Riparian Management Zones

The land next to water has remained controversial for the last generation. In an article titled "How Did Fixed width Buffers become Standard Practice", Richardson, Naiman and Bisson (2012) wrote: "In an increasingly complicated management arena, the challenge will be to find alternatives to fixed width buffers that meet the multiple objectives of providing clean water (minimizing nutrient and sediment inputs), aquatic habitat, habitat for riparian species, connectivity across landscapes, and related responses." This section reviews history of riparian zone management in the west, and describes lessons learned since aquatic conservation strategies were implemented in the mid 1990's. What follows is a brief history of how the Forest Service arrived at current riparian management practices, followed by new best available scientific information (BASI) and finally, the need for change.

Background

The quality of water emanating from public lands has been controversial for over 150 years. Land use after the civil war led to vast forest removal in the great lakes region, and increasing desire to exploit western public forests. Mining and grazing practices also expanded across the nation. The aggressive land use practices in the late 1800's were found to damage watersheds and reduce drinking water quality. Visionaries such as George Perkins Marsh warned of the negative changes on the landscape that humans could create if development was not managed. Beginning with the Organic Act in 1897, forest reserves were set aside for, "forest protection, watershed protection, and timber production, thus providing the charter for managing the forest reserves, later called national forests, for more than 75 years." (Williams, G. 2005).

After World War II, increasing demands for lumber, improved technology, and more efficient harvest methods accelerated the timber removal from National Forest Lands. As these changes occurred, so did the demand for recreation opportunities and the ability of Forest Service Research to monitor effects of different programs (Williams, G., 2005). Several Acts (MUSYA 1960; NEPA 1969; ESA 1973; NFMA 1976) were passed in the 1960's and 70's to help balance resource extraction with other needs and uses, but ultimately the new laws did not end the controversy. Public opposition continued to grow, especially with respect to increasing harvest and road building on National Forest Lands.

In response to studies in the 1960's and 70's that continued to document harmful effects that harvest methods and road building had on streams, states and federal agencies began passing a series of management requirements for activities near streams that were referred to as Best Management Practices (BMP's). Everest and Reeves (2007) disclosed the following regarding BMP development for the pacific-northwest, "The BMPs were developed through the normative process that weighed, evaluated, and incorporated many types of information. However, in arriving at decisions, compromises were often made in social, political, economic, and ecological goals for riparian management. The best available scientific information for protection of riparian and aquatic habitats was not always incorporated into forest practice rules." This cycle was repeated several times even as successive monitoring efforts continued to document degraded stream conditions (Reeves et al. 2016).

Riparian management in the western United States reached a crisis point in the early 1990's when several stocks of salmon and trout were reaching critically low numbers (Nehlsen et al. 1991) and ultimately becoming listed as threatened or endangered under the Endangered Species Act. Along with the Northwest Forest Plan, PACFISH and INFISH (all three hereafter referred to as 'the Strategies') made a

significant departure from past management philosophy. Past philosophy focused on providing the minimum of protection needed, and placed the burden of proof on resource specialists to show that management would cause riparian degradation (Everest and Reeves, 2007). These new Strategies alleviated that burden and established more stringent requirements in order to protect species habitat.

Under the new Strategies of the mid 1990's, riparian management zones (i.e. Riparian Reserves in NWFP and Riparian Habitat Conservation Areas (RHCA) in PACFISH/INFISH) were extended farther from the stream than previous direction to protect ecological processes next to streams. Also, the precautionary principle was invoked. Reeves et al (2016a) described this principle as, "Forest managers who wanted to alter the comprehensive default prescriptions for riparian management under the NWFP in order to pursue other management goals were required to demonstrate through watershed analysis that changes would not compromise established riparian-management goals." Not only did the burden of proof shift, these new strategies also required managers to consider ecological processes at the watershed scale. The components used in the NWFP, including the concept of the precautionary principle, were included in PACFISH and INFISH. Harvest volumes decreased following implementation of these broad conservation strategies. Subsequently, goals for forest management outputs were not met (McAlpine et al. 2006, Thomas et al. 2006).

Riparian management has remained controversial, in part because of competing values and uses (Lee et al. 2004). While strategies employed by NWFP, PACFISH, and INFISH appear to have been successful at halting the loss of old growth and preventing damage to aquatic systems in the PNW (Thomas et al. 2006) and the intermountain region, many believe that the strategies have brought undue social, economic, and even ecological costs. Some suggest a protection mindset emerged that has prevented management that promotes ecological processes (Thomas et al. 2006, Liquori et al. 2008; Ryan and Calhoun, 2010). Speaking of the need to restore ecological conditions and make good on social, economic, and ecological commitments in the NWFP, Thomas et al. (2006) wrote, "Minimization of short-term risks (the modus operandi of regulatory agencies and the federal courts) has a price tag, and a very big one, related to significantly increased longer-term risks of failure to meet objectives over very long time frames. Unless the federal agencies consider the peril of inaction equal to the peril of action, the goals of the NWFP will not be reached."

New science

Regarding the widths of management areas next to streams, the interim minimum distances listed for fish bearing (300') and perennial streams (150') arguably remain as the most controversial components of the existing Strategies. Numerous studies have been completed since the Strategies were first published that investigate how management effects the different ecological processes that are a function of riparian management zones. The ecological processes that function within riparian zones are first discussed individually and then in combination as they affect both aquatic and riparian conditions and biota.

Stream Temperature

Among the more commonly studied management concerns as they relate to ecological processes near streams are the effects of nearby harvest on stream temperature. Initial studies completed by Chen et al (1993; FEMAT, 1993) found that streamside buffers of approximately 125m were needed to protect ecological processes such as wind speed and humidity near streams, which at the time were thought to be able to increase stream temperature. This finding was partially responsible for the second tree height

applied to riparian reserve and RHCA widths in the existing strategies (Everest and Reeves, 2007; Reeves et al. 2016a).

A study that modeled the effects of riparian reserves on stream temperature in Washington found that the first 10m were most important in protecting stream temperature and buffers greater than 30m did not appreciably lower stream temperatures (Sridhar et al. 2004). A study on headwater stream microclimate by Anderson et al (2007) found that the first 10m had the most effect on microclimate above the stream and that temperatures in the streambed increased only when streamside vegetation closer than 50 feet was removed (Anderson and Poage, 2014). A review of studies by Moore et al (2005) suggested that a riparian reserve that was the width of one tree height was likely large enough to protect the ecological processes that control stream temperature. A subsequent study completed by Rykken et al. (2007) found that stream effects helped to offset edge effects documented by Chen et al (1993). While Pollock et al (2009) did not find a correlation between recent (<20 year old) streamside harvest 600 feet upstream of a monitoring site and increased stream temperature, they did find a significant relationship between basins that had greater than 25% harvest in the last 40 years and increased stream temperature. While the increased temperature reported by Pollock et al (2009) was significant, it is unclear if there is a corresponding biological effect on native salmonids in the region where the studies were conducted (Reeves et al. 2016a).

For the past generation, many researchers suggest that a 30m buffer next to fish bearing and perennial streams is generally likely to be sufficient to protect against temperature increase (Reeves et al. 2016a, Sweeney and Newbold, 2014; Anderson and Poage, 2014, Witt et al. 2016). Even so, considerations of context and geography is also appropriate. In a discussion of fixed width riparian buffers, Richardson et al. (2012) state that while these types of protections are administratively simple to implement at a reach scale, watershed considerations and location within the catchment provide additional important context. Reeves et al (2016a) state that with tools currently available, widths can be more easily adjusted and justified, for both wider and narrower buffers.

Large Wood

The fate of large wood in streams has been an important focus for aquatic scientists and managers in the western United States for decades (Richardson et al. 2012). Up until the 1980's, many managers were concerned about how wood in streams affected water quality, and about how accumulations of wood in streams could sometimes block fish migration. These concerns led to instream wood removal programs (Mellina and Hinch, 2009). By the 1980's, scientists more fully recognized wood's role in channel formation and maintenance (FEMAT, 1993). As with stream temperature, the precautionary principle applied by the Strategies to riparian reserves and RHCA's also ensured that the interim widths were set wide enough to encompass any trees that could be delivered to streams, especially the two tree width for fish bearing streams. (Everest and Reeves, 2007).

Regarding the riparian width needed to ensure streamside wood delivery to streams, debate and scientific inquiry has continued since the Strategies were adopted. Studies have been completed to help identify where wood in streams comes from (Reeves et al. 2003, Benda et al. 2003) and the fate of wood once delivered above or to the stream (Beechie et al. 2000). In addition to streamside delivery, disturbance combined with topography can deliver a significant percentage from outside riparian management zones, especially steeper watersheds that are more dissected. Models have also been developed to help identify the likelihood of riparian trees being delivered to the stream channel (Beechie

et al. 2000, Welty et al. 2002, Meleason et al. 2003, Benda et al. 2003, Pollock et al. 2012, and Spies et al 2013). Models focused on wood delivery from the riparian consider distance from the stream, median tree height, and the direction that trees fall. A paper by Benda et al (2016) also discusses how to implement tree tipping to balance effects of thinning dense second growth stands to accelerate large wood development. Modeling completed by Meleason et al. (2003) found that > 90% of wood was contributed from within 30m of the stream edge for modeled conifer riparian stands in western Oregon and Washington. In a literature review, Spies et al (2013) found that 95 percent of wood delivered to streams from hardwood stands came from within 82 feet, and within 146 feet for conifer stands in for forests in the western cascades of Oregon and Washington.

After considering new science, Reeves and all (2016a) proposed two options to direct management in riparian management zones in the Northwest Forest Plan area. Their first option, which the authors considered a "one-size-fits-all-approach," retains the fixed buffer width where the inner 75 feet next to the stream is managed strictly to conserve aquatic function, and outer 75 feet allows ecological forestry to meet other resource objectives including commercial harvest. The use of the term "ecological forestry" is referring to Franklin and Johnson paper (2012) where harvest retains structural and compositional elements of the pre-harvest stands, follow natural stand development principles, applies return intervals that are consistent with disturbance regimes, and all management activities and applications are informed by landscape considerations. The second option, described as a "context-dependent approach," by Reeves and all (2016a) does not have a fixed inner width, instead the inner width is variable and context dependent based on characteristics of the stream reach, "…..susceptibility to surface erosion, debris flows, thermal loading, and habitat potential for target fish species." The second option allows for natural variation and will require more analysis to inform decision maker choices to benefit all resources. The context-dependent approach depends on landscape considerations that were expected to occur with watershed analysis. Unlike when earlier attempts at watershed analysis struggled because of lack of analytical tools (Reeves 2006), better tools and data are now readily available (Burnett et al. 2007, Benda et al. 2007, Irvine et al. 2015, Isaak et al, 2015, McKelvey et al, 2016). Both options proposed by Reeves et al are for second growth stands less than 80 years old in areas designated for multiple use. While the options were developed for the Northwest Forest Plan Area and therefore are influenced by the conditions in that region, the underlying concepts of both options can be applied to the Northern Region.

Debate remains among scientists and the public as to whether active vegetation management should occur anywhere in riparian management zones, even when large percentages of those zones were previously managed for strictly economic purposes and no longer match distributions of conditions that would have occurred naturally. Consequently, differing opinions between scientists makes it difficult for managers to design and implement restoration actions in riparian management areas (Reeves et al., 2016b). Pollock and Beechie (2014) urge caution when considering vegetation treatments near streams, as there are many trade-offs to consider, especially for some terrestrial vertebrate species that depend on large dead wood. Their study shows that emphasizing development of large diameter trees via thinning to create key pieces available for streams can have negative consequences for terrestrial vertebrate species. Reeves et al. (2016a) and (2016b) discuss how tree tipping can be used to offset short-term deficiencies of woody debris in small streams and adjacent riparian areas. Rieman et al. (2015) suggest it is not clear whether considerable funding to date on habitat restoration treatments have been successful. Going forward, they recommend, "(1) a scientific foundation from landscape

ecology and the concept of resilience, (2) broad public support, (3) governance for collaboration and integration, and (4) a capacity for learning and adaptation." Monitoring and adaptive management will be essential to continually learn from and refine riparian management, including when only passive management occurs.

Sediment and Nutrients

Forest Management practices such as road building and harvest have long been a concern regarding their potential to generate fine sediment and subsequent effect on water quality (Beschta, 1978). Altered sediment rates have also been linked to changes in stream condition and ultimately trout and salmon survival in cold water streams (Jensen, 2009). Some activities that led to degraded stream conditions and water quality, i.e. clearcutting next to streams and aggressive forest road building, are highly unlikely to occur present day on Forest Service lands in the Northern region. Reductions in sediment and nutrient delivery have resulted from sequentially improving BMPs (Everest and Reeves, 2007) and regional strategies that have offered greater protection (PACFISH, INFISH, 1995). In recent decades, researchers interested in forest management and water quality have investigated the effectiveness of management policy and law (Brown et al. 1993, Rashin et al. 2006; Cristan et al. 2016). In general, more recent forest practice reviews have found very little unnatural introductions of total suspended sediments and nutrients when BMPs are properly installed before activities begin and maintained throughout management efforts (Sugden et al. 2012, Cristan et al. 2016). Depending on geology of the planning area, sediment introduction from roads receiving little use can be quite low (Al-Chokachy et al. 2016). Increased Nitrogen levels may be an exception and still have levels outside of expected natural conditions (Gravelle et al. 2009). Standards and guides carried forward from existing strategies combined with conservation and improvement strategies discussed elsewhere in this document should help to continue improving trends.

Bank Stability

Bank stability is discussed here as an ecological process; especially as it relates to the effects of anthropogenic activities. The USDA Travel Management Rule (2005) addressed the issues associated with motorized use with specific guidance for roads near streams so that category of activities is not discussed further for this process. The management activity discussed in detail here is grazing and how it interacts with bank stability. Most of the literature reviewed pertains to varied conditions found in western riparian areas and is most applicable to riparian areas in sagebrush grasslands, western interior forests, and Palouse prairie settings. Many of these rangelands can be affected by varying amount of grazing use (Holechek et al. 2011).

Grazing in the west is controversial, with some recommending the practice should be removed or greatly curtailed on public land with the approaching effects of climate change (Beschta et al, 2013), while others suggest grazing is an essential tool to help reduce fine fuels on western Rangelands (Svejar et al, 2014). The American Fisheries Society have issued two policy statements on this particular subject: #14 Strategies for Stream Riparian Area Management and, #23 The Effects of Livestock Grazing on Riparian and Stream Ecosystems (http://fisheries.org/policy-media/policy-statements/). These policy statements assert: Grazing has had and continues to have deleterious effects to streams in the West. The Society recommends actions that improve livestock management on public lands to enhance and maintain in-stream and riparian habitat and they request riparian areas are considered as unique and distinctive habitats in the planning and management of federal lands, and f that riparian area prescriptions be

adhered to and monitored for effectiveness. Further, land management agencies should develop and promote research and inventories to understand the effects and potential recovery of streams affected by livestock grazing.

Low gradient stream reaches that support cold water fish species are of particular concern. Perennial vegetation on or near the water's edge (greenline) in these habitats encounters the most erosional stress during floods. Flooding is a natural disturbance process that maintains heterogeneity in riparian and in-stream structure, function, and composition (Naiman and Decamps 1997). The natural disturbance regime effects of flooding can be compounded by various land-use practices resulting in decreased riparian function. Riparian vegetation has the best opportunity to slow velocity and induce deposition of materials, stabilize banks, and re-create channel pattern, profile, and dimension appropriate for the landscape setting. Where streambank instability or changes in channel form may arise from channel widening or channel incision, vegetation along the greenline is most critical. Depending on site potential, greenline, riparian, and floodplain plant communities also contribute wood and aid floodplain energy dissipation, sediment and nutrient sequestration, and aquifer recharge (Swanson et. al., 2015).

A publication discussing grazing in southwest Montana disclosed some of the history of grazing and focused attention on the stream channel response and management options (Bengeyfield, 2006). Extensive grazing by both wild and domestic ungulates can remove woody plants (Batchelor et al. 2015), reduce the vigor of perennial forbs and grasses, and cause channel profile and function changes via bank collapse on low gradient streams (Trimbell and Mendel 1995; Bengyfield 2006). Widening channels, increased stream temperature, increased fine sediment, altered bank structure and loss of overhanging vegetation that may occur from excessive grazing (Myers and Swanson, 1996; Kershner et al, 2004) is often harmful to aquatic fauna, especially cold-water dependent species (Belsky et al, 1999; Saunders and Fausch, 2007). Furthermore, some studies have demonstrated trout respond positively to livestock exclusion (Sievers et al. 2017), though mechanisms are not clearly understood. In the Northern Great Plains Stephens et al. (2016) found no effects to aquatic habitat from livestock grazing but then explained there is a lack of a non-grazed reference condition in their study and across the Northern Great Plains and recommended long-term extensive enclosures to elucidate the role of this land-use practice on aquatic habitat and fish communities in this Northern Great Plains ecoregion.

Funding available to National Forests to monitor grazing implementation can be limited while methods available to monitor are varied and being improved (Henderson et al 2005, Kershner et al, 2004, Bryant et al. 2006; Coles-Richie et al, 2007; Al-Chokachy et al, 2010; Burton et al, 2011; Hough-Snee et al, 2013; Batchelor et al. 2015, Laine et al, 2015). While no one method works everywhere, stubble height has been extensively studied and is widely put in practice as a trigger for cattle movement or end of season monitoring indicator.

Two time of year categories used for annual grazing monitoring indicators are within season annual indicators and the end of season annual indicators. Within season annual indicators are normally used to indicate when it is time to remove livestock from a given area so that end of season indicators can be met. End of season annual indicators are used to indicate that management for that particular unit and season has been satisfactory. End of season annual indicators may also indicate that management is not meeting or moving towards desired conditions and thus changes to management should be considered prior to the next operating season.

Some types of annual indicators used to monitor livestock grazing uses are: within season or end of season stubble height, streambank alteration, woody species utilization, and bare ground can be valuable tools in providing a link between on-the-ground management and attainment of long-term desired conditions. When designed with and supported by best available science, annual indicators provide a reasonable assurance that if they are consistently met, long-term desired condition attainment would be expected within reasonable time-frames. As such, they provide a short-term means of adapting management on an annual basis to meet or move toward the long-term desired conditions.

End of season stubble (greenline vegetation height) has been shown to be a good indicator of two primary factors: 1) the effect of grazing on the physiological health of herbaceous, hydrophytic plants, and 2) the ability of the vegetation to provide streambank protection and bank building function. Stubble height criteria should be used where streambank stability is dependent upon herbaceous plants. Alternatively, woody plant utilization or streambank alteration could be used as a management guide in situations where streambank stability is controlled by substrate or the stream is deeply incised (Clary and Leininger, 2000).

Rationale for Stubble Height Conservation Strategy Criteria

This end of season stubble height is recommended as a starting point for the following reasons: 1.) Clary and Webster (1990) recommended that in the Intermountain West, a minimum stubble height of approximately 10 to 15cm should remain at the end of the grazing season to maintain plant vigor and provide for bank protection and for sediments to be deposited. However, 19-20 cm stubble height was demonstrated as the optimal length to retain sediment deposits (Abt et al. 1994, Thorp et al 1997). Similarly, Clary and Leininger (2000) indicated that 15-20cm stubble height would be necessary to protect willow and vulnerable streambanks. 2.) Clary (1999) found that 10 cm protected most of the stream attributes while 14.1 cm was needed to protect all stream attributes. These heights were measured when cattle were removed from the pasture, but the height at the end of the growing season was actually 12.9 cm and 16.4 cm respectively (Clary 1999). 3.) Higher average stubble height at the end of season is more likely to provide plants with enough growth during the season to retain vigor in the following season (Clary 1995, Boyd and Svejcar 2012).While height at the end of the growing season still needs more study, some have found positive relationships between higher stubble height at the end of the season and stream habitat conditions (Goss, 2013).

While no one category or indicator type works everywhere, stubble height narrowly focused along the greenline best suits the needs of the northern region to maintain and improve sensitive fish habitat. Bank alteration, while not necessarily discouraged, has not been recommended because of the challenges with consistently measuring this indicator (Heitke et al. 2008). Because of the challenges with maintaining enclosures and the potential for varied presence of woody browse next to low gradient streams without enclosures, this indicator is also neither discouraged nor encouraged for inclusion.

As part of the Northern Region Aquatic Riparian Conservation Strategy it is recommended that the stubble height criteria along the green line at the end of grazing season be 15cm to use in the plan components section of upcoming northern region plan revisions. While the handbook discourages the use of numeric indicators in plan components, it is nevertheless recommended as a guideline with a very narrow application to protect low gradient streams where herbaceous vegetation provides bank stability

near cold water fish habitat habitat. Further, it should be applied to help achieve conditions at site scales that enable attainment and maintenance of desired conditions in these locations. Application of the stubble height numeric value should only be applied when it reflects existing and natural conditions for the specific geo-climactic, hydrologic, and vegetative conditions where it is being applied. Indicator values should be adapted over time based on long-term monitoring and evaluation of conditions and trends. Alternative use and disturbance indicators and values, including those in current ESA consultation documents, may be used if they are based on best available science and monitoring data and meet the purpose of this guideline.

Monitoring and adaptive management should be used to fine-tune relationships between local factors and fit short-term indicator monitoring to the achievement of long-term management objectives. Often, there may be a need to evaluate multiple annual indicators. Long-term indicators for positive trends are expressions of ecological characteristics such as shifts s in frequency of hydric, mesic, and upland functional plant groups, shifts in stream width (greenline-to-greenline), changes in bank stability, and changes in woody species regeneration. The long-term indicators are used to determine ecological trends over time.

Warming Climate and Fire

Fire and changing conditions on the landscape that result from a warming climate must be kept in mind when considering riparian management needs (Luce et al. 2012; Dwire et al. 2016; Reeves et al. 2016b; Joyce et al. 2016, Luce, 2016; Keane et al 2016). When considered by subregion, model runs in the Northern Region show that averaged temperatures will continue to become warmer during the first half of the 21st century (Joyce et al. 2016). Some locations in the region are expected to become drier and have more periods of drought; while overall, precipitation is expected to range from 5% less to an increase of up to 25%, with a mean increase expected to be 6 to 8% (Joyce et al. 2016). Climate is expected to reduce streamflows (Luce and Holden, 2009), reduce the storage capacity associated with snowpack (Luce et al. 2014), and shift the timing of run-off in some locations (Luce et al. 2012; Luce, 2016).

Climactic changes are expected to differentially effect tree species and their distribution on the landscape, as well as some of the pathogens that act upon them (Keane et al. 2016). There is also significant concern that climate change effects combined with altered disturbance regimes caused by fire suppression will change ecosystems (Hessburg et al. 2005, Luce et al. 2012) Finally, climate change may create conditions heretofore not observed and cause ecosystems to shift in novel ways (Luce et al. 2012, Reeves et al. 2016a; Reeves et al 2016b). These changes include how riparian areas respond to potentially novel disturbance regimes (Dwire et al. 2016; Hessburg et al. 2015; Reeves et al. 2016b) . How land managers prepare and respond becomes ever more crucial.

The relation of fire behavior between riparian areas and adjacent uplands is influenced by a variety of factors, contributing to high spatial variation in fire effects to riparian areas. Landform features, including broad valley bottoms and headwalls, appear to act as fire refugia (Camp et al. 1997). Biophysical processes within a riparian area, such as climate regime, vegetation composition, and fuel accumulation are often distinct from upland conditions (Dwire and Kaufmann, 2003; Reeves et al. 2016a). This can be

especially true for understory conditions (Halofsky and Hibbs, 2008). Riparian areas experiencing moderate annual climate conditions can have higher humidity and can act as a buffer against fire and therefore as a refuge for fire-sensitive species (Halofsky and Hibbs, 2008). Some studies have found fire typically occurs less frequently in riparian areas (Russell and McBride, 2001; Dwire et al. 2016).

Depending on geologic and topographic features, riparian conditions and response to fire vary (Halofsky and Hibbs, 2008). A study in mixed severity conifer stands found that riparian and upland conditions are similar and consequently fire effects are similar (van der Water et al. 2010). Under severe fire weather conditions and high fuel accumulation, riparian zones may become corridors for fire movement (Pettit and Naiman 2007). Fire effects occurring upstream will likely influence downstream conditions (Wipfli et al. 2007), as well as future fire behavior (Pettit and Naiman, 2007). Effects of high severity fire on aquatic systems will likely have short term negative affects at the reach scale but beneficial effects over time at that same scale as recolonization naturally occurs (Gresswell, 1999). At a watershed scale, fire effects for one life history phase can be negative, while in the same watershed, the fire effects will be beneficial for another life history phase (Flitcroft et al. 2016). Considering these varied conditions that occur from the stream edge to upslope and from river mouth to mountaintop, riparian response to fire is complex and heterogeneous and therefore requires considerate effort to design treatment plans that maximize benefits for both terrestrial and aquatic dependent species.

In the face of larger fires and disease outbreaks, the challenge of how to integrate management of aquatic and terrestrial resources has now confronted the agency for over a generation, including the Northern Region. Rieman et al. (2000) spoke directly to this perception and identified opportunities for convergence, as have many others since (Rieman et al. 2010, Hessburg et al.2015, Hessburg et al. 2016, Reeves et al. 2016a and 2016b). Current habitat has been degraded in many dry and mesic forests, and treatments (such as road improvement or relocation, culvert replacement, thinning, prescribed fire and wildfire use to restore old forest structure) could create more suitable aquatic habitat in the long term. Rieman et al. (2000) stated, "By working strategically it may be possible to establish mosaics of fuel and forest conditions that reduce the landscape risk of extremely large or simultaneous fires without intensive treatment of every subwatershed." Further, they suggested recovery of function in some watersheds may not be possible without some human intervention. Dry forest treatments, while still controversial (Williams and Baker (2012), are broadly supported by current scientific literature (Hessburg et al. 2016) and have continued to gain acceptance from the public and greater use by managers.

In the Northern Region of the Forest Service, restoring mixed severity fire regimes remains controversial and complicated for numerous reasons such as the habitat needs of endangered species bull trout, lynx and grizzly bear. Therefore treating riparian areas in mixed severity forests can be especially controversial and complicated. In locations where up-slopes and riparian forests have qualitatively similar fire effects, treatments guided by scientific findings are likely to restore ecological function of fire regimes at the landscape level (Finney et al. 2007). Position in the landscape relative to elevation, location within the stream network, and climate regime should be carefully considered to ensure understanding of riparian function (Pettit and Naiman 2007; Reeves et al. 2016a and 2016b). Because the effects of restoration treatments on departed riparian habitats are poorly understood, focused research in an adaptive management framework will be neccessary.

In addition to vegetation treatments in riparian areas, stream channel restoration treatments will likely be considered to help aquatic ecosystems adapt to climate change. In a paper titled "Restoring Salmon

Habitat for a Changing Climate" by Beechie et al. (2013), the authors recommend actions that connect streams to floodplains, restore flow, and help degraded channels aggrade as actions most likely to improve water temperatures. They also disclose that instream channel actions are unlikely to ameliorate climate change effects.

Riparian Dependent Terrestrial species

Best available science since the Strategies were published has sharpened focus on aquatic/riparian interactions. One review found that buffers wider than 30m are large enough to protect water quality and aquatic biota in small streams (Sweeney and Newbold, 2014). In some circumstances such as a narrow band of riparian dependent vegetation alongside an intermittent stream that has low connectivity, these characteristics could lead to a reduced width for the riparian management zone if only aquatic functions are being considered (note: this updated ARCS will retain the original language from Strategies that requires enlargement of riparian management zones when specific conditions such as extensive floodplains are found in a project areas). However, riparian management zones have had increasing focus applied to their ability to support terrestrial organisms and processes. Starting as far back as FEMAT (1993), "Protection of riparian-associated terrestrial organisms has become an explicit conservation objective associated with protection of streams (Richardson et al. 2012)." Numerous studies have published research on riparian use by species from invertebrates (Bunnell and Houde, 2010) to amphibians (Olson and Burton, 2014) and from mammals (Wilk et al. 2010; McKelvey and Buotte, 2016) to avifauna (Lemkuhl et al. 2007; Marcot et al. 2016).

Science published on wildlife use of the riparian is more varied and subsequently more complicated. In a literature review considering appropriate widths for riparian management zones, Wenger (1999) found that buffer distances reported to protect terrestrial wildlife ranged from as little a few feet to over 1000 feet. A distance of 300 feet was recommended for most wildlife acknowledging that the distance might be difficult to implement in all management applications. Lee et al (2004) completed a literature review of management prescriptions next to water bodies in both Canada and the United States. They found that while prescriptions for buffer widths varied by water type such as wetlands, intermittent streams, and fish bearing streams, they were generally wide enough to protect many of the important riparian processes that support aquatic biota. However, buffers were generally less than recommended widths to protect terrestrial fauna. Marzak et al (2010) found that for buffers less than 50m wide, responses by different taxa became more variable as compared to untreated riparian areas. They also found that taxa did not respond similarly to riparian treatments; edge related species increased in abundance or diversity while some interior associated species declined. Some species presence and abundance remained unchanged. Ultimately, they found that current buffers do not retain terrestrial fauna at levels comparable to unmanaged sites for all Taxa. They offered that sometimes upland terrestrial vegetation might need to be combined with the protections that come with riparian management zones for some sensitive terrestrial species (Semlitch and Bodie, 2003). They concluded that increases in protections in some locations should be balanced with some riparian areas allowing partial resource extraction Marzak et al. 2010, Spies et al. 2007, Reeves et al. 2016a).

Challenges of managing for an ideal numerical value for a single process

For the purposes of clarity, much of the Riparian Management Zone discussion so far has looked at ecological processes individually, especially since there is such a large body of literature demonstrating the importance of the riparian for some attributes like stream temperature and large woody debris. Values identified by researchers in the late 1980's and early 1990's for several of these processes were included as Riparian Management Objectives (RMOs) in PACFISH and INFISH (USDA/USDI 1995, USDA 1995). Resulting regulations were also based on protecting these individual processes. Regulatory frameworks in use today (NMFS, 1996; USFWS, 1998) include a Matrix of Pathway Indicators (MPI) and set numerical ranges to describe targets of healthy habitat. Several of the MPIs correspond to PACFISH/INFISH RMOs. The portion of numerical ranges that correspond with professional opinion of high quality habitat is called "proper functioning condition" in the regulatory frameworks. Over time, an expectation has been created that all watersheds can be managed to a rating of proper functioning condition at the same point in time (Reeves and Duncan, 2009). A review by Kershner and Roper (2010) discussed results of monitoring eight RMO's and their related MPI rankings and noted that many locations in unmanaged watersheds do not meet proper functioning condition under this approach, largely due to the mosaic of watershed conditions in unmanaged watersheds. Several years into this PIBO monitoring effort, Kershner and Roper (2010) also disclosed the 8 RMO's monitored in 726 reference and managed subwatersheds had never all been properly functioning in one watershed at the same time.

Managing for a single process with seemingly simple to achieve objectives can have undesirable consequences. Holling and Meffe (1996) discussed the concept of "command-and-control" to deal with the pressures of increasing human populations on declining natural resources. In their paper, they describe this outlook as, "The expectation is that the solution is direct, appropriate, feasible, and effective over most relevant spatial and temporal scales." They go on to say, "The command-and-control approach implicitly assumes that the problem is well-bounded, clearly defined, relatively simple, and generally linear with respect to cause and effect. But when these same methods of control are applied to a complex, nonlinear, and poorly understood natural world, and when the same predictable outcomes are expected but rarely obtained, severe ecological, social, and economic repercussions result." They caution that dependence on "command-and-control" leads to every greater dependency but rarely creates sustainable solutions.

If command-and-control doesn't work, what will? Hiers et al. (2012) discuss the challenges of ecological restoration from the standpoint of "past as prologue", and the possibility that the approach will not be effective with the current and future conditions of climate change, exotic introductions, and broad human perturbations. They discuss a method of restoration planning where they quantify changes in reference conditions while at the same time they measure change in restoration sites. This method of using dynamic reference conditions provides a method to guide restoration where there is no longer an analogue. In Hiers et al. (2016), the authors ask the question, "Can precision be a prescription for failure?" Specifically, this questions the use of targeting a narrow range of desired habitat or ecosystem conditions. Similar to the concerns raised by Holling and Meffe (1996), Hiers et al. (2016) question restoration actions that are precisely designed to meet an idealized condition regardless of nearby natural conditions that are different. As an example relevant to aquatic habitat and riparian management zones, they speak to the widespread implementation of naturally designed channels, often built to exact standards at significant expense that have in turn failed to perform as expected. Of greater concern to Hiers et al. (2016) is the possibility that overly specific targets can reduce variability at different scales and that in turn, the loss of variability can reduce environmental resiliency. With the challenges to precision

and single processes disclosed, the concept of ecological tradeoffs should be considered (Reeves et al. 2016a). They address the reality that ecological processes on the landscape are inextricably linked, and that by maximizing attainment for one process, restoration practitioners could diminish the conditions for other processes.

Need for Change and options for Management based upon BASI

INFISH was originally expected to last 18 months to three years while an effort similar to the Northwest Forest Plan, the Interior Columbia Basin Ecosystem Management Project, was completed for the Interior Columbia River Basin. That strategy was never completed, but science from that effort has been retained in the form of guidance for plan revisions occurring in areas covered by INFISH and PACFISH (ICEBMP Framework, 2014). In addition to following this guidance, this strategy also follows direction in the 2012 Planning Rule. Specifically, greater emphasis is placed on meeting improved and more refined desired conditions, and "Standards and Guidelines" that were not differentiated in PACFISH/ INFISH are separated into Standards or Guidelines in this strategy.

As noted, there has been significant debate about the width of interim RHCAs that were required under PACFISH, INFISH and Interim Riparian Reserves the Northwest Forest Plan. Everest and Reeves (2007) reviewed literature and data associated with riparian reserve widths and concluded that they were not excessive. They did acknowledge that changes in widths were not often made and, "Additional alternative riparian management strategies could be implemented and evaluated in concert to shorten the time needed to realize effective strategies that fully meet riparian management goals." Literature since that 2007 paper and discussed by this review supports vegetation management as close as 100* feet of perennial streams, and 50* feet of intermittent streams with a low probability of affecting riparian processes. No clear distance emerges from the literature as to what width would support most or all terrestrial species, therefore overall widths of RHCAs are retained by RMZs in this strategy to provide for terrestrial wildlife protection. Based on the BASI reviewed, this strategy splits riparian management zones into inner and outer zones. This differentiation is similar to the "one size fits all" option in Reeves et al. 2016a. This more simplistic method of riparian designation provides guidance that will protect riparian processes in lieu of completing a Multi-Scale analysis. It is less flexible than the -context dependent" approach and forgoes some restoration options. Should projects wish to consider more active management in the inner riparian management zone, Multi-Scale analysis would be required to identify context specific opportunities for management.

In the 21st century, forest management occurs at the edge of knowledge attainment and scientific enquiry, where simple and direct answers are rarely available. This is especially true in the northern region with the increase in wildfire size and changes that are likely to occur with climate change. The inner and outer riparian reserve strategy (or "one size fits all") has been designed to: provide assurances to regulatory agencies that desired conditions will be maintained and improved, give simple and clear guidance to project proponents that can be effectively implemented, and include BASI that allows for some appropriate flexibility. This strategy is expected to increase the quality of management for multiple resources and assure that values desired by society will be considered and protected. Should Forests invest in Multi-scale analysis for watersheds, more context specific management next to streams would be appropriate and consistent with both the new Planning Rule and BASI.

*exceptions requiring RHCA extension that were described in original strategies are retained in this ARCS

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