests. Livestock grazing is the primary agricultural use of approximately 1 million hectares (2.5 million acres) of hill land in western Oregon (Sharrow 1993; Sharrow and Fletcher 1994). In Washington, a survey of nonindustrial private forest landowners found 39 percent of respondents practiced forest grazing; among respondents in eastern Washington, 47 percent practiced forest grazing (Lawrence et al. 1992). Although silvopasture differs from forest grazing commonly practiced in the Northwest (particularly on public lands), an opportunity exists for this agroforestry practice to expand. This change would require more intentional, intensive management of trees, forage, and livestock. Research specific to western Oregon has found that silvopastures may be more efficient at sequestering carbon than forest plantation or pasture monocultures (Sharrow and Ismail 2004).

Sheep grazing is a traditional use of temperate coniferous forests in the United States and Canada. Like any management tool, prescription sheep grazing can be misused. Properly applied sheep grazing often reduces competition between trees and other ground vegetation, thus increasing tree growth (Sharrow 1994). Conifers on grazed plantations in western Oregon had increased height and diameter growth, averaging 63 centimeters (cm) (25 inches [in]) taller and 0.7 cm (0.3 in) greater in diameter at breast height than the nongrazed plots after 12 years of plantation growth (Jaindl and Sharrow 1988). This long history of sheep grazing in forests in the Northwest also indicates opportunities for increased silvopasture applications.

Riparian Buffers

Riparian forest buffers in crop and grazing lands have gained increasing attention in the Northwest because of popular demand and regulation to protect salmon and steelhead. In Oregon, this attention has also come through the Governor's Salmon and Watershed Restoration initiatives (Independent Multidisciplinary Science Team 1999; Nicolas 1997). The focus during the past 15 years of riparian land use in Oregon has been to achieve water quality and restore aquatic habitats (Riparian Management Work Group 2000; Bishaw et al. 2002). These efforts seeking to lower stream temperatures using shade and to enhance fish habitat through large woody debris are only more critical with climate change projections. These efforts have been ongoing in Washington also, with requirements for streamside buffers in forest lands through the Salmon Recovery Act of 1999 (Engrossed Substitute House Bill (ESHB) 2091 [1999]) and the resulting Forest Practices Habitat Conservation Plan passed in 2006 and also with voluntary buffer programs on agricultural lands (Washington State Department of Natural Resources 2015). In July 2014, the U.S. Environmental Protection Agency began requiring Washington State to include conditions in Federal pass-through grants that require projects to be consistent with National Marine Fisheries Service buffer guidance to help protect and recover Washington's salmon runs (Washington State Department of Ecology 2013).

Both State and Federal Governments currently offer incentive programs to encourage landowners to establish riparian forest buffers. In Oregon, between 1999 and 2012, Federal and State Governments spent $18 million USD to establish more than 40,300 acres of riparian buffers (Oregon Watershed Enhancement Board 2012). Other State and nonprofit organizations, particularly watershed councils, are also involved in establishing riparian forest buffers, both through regulatory and voluntary incentive programs (Cochran and Logue 2011; Lurie et al. 2013). Currently in development in Washington State, the Puget Sound Working Riparian Buffer Feasibility Study project is seeking to provide best available science on agroforestry strategies specific to enhancing ecosystem service function within Puget Sound watersheds. The project goal is to work with local tribes, regulatory agencies, and the agricultural community to provide a policy and implementation framework for allowing for the management of native and nonnative species within the riparian buffer corridors as opposed to the "no-touch" buffer framework that is currently enforced. Throughout the Northwest region, riparian forest buffers, if properly practiced and managed, have great potential to improve water quality and create favorable fish habitat in the region, promoting adaptation to the impacts of field runoff created by extreme precipitation events and unfavorable temperatures.

Forest Farming

Forest farming, also called multistory cropping, is a practice in which existing forest stands are intentionally and intensively managed to create an appropriate environment for growing understory crops. The chanterelle mushroom harvest from Pacific Northwest forests is a multimillion-dollar industry, yet managers, harvesters, and scientists lack a current synthesis of information about chanterelles. Because chanterelles grow symbiotically with the roots of forest trees, managing the fungi for sustainable harvests also means managing forest habitats (Pilz et al. 2003). Research on the biology, ecology, and management of truffle fungi in the Northwest has increased interest

in forest farming and forest gardening systems that combine trees and truffles (Trappe et al. 2009). Along with a variety of other mushrooms, other nontimber forest products harvested in the Northwest include fruits (such as huckleberries), decorative woody florals, and medicinal plants (such as Oregon grape and elderberries). Many of these are harvested from naturally occurring stands.

Forest farming provides a significant opportunity to increase the harvest of these nontimber forest products while ensuring their sustainability. Some researchers have studied the design of agroforestry systems that integrate high-quality timber and matsutake mushroom production in the Cascade Range of southern Oregon. These systems could also produce ornamental conifer boughs, pine cones, and Christmas trees (Weigand 1998). Forest farming, however, has not been widely implemented. Forest farming enterprises could prove profitable for family forest owners in the Northwest.

The projected shifts in temperatures and precipitation that threaten forests are likely to also affect forest-farming systems. These projected impacts include greater fire risk, decreasing tree growth, and increasing insect attacks (USGCRP 2009). Climate change impacts on nontimber forest products cultivated through forest farming systems, however, are not well understood.

Agroforests

Agroforests include the management of forests on farmlands. Agroforests are a complex mix of trees and shrubs, often incorporating multiple agroforestry practices on one parcel. This system has high levels of biodiversity and achieves the ecological dynamics of a forest ecosystem (Michon and de Foresta 1999). Farm diversification requires a holistic landscape approach. Diversifying a farm with woody crops involves intentionally integrating trees into the farming system. Practices are designed for the conditions and needs of specific parcels of land, to integrate and create interaction between crops and trees, and to use the management skills of the landowner. Such plantings meet landscape integration criteria for agroforestry. These woody perennials enhance biodiversity, diversify producer income, minimize risk, generate alternative profits, and create a more integrated and visually appealing land use system that may be more environmentally, economically, and socially sustainable than the original farm (Angima 2009). For example, converting 40 acres of marginal agricultural land to incorporate hybrid poplar, hazelnut, or Christmas trees through alley cropping, windbreaks, or other practices introduces trees and shrubs into the whole farm system. Research evaluating the level of resources and habitats for important beneficial insects has benefited some agroforestry systems (Russell 2013). Agroforestry practices also can increase beneficial insect habitat and resources. This diversified agroforestry approach may be particularly suitable to the smaller scale farms in the region. Diversified operations may be more resilient to weather variability caused by climate change.

Alley Cropping

Alley cropping is an agroforestry practice in which agricultural or horticultural crops are grown in the alleyways between widely spaced rows of woody plants. Alley cropping can diversify farm income, increase crop production, improve landscape aesthetics, enhance wildlife habitat, and provide protection and conservation benefits to crops. By combining annual and perennial crops that yield multiple products and profits at different times, a landowner can use available space, time, and resources more effectively. Although alley cropping can increase soil organic carbon, yield decreases to the primary crop grown between the rows can be significant, constraining the appeal of alley cropping (Seiter et al. 1999). Some hazelnut growers in the Northwest plant snap beans or other crops between newly planted trees (Hazelnut Marketing Board 2013). Apple growers in Hood River and the Willamette Valley historically planted strawberries between apple rows (Fortier 1940).

The Northwest's orchards and vineyards may provide some innovative opportunities for alley cropping systems, if growers are interested in adding crops for soil retention, pollination, or income production reasons. In particular, the extensive hazelnut orchards in the Northwest may allow for opportunities for alley cropping additional crops between the rows of existing or new orchards. Relatively few studies clearly show how alley cropping or agroforestry systems contribute to managing the risks from climatic variability, which include the potential to reduce available winter chilling days and crop yields. Luedeling et al. (2011) projected climate change effects on winter chill, an agroclimatic factor that affects agroforestry systems that include temperate fruit trees. These models project sufficient winter chill in the Northwest, which may shift more fruit growing to this region from regions that will not have sufficient winter chill. Concerns remain, however, about early bud break followed by a freeze that could potentially kill the developing buds or flowers. These concerns call for more research on fruit and nut trees' adaptations to climate change and also on the potential development of new or existing cultivars more resilient to these stressors.

Windbreaks

In some parts of the Northwest, particularly the Columbia River Gorge and coastal areas, windbreaks play an important role in protecting agricultural enterprises from harsh winds. This protection is particularly important for high-value crops

grown in the region, such as fruit, wine grapes, and vegetables. Livestock are also affected by wind. Hedgerows are also common in western Oregon, particularly among those landowners interested in sustainable farming methods. Oregon State University Cooperative Extension has released publications that suggest hedgerows can enhance the beauty, productivity, and biodiversity of farms in the region (Hobbs and McGrath 1998). Washington State University's Tree Fruit Research and Extension Center reported bees are more numerous in orchards having windbreak protection (Hanley and Kuhn 2003). Windbreaks are also used in the region as living snow fences to protect roads, communities, and livestock (Hanley and Kuhn 2003). With effective planting and management practices, it is possible to establish windbreaks and hedgerows to provide ecological and economic benefits to landowners and to address climate change in the Northwest.

Special Uses

Agroforestry practices can be designed to produce certain specialty products. Short-rotation biomass species are one specialty product that can be incorporated into agroforestry design. Advanced Hardwood Biofuels Northwest (AHB) grows hybrid poplar trees to demonstrate the latest biofuel development in the region. AHB is a "consortium of university and industry partners led by the University of Washington. AHB is working to prepare Washington, Oregon, Northern California, and Northern Idaho for a sustainable hardwood bioproducts and biofuels industry" (AHB 2014). The longer term goal is to develop poplar-based biofuels, including jet fuel, diesel, and gasoline that can supplement existing fossil fuels (AHB 2014). These species could be integrated into existing or new agroforestry systems.

Northwestern tribal communities are active in conserving and managing their natural resource base. This management is carried out in part through tribal natural resources agencies. Some of the agroforestry practices discussed in the region may overlap with TEK and management strategies. These practices may help preserve and maintain this TEK and can also provide substantial economic development and food sovereignty potential for tribal communities (Anderson 2007).

Problems and Limitations

Agroforestry is widely underexploited for both the production of goods and environmental services in the Northwest. Priorities include developing regional and site-specific practices and demonstrations of the ecological and economic performance of various agroforestry practices. The benefits of riparian buffers and effective planting strategies need to be developed and verified. Evaluation of options and impacts of the following should be assessed: (1) forest grazing compared with establishing silvopasture systems and (2) wild harvesting of nontimber forest products compared with forest farming.

Interest in agroforestry in the Northwest is expected to grow as increasing emphasis is placed on land stewardship and environmental protection in agroecosytems in the region. The potential of agroforestry to simultaneously provide economic, environmental, conservation, and social benefits is rapidly being recognized by Federal and State agencies, universities, and conservation organizations. Despite its potential, however, numerous barriers have impeded the development and application of agroforestry in the Northwest. The challenges surrounding agroforestry are that it is unconventional, lacks recognition, and cuts across agencies and disciplines. In addition, the large equipment used by producers in large-scale crop production may not be compatible with what is needed to install and maintain agroforestry practices. Agroforestry may also have higher labor requirements than existing large-scale crop-production systems. Current agroforestry research and development and related extension activities are limited, disconnected, and minimally funded in relation to the need and interest.

Agroforestry can address many important natural resource concerns in the region. Water-quality problems can be addressed with agroforestry practices such as riparian forest buffers that increase stream protection to reduce erosion, capture agricultural chemical pollutants, provide shade to cool stream temperatures, provide thermal protection for wildlife, and improve drinking water. Agroforestry practices used as climate-change adaptation and mitigation tools should be explored at the watershed and landscape levels to optimize integrated land-use systems and provide landowners with products and ecosystem services. Riparian buffers and hedgerows can provide habitat to improve the health of bees and other pollinators in the region. These pollinators are very important for food crop production, which is heavily centered on pollinator-dependent fruits and vegetables in some parts of the region. New markets can create opportunities for agroforestry products. For example, vineyards could have salmon-safe certification for their value-added products and edible fruits, and nontimber forest products could be grown in riparian areas. Agroforestry can also help with diversifying income sources for rural communities and make farmers more economically and ecologically resilient while coping with climate variability and change.

The Northwest faces some limitations specific to the region. The region is very diverse ecologically and agriculturally, which may limit the abilities of landowners from across this region to learn from one another. What practices and species work in one part of the region may not work in another part. This diversity may make the development of interest groups related to agroforestry more difficult. In addition, significant

portions of these States are publically owned. These forested areas largely cannot be managed using agroforestry practices, though recent interest in landscape-scale conservation may increase the appeal of agroforestry for its ability to work across landownerships.

Although riparian forest buffers are strongly encouraged because of salmon and other fish species concerns, some of these riparian buffers are "no touch" and do not allow for any harvesting. This policy may make their implementation more challenging and limit the integration of nontimber forest products into these buffers. The region also has a shortage of trained professionals in agroforestry to disseminate the many economic benefits and ecological services of agroforestry to landowners. Strengthening partnerships and cooperation among agencies and forming alliances among Federal, State, university, and private sectors will help develop, disseminate, and apply agroforestry. The establishment of the Pacific Northwest Agroforestry Working Group brings together agroforestry professionals to conduct joint research and training and will help remove the barriers between agencies and universities and create cooperation among scientists, natural resources professionals, and landowners.

Key Information Needs

- Ecological and economic performance of various agroforestry practices, as determined by site-specific research and demonstration.
- Site-specific adaptation of agroforestry practices by landowners that reflects the tremendous diversity of sites and conditions in the Northwest and limited technical resources.
- Benefits of riparian buffers and effective planting strategies among landowners.
- Long-term impacts of silvopasture and harvesting of nontimber forest products.
- Cultural practices for the sustainable production of nontimber forest products.
- Potential of alley cropping systems with existing and new growers.

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