

The Working Buffer Opportunity:

A proposal for ecologically sound and economical viable riparian buffers on agricultural lands



Photo Credit: United States Dept. of Agriculture

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Introduction

Individuals in environmental organizations, government agencies, and tribes along with fishermen and farmers throughout the Puget Sound region all recognize the importance of sustaining natural resources for future generations. In our managed landscapes, returning to pre-settlement conditions is neither feasible nor would it sustain our current population. We will need to work together to develop a mosaic of natural resource lands, farmlands, and urban areas that meet our needs and recover habitats. This is especially important as the impacts of climate change may begin to threaten our ability to harvest food, fiber and sustain fisheries.

Washington State ranks 17th in the nation for agricultural production, reaching \$9.89 billion in products in 2012. In Snohomish County alone, we have approximately 1,400 farms on over 70,500 acres of farmland. Agricultural production supports around 18,000 jobs in the state and \$2.2 billion in personal income (USDA 2014). Protection of Washington farmland is a performance metric for the state of Washington, and the stated goal of Snohomish County governance (Snohomish County 2005; WAGOV 2015).

The agriculture industry is not alone in relying on natural resources and contributing to community sustainability. Non-treaty commercial and recreational fishing in Washington, for example, supported over 15,000 jobs and \$540 million in personal income in 2006 (WDFW 2008). Providing fishing opportunities into the future was promised in treaties between tribal nations and the United States government (NWIFC 2011), yet our salmon populations are at a fraction of historic levels and several species are on the Endangered Species List.

Finding creative solutions that enhance Washington's natural resources and our ability to maintain both economically viable agriculture and healthy fish populations is critical to creating a thriving community.

Agricultural viability intersects with fish habitat recovery most strongly in the riparian zone of our streams and rivers. Privately owned farms are part of an economy and culture that spans four to six generations, with unique and irreplaceable economic and social value that is currently at risk (Snohomish County 2005; Canty et al. 2012). The lowland Puget Sound landscapes surrounding large rivers and streams where agricultural activities primarily occur are also vital to the recovery of threatened Puget Sound Chinook salmon (Montgomery et al. 2002; SBSRF 2005). Riparian management can mitigate the water quality impacts of farming and restore the stream structure that provides salmon habitat.

One reason for our failure to improve riparian management on agricultural lands is our traditional “no touch” approach to creating riparian zones. Farmers in Washington face high-risk and low profit margins so losing productive land to these no touch buffers is not always an economically feasible option. In addition, continued population growth increases pressure to convert working farms into large-lot rural estates in Western Washington. In the last 65 years, the Puget Sound region has lost 60 percent of its farmland, mostly to urbanization (Canty et al. 2012). Both farming and fish habitat advocates face the same development pressure and conflict as they try to control a dwindling land base.

In Snohomish County, more than 80 percent of farms are less than 50 acres in size. On these smaller farms, a no-touch riparian zone can take a large proportion of available land, creating a significant financial hardship. If we recognize the importance of agricultural land: 1) to our economy, 2) as the

alternative to urbanization, 3) as part of our cultural heritage, and 4) our source of food security, we must figure out how to improve fish habitat while increasing agricultural viability. These two activities must occur on the same landscape.

How can we find a way to help farmers thrive while at the same time recovering stream habitat to restore salmon populations? In a 2014 survey by American Farmland Trust and the Snohomish Conservation District, 64 primarily agricultural landowners living along streams in Snohomish and King Counties were asked if they would be willing to plant a riparian buffer. Only eight percent of respondents said “no”; the remaining answered “yes” or “maybe”. What then, are the barriers keeping 92 percent of our waterways from being planted with streamside vegetation? Survey respondents suggested that the main issues are: 1) limited awareness of incentive programs, 2) a desire to maintain control of their land, 3) mistrust of large distant government agencies, 4) potential loss of income, and 5) a lack of willingness to plant wide buffers that are required by many incentive programs.

One way to provide increased buffering functions on agricultural land is by integrating well-designed agroforestry and runoff management practices near water. Agroforestry is the incorporation of trees into crop or livestock farming to increase ecological functions, increase yield, and diversify farm income. Agroforestry systems can be designed to provide a mix of ecological services while allowing harvest. By implementing what we call “working buffers”, the functional width of buffers can be increased while continuing to allow farmers to control and derive income from their land.

This “working buffers” approach is based on a set of logical assumptions, informed by conservation values and our continuing review of available scientific evidence about riparian function. These assumptions are:

- We need to increase riparian zone functions to improve water quality and recover salmon.
- We want to sustain local agricultural production and economies, to preserve our open space, our culture, and to increase food security.
- Our current approach to improving riparian zone management is not working quickly or efficiently - public resources are limited as is landowner willingness to take land out of production.
- Increasing speed and efficiency of riparian zone enhancement will require collaboration between private streamside landowners and our public agencies. Collaboration requires developing shared interests, trust, and appropriate sharing of costs and risks.
- Good riparian zone management responds to the character of the site and combines the knowledge of ecologists with the knowledge and efficient stewardship of private landowners.
- Site specific design solutions that integrate conservation and agroforestry will be different than current practices and will require the experimentation and evolution in both agricultural and conservation techniques.

This paper explores the possibility of a “working buffers” approach. We discuss how water quality and habitat functions could be provided by the design of runoff management and agroforestry systems in the Puget Sound region.

Redefining Riparian Buffers

The term “riparian buffer” describes a vegetated strip that buffers the stream against the activities that lie beyond it. Both natural resource planners and farmers commonly assume that buffers must be composed of native forest vegetation, with the least possible intervention. A buffer is defined as a “no-touch zone” with a distinct boundary – agricultural practices only found beyond that boundary. A working buffers approach requires a broadening of this definition, a blurring of this distinct line between conservation and agriculture, and a more comprehensive approach to the design of buffering functions in agricultural landscapes.

Tremendous energy is expended debating the necessary width of a forested riparian buffer and the conditions under which landowners should be encouraged or required to plant these buffers. Meanwhile, the actual rate of riparian zone improvement is very slow and difficult to track. Federal programs designed to enhance riparian zone condition may not be achieving the desired impacts to recover fish populations (Breslow 2001; NWIFC 2011).

In the 2014 survey of landowners mentioned above, private streamside landowners within priority Chinook salmon recovery areas in Snohomish County were asked a variety of questions about their knowledge of and preferences on installing and managing riparian zones on their property (AFT and SCD 2014). Survey results suggest that:

- Most landowners were very unfamiliar with, or unaware of, the range of public programs to assist with riparian zone management.
- Most landowners would prefer to work with local groups, particularly the Conservation District, and 65 percent wanted to learn more about assistance programs.
- Only eight percent indicated that they were unwilling to plant a riparian buffer.
- 82 percent indicated they would like to retain ownership of their riparian lands.
- Willingness to plant a buffer decreased as buffer width increased.
- Those most willing to plant a buffer were involved in pasture production rather than crop production.
- 78 percent said they would be interested in having a buffer where they could retain some use like seasonal grazing, fuel or pole harvest, recreation, or non-timber forest product harvest.

These survey results do not apply to every farmer. They do suggest, however, that there may be fertile ground for designing a more flexible, dynamic, and hopefully successful approach to riparian restoration and management where ecology is mixed with agriculture in a “win-win” public-private partnership.

The Case for Flexible Buffer Widths

The prescription of fixed buffer widths for different types of streams is widely adopted for regulatory purposes. This approach can be easier to enforce especially for protecting existing riparian forest or establishing setbacks for construction. When considering restoration of impaired riparian zones where riparian vegetation would be newly planted, the fixed buffer width approach may not be feasible nor achieve the ecological function desired. Some authors suggest that a more site specific approach aimed at achieving distinct water quality or habitat functions may be a more effective approach (Castelle et al. 1994; Asbjornsen et al. 2013).

Haberstock et al. (2000), for example, outline an approach whereby the riparian buffer is divided into two management zones with a 35 foot low-disturbance zone next to the waterbody and then a zone of managed forest beyond that. They proposed that the width of the outer zone be based upon specific site conditions such as topography and soil characteristics. This approach would allow natural resource planners to determine the appropriate level of management in the second zone as well as the width needed to achieve water quality and habitat functions. It would also allow the landowner to derive economic return from production of timber and non-timber products in this zone.

Literature reviews on buffer width usually provide a range of widths rather than prescribing fixed buffer widths for specific water quality or habitat functions. The Environmental Law Institute compiled research from numerous studies to develop their *Planner's Guide to Wetland Buffers for Local Governments* (2008). Their findings indicate the wide range of recommended buffers show in Figure 1. Knutson and Naef (1997) found similarly varied buffer widths needed to provide a number of ecological functions shown in Table 1.

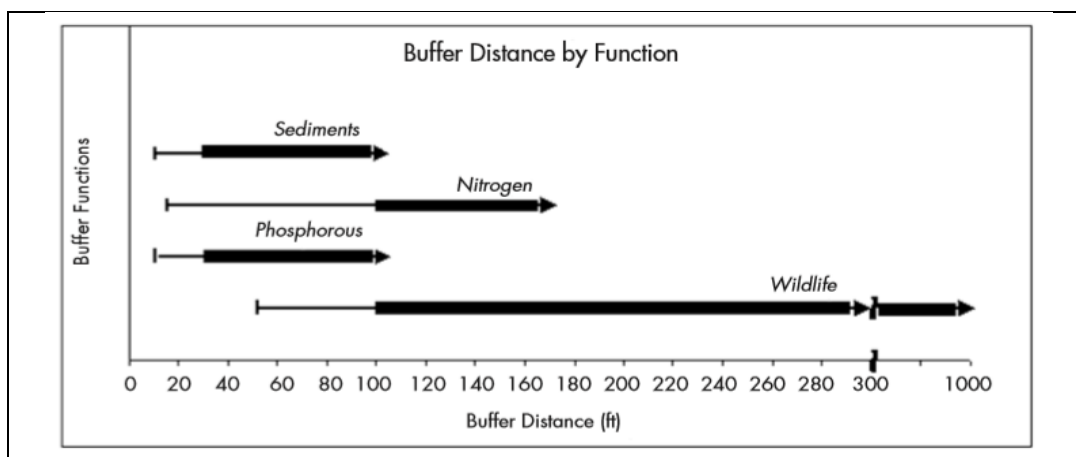


Figure 1: Recommended buffer widths from Environmental Law Institute, 2008.

Table 1: Riparian buffers widths appropriate to achieve function from Knutson and Naef, 1997.

Riparian habitat function	Range of reported widths in meters (feet)	Average of reported widths in meters (feet)
Temperature control	11-46 (35-151)	27 (90)
Large woody debris	30-61 (100-200)	45 (147)
Sediment filtration	8-91 (26-300)	42 (138)
Pollution filtration	4-183 (13-600)	24 (78)
Erosion control	30-38 (100-125)	34 (112)
Microclimate maintenance	61-160 (200-525)	126 (412)
Wildlife habitat	8-300 (25-984)	88 (287)

One reason for the disparity in buffer width recommendations is that buffer widths were difficult to correlate to ecological function. Many landscape characteristics can enhance or compromise buffer effectiveness. Buffer function can be affected by whether surface runoff is spread evenly as sheet flow through vegetation, the type of vegetation present, slope, soil infiltration rates, and the intensity of adjacent land-use practices (Hruby 2013). Studies that look at how different buffer widths filter sediment and pollutants indicate that soil type and subsurface soil characteristics affect function (Mayer et al. 2007; Dosskey et al. 2002). In addition, the ability of plants to uptake nutrients and of soils to decompose toxins is different between the growing season and dormant season.

While it is difficult to predict the buffer widths needed to achieve full function at a given site, narrower buffer widths do provide habitat and water quality functions. Figure 2 suggests that while buffer widths of one to three site potential tree heights achieve the maximum ecological functions, there are significant benefits achieved by smaller buffers as well (FEMAT 1993; Naimen et al. 2000).

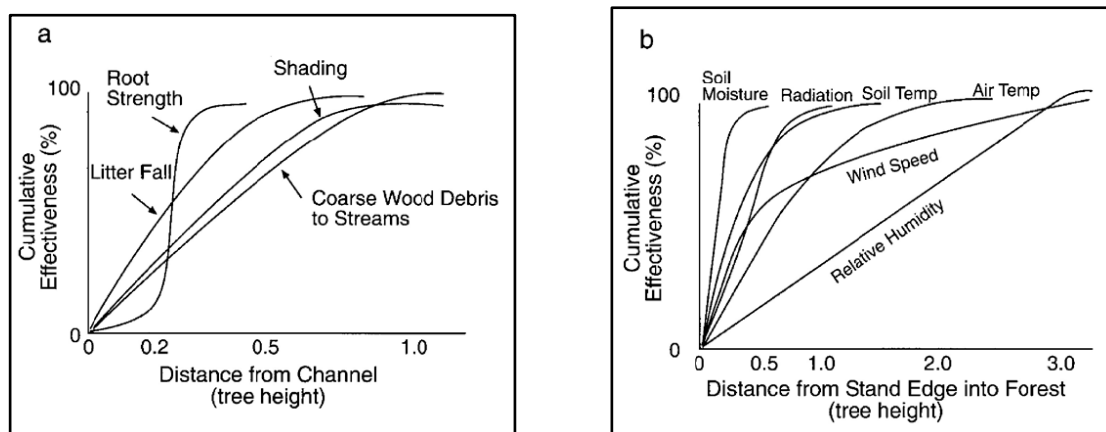


Figure 2: Functions provided by riparian buffers from Snohomish County (2006), adapted from FEMAT (1993) and Naimen et al. (2000).

Research into the buffer width required to maintain low stream temperatures illustrates the difficulties in prescribing fixed buffers. Sridhar et al. (2004) modeled ecological function to conclude that a 100 foot buffer with mature canopy next to the channel caused the greatest stream temperature reductions in the Beckler and Entiat Rivers, Washington. By contrast, an exploratory study by Benedict and Shaw (2012) found that densely planted narrow buffers (5-15 feet wide) in agricultural landscapes can provide effective shading and above-stream air temperature reductions similar to much larger buffers (35 to 180 feet wide). Air temperature is strongly correlated with stream temperature in several studies (Mohseni and Stefan 1999; Erickson and Stefan 2000; Morill et al. 2005).

The Critical Effects of Concentrated Flow

The ability of a riparian buffer to filter pollutants and infiltrate surface flows depends, in large part, on how much of the buffer land surface the water is actually flowing across. Dosskey et al. (2002) studied runoff from four crop farms in Nebraska and found that the effective buffer area (area that field runoff actually flowed across) varied from 6, 12, 40, and 81 percent of the total (gross) buffer area. They concluded that the degree to which flows were concentrated was actually more important than buffer width for trapping sediment (Figure 3). This points to the need to implement both dispersal and

infiltration practices on the landscape to reduce the amount of concentrated flow reaching surface waters.

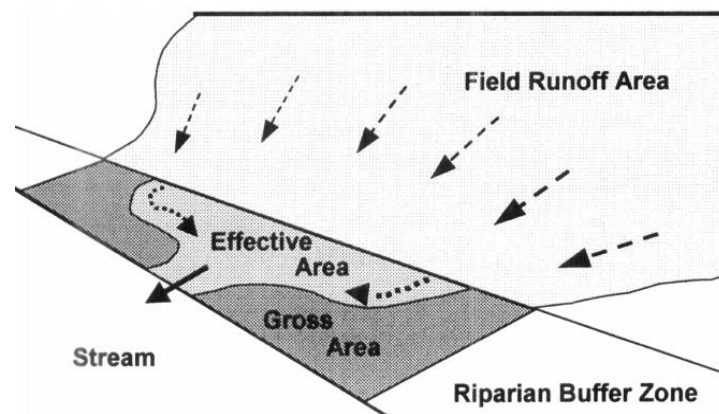


Figure 3: Diagram showing relationship between field runoff areas, gross riparian buffer area, and effective riparian buffer area from Dosskey et al., 2002.

A Proposal for Floodplain Design

We propose that a “one-size-fits-all” approach to riparian buffer design is not as effective as a site-specific design approach. The intensity of farming practices near a stream is a large factor in determining the need for water quality buffering. The potential for channel migration affects the area needed to support stream processes and habitat. Varied topography and soil texture strongly affects patterns of surface runoff and pollutant transport differently at the field and landscape scale. Soil ecology and harvest cycles can affect the ability to absorb and sequester nutrients. It therefore follows that natural resource planners may want to look at current farming practices and potential pollution types, landscape topography and hydraulics and their corresponding soil types, the migration and habitat needs of the stream segment, and the interests of the landowner to design a buffering approach that increases ecological functions while providing agricultural value.

Such an approach could combine on-farm runoff management with a flexible-width, two-zone approach for buffer design (Figure 4):

The Riparian Buffer Zone – An inner riparian zone is used to enhance the physical, structural, and biological character of stream habitats. This zone is immediately adjacent to the stream channel and uses the appropriate vegetation to maximize the ecological functions needed for that particular reach (e.g. shade to water, source of litter input, bank stability, and wood recruitment). Low impact harvest could be integrated into the Riparian Buffer Zone (e.g. small fruit, wild greens, boughs, and mushrooms). Timber or pole harvest could be integrated as part of a plan for long-term forest succession (e.g. alder thinning and conifer underplanting). Riparian Buffer Zones are dynamic and may integrate areas acquired by the public for protection or managed by the landowner for recreational purposes.

The Working Buffer Zone – An outer Working Buffer Zone is focused on infiltrating landscape runoff into the soil and breaking down pollutants. This zone is immediately beyond the Riparian Buffer Zone and protects stream habitat functions and mitigates water quality while also providing a source of revenue to the landowner. This zone is managed in large part to filter and remove pathogens,

nutrients, and toxins from the surrounding area by spreading and infiltrating surface runoff before it reaches the Riparian Buffer Zone as concentrated flow.

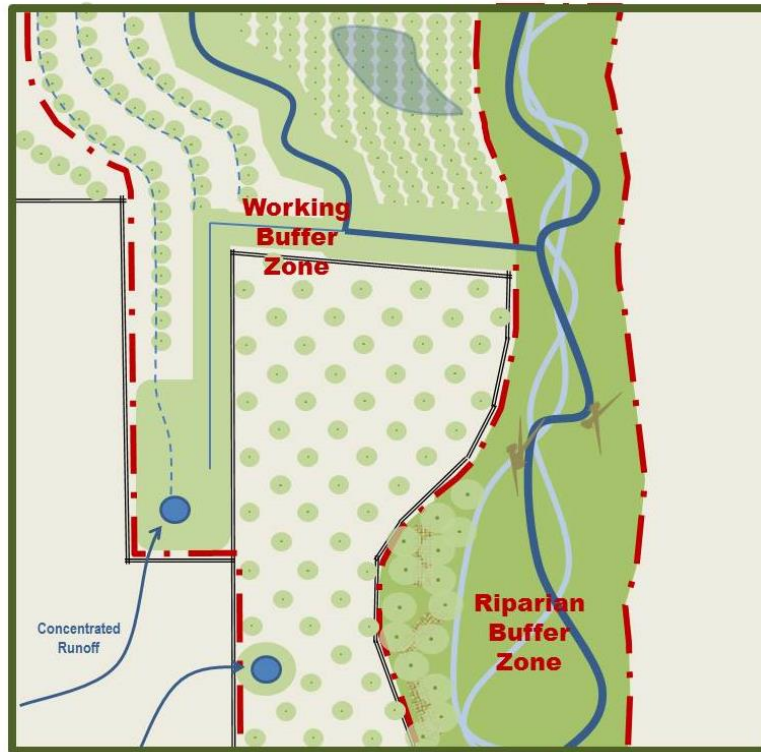


Figure 4: Conceptual model of integrated design using a Riparian Buffer Zone, Working Buffer Zones, and integrated runoff management.

It is critical to incorporate best management practices adjacent to or within the Working Buffer Zone that will improve the effectiveness of the planted buffer by dispersing or infiltrating surface flows. The Natural Resource Conservation Service (2015) identifies several agricultural practices that, when implemented, can reduce concentrated flow and associated erosion:

- **Water spreading** – Contour or near-contour swales can be used to distribute surface runoff for infiltration in drier areas of a property. Level spreader structures or grass filter strips can be used to distribute flow into a buffer.
- **Wetland enhancement, creation and restoration** – Where concentrated flow is inevitable, constructed seasonal wetlands (perhaps associated with biomass production) can infiltrate and denitrify runoff.
- **Water and sediment control basin** – Swales and water detention basins slow runoff, increase soil infiltration and reduce sedimentation across a landscape. Vegetation in control basins can be harvested to further remove nutrients stored in soil after infiltration.
- **Contour farming** – Runoff and soil erosion can be slowed by preparing, planting, and cultivating land on slope contours. Contour buffer strips, narrow strips of permanent, herbaceous vegetation spread out across the farm, also help to slow and disperse surface flows.

What is a Working Buffer?

A “working buffer” is a way of extending the width of a traditional riparian buffer to provide benefits to both natural resources and the farmer through use of agroforestry practices. Simply put, a working buffer is the addition of trees to an area that is still used for agricultural purposes. The USDA defines the term “agroforestry” as the addition of agronomically productive trees to traditional farming involving either crops or livestock. While agroforestry techniques are used all over the world, we propose use of these techniques specifically within floodplains and riparian corridors to increase ecological function of our managed landscape. The following are types of agroforestry practices that could be incorporated into the Working Buffer Zone (explained in more detail in the attached Templates):

- **Forest Farming** – cultivation of specialty crops under a forest canopy. The forest canopy can be managed to provide the appropriate amount of shade as well as timber products through thinning, though constant forested canopy is always maintained. Crops that can be farmed under the canopy include mushrooms, medical plants, nursery cuttings, and ornamental plants. Forest farming can produce large woody debris, shade, and biotic inputs. Selective thinning can provide high-value saw logs and understory crops may include high-value specialty products.
- **Alley Cropping** – growing an annual or perennial agricultural crop simultaneously with a long-term woody crop, both in rows, typically on contour. The trees or shrubs can be harvested for nuts or fruit or be harvested themselves for high-value lumber or veneer logs. Agricultural crops between rows of trees can include corn, hay, or other cultivated crops. Woody crop rows, particularly when combined with water spreading earthworks, provide greater soil development, intercepting and percolating runoff, and increasing the beneficial capture of nutrients. Both the woody crop and the field crop may have economic value.
- **Silvopasture** – grazing livestock under a savannah or woodland canopy. The canopy is managed for timber or fruit/nut production while the understory is managed for seasonal and rotational livestock forage. The canopy may be distributed, clumped, or on contour and associated with fencing or water spreading earthworks. Woody plants increase soil porosity and depth, improving percolation and filtration. The tree canopy and associated soil health benefits may improve pasture quality and yield.
- **Short Rotation Biomass** – Frequently harvested fast-growing trees or shrubs that stump-sprout (coppice) are harvested for biomass. Willow, cottonwood, or hybrid poplar can provide biomass for biofuel, combustion, paper pulp, livestock bedding or feed, or a number of other uses. Historically common throughout Europe, coppice can be grown in seasonally flooded situations, unsuited for tillage or grazing, and provide a yield while establishing nearly permanent shrub land habitat.

These practices are part of a dynamic design for a riparian area that may change over time as trees mature. For example, silvopasture and rotational grazing practices may help control competing Eurasian pasture species during initial tree establishment. As the canopy develops, management may shift to forest farming. Thinning and gap harvests may introduce native species used for specialty products. The finished result may be a multistory native forest with high-value species in the understory.

There are certainly barriers to managing working buffers. These practices are not familiar to farm planners or many farmers. Some markets for working buffer products are untested, unproven, or require development and many farming businesses cannot afford to invest in a new product line without financial assistance.

Early adoption, however, may be supported where working buffers and their products can be easily integrated into existing farm operations and where financial incentives are provided to buffer economic risk. For example, grazing operations may benefit from rotational grazing in a silvopasture or dairies may use biomass for bedding or forage. Federal Farm Bill subsidies for agricultural development may subsidize capital costs and reduce risks for innovative farmers, while more effectively directing farm bill money toward improving the functions of riparian ecosystems.

Benefits of Working Buffers for Climate Change Adaptation

Working buffers provide a number of benefits that increase the viability of our agricultural communities as well as the health of our natural resources, especially in the face of a changing climate. Climate models for the Pacific Northwest predict that we will experience flashier, more intense flooding in winter months and higher temperatures with less rainfall in summer months (CIG 2013). These changes have the potential to adversely impact our already endangered salmon runs as well as cause hardship on our agricultural communities.

Incorporating agroforestry techniques into our landscapes can mitigate the effects of climate change and offer farmers tools to adapt to increased flooding and drought (Schoeneberger et al. 2012). Table 2 illustrates ways agroforestry sequesters carbon, reduces greenhouse gas emissions, allows for species migration, and increases the resilience of agriculture (Schoeneberger et al. 2012). In addition to functions that help farmers adapt to potential droughts and flooding, adding working buffer techniques to their farm increases diversification of products and can reduce economic risk.

Climate change activity*	Major climate change functions	Agroforestry functions that support climate change mitigation and adaptation
Mitigation		
Activities that reduce GHGs in the atmosphere or enhance the storage of GHGs stored in ecosystems	Sequester carbon	Accumulate C in woody biomass Accumulate C in soil
	Reduce GHG emissions	Reduce fossil fuel consumption: Reduce equipment runs in areas with trees Reduce farmstead heating and cooling Reduce CO ₂ emissions from farmstead structures Reduce N ₂ O emissions: By greater nutrient uptake through plant diversity By reduced N fertilizer application in tree component Enhance forage quality, thereby reducing CH ₄
Adaptation		
Actions to reduce or eliminate the negative effects of climate change or take advantage of the positive effects	Reduce threats and enhance resilience	Alter microclimate to reduce impact of extreme weather events on crop production Alter microclimate to maintain quality and quantity of forage production Alter microclimate to reduce livestock stress Provide greater habitat diversity to support organisms (e.g., native pollinators, beneficial insects) Provide greater structural and functional diversity to maintain and protect natural resource services Create diversified production opportunities to reduce risk under fluctuating climate
	Allow species to migrate to more favorable conditions	Provide travel corridors for species migration

* Definitions from Ontario Ministry of Natural Resources, http://www.mnr.gov.on.ca/en/Business/ClimateChange/2ColumnSubPage/STDPROD_090121.html.

Notes: GHG = greenhouse gas. C = carbon. CO₂ = carbon dioxide. N₂O = nitrous oxide. CH₄ = methane.

Table 2: Agroforestry has the potential to provide mitigation and adaptation benefits in a changing climate (from Schoeneberger et al. 2012).

Regulation and Working Buffers

One rationale for adopting simple “no touch” fixed-width buffers is the supposed ease of enforcement. There is certainly a practical appeal to managing critical areas without having to rely on the willingness of landowners and easily verify buffer width upon inspection. What may be lost in that approach, however, is the actual purpose of riparian zone management—the enhancement of fish habitat and water quality at a watershed scale.

Protection of habitat, recovery of fish populations, and improved water quality are all goals that emerge at a larger scale than the individual parcel. Piecemeal implementation of conservation may fail to change the course of ecosystem degradation. Individual buffers that don’t recognize how water is moving in the landscape may meet fixed-width criteria, and still not resolve an acute resource concern.

We have approximately 150 lowland sub-basins throughout Puget Sound. Each of these sub-basins offers an opportunity to achieve the vision of ecosystem recovery—an end to the downward spiral of aquatic ecosystem degradation. In each of these systems, the land best suited for growing food is intermixed with the land best suited to producing fish. We propose that the best outcome is one where we are able to maintain agricultural production by using methods that also protect and enhance fish habitat and water quality.

Conclusion

We do not propose that working buffers are fitted to all situations, or that agroforestry techniques will restore all ecological functions and resolve all conflicts. We do, however, consider working buffers a vital component of a watershed strategy that could foster partnership between farmers in the business of growing food and public agents working to restore aquatic ecosystems.

Agricultural sub-basins and floodplains provide an opportunity to develop land-use patterns that provide necessary habitat for humans and fish. This sustainable land-use pattern will involve farming as the primary land-use alongside areas set aside for habitat. These farms will need to be economically viable. Unlike government agents, farmers face painfully simple economics. They must make a profit to survive and the easiest way out is to sell land for development. Working buffers offer an opportunity to enter into a public-private partnership for ecosystem stewardship and economically viable farms. This proposal is an attempt to begin exploring this possibility.

This process will require experimentation, flexibility and accountability. We may need to identify specific areas where we test the viability of working buffers. In those trial areas, we will need to decide who designs and manages working buffers. We will need to consider who bears the costs and risks, and who earns the profits. And we will need to evaluate if this approach is effective. These explorations ultimately offer us an irreplaceable value—cultivating and placing the responsibility of stewardship among the people who actually live next to our streams.

Attachments

Attached are four templates that describe four agroforestry practices: Forest Farming, Alley Cropping, Silvopasture and Short Rotation Biomass production. The templates detail the ecological benefits provided by each practice, guidance on when to prescribe each practice, and information on the plant species that can be installed and how to manage them.

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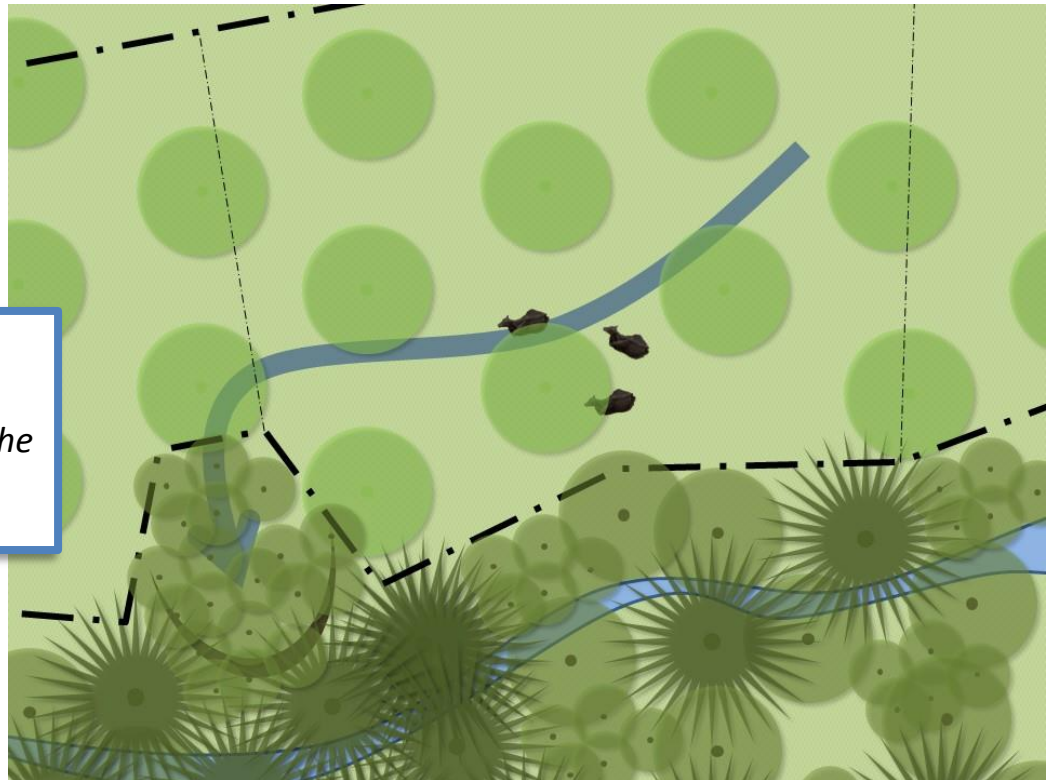
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Silvopasture

"Silvopasture is the integration of trees and livestock operations on the same ground."



Description:

Silvopasture is the deliberate integration of trees and livestock operations on the same ground. Well managed silvopastures employ agronomic principals, typically including introduced or native pasture grasses, nitrogen-fixing legumes, and managed intensive grazing (MIG) systems applying short grazing periods which maximize vegetative plant growth and harvest (Garrett et al., 2004; Hamilton, 2008; Brantly, 2013). The tree canopy is managed for timber, fruit/nut production, or any combination of forest products. By stacking grazing and forage production systems with canopy forest products, producers can maximize and diversify their agricultural operations within close proximity to riparian corridors while providing the ecosystem services to meet environmental conservation goals.

Placement and management of silvopasture systems is specific to the site conditions and landowner needs. This strategy is not intended to replace a properly functioning, closed canopy riparian forested buffer, rather, the goal is to provide a way for the landowner to increase the buffer size and function while at the same time realizing economic benefits. Silvopasture can be a long-term management strategy or it can be a short-term approach to controlling competing vegetation during establishment of a forest canopy.

In silvopasture, livestock are used to manage the vegetative dynamics of this agro-ecosystem through short and low intensity grazing periods, much like the migratory nature of large mammal species found in natural savannas. This ensures the continued and rapid regrowth of dense understory vegetation, sequestering and cycling the additions of nutrients and enhancing the biological process within the upper soil horizon. This

process increases the productive period of the forage plants during the dry season, extending overall site productivity and biological processes that can be supportive to riparian ecosystem habitat and functionality.

Conservation Benefits

The implementation of silvopasture management within a riparian zone provides a unique opportunity for landowners to maintain livestock operations while providing shade, leaf litter, carbon storage, and the water quality enhancement capabilities of trees along riparian corridors. Though livestock can create sediment and fecal coliform pollution if managed improperly, research has shown that proper integration of silvopasture techniques with riparian buffers along the stream, exclusion fencing, and grazing management can provide numerous environmental benefits:

Benefits of trees:

- Incorporating deep rooting trees into a pasture landscape diversifies rooting depths and increases nutrient and water uptake (Hooper and Vitousek, 1997).
- Tall trees provide shade to both the stream, keeping water temperatures cool for fish, and the pasture. Shading the pasture during droughty conditions increases soil moisture and the length of the growing season, allowing for increased nutrient uptake.
- From a structural perspective, during flood or winter storm events, trees within pastures slow moving surface water and encourage infiltration thereby reducing fecal matter and nutrient runoff (Michel et al., 2007; Jose, 2009). Rows of trees planted either on contour or parallel to the riparian channel can provide a physical barrier to pollutants moving toward a waterway.
- Incorporating trees into the agricultural landscape increases carbon sequestration both above and below ground (Schoeneberger et al., 2012).
- A forest with an open understory creates a unique natural habitat that can enhance nesting site potential (ground and aerial nesting sites), movement of migratory mammals, and increases flowering of trees and shrubs for pollinator habitat when compared to open pasture systems (Garrett et al., 2004; Hinsely and Bellamy, 2000; Varah et al., 2013). Trees provide birds with refuge, shelter and forage sites. Bald eagles feeding on salmon carcasses can bring salmon and their nutrients further into the pasture settings aiding in upland fertility.

Benefits of grasses and other forage crops:

- Grasses and other understory forage species have a much longer productive period than woody shrubs and trees as well as much more rapid vegetative growth. As such, forage grasses that are buffered from summer droughty conditions yet allowed full winter sun potential under a deciduous tree canopy have the potential for increased nutrient uptake as compared to native forest understory (Sovell et al., 2000).
- Well managed pasture grasses have deep soils that are rich in organic matter where healthy microbial systems filter pollutants before they reach surface waters.
- The high stem density of grasses spreads surface flows, reducing concentrated flow paths and allowing for greater water infiltration, pollutant removal, and nutrient uptake. Proper rotational grazing,

whether on open pastures or under a sparse tree canopy, has been shown to reduce fine sediment and fecal loading into surface waters more than traditional exclusion fencing (Sovell et al., 2000; Lyons et al., 2000).

- In a well-managed and long-term rotational grazing system, nutrient removal can be achieved through livestock consumption or harvest of forage grasses.

Landowner Benefits

Silvopasture provides farmers reduced economic risk by managing for three enterprises on the same land: tree crop, livestock, and forage. In addition:

- Trees provide livestock shelter from summer heat while diversifying their diet. Current research nationwide is showing increased weight gain, calve/kidding success rates, and milk production when livestock are produced in silvopasture scenarios (Angima, 2009; Garrett et al., 2004).
- Properly managed rotational grazing systems provide an opportunity to increase animal stocking rates, even on seasonally grazed sites, by maximizing forage growth throughout the season (Hancock and Anrae, 2009; Nygard, 2014).
- A canopy tree crop can increase the nutritive quality of the forage, which compensates for the slight decrease in forage productivity, translating to higher livestock growth rates (Garrett et al., 2004; Kallenback et al., 2006; Moreno, 2008).
- A canopy also provides the potential for extending the growing season of forage or hay due to increased soil moisture and shade during droughty summer months (Kallenback et al., 2006; Feldhake 2001 and 2002).
- If the goal is to develop a timber stand in the long-term, livestock can be used to reduce labor and cost for weed and grass suppression, while increasing tree growth productivity (Burner, 2003).



Design and Implementation

Design, implementation and management of silvopasture systems are always defined by site environmental conditions matched to the landowner's economic goals and management interests. The intent with silvopasture systems is to integrate livestock and forage production with long-term forest establishment. Though the intent is not to remove livestock from agricultural operations, this technique can be used as a successional management tool leading towards a focus on tree crops while providing economic gains in the

short-term through livestock sales. In this instance, highly monitored and flash grazing practices can be allowed in the first year or two of riparian buffer plantings to reduce competition

Livestock Selection:

- *Marketable*
- *Best suited to tree crops and forage*
- *Able to be intensively managed*

between grasses and early pioneer woody perennials, while also selectively managing for invasive weeds.

Consideration for weed pressures, proximity to streambank, flood potential, and types of trees should be considered when selecting livestock type and rotation scheduling. Long-term silvopasture grazing systems should be implemented no closer than 35ft from the top of bank within a riparian zone and should be implemented in conjunction with a forested riparian buffer along the water course to ensure water quality benefits are achieved. As such, fencing should be installed along boundaries of the silvopasture to exclude livestock from the riparian buffer along the stream and also to allow proper rotational grazing.

Silvopasture systems are most successful on well-drained upland areas that are not prone to seasonal flooding to prevent manure from moving directly into riparian corridors. To reduce surface runoff, trees should be planted using techniques to prevent movement of manure solids and nutrients into surface flow (i.e on contours of slope, on parallel to riparian vegetation zone, or perpendicular to concentrated flow paths).

Timing of grazing is important to maintain vigorous growth of the forage during the growing season but also to reduce mud and soil compaction from overgrazing or grazing during the rainy season. The practice of silvopasture in the Pacific Northwest is new and provides for a wealth of innovation and niche market development opportunities for the landowner. This, of course, presents the challenge of designing each specific component of the silvopasture scenario to work in conjunction with the natural resources influencing the site and the intended products to be managed for.

Trees will need to be protected in their early development.

Electric/temporary or permanent fencing may be required to keep livestock from browsing on terminal buds. In some cases, it may be best to remove livestock grazing during the first few years of tree growth. During this time, cutting the forage for livestock feed can still be used to manage understory growth and provide needed on-farm feed or income.

Tree Selection:

- *Marketability*
- *High Quality*
- *Fast Growing*
- *Deep Rooted*
- *Site and Climate Tolerant*
- *Produces Light Shade*

Placement of trees will depend on the landscape and the intended cropping system. On sloped land, trees placed in rows are best suited to capture runoff and reduce soil erosion. Rows may also aid in tree crop harvest, management of tree growth and management of grazing patterns. Trees should be spaced to provide even shade coverage for livestock and forage, maximize tree growth, and allow ripening of fruit or nut crops.

Suitable Tree Species for PNW Silvopasture

Common Name	Family	Genus	Harvestable Material	Notes
Well Drained Soils				
Douglas-fir	<i>Pinaceae</i>	<i>Pseudotsuga</i>	Trees	Christmas trees
Chestnuts	<i>Fagaceae</i>	<i>Castanea</i>	Nuts	High value nut and timber
Butternuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber
Black Walnut	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber
Filberts	<i>Betulaceae</i>	<i>Corylus</i>	Nuts	High value nut crop
Stone Pines	<i>Pinaceae</i>	<i>Pinus</i>	Nuts	High value nut
Domestic Apple	<i>Roseaceae</i>	<i>Malus</i>	Fruit	Cider production

Wetter Conditions				
Spruce (all species)	<i>Pinaceae</i>		Ornamental/Timber	Large market and distribution available
Western Red Cedar	<i>Cupressaceae</i>	<i>Thuja</i>	Boughs/Timber	Large market and distribution available
Alder	<i>Betulaceae</i>	<i>Alnus</i>	Timber and Syrup	Furniture, firewood and syrup
Birch	<i>Betulaceae</i>	<i>Betula</i>	Timber and Syrup	Furniture, firewood and syrup
Hybrid Poplar/Cottonwood	<i>Salicaceae</i>	<i>Populus</i>	Timber and Syrup	Biomass, firewood and syrup
Cascara	<i>Rhamnaceae</i>	<i>Rhamnus</i>	Medicinal bark	Large market and distribution available
Heartnuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber
Elderberry	<i>Caprifoliaceae</i>	<i>Sambucus</i>	Fruit	High value fruit
Crabapple	<i>Roseaceae</i>	<i>Malus</i>	Rootstock	Grafter to high value fruit
Pear	<i>Roseaceae</i>	<i>Pyrus</i>	Fruit	Cider production source
Plum	<i>Roseaceae</i>	<i>Prunus</i>	Fruit	Local high value fruit
Cherry	<i>Roseaceae</i>	<i>Prunus</i>	Fruit/Timber	High value fruit and hardwood
Quince	<i>Roseaceae</i>	<i>Cydonia</i>	Fruit	High value fruit
Fig	<i>Moraceae</i>	<i>Ficus</i>	Fruit	High value fruit
Mulberries	<i>Moraceae</i>	<i>Morus</i>	Fruit	Great mast crop and high value fruit

Pacific Northwest Production Models:

Various livestock species can be matched with a diverse array of tree crops depending on the operator's goals. All species of livestock production, including chickens, pigs, cattle, sheep, goats, and horses, can benefit greatly from the integration of tree crops.

Chestnuts (*Castanea Spp.*): Chestnut production is a potential high-value cropping system for the Pacific Northwest. Traditionally, chestnuts have been used worldwide for flour for pasta and bread as well as beer making. It is currently recognized as a gluten-free substitute for many wheat products. Demand for chestnuts is growing in the US and high-productivity, low maintenance and relatively short planting to harvest time makes this a viable alternative crop particularly when matched with livestock production. The Washington Chestnut Company in Everson, WA started commercially harvesting chestnuts on 4 year old trees in the Skagit Valley floodplain with an expected average yield of 2,000 lbs per acre (Hilgart, 2014). Given ideal conditions, 3,000-4,000 tons can be realized. Currently, chestnuts are selling for \$3.60/lb wholesale and upwards to \$8.00/lb retail (Hilgart, 2014). Allen Creek Farm in Ridgefield, WA currently sells their harvest for between \$5.75/lb and \$8.00/lb depending on nut size (ChestnutsOnline.com). As chestnut harvest occurs between late September and early December, livestock can still be maintained as the primary use of the landscape during spring and summer months.

Agricultural Production

Tree crops:

- Timber
- Firewood
- Fruit/Nut crops

Livestock production:

- Improved pasture and hay production

Additional economic opportunities:

- Recreation, hunting and fishing leases
- Conservation incentive programs

Alder (*Alnus Spp.*): Alder is an ideal candidate for many different working buffer techniques including silvopasture. Preferring disturbed and wet soils, alder can be used along riparian corridors, drained wetlands,

or floodplains with shallow water tables. The nitrogen fixing capability of alder makes this species well suited for restoring highly degraded pastures or grasslands that are poor in fertility and soil structure. It can be harvested and sold for a multitude of uses and at various stages of growth. As timber, alder has been desired as a cabinetry or furniture wood currently valued at over \$800/thousand board feet (MBF) for logs greater than 12 inches in diameter, achievable in a 25 year time frame (Wick, 2015; Scott, 2003). On a shorter rotation, alder can be used for mulch (on-farm), packaged as green shavings for horse and livestock bedding (retail \$38 for 1/3 cubic yard on smallcrop.com), “value-added” for smoking meats, or used to cultivate mushrooms from plug spawn (branches) or sawdust inoculations (\$7.50/10 lb bag on Fungi.com). Due to the low tannin and lignin structure found in alder sawdust, livestock operators, large-scale composters and mushroom producers are seeking alder sawdust resources nationwide.

Financial Assistance and Cost-Share Opportunities

Financial assistance in the form of cost-share funds or public subsidies can aid landowners interested in implementing silvopasture management practices. Agencies currently equipped to provide this funding, including implementation funds and technical assistance, can be secured through the following agencies and programs:

- Conservation Districts – Local conservation districts can help to provide technical assistance and planning, and seek funds through the Washington State Conservation Commission and other local funding sources.
- National Resource Conservation Service (NRCS) – EQIP and CSP programs. Contact your regional NRCS Field technician for application details: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/wa/contact/local/>

Sources of Funding and Assistance

- USDA Farm Service Agency – Conservation Reserve Enhancement Program (CREP)
- NRCS – Environmental Quality Improvement Program (EQIP)
- NRCS – Conservation Stewardship Program (CSP)
- Washington Conservation Commission – Livestock and Shellfish Funding Programs
- Department of Ecology – Pollution Identification and Correction (PIC) program
- Local Conservation District, NGO, and other Environmental Protection Partnerships

Approved WA NRCS Best Management Practice Standards:

The NRCS provides Best Management Practice (BMP) standards for Washington State to ensure cost-share subsidies are used appropriately for the natural resource concerns to be addressed. The following NRCS BMP standards have been developed in accordance to state environmental policy specifically addressing natural resources management within agricultural landscapes:

Silvopasture (381): Establishing tree species in a silvopasture setting that have a potential to yield wood products, are conducive to high nutrient uptake, provide wildlife habitat and are planted to ensure water and soil conservation. Resources are also provided to install highly productive forage species. Prescribed Grazing (582) must be implemented to ensure successful implementation and environmental benefits.

Prescribed Grazing (582): Developing and implementing a prescribed grazing plan to meet the silvopasture production scenario. This plan will provide the operator with technical assistance and monitoring to ensure livestock forage and production is maximized while conserving on-site natural resources.

Plant Enhancement Activity – PLT18 – Increasing on-farm food production with edible woody buffer landscapes: As part of the their Conservation Stewardship Program, NRCS has recently added this enhancement funding source to provide resources for enhancing windbreaks, alley cropping, silvopasture and riparian forested buffers with trees and shrubs that provide food for human and wildlife consumption.

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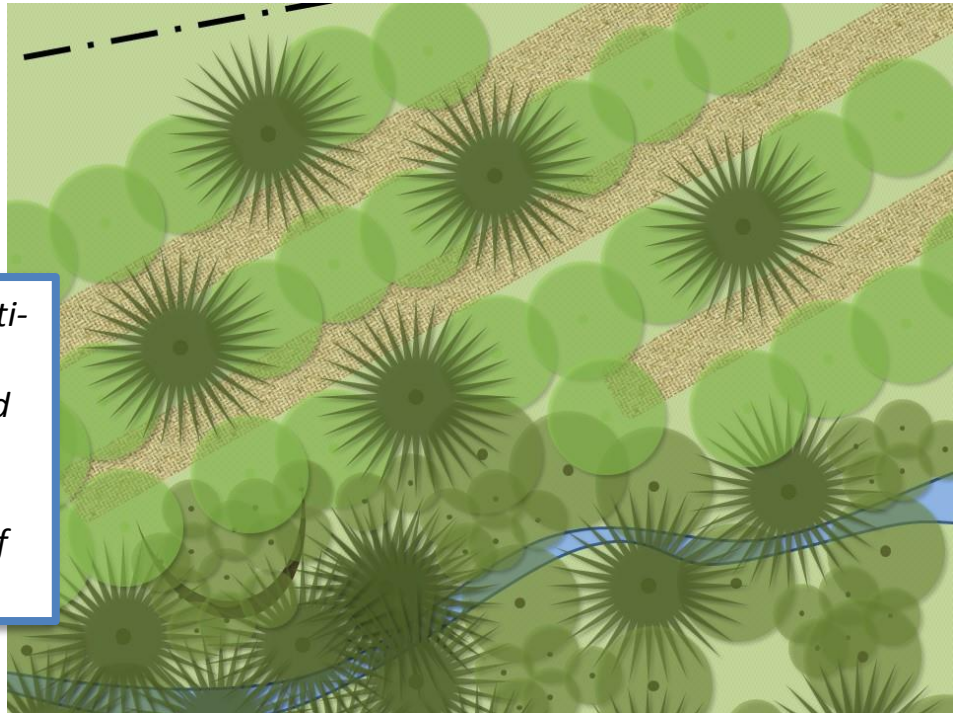
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Forest Farming

*"**Forest Farming** is a multi-story cropping system where trees are managed as an overstory with an understory of plants that are grown for a variety of products."*



Description:

Forest Farming or Multi-Story Cropping is the production model that most closely resembles a natural riparian forest, yet provides the opportunity for a farmer to diversify agricultural operations by harvesting both a tree crop and an understory crop. A tree canopy is managed for timber or fruit/nut production or boughs. The understory typically consists of shade-tolerant niche market crops such as medicinal herbs, mushrooms, or greens for the floral market. Establishment of this management system where a tree canopy is not already present, however, presents a multitude of opportunities to grow products at different successional stages of forest development. For example, berries can be grown and harvested during early succession when trees are not yet providing full shade. Farmers may also choose to employ alley cropping or silvopasture working buffer techniques to control weeds and generate income until trees mature and a shaded understory habitat is fully realized.

Depending on the intensity of management and harvest in a Forest Farming system, a riparian buffer may or may not be prescribed between the stream or river and the Forest Farming zone. Forest Farming can be a way for the landowner to increase the riparian buffer size and function while at the same time realizing economic benefits from the land.

Conservation Benefits:

Forest Farming provides landowners with the opportunity to manage a forest and understory for production, while providing the environmental benefits associated with the incorporation of trees and shrubs near stream corridors: shade, microclimate, leaf litter, carbon storage, wildlife habitat, and pollutant filtration. Though management techniques such as thinning of timber, control of understory vegetation, and potential application of pesticides can negatively impact riparian habitat, the proper integration of forest farming techniques with riparian buffers along the stream can provide numerous environmental benefits:

- Incorporating deep rooting trees into agricultural landscapes diversifies rooting depths and increases nutrient and water uptake (Hooper and Vitousek, 1997).
- From a structural perspective, during flood or winter storm events, trees slow moving surface water and encourage infiltration thereby reducing sediment, nutrient, and chemical pollutant runoff (Michel et al., 2007; Jose, 2009). Rows of trees planted either on contour or parallel to the riparian channel can provide a physical barrier to pollutants moving toward a waterway.
- Trees and shrubs provide shade to the stream, maintaining cool water temperatures for fish.
- Incorporating trees into the agricultural landscape increases carbon sequestration both above and below ground (Schoeneberger et al., 2012).
- A forest with an open understory (optional in this management system) creates a unique natural habitat that can enhance nesting site potential (ground and aerial nesting sites), movement of migratory mammals, and increases flowering of trees and shrubs for pollinator habitat when compared to open pasture systems (Garrett et al., 2004; Hinsely and Bellamy, 2000; Varah et al., 2013).
- Trees provide birds with refuge, shelter and forage sites. Bald eagles feeding on salmon carcasses can bring salmon and their nutrients further into the fields aiding in upland fertility.

Landowner Benefits:

Forest farming provides farmers reduced economic risk by managing for a multitude of potential enterprises or personal uses on the same land: timber, high-value medicinals, nursery cuttings, boughs, berries, nuts, mushrooms, etc. In addition:

- Diversifying agricultural revenue sources can provide economic security in the face of potential floods and droughts due to climate change (Schoeneberger et al., 2012).
- Farmers can more intensively manage the understory of the forest to control weeds and reduce competition with the tree crop or adjacent agricultural operations.
- Trees and woody vegetation can increase soil moisture by reducing the evapotranspiration effects of wind, providing shade at certain times of the day, and increasing soil organic matter inputs that can positively affect adjacent agricultural fields (Cleugh, 1998).
- During floods, trees act as a “fence” to trap large wood from the river that would otherwise be deposited on fields or damage fencing.
- Depending on the system, the timing of management, harvest and labor can be staggered throughout the year to provide for year-round income and farm labor employment.

- The Forest Farming systems can provide nesting habitat for both pollinators and predatory insects thus improving the yields of annual crops and reducing the need for pesticides.

Design and Implementation:

The design and implementation of forest farming cropping scenarios is highly dependent on the successional stage and/or health of the existing vegetation where you want to employ this strategy. In general, there are two scenarios we expect most farmers to encounter: planting a forest where none currently exists or modifying an existing riparian buffer where management could improve ecological functions. Initiating forest farming in an intact and healthy riparian forest is not recommended nor is it often allowed under local critical area ordinances/regulations. In most cases, landowners are converting agricultural land or transitioning alley cropping or silvopasture working buffer techniques to a forest farming system. Development of a mature forest requires considerable labor and time investment, therefore, landowners should consider managing the early successional forest for alternative products as trees grow. For example, trees and shrubs that do well in full-sun such as Red Alder, willows and berries can be harvested for economic gain, while longer-term species such as cedar, firs and maples are planted to replace them after harvest. Alternatively, lands where forested riparian buffers already exist, improving the function of the buffer by thinning of deciduous trees and replacement with conifers can provide economic return. In either case, multi-story cropping, much like any managed or un-managed forested landscape is not a static system and management plans should be developed that consider short and long-term economic and production goals.

Landowners have quite a bit of flexibility when designing for the progression of newly planted forest farming scenarios and the associated forest products. One option is to implement silvopasture or alley cropping systems (see other Working Buffer templates) before trees grow to a size that shades out annual crops and forage. Alternatively, there are several high value berry crops that require full-sun to produce that can be planted



between trees and replaced once the canopy shades them out. High-yielding fruit-bearing shrubs such as Elderberries, Huckleberries, and Saskatoon can provide high-value crops for wholesale, retail and value added markets. Fast growing, high yielding woody perennials such as Alders, Willow or Cottonwood can be grown initially to improve health of soils, provide shade to surface waters, and filter pollutants. These can be harvested and replaced as the forest transitions to a more conifer-dominated overstory. These fast-growing tree and shrub species can be harvested for firewood, veneer, timber or biomass.

Once the tree canopy matures, several ground-level cropping alternatives can be implemented for high value medicinal, ornamental, nursery, floral or mushroom production. Management of the forest floor should be low intensity with minimal soil disturbance. Species should be selected that can withstand and produce under shade, although the shade level can be managed to some extent through thinning of the forest canopy. Already established native vegetation provides the opportunity for nursery seed and vegetative propagation

to meet the high demands of restoration projects throughout the region (Buttolph and Jones, 2012). An opportunity for forest-farming producers is available for “wild-simulated” medicinal herb production (Thomas and Schumann, 1993; Chamberlain and Hammet, 2002; Adams, 2004). These species include Goldenseal, Oregon Grape, American Ginseng, Blue/Black Cohosh, and Devils Club to name a few high yielding and important species for biodiversity preservation and cultural use. Management for mushrooms, whether wild-crafted species (e.g. chanterelles, chaga, or boletes) or mushrooms inoculated into hardwood substrates provides additional opportunities to capture the benefits of the shady, moist microclimate of riparian forest buffers.

Below is a table of selected perennial species, ideally suited to marketable or farmstead resource production for forest farming cropping systems in the Puget Sound Region. This is not an exhaustive list of potential species but rather those species that present current, high-value commercial marketability. Additional information can be found in the *Nontimber Forest Product Resources for Small Forestland Owners and Business Database* at <http://www.ntfpinfo.us/>.

<i>Suitable Tree Species for PNW Forest Farming</i>				
Common Name	Family	Genus	Harvestable Material	Notes
Canopy Layer				
Chestnuts	<i>Fagaceae</i>	<i>Castanea</i>	Nuts	High value nut and timber
Walnuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber, Black, European and Persian
Butternuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber, prefers drier sites
Heartnuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber, withstands wetter conditions
Hickory	<i>Juglandaceae</i>	<i>Carya</i>	Timber, Nuts	High value timber and nut
Maple	<i>Aceraceae/Sapindaceae</i>	<i>Acer</i>	Timber and Syrup	Potential niche market
Yellowhorn	<i>Sapindaceae</i>	<i>Xanthoceras</i>	Ornamental/Nut	Chinese native with traditional culinary uses
Cedar	<i>Cupressaceae</i>	<i>Thuja</i>	Ornamental/Timber	Large market and distribution available
Spruce	<i>Pinaceae</i>	<i>Picea</i>	Ornamental/Timber	Large market and distribution available
Fir	<i>Pinaceae</i>	<i>Abies</i>	Ornamental Timber	Large market and distribution available
Stone Pines	<i>Pinaceae</i>	<i>Pinus</i>	Nuts	Korean and Italian Stone pines or pine nuts
Turkish Tree Hazel	<i>Betulaceae</i>	<i>Corylus</i>	Nuts	Large, stress tolerant tree produces heavy shade
Monkey Puzzle	<i>Araucariaceae</i>	<i>Araucaria</i>	Nuts	Large and abundant nut producer
Early Succession/ Forest Edge				
Alder	<i>Betulaceae</i>	<i>Alnus</i>	Timber and Syrup	Furniture, firewood and syrup
Birch	<i>Betulaceae</i>	<i>Betula</i>	Timber and Syrup	Furniture, firewood and syrup
Hybrid Poplar	<i>Salicaceae</i>	<i>Populus</i>	Timber and Syrup	Biomass, firewood and syrup
Black Cottonwood	<i>Salicaceae</i>	<i>Populus</i>	Timber and Syrup	Biomass, firewood and syrup
Cascara	<i>Rhamnaceae</i>	<i>Rhamnus</i>	Medicinal Bark	Large market and distribution available
Oaks	<i>Fagaceae</i>	<i>Quercus</i>	Timber, Bark, Nuts	White, Cork, Oregon Species. Prefers well drained sites
Elderberry	<i>Caprifoliaceae</i>	<i>Sambucus</i>	Fruit	High value fruit
Crabapple	<i>Roseaceae</i>	<i>Malus</i>	Rootstock	Grafter to high value fruit
Apple	<i>Roseaceae</i>	<i>Malus</i>	Fruit/Timber	High value cider market and wood product
Pear	<i>Roseaceae</i>	<i>Pyrus</i>	Fruit	Cider production source
Plum	<i>Roseaceae</i>	<i>Prunus</i>	Fruit	Local high value fruit
Cherry	<i>Roseaceae</i>	<i>Prunus</i>	Fruit/timber	High value fruit and hardwood
Quince	<i>Roseaceae</i>	<i>Cydonia</i>	Fruit	High value fruit
Fig	<i>Moraceae</i>	<i>Ficus</i>	Fruit	High value fruit
Mulberries	<i>Moraceae</i>	<i>Morus</i>	Fruit	Great mast crop and high value fruit
Huckleberries	<i>Ericaceae</i>	<i>Vaccinium</i>	Fruit	Marketable native with potential for further domestication
Saskatoon	<i>Rosaceae</i>	<i>Amelanchier</i>	Fruit	High value fruit, superfood
Salmon Berry	<i>Rosaceae</i>	<i>Rubus</i>	Fruit	Marketable native with potential for further domestication
Hawthorne	<i>Rosaceae</i>	<i>Crataegus</i>	Medicinal Fruit and Flower	Highly marketable native species

Sumac	<i>Anacardiaceae</i>	<i>Rhus</i>	Fruit	High value culinary spice
Aronia	<i>Roseaceae</i>	<i>Aronia</i>	Fruit	High value fruit, superfood
Currants/Gooseberries	<i>Grossulariaceae</i>	<i>Ribes</i>	Fruit	High value fruit, native and non native
Ground Covers				
Nettles	<i>Urticaceae</i>	<i>Urtica</i>	Aerial Parts	High value vegetable for local markets
Miners Lettuce	<i>Montiaceae</i>	<i>Claytonia</i>	Aerial Parts	High value vegetable for local markets
Oregon Grape	<i>Berberidaceae</i>	<i>Mahonia</i>	Fruit/Medicinal Root	Berberine alkaloid popular medicinal nationwide
Salal	<i>Ericaceae</i>	<i>Gaultheria</i>	Fruit/Ornamental	Ornamental cut greens and berries
Devils Club	<i>Araliaceae</i>	<i>Oplopanax</i>	Root	High value medicinal
American Ginseng	<i>Araliaceae</i>	<i>Panax</i>	Root	Extremely high value , International markets
Goldenseal	<i>Ranunculaceae</i>	<i>Hydrastis</i>	Roots/Rhizome	High value medicinal herb, high demand
Black/Blue Cohosh	<i>Ranunculaceae</i>	<i>Actaea</i>	Roots/Rhizome	High value medicinal
Arnica	<i>Asteraceae</i>	<i>Arnica</i>	Flower	High Value medicinal
Ramps	<i>Amaryllidaceae</i>	<i>Allium</i>	Stalk and bulb	High value culinary with high demand
Water Cress	<i>Brassicaceae</i>	<i>Nasturtium</i>	Leafy greens	Traditional vegetable with local demand
Wasabi	<i>Brassicaceae</i>	<i>Eutrema</i>	Root	High value root crop with international market demand
Ostrich Fern	<i>Dryopteridaceae</i>	<i>Metteuccia</i>	Spring Fiddleheads	Potential high value fiddlehead fern
Mushroom				
Shiitake	<i>Marasmiaceae</i>	<i>Lentinula</i>	Fruitbody	High value with local demand
Maitake	<i>Meripilaceae</i>	<i>Grifola</i>	Fruitbody	High value with local demand
Oyster Mushroom	<i>Pleurotaceae</i>	<i>Pleurotus</i>	Fruitbody	High value with local demand, cultivated or wildcrafted
Turkey Tail	<i>Polyporaceae</i>	<i>Trametes</i>	Fruitbody	High value with local demand, cultivated or wildcrafted
Reishi	<i>Ganodermataceae</i>	<i>Ganoderma</i>	Fruitbody	High value with local demand, cultivated recomm.
Chaga	<i>Hymenochaetaceae</i>	<i>Inonotus</i>	Fruitbody	High value with local demand, wildcrafted recomm.
Truffle	<i>Tuberaceae</i>	<i>Tuber/Leucangium</i>	"Tuber" or Sclerotia	High value potential, native to PNW

Pacific Northwest Production Models:

Forest Farming and multi-story cropping can provide the most diverse economic benefit for landowners interested in achieving environmental stewardship in riparian corridors. Below are a few examples of highly marketable species, both domestically and internationally, gaining popularity and research interest in the Puget Sound region.

Pine Nuts (*Pinus Spp.*): Pine nuts, produced primarily in the Southeast U.S., are a high demand and extremely productive and valuable nut crop. In the U.S., the pine nut is a \$100 million market, though 80% of these nuts are imported (Sharashkin and Gold, 2004). Pine nuts come from several species of pine, most notable of the commercially viable species are the Siberian (*Pinus sibirica*), Korean stone pine (*Pinus koraiensis*), Chilgoza pine (*Pinus gerardiana*), Italian Stone pine (*Pinus pinea*) and the few native to the U.S. are Colorado pinyon (*Pinus edulis*) and Single-leaf pinyon (*Pinus monophylla*). Italian Stone pine and Korean stone pine are the two species that provide most commercially viable potential west of the cascades, yielding upwards to 100lbs/acre shelled nuts when planted in ideal conditions (Geisler, 2013). Sharashkin and Gold (2004) report that shelled nuts, the most expensive nut on the market, range from \$20-\$35/kg and \$70-\$140 per liter of pine nut oil. Producers can earn more if it is sold as a flour or the oil is marketed as a medicinal product (Sharashkin and Gold, 2004). WholesalePineNuts.com is currently marketing bulk U.S. grown pine nuts for \$13.49-\$14.99/lb in 2015. Additional research and experimentation for production in the Puget Sound region is needed.

Elderberries (*Sambucus Spp.*): Elderberry is a very well known medicinal plant throughout the U.S. and Europe and the use and cultivation for berries by Native American cultures has been well documented (Turner and Peacock, 2005; Moerman, 1998). Black Elderberry (*Sambucus nigra*) is currently produced commercially for juices, wine and medicinal tonics in Europe. More recently in the U.S., much attention has turned to our

native species of Elderberries for their prized culinary and medicinal attributes. In Western Washington there are two native species of elderberry, Red Elderberry (*Sambucus racemosa*) and Blue Elderberry (*Sambucus caerulea*), though the Blue elderberry is primarily harvested for its sweeter juices for making jams, sweeteners, wines and liquors. In the Midwest and Eastern U.S., research into the value of elderberry (primarily *Sambucus canadensis*) is aiding in developing of this market. A recent study by the University of Missouri's Center for Agroforestry describes a multitude of economic uses including nursery plants (\$6/plant) and fresh berries (\$.50/lb to winery, \$1.25/lb U-Pick, \$3lb de-stemmed, \$5/lb to winery de-stemmed, and \$11/lb to dietary supplement manufacturers). Average prices for processed juice range from: wine (\$10-\$14/bottle), fresh juice (\$12-\$17/11oz bottle retail) and juice concentrate (\$25/375ml bottle retail) (Byers et al., 2014). Elderberries are an extremely productive species, with some domesticated cultivars providing fruit within the first year after planting and producing up to 12,000 lbs/acre in intensive commercial plantings (Stafne, 2006).

Goldenseal (Hydrastis canadensis): Goldenseal is a member of the Ranunculaceae family and is native to the eastern North American continent. High domestic and international market demand for this species has caused wild populations to diminish across the continent resulting in being listed as "threatened" on the U.S. Endangered Species List as well as being on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list since 1997 (Predney and Chamberlain, 2005). Current markets are seeking sustainable "wild-simulated" sources of goldenseal throughout the country. A few producers in western Washington are contracting with Mountain Rose Herbs and other medicinal product wholesalers, proving production viability in the Puget Sound region. Goldenseal requires consistently moist soils under closed canopy shade and is therefore, ideally suited for riparian buffer production. Yield estimates range from 1,000-2,500lbs/acre every 3-5 years when harvested under artificial shade production, though some suggest that this may be a low estimate (Burkhart et al., 2006). In 2012, researchers at North Carolina State University found producers receiving \$30-\$35/lb of dried root from wholesalers while retail averaged about \$115/lb dried root. Current retail pricing at Mountain Rose Herbs is \$93/lb of dried root. Sego's Herb Farm in La Center Washington produces goldenseal under artificial shade for the wholesale market. They have produced a production budget, published on the WSU Small Farms Team website, detailing 8,000lbs of fresh (wet) root production on one acre and receiving \$15/lb in 2001. See <http://smallfarms.wsu.edu/crops/medicinalherbs/organicGoldenseal.html> for more information.

Shiitake (Lentinula edodes): Shiitake mushrooms are a species of saprophytic (decomposing) fungi that produce fruit bodies (mushrooms) on decomposing hardwood branches and trunks. Native to Asia, this highly prized edible mushroom species is currently in high demand in the restaurant and retail markets. Demand for Shiitakes, one of the two most popular mushroom species in the world (Davis and Harrison, 2011), outpaces production nationwide. Shiitakes can be



produced as an alternative enterprise within your riparian buffers in a process known as log culture. Shiitake spawn is plugged into holes drilled within hardwood (alder) logs and stacked until fruiting. Producers can expect to begin harvest within a year after inoculation and logs can produce for up to 5 years. Research conducted on market pricing has shown a wide range of wholesale and retail pricing ranging from \$4-\$8/lb and \$10-\$20/lb respectively (Frey, 2014; Bruhn, 2008) with an estimated yield of 500lbs per every cord of wood inoculated (Davis and Harrison, 2011). Shiitakes can be sold fresh and dried in order to help provide consistent income throughout the year from wholesale and retail sales.

Financial Assistance and Cost Share Opportunities

Financial assistance in the form of cost-share funds or public subsidies can aid landowners interested in implementing forest farming or multi-story cropping management practices. Agencies currently equipped to provide this funding, including implementation funds and technical assistance, can be secured through the following agencies and programs:

- Conservation Districts – Local conservation districts can help to provide technical assistance and planning, and seek funds through the Washington State Conservation Commission and other local funding sources.
- National Resource Conservation Service (NRCS) – EQIP and CSP programs. Contact your regional NRCS Field technician for application details:
<http://www.nrcs.usda.gov/wps/portal/nrcs/main/wa/contact/local/>

Sources of Funding and Assistance

- USDA Farm Service Agency – Conservation Reserve Enhancement Program (CREP)
- NRCS – Environmental Quality Improvement Program (EQIP)
- NRCS – Conservation Stewardship Program (CSP)
- Washington Conservation Commission – Livestock and Shellfish Funding Programs
- Department of Ecology – Pollution Identification and Correction (PIC) program
- Local Conservation District, NGO, and other Environmental Protection Partnerships

Approved WA NRCS Best Management Practice Standards:

The NRCS provides Best Management Practice (BMP) standards for Washington State to ensure cost-share subsidies are used appropriately for the natural resource concerns to be addressed. The following NRCS BMP standards have been developed in accordance to state environmental policy specifically addressing natural resources management within agricultural landscapes:

Multi-Story Cropping (512): Provides resources for implementing practices within established forest or newly planted forest whereby the intent is to manage the understory for multiple non-timber forest products while concurrently managing the canopy overstory.

Riparian Forest Buffer (391): Establishing plantings along riparian corridors. The standard encourages “tree and shrub species that have multiple values such as those suited for timber, biomass, nuts, fruits, browse, nesting, aesthetic and tolerance to locally used herbicides (NRCS, 2007).”

Tree/Shrub Establishment (612): Establishing the planting of trees and shrubs for a multitude of conservation and agricultural purposes. Within this practice standard, priority has been established for the development of renewable energy systems.

Plant Enhancement Activity – PLT18 – Increasing on-farm food production with edible woody buffer landscapes: As part of the their Conservation Stewardship Program, NRCS has recently added this enhancement funding source to provide resources for enhancing windbreaks, alley cropping, silvopasture and riparian forested buffers with trees and shrubs that provide food for human and wildlife consumption.

Plant Enhancement Activity – PLT05– Multi-story cropping, sustainable management of nontimber forest plants: As part of the their Conservation Stewardship Program, NRCS has recently added this enhancement funding source to provide resources for enhancing forest and croplands where the forest is managed for harvestable non-timber plants in addition to or instead of timber.

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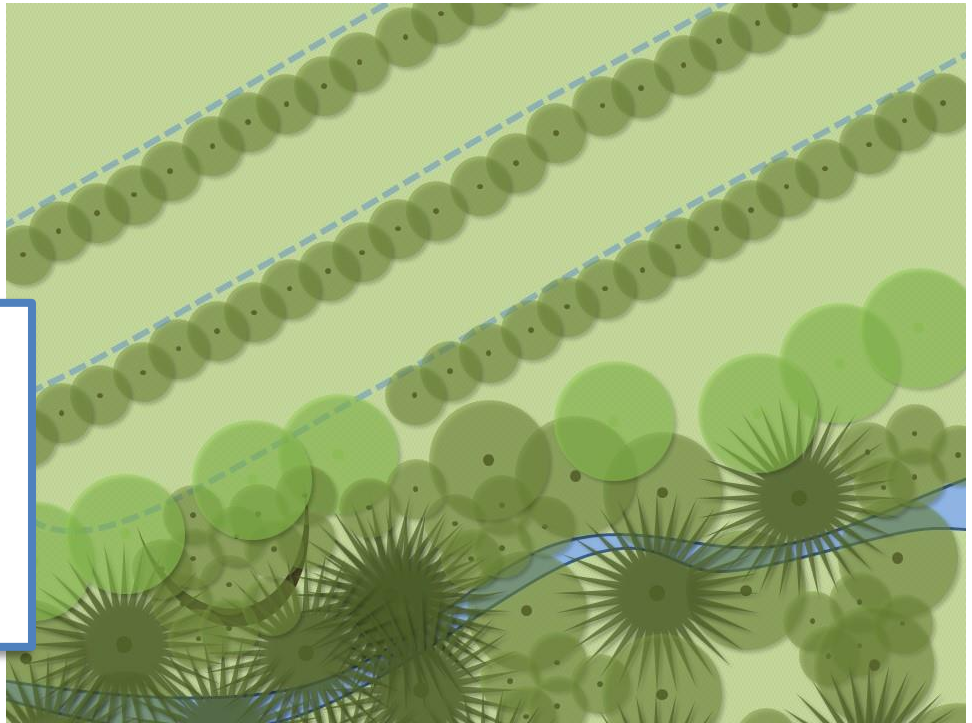
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Alley Cropping

*"**Alley Cropping** is the planting of trees in rows with agronomic, horticultural, or forage crops cultivated in the alleys between the rows."*



Description:

Alley cropping is a production model where a tree crop is grown in rows that are wide enough to simultaneously allow for cultivation of ground-level crops. Rows of highly productive tree or shrub species can be managed for fruit, nut, medicinal, timber, and/or ornamental production while allowing for continued production of cultivated crops (small grains, vegetables, ground cover fruits) or forage (hay, silage, etc.). Stacking these two production systems allows farmers to better cope with market fluctuations or crop failures by diversifying outputs while providing the ecosystem services to meet environmental conservation goals.

Placement and management of alley cropping systems is specific to site conditions and landowner needs. This strategy is not intended to replace a properly functioning, closed canopy riparian buffer, rather, its goal is to provide a way for the landowner to increase the buffer size and function while at the same time realizing economic benefits. Alley cropping can be a long-term management strategy or it can be a short-term approach to maximizing farm production during establishment of a forest canopy.

Conservation Benefits:

Alley cropping systems provide the opportunity for farmers to continue cultivation of their land while realizing the environmental benefits associated with the incorporation of trees near stream corridors: shade, leaf litter, carbon storage, and pollutant filtration. Though traditional soil cultivation can create sediment, nutrient, and chemical pollution if managed improperly, proper integration of alley cropping techniques alongside riparian buffers can provide numerous environmental benefits:

- Incorporating deep rooting trees into an annual crop or forage system diversifies rooting depths and increases nutrient and water uptake (Hooper and Vitousek, 1997; Licht, 1990).
- From a structural perspective, during flood or winter storm events, trees within cultivated fields slow moving surface water and encourage infiltration thereby reducing sediment, nutrient, and chemical pollutant runoff (Michel et al., 2007; Jose, 2009). Rows of trees planted either on contour or parallel to the riparian channel can provide a physical barrier to pollutants moving toward a waterway.
- Rows of trees also provide a windbreak that can reduce the drift of air-borne pesticide and herbicide applications used to manage pests and weeds within the annual cropping management framework (Ucar and Hall, 2001).
- Tall trees provide shade to the stream, maintaining cool water temperatures for fish.
- Incorporating trees into the agricultural landscape increases carbon sequestration both above and below ground (Schoeneberger et al., 2012).
- A forest with an open understory creates a unique natural habitat that can enhance nesting site potential (ground and aerial nesting sites), movement of migratory mammals, and increases flowering of trees and shrubs for pollinator habitat when compared to open field systems (Garrett et al., 2004; Hinsely and Bellamy, 2000; Varah et al., 2013). Trees provide birds with refuge, shelter and forage sites. Bald eagles feeding on salmon carcasses can bring salmon and their nutrients further into the fields aiding in upland fertility.

Landowner Benefits:

Alley cropping research for temperate systems in the mid-western U.S. and Canada has shown a multitude of benefits that support the farmers' long-term economic goals. Alley cropping provides farmers reduced economic risk by managing for both a tree crop and annual crop on the same land. In addition:

- Producers seeking to transition into full canopy coverage or intensive tree crops can cultivate annuals within the alleys for economic gain until trees reach canopy closure or maturation.
- Diversifying agricultural revenue sources can provide economic security in the face of potential floods and droughts due to climate change (Schoeneberger et al., 2012).
- Depending on the system, the timing of management, harvest and labor can be staggered throughout the year to provide for year-round income and farm labor employment.
- Rows of taller trees can increase soil moisture by reducing the evapotranspiration effects of wind, providing shade at certain times of the day, and increasing soil organic matter inputs (Cleugh, 1998).
- Planting of nitrogen fixing trees or shrubs can reduce fertilization needs (Cleugh, 1998).
- Rows planted perpendicular to surface or groundwater flow can trap runoff of topsoil and nutrient inputs which, over time, can reduce fertilizer requirements (Licht, 1990).



- Alley cropping typically integrates flowering species and provides rows of undisturbed soil. These rows provide nesting habitat for both pollinators and predatory insects thus improving the yields of annual crops and reducing the need for pesticides.

Design and Implementation:

Proper planning and design is critical for the success of any alley cropping system. A wealth of integrative tree/shrub and annual production systems are available to the producer in the Puget Sound region. Producers should match their current cropping and management practices with their alley cropping plan and take into account site conditions, access to needed equipment and infrastructure, impact of tree management on annual cropping, and potential markets. Choosing tree species that compliment, rather than compete with, annual crops is key. Things to consider here are shade, increased soil moisture or competition for soil moisture, nitrogen fixation or competition for soil nutrients, soil condition requirements such as pH and soil depth and habitat quality for providing predator-pest relationships as needed.

Tree Selection:

- *Marketability*
- *High Quality*
- *Fast Growing*
- *Deep Rooted*
- *Site and Climate Tolerant*
- *Produces Light Shade*

Some landowners may choose to maintain annual cropping or forage production in the alleys permanently, while others may choose to phase out of annual production as the canopy of perennial tree crops begin to mature. Deciding on the long-term goal of the tree crop is, therefore, critical when selecting species and row spacing. A landowner may also choose to install rows of perennial species within the alleys, either immediately or to transition out of annual cropping at a later time (e.g. installing trellised Kiwi berries between rows of apples).

The success of alley cropping systems in maximizing natural resource conservation objectives (nutrient retention, soil enhancement, wildlife habitat) is dependent on locating the rows of perennial production on contour or in ways that spread or block concentrated runoff flows. Making careful observations on surface water flows before designing your site plan is, therefore, a critical first step.

Nitrogen fixation characteristics and/or high biomass producing tree species are recommended in many cases where nutrients and organic matter inputs will reduce fertilizer needs and enhance soil health in the alleys. Diversity of flowering species and their respective bloom time should be considered for enhancing pollinator, pest-prey interactions and wildlife habitat. Mulching the rows of trees and practicing conservation tillage within the alleys will better serve insects and other wildlife that rely on undisturbed soil as habitat which can also reduce the need for herbicide and pesticide sprays.

Below is a table of selected perennial species, ideally suited to marketable production for alley cropping systems in the Puget Sound Region:

Suitable Tree/Shrub Species for PNW Alley Cropping				
Common Name	Family	Genus	Harvestable Material	Notes
Trees				
Chestnuts	<i>Fagaceae</i>	<i>Castanea</i>	Nuts	High value nut and timber
Butternuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber
Walnuts	<i>Juglandaceae</i>	<i>Juglans</i>	Nuts	High value nut and timber
Pine Nuts	<i>Pinaceae</i>	<i>Pinus</i>	Nuts	High value nut
Alder	<i>Betulaceae</i>	<i>Alnus</i>	Timber and Syrup	Furniture, firewood and syrup
Birch	<i>Betulaceae</i>	<i>Betula</i>	Timber and Syrup	Furniture, firewood and syrup
Hybrid Poplar/Cottonwood	<i>Salicaceae</i>	<i>Populus</i>	Timber and Syrup	Biomass, firewood and syrup
Cascara	<i>Rhamnaceae</i>	<i>Rhamnus</i>	Medicinal Bark	Large market and distribution available
Apple	<i>Roseaceae</i>	<i>Malus</i>	Fruit	Cider production source
Crabapple	<i>Roseaceae</i>	<i>Malus</i>	Rootstock	Graft to high value fruit
Pear	<i>Roseaceae</i>	<i>Pyrus</i>	Fruit	Cider production source
Plum	<i>Roseaceae</i>	<i>Prunus</i>	Fruit	Local high value fruit
Cherry	<i>Roseaceae</i>	<i>Prunus</i>	Fruit and Timber	High value fruit and hardwood
Quince	<i>Roseaceae</i>	<i>Cydonia</i>	Fruit	High value fruit
Fig	<i>Moraceae</i>	<i>Ficus</i>	Fruit	High value fruit
Mulberries	<i>Moraceae</i>	<i>Morus</i>	Fruit	Great mast crop and high value fruit
Shrubs				
Willow	<i>Salicaceae</i>	<i>Salix</i>	Woody biomass	Livestock feed, biomass, medicinal markets, nursery cuttings
Curly Willow	<i>Salicaceae</i>	<i>Salix</i>	Ornamental branches	Ornamental market opportunities
Red Osier Dogwood	<i>Cornaceae</i>	<i>Cornus</i>	Ornamental branches	Ornamental market or nursery cuttings
Tea Plant	<i>Theaceae</i>	<i>Camellia</i>	Leaves	New local niche market
Filberts	<i>Betulaceae</i>	<i>Corylus</i>	Nuts	High value nut crop
Elderberry	<i>Caprifoliaceae</i>	<i>Sambucus</i>	Fruit	High value fruit, medicinal and edible
Saskatoon	<i>Roseaceae</i>	<i>Amelanchier</i>	Fruit	High value fruit, superfood
Blueberry	<i>Ericaceae</i>	<i>Vaccinium</i>	Fruit	High value fruit
Strawberry Tree	<i>Ericaceae</i>	<i>Arbutus</i>	Fruit	Related to Madrone, great juice/jams
Aronia	<i>Roseaceae</i>	<i>Aronia</i>	Fruit	High value fruit, superfood
American Cranberry	<i>Adoxaceae</i>	<i>Viburnum</i>	Fruit	Highly productive native w/ marketability
Buffalo Berry	<i>Elaeagnaceae</i>	<i>Shepherdia</i>	Fruit	High market potential, superfood
Sea Buckthorn	<i>Elaeagnaceae</i>	<i>Hippophae</i>	Fruit	High market potential, superfood
Goumi	<i>Elaeagnaceae</i>	<i>Elaeagnus</i>	Fruit	High value fruit
Currants	<i>Grossulariaceae</i>	<i>Ribes</i>	Fruit	High value fruit
Gooseberries	<i>Grossulariaceae</i>	<i>Ribes</i>	Fruit	High value fruit
Jostaberry	<i>Grossulariaceae</i>	<i>Ribes</i>	Fruit	High value fruit
Wolfberry/Goji Berry	<i>Solanaceae</i>	<i>Lycium</i>	Fruit	High value fruit
Vines				
Kiwi Berry	<i>Actinidiaceae</i>	<i>Actinidia</i>	Fruit	Highly productive and marketable
Grapes	<i>Vitaceae</i>	<i>Vitis</i>	Fruit	Ample processing potential

Pacific Northwest Production Models:

The opportunities to integrate perennial trees and shrubs with cultivated annuals are numerous in the Pacific Northwest. The examples below demonstrate a few of the possibilities for tree crops that are well-suited to climate conditions on the west side of the Cascades and have established markets. These examples represent harvest of fruits and nuts whereas other systems could include timber production for sawlogs, veneer, firewood or biomass production for mulch, livestock bedding, biomass combustion, etc.

Saskatoon (Amelanchier Spp.): Also known as Serviceberry or June berry, this is a native shrub with a rich history of use by indigenous peoples and recent European settlers. More recently, areas of Canada and the northern areas of the mid-western United States have turned to this highly productive shrub for its prized sweet and highly nutritional fruit as an agricultural crop for the fresh and processed food markets. Commercial production has not been able to meet demand in Canada as the market has been growing rapidly since the turn of the century. *Amelanchier alnifolia*, the native species west of the cascades, is the main commercially viable species grown, making this an ideal crop for the alley cropping scenario seeking to enhance on farm and regional conservation goals. Research in Canada has shown full production within 7-10 years, grossing 3,500 lbs of berries per acre (St. Pierre, 1997; Faye, 2008). Direct market pricing in Alberta ranged from \$2.40-4.50/lb. for U-pick while retail ranged from \$2.50- 5.25/lb. (Spencer and Morton, 2014).

Agricultural Production

Tree crops:

- Timber
- Firewood
- Fruit/Nut crops
- Christmas trees/ornamental

Annual crops:

- Cultivated crops
- Forage

Cider Apple (Malus Spp.): The production of cider apples and other fruits for fresh cider juice and hard cider is taking off nationwide as popularity gains for artisanal hard ciders. As of fall 2014, there are 40 cider producers in the Pacific Northwest alone, many facing challenges in locating the supply of specific varieties for hard cider. There are an incredible amount of cider specific apple varieties found around the world, so selection of specific varieties should be thoroughly researched for disease resistance, production and marketability. Production of apples for the cider market is particularly noted in this template for three reasons: 1) Cider apples do not require the demand for

pristine appearance or shape, translating to less pesticide spray requirements, ease of management, and closer to 100% of production being marketable (Galinato and Gallardo, 2014), 2) Apples and other tree fruits can be espallied or trellised making them ideal for alley cropping scenarios, 3) Though most eating or cider producing apples are non-native and require well-drained soils not typically associated with riparian zones, they can be grafted onto the native pacific crabapple (*Malus fusca*), a species that thrives on seasonally inundated sites and has disease resistant rootstock. Currently, demand of cider specific varieties outweigh supply, leading 2014 season wholesale pricing to range between \$800-\$1000 per ton or \$340-\$425 per bin (Warner and Mullinax, 2014). In 2013, the median price in Western Washington for locally grown cider apples is described as \$315/bin (Galinato and Gallardo, 2014). Average yield per acre varies greatly based on varietal choice and conditions. In a recent budget estimation publication by a WSU Extension researcher, however,

Galinato and Gallardo (2014) describes average expected yield for mature orchards to be 46 bins per acre (not in an alley cropping system).

Walnut (Juglans Spp.): Western Washington and Oregon had a particularly rich history of Walnut production in the early to mid 1900's and remnant stands can still be found in many agricultural landscape or towns that grew up around existing farmland (Stebbins, 1993). Butternuts, Heartnuts, European Walnuts and even the American native Eastern Black Walnut (*Juglans nigra*) have a great potential to increase farm income through alley cropping for both nut and timber production (Goby, 2005). Black Walnut trees begin to come into commercial nut production around year 10 and average 2/3 of a ton per acre in the Pacific Northwest for a mature healthy orchard (Stebbins, 1993). Black Walnuts range in price for regional wholesale buyers from \$0.13 – \$0.45/lb for unprocessed nuts (Godsey, 2010) to \$0.50 for processed nuts. Direct marketing of processed walnuts are often sold for over \$12/lb (Jensen, 2014).

Christmas and Ornamental trees (Various species): Both native and non-native Christmas tree species can be integrated into alley cropping scenarios. Christmas tree production, ornamental and seasonal boughs, as well as pine/fir cones can diversify income, while also becoming a long-term canopy crop for timber, firewood as well as wildlife habitat. Douglas-fir trees reach a 6ft marketable height in 7 years and can be sold directly or on the wholesale market. The Pacific NW is the world's largest producer of Douglas-fir trees (PNW Christmas Tree Association).

Financial Assistance and Cost Share Opportunities

Financial assistance in the form of cost-share funds or public subsidies can aid landowners interested in implementing alley cropping management practices. Agencies currently equipped to provide this funding, including implementation funds and technical assistance, can be secured through the following agencies and programs:

- Conservation Districts – Local conservation districts can help to provide technical assistance and planning, and seek funds through the Washington State Conservation Commission and other local funding sources.
- National Resource Conservation Service (NRCS) – EQIP and CSP programs. Contact your regional NRCS Field technician for application details:
<http://www.nrcs.usda.gov/wps/portal/nrcs/main/wa/contact/local/>

Sources of Funding and Assistance

- USDA Farm Service Agency – Conservation Reserve Enhancement Program (CREP)
- NRCS – Environmental Quality Improvement Program (EQIP)
- NRCS – Conservation Stewardship Program (CSP)
- Washington Conservation Commission – Livestock and Shellfish Funding Programs
- Department of Ecology – Pollution Identification and Correction (PIC) program
- Local Conservation District, NGO, and other Environmental Protection Partnerships

Approved WA NRCS Best Management Practice Standards:

The NRCS provides Best Management Practice (BMP) standards for Washington State to ensure cost-share subsidies are used appropriately for the natural resource concerns to be addressed. The following NRCS BMP

standards have been developed in accordance to state environmental policy specifically addressing natural resources management within agricultural landscapes:

Alley Cropping (311): Establishing tree species in rows where agricultural, horticultural or forages are produced in the alleys with the intent to enhance microclimates, reduce surface runoff and erosion, decrease offsite movement of nutrients or chemicals, enhance wildlife and pollinator habitat, enhance soil health, increase carbon storage, improve air quality, increase crop diversity, develop renewable energy resources, etc.

Plant Enhancement Activity – PLT18 – Increasing on-farm food production with edible woody buffer landscapes: As part of the their Conservation Stewardship Program, NRCS has recently added this enhancement funding source to provide resources for enhancing windbreaks, alley cropping, silvopasture and riparian forested buffers with trees and shrubs that provide food for human and wildlife consumption.

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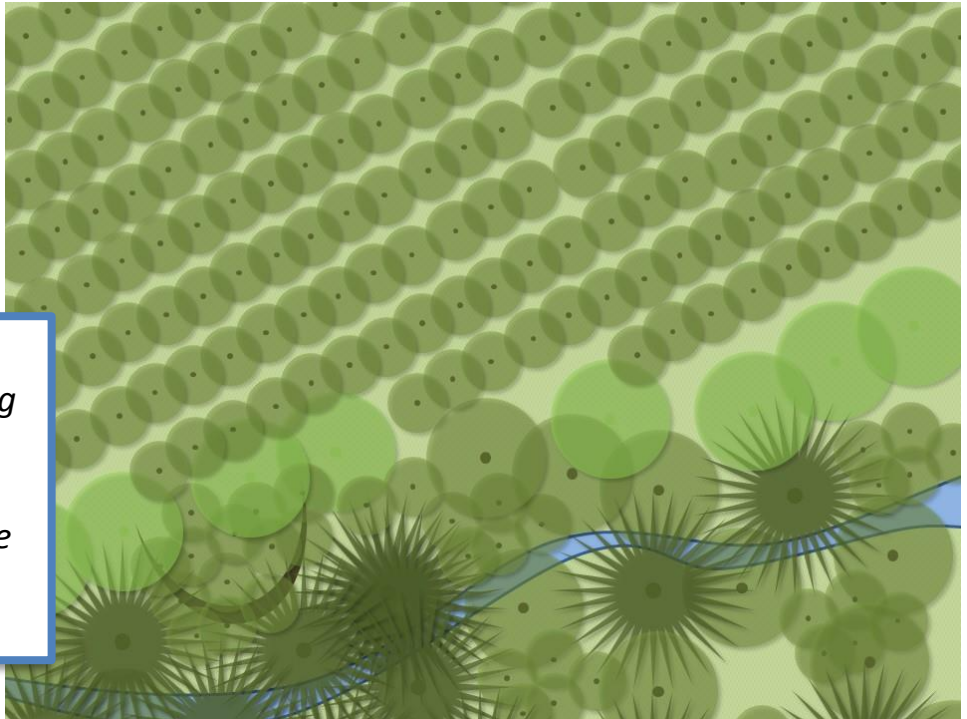
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Short Rotation Biomass

"Short rotation biomass is planting of fast-growing woody tree or shrub species that are rotationally cut to provide biomass."



Description:

Fast-growing woody shrub or tree species can be grown densely and harvested for biomass in the Short Rotation Biomass technique. The species recommended for this approach can re-sprout from stumps or roots and are harvested through coppicing, cutting them off near the base of the plant, or pollarding, cutting of the upper branches to promote dense heading on the trunk. On the landscape, these dense shrub zones serve to reduce concentrated flow paths, infiltrate water, filter out pollutants and absorb nutrients (Abrahamson et al., 2012). They may be prescribed to expand the width of a traditional riparian buffer or along seasonal ditches where shrubs and smaller trees are able to provide sufficient canopy cover to shade the surface water. Many of the recommended species are shrubs that can be grown adjacent to crop fields without having a significant shading effect. While some recommended species are taller growing trees, these are usually coppiced before reaching 15-30ft, depending on the selected species.

Biomass harvested from these fast-growing species can be used in biomass combustion for heat production, biofuels, paper production, timber, livestock bedding material, and feedstock among other emerging markets. In addition, several native willow, dogwood, and cottonwood species can be grown to produce livestakes for the nursery market. Livestakes are coppiced from plants and are sold for restoration planting projects on the local market.

Placement and management of short rotational biomass systems is specific to site conditions and landowner needs. This strategy is not intended to replace a properly functioning, closed canopy riparian buffer, rather, the goal is to provide a way for the landowner to increase the buffer size and function while at the same time

realizing economic benefits. This technique can be a long-term management strategy or it can be a short-term approach to maximizing farm production during establishment of a forest canopy.

Conservation Benefits:

Short rotational biomass systems are incorporated into a comprehensive approach to managing for natural resource conservation on a farm. While taller riparian buffers may be prescribed along fish-bearing streams to realize the habitat benefits needed, biomass production zones can be a valuable tool used along smaller seasonal ditches, in lower seasonally wet zones, in areas where flow concentrates, and alongside traditional crops where tall shade trees would limit crop production. Biomass should be harvested in zones and in rotation, providing a diverse range of buffer age and function to minimize the effects of harvest and maximize conservation values. Environmental benefits include:

- Incorporating deep rooting woody trees and shrubs into an annual crop or forage system diversifies rooting depths and increases nutrient and water uptake (Hooper and Vitousek, 1997).
- Fast growing shrub and trees species take up nutrients quickly which are then removed with harvest. This technique is an effective way of removing nutrients from agricultural runoff before they reach the stream and can aid in remediating contaminated groundwater flows (Licht, 1990).
- Deciduous trees and shrubs build soil organic matter content increasing soil infiltration rates, biological activity, and pollutant degradation and filtration capacity.
- From a structural perspective, during flood or winter storm events, trees and shrubs within cultivated fields slow moving surface water and encourage infiltration thereby reducing sediment, nutrient, and chemical pollutant runoff (Michel et al., 2007; Jose, 2009). Rows of trees or shrubs planted either on contour or parallel to the riparian channel can provide a physical barrier to pollutants moving toward a waterway.
- The dense stem count of short rotational biomass systems results in flow dispersal across the landscape. Reducing concentrated flow pathways allows for improved infiltration rates and pollutant filtration functions of riparian buffers.
- On smaller streams or agricultural ditches, narrow buffers can provide similar effective shading and above-stream air temperature reductions as wider buffers (Benedict and Shaw, 2012), maintaining cool water temperatures for fish.
- Incorporating woody vegetation into the agricultural landscape increases carbon sequestration both above and below ground (Schoeneberger et al., 2012).



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“Alternative agricultural management strategies for enhancing riparian buffer function.”

- Flowering trees and shrubs provides for pollinator habitat when compared to open pasture systems (Varah et al., 2013).

Landowner Benefits:

Short rotational biomass systems provide a way for farmers to reduce economic risk by diversifying their production model on a much shorter timeframe than many of the other working buffer techniques.

Incorporating zones of fast-growing trees and shrubs can result in many benefits to farmers:

- Diversifying agricultural revenue sources can provide economic security in the face of potential floods and droughts due to climate change (Schoeneberger et al., 2012).
- Trees and woody vegetation can increase soil moisture by reducing the evapotranspiration effects of wind, providing shade at certain times of the day, and increasing soil organic matter inputs that can positively affect adjacent agricultural fields. Planting of nitrogen fixing trees or shrubs can reduce fertilization needs (Cleugh, 1998).
- During floods, trees and shrubs act as a “fence” to trap large wood from the river that would otherwise be deposited on fields or damage fencing.
- Depending on the system, the timing of management, harvest and labor can be staggered throughout the year to provide for year-round income and farm labor employment.
- Short rotational coppicing can provide nesting habitat for both pollinators and predatory insects thus improving the yields of annual crops and reducing the need for pesticides.
- Rows planted perpendicular to surface or groundwater flow can trap runoff of topsoil and nutrient inputs which, over time, can reduce fertilizer requirements.
- Most recommended species do well in poorly drained soils and can be an added source of income in areas where crop production rates are poor or pastures are degraded and muddy.

Design and Implementation:

Short rotation coppicing production is ideally suited to marginal lands, such as drained or disturbed wetlands, low elevation depressions within a floodplain, hydric soils or any marginally productive farmland. We recommend that this practice be implemented along smaller, non-fish bearing streams or in conjunction with permanent buffers along fish-bearing streams to maintain stream temperatures post-harvest of biomass crops. Surface or sub-surface drainage (tile drains, field ditches, etc.) can be re-routed to short rotation biomass planting zones where these rapidly growing species can sequester pollutants and excess nutrients that are then removed through harvest. Short rotation biomass may be used as part of an alley cropping model, where singular or multiple rows of coppiced trees and shrubs are grown alongside more traditional crops or forage. Many of the recommended species are coppiced before reaching 15-30 feet in height so do not provide significant shading to adjacent crops.

Short-rotation biomass cropping has a tremendous amount of opportunity to enhance farm economic diversity, though species selection and production models should be well researched to match market

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demands, site specific growing conditions and availability of equipment and infrastructure needs. For production of homesteading materials such as livestock bedding, firewood, mulch or timber, landowners can manage a diverse array of species to match their production needs. Landowners interested in producing for the renewable energy markets (biofuels or biomass combustion) or paper production are strongly encouraged to seek partnerships with other producers, research agencies, and buyers before implementing their production plan.

Site selection for short-rotation biomass production is critical as site conditions may impact a farmer’s ability to harvest the material. For most species harvested as sources of renewable energy, harvest typically takes place during the species dormant period prior to budding in the spring, similar to livestock nursery cutting. Extremely wet areas, therefore, may not allow for equipment access at this time of year. Livestock bedding material could be harvested year-round, while livestock feed harvest would likely take place in the fall. Planning for timing and equipment access for harvest and management should be part of your working buffer management plan.

Below is a table of selected perennial species, ideally suited to marketable or farmstead resource production for short-rotation biomass systems in the Puget Sound region:

<i>Suitable Tree and Shrub Species for PNW Short Rotation Biomass</i>				
Common Name	Family	Genus	Harvestable Material	Notes
Willow	<i>Salicaceae</i>	<i>Salix</i>	Biomass (bedding, mulch, livestock feed), nursery livestakes	Currently being researched for silage production
Hybrid Poplar	<i>Salicaceae</i>	<i>Populus</i>	Biomass, paper pulp	Research project for biofuels underway
Cottonwood	<i>Salicaceae</i>	<i>Populus</i>	Biomass, nursery livestakes	Native species related to hybrid poplar
Alder	<i>Betulaceae</i>	<i>Alnus</i>	Biomass, timber, bedding, mulch	Ideal for early succession reforestation, nitrogen fixer
Birch	<i>Betulaceae</i>	<i>Betula</i>	Bedding, mulch	Ideal for livestock bedding
Oregon Ash	<i>Oleaceae</i>	<i>Fraxinus</i>	Biomass, bedding, mulch	Native species, rapid growth

Pacific Northwest Production Models:

In the Pacific Northwest, there are a number of opportunities for landowners to realize economic gain on marginal lands using native or closely related species for short rotational coppicing and forestry. Several species can be used for homesteading products on farm, and several can be sold on the local market. Below are a few examples of marketable species gaining popularity and research interests in the Puget Sound region.

Shrub Willow (Salix Spp.): In recent years, much research has been conducted on the use of shrub willow species for hardwood biomass production for the renewable energy sector. This includes heat, power, biofuels and/or bioproducts. Research conducted in the Northeast U.S. estimates current production at 12 odt (oven dry tons)/hectare/year with a delivered price of \$60/odt paid to the producer (Abrahamson et al., 2012). Coppicing willow for the energy industry is typically done in 3-5 years rotations allowing producers to plan for annual harvests throughout several zones of their production system. There are currently no biorefineries in

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Washington State making this a speculative emerging product. As an alternative to the biofuels industry, researchers in the UK have been assessing this same production model as a source for ensiled livestock feed (Smith et al., 2014). Livestock producers may find these developments particularly intriguing in producing on-farm feed on marginal production sites while mitigating water quality concerns from their operations.

Hybrid Poplar/Cottonwood (Populus Spp.): Hybrid poplars are a cross between American cottonwoods and European poplars with a number of breeding programs developing further cultivars for the use as a renewable energy source worldwide. The Advanced Hardwood Biofuels Northwest program is a research initiative sponsored by the USDA to look into the opportunities available in the PNW for poplars as a renewable energy source. Recent studies indicate a rate of \$60-\$80/ton paid for poplar woodchips with a goal of 10 tons/acre harvested every two to five years depending on site conditions. Much like willow, poplars are extremely fast growing with multiple market opportunities, such as pulp wood, timber, bedding and highly nutritious livestock feed (Isebrands, 2007). As market fluctuations increase in the coal and fossil fuel markets, renewable biofuels from poplars and other hardwoods could become more profitable (Abrahamson et al., 2012). Operators are strongly encouraged to seek contracts or partnerships with local buyers and research groups prior to implementation. There are currently no biorefineries in Washington State making this a speculative emerging product though teams of researchers at Advanced Hardwood Biofuels Northwest are actively seeking to develop local opportunities.

Alder (Alnus Spp.): Alder is an ideal candidate for short rotation production because it can rapidly produce high amounts of biomass in disturbed or marginally productive sites. Preferring disturbed and wet soils, alder can be used along riparian corridors, drained wetlands, or floodplains with shallow water tables. The nitrogen fixing capability of alder makes this species well suited for restoring highly degraded pastures or grasslands that are poor in fertility and soil structure. In addition to site restoration, alder has a multitude of potential on and off farm uses with economic potential. As timber, alder has been desired as a cabinetry or furniture wood currently valued at over \$800/thousand board feet (MBF) for logs greater than 12 inches in diameter, achievable in a 25 year time frame (Wick, 2015; Scott, 2003). On a shorter rotation, alder can be used for mulch (on-farm), packaged as green shavings for horse and livestock bedding (retail \$38 for 1/3 cubic yard on smallcrop.com), “value-added” for smoking meats, or used to cultivate mushrooms from plug spawn (branches) or sawdust inoculations (\$7.50/10 lb bag on Fungi.com). Due to the low tannin and lignin structure found in alder sawdust, livestock operators, large-scale composters and mushroom producers are seeking alder sawdust resources nationwide.

Agricultural Production

Tree and shrub crops:

- Timber
- Paper pulp
- Biomass for combustion
- Biofuels
- Nursery cuttings
- Bedding material
- Livestock feed

Financial Assistance and Cost Share Opportunities

Financial assistance in the form of cost-share funds or public subsidies can aid landowners interested in implementing short rotational biomass management practices. Agencies currently equipped to provide this

funding, including implementation funds and technical assistance, can be secured through the following agencies and programs:

- Conservation Districts – Local conservation districts can help to provide technical assistance and planning, and seek funds through the Washington State Conservation Commission and other local funding sources.
- National Resource Conservation Service (NRCS) – EQIP and CSP programs. Contact your regional NRCS Field technician for application details: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/wa/contact/local/>
- Farm Service Agency (FSA) – A federal agency that manages the Conservation Reserve Enhancement Program (CREP) and the Biomass Crop Assistance Program for the USDA. Contact your local Conservation District or FSA representative for application details: <http://www.fsa.usda.gov>

Sources of Funding and Assistance

- USDA Farm Service Agency – Conservation Reserve Enhancement Program (CREP)
- NRCS – Environmental Quality Improvement Program (EQIP)
- NRCS – Conservation Stewardship Program (CSP)
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Approved WA NRCS Best Management Practice Standards:

The NRCS provides Best Management Practice (BMP) standards for Washington State to ensure cost-share subsidies are used appropriately for the natural resource concerns to be addressed. The following NRCS BMP standards have been developed in accordance to state environmental policy specifically addressing natural resources management within agricultural landscapes:

Forage and Biomass Planting (512): Provides technical assistance, planning and resources for establishing plantings for the purpose of feedstock for biofuel or energy production. This practice seeks to implement these plantings in a manner to reduce soil erosion, improve soil and water quality and increase carbon sequestration

Riparian Forest Buffer (391): Establishing plantings along riparian corridors. The standard encourages “tree and shrub species that have multiple values such as those suited for timber, biomass, nuts, fruits, browse, nesting, aesthetic and tolerance to locally used herbicides (NRCS, 2007).”

Hedgerow Planting (422): Establishing a dense and linear planting of woody shrubs along a narrow waterway, slope contours, or other features of a farm. This practice seeks to provide food and cover for wildlife, improve water quality, increase carbon storage and serve as barriers to dust, airborne particulates and chemical drift.

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Tree/Shrub Establishment (612): Establishing the planting of trees and shrubs for a multitude of conservation and agricultural purposes. Within this practice standard, priority has been established for the development of renewable energy systems.

USDA Biomass Crop Assistance Program: Serviced by the Farm Service Agency (FSA), USDA’s BCAP project provides landowners with cost share assistance for implementing biomass production for heat, power, bio-based products and biofuels nationwide. See the 2014 Conservation Fact Sheet at:
https://www.fsa.usda.gov/Internet/FSA_File/bcap_fact_sht_2014.pdf

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