Northwest Fisheries Science Center
Environmental Conservation Division
2725 Montlake Boulevard East
Seattle, Washington 9812-2097

March 17, 2003

MEMORANDUM FOR: F/NWR - Robert D. Lohn

FROM: F/NWC - Usha Varanasi

SUBJECT: Review "Efficacy and Economics of Riparian Buffers on Agricultural Lands"

We have reviewed the scientific merit of "Efficacy and Economics of Riparian Buffers on Agricultural Lands" (herein referred to as the "Report") as it relates to conservation and recovery of Pacific salmon. Our general comments are summarized below along with section-by-section detailed comments (See attached).

Introduction

The Washington Hops Association, Agricultural Caucus, and the Agriculture Fish Water Process hired GEI consultants to review the functions and design dimensions for riparian buffers, their use and efficacy, their applicability to agricultural lands, and potential alternatives to fixed-width buffers. The question they address is whether it is necessary to "broadly prescribe buffers of a specific width on agricultural lands to protect listed salmon", and the Report has two primary objectives: (1) to determine what scientific and technical data and analyses have been applied to the issue of agricultural buffers, and whether the data and analyses are being appropriately matched to buffer zone applications, and (2) to evaluate the economic costs associated with the proposed set asides. We do not have the expertise to comment on the economic analysis in the report; therefore, our analysis focuses on evaluating the first objective.

The authors of the Report do not dispute the ecological importance of riparian vegetation for fish, wildlife, and water quality. The premises and conclusions of the Report can be summarized as follows: 1) current regulations to manage riparian areas are based on studies conducted in high-elevation, high-gradient forested lands of western Washington and Oregon; 2) standards based on these studies are not applicable to low-gradient agricultural lands; 3) buffer standards applied to forested lands are intended to maintain recruitment of large woody debris (LWD; 4) these standards are the principal basis for wide buffer recommendations in agricultural lands; 5) buffers in agricultural lands should be designed to stabilize stream banks, trap sediments, filter pollutants, retain stormwater, and protect the stream from direct and indirect effects from farm animals; and 6)peer-reviewed literature suggest that relatively narrow buffers of 10 meters or less, can be highly effective in protecting ecological functions against these types of agricultural impacts.

General Comments

We have three major comments related to this document: 1) the lack of sufficient evidence, especially relevant field studies, to support the assumption that narrow buffers are adequate for both protecting key habitat functions and ameliorating the effects of agricultural practices and pollution on aquatic biota and their habitat, 2) the heavy reliance on gray literature and incomplete studies, and 3) giving no weight to recent studies that clearly show the importance of wood and riparian areas in the function of low elevation, low gradient streams and rivers typical of agricultural areas.

It is the major conclusion of the Report that narrow buffers (about 10 m or less) are sufficient for protecting low-elevation streams in agricultural lands from impacts specific to farming (sediment, pollutants, nutrients). This conclusion is supported primarily by citation of non peer-reviewed gray literature, which is in contrast to the statement that the report relies "primarily on reviews of peer-reviewed scientific literature". This approach is not consistent with the criteria presented in the report of using all the best available science (Appendix B of the Report). Additionally, because we were only able to obtain some of this gray literature for review (a major problem with gray literature is that it is often difficult to obtain), it is unclear whether the cited literature actually supports the statements made in the report. Moreover, at times peer-reviewed literature was misquoted or inaccurately cited. We acknowledge, however, that in some cases gray literature is the only available source of information for supporting technical issues. In FEMAT, gray literature documents were used frequently to support development of standards and guidelines for forest practices. The Report reviewed here, however, relies heavily on often obscure and difficult to obtain gray literature to support conclusions. The conclusions are, therefore, speculative without additional documentation of findings from several gray literature sources and accurate citation of data from peer-reviewed papers.

Furthermore, the cited literature which we were able to obtain (much was not readily available) does not evaluate the long-term consequences of chronic inputs that can negatively impact aquatic habitat. Nor are the cited studies clearly linked with potential impacts on Pacific salmon. Because the Report recommends buffer widths much narrower than what the bulk of the scientific literature supports, the Report should clearly demonstrate that narrow buffers would provide protection to maintain properly functioning aquatic habitat for Pacific salmon.

Fully functioning riparian zones are critical to properly functioning stream ecosystems. Riparian forests regulate nutrient cycling and productivity, maintain water quality, and exert strong influences on stream ecosystems by modifying the flow of materials (e.g., energy, light) across the landscape. Alterations of riparian forests are felt throughout the stream network. There has been extensive review of the effects of buffer width on stream ecosystems. These include studies on microclimatic gradients (Broskofske et al. 1997), nutrients (Pinay and Dècamps 1988; invertebrate communities (Newbold et al. 1980; Murphy et al. 1986; Davies and Nelson 1994), and fish (Murphy et al. 1986). These studies have consistently shown that narrow buffers (30 m or less) are not as effective at protecting streams from the impacts of upslope activities. We agree that fewer studies have been conducted on lowland streams and rivers impacted by agricultural activities, especially as they pertain to fish. However, recent studies have clearly shown the link between fully functioning riparian forests of large, low elevation rivers and habitat conditions in the adjacent river (Abbe and Montgomery 1996; Hyatt and Naiman 2001; Collins and Montgomery 2002; Collins et al. 2002). Moreover, it has been shown that Pacific salmon prefer stream habitats associated with large wood debris. Therefore, we conclude that the full breadth of evidence demonstrates the strong link between well-developed riparian forests and the structure and function of streams, even large rivers.

It is suggested in the Report that 10 m buffers are sufficient for protecting the stream from a host of impacts associated with agricultural practices. Absent from the Report is a discussion of long-term consequences of chronic inputs of sediment, nutrients, and pollutants on low-elevation streams or how these impacts may interact. For example, high sediment loads to streams has negative effects on stream invertebrates (Zweig and Rabeni 2001; Osmundson et al. 2002) and fish communities (Osmundson et al. 2002). The long-term effectiveness of these narrow buffer strips has been questioned in other studies (Osborne and Kovacic 1993). From the information presented and our inability to obtain several reports, we cannot determine the relevance of studies cited in the report on the effectiveness of narrow buffers to conditions in the Pacific Northwest or whether the proposed 10 m buffers would be adequate to conserve and restore listed salmon stocks. The information presented suggests that there is substantial uncertainty on whether 10 m buffers would be adequate.

Providing adequate riparian protection along lowland streams and associated riparian habitats is especially important for salmon populations, as these areas were historically the most productive in many watersheds (Beechie et al. 1994). Habitat functions do not vary by land-use type (e.g., fish still need instream LWD, regardless of whether land use activities in the uplands is agriculture or logging). Because the majority of the ecological literature demonstrates that buffers that are 30-60 m or greater provide more protection than narrow buffers for the full suite of habitat functions, we suggest there is more certainty that a wider buffer is more protective of aquatic habitat and fish populations than a buffer that is less then 30 m. Moreover, unconstrained (floodplain) stream channels may migrate from less then tenths to tens of meters during the course of a winter or even one high flow event (Nanson and Beech 1977; Abbe and Montgomery 1996). Thus, narrow fixed buffers may be particularly inappropriate for dynamic floodplain channels as narrow buffers could easily be eliminated during a high flow event on an active channel.

The Report acknowledges that agricultural activities place an additional suite of burdens or needed functions on riparian buffersFor example, agricultural activities often include the application of numerous pesticides, herbicides and chemical fertilizers, many of which can degrade instream habitat or have direct toxic impacts to salmon and other instream biota (Hunt et al. 2003). Similarly, agricultural practices also can result in sheet erosion because of tilling activities, something not seen in forested landscapes. The reportdoes not adequately discuss how 10 m buffers would address these additional stressors. There have been a number of studies suggesting buffer widths needed to protect streams from agricultural practices that cause substantial erosion, and also numerous studies demonstrating buffer widths needed to prevent contamination of streams from fertilizer (e.g. nitrates and phosphorus) run-off (references summarized in Correll 2003) However, there have been few studies providing information that can be used to determine buffer widths needed to protect salmon from the many biocides in use on agricultural crops. There are numerous difficulties inherent in making such a determination, among them the fact that biocides have differing toxic effects on salmon, that they differ in their breakdown or absorption rates as they move through riparian buffers, and that these rates vary depending on the vegetation type, hydrology, geology and soil characteristics.

The Report, however, did cite some of the few papers that are available regarding relations between buffer width and biocide breakdown, and these papers are instructive to understand the range of buffer widths that might be needed, and whether 10 m wide buffers are adequate for agricultural areas. Lowrance and others (1997) examined how the common herbicides alachlor and atrazine are transported through a riparian buffer. Their results are complex and not easily distilled, but generally, a 45 m wide forested buffer was able to reduce concentrations of these two herbicides to about 1 ug/L or about a 97% and 91% reduction in atrazine and alachlor, respectively, relative to the initial concentrations after application at the upland edge of the buffer. What, if any effects that concentrations of 1 ug/L might have on stream biota was not discussed, but other studies suggest that even short-term exposure to atrazine at concentrations of as little as 2 ug/L have serious sublethal effects on salmonids (Moore and Waring 2002). Thus it is unclear what the proper buffer widths to protect stream biota against biocides, but available studies suggest something much greater than 10m.

Arora and others (1995) examined retention of the herbicides atrazine, metachlor and cyanazine by a 20 m wide grass buffer and found that such a buffer retained anywhere from 8% to 100% of these compounds, depending on soil moisture conditions, and when the initial concentrations were 580, 730 and 1200 ug/L for each of these herbicides, respectively. While these studies do not offer conclusive support for how wide buffers need to be to adequately filter biocides, they also do not support the contention that 10 m wide buffers are sufficient for agricultural lands. Rather, they suggest that in at least some circumstances, substantially wider buffers may be needed.

Finally, the Report does not cite much of the published literature concerning the role of LWD in low-elevation streams, leading to the inaccurate conclusions that riparian forests along such streams do not contribute substantially to regulation of stream temperatures, instream LWD, or that LWD is an important component of habitat for Pacific Salmon in larger river/stream systems. To support this contention, the Report cites a personal communication with one of our scientists Dr. Blake Feist. When we contacted Dr. Feist directly, he was unaware of any such personal communication.

Current conditions in low-elevation streams are highly modified from historic conditions and LWD was removed for many decades for navigation and other purposes, because the benefits of this wood to fish were not known. It is our opinion that to examine the role of wood in low elevation streams one needs to examine relatively unmanaged systems and compare this to modified streams. Recent studies addressing this issue strongly suggest that floodplain forests are a major source of LWD in unmanaged streams, that LWD is orders of magnitude more abundant in these streams than modified streams, that this wood plays a major role in creating habitat complexity, and that abundance of Pacific salmon is higher in habitat with LWD compared to similar habitat without wood (Abbe and Montgomery 1996; Collins and Montgomery 2002, Collins et al. 2002).

To conclude, low-elevation streams were and in many cases still are major producers of Pacific salmon (e.g., Williams et al. 1975; Groot and Margolis; Beechie et al. 1994;

Collins et al. 2003). Therefore, restoring natural processes that created the complex habitat in these streams would be a substantive contribution to the recovery of listed stocks. The Report does not present new information to the contrary or present convincing arguments that the use of narrow buffer strips are adequate to mitigate the impacts of the full range of agricultural practices. Even if the effects of buffer width on LWD recruitment and physical habitat are ignored, there is still scientific uncertainty that narrow ($\leq$ 10 m) buffers would be adequate for protecting against long-term chronic impacts of sedimentation and alterations to water quality.

If you have any questions concerning our general or specific comments, please contact Dr. John Stein at (206) 860-3330.

Attachment

Cc: F/NWR3 - Landino
F/NWC5 - Kiffney
F/NWC5 - Pollock
F/NWC5 - Roni
F/NWC5 - Stein

Specific Comments

Page 5, section 2.4, 2nd paragraph: It is suggested that "the use of buffer prescriptions for timber exaggerates the conditions that apply to agriculture for a variety of ecological needs, impact assessment, or salmon protection".

We found that evidence presented in this report was not adequate to support this assertion. There was not a clear substantiation that narrow buffers would be protective of aquatic habitat and would ensure the sustainability of listed salmon populations.

Page 6, first full paragraph: It is suggested, "that LWD is primarily a product and function of large trees from coniferous forests, rather than valley bottoms. LWD from upland forests eventually reaches valley bottoms via hydraulic transport". In other words, most of the in-stream LWD in low elevation agricultural streams comes from high-elevation forested streams. There is little scientific support for this conclusion. Published literature was not cited to support this statement. A statement on page 21, para 2 demonstrates how this argument is not well substantiated. They note that LWD was removed from streams between 1950 and 1970 because it was considered harmful to salmon. It was also suggested that LWD in low-elevation rivers was not historically linked to riparian forests by citing a personal communication from Dr. Feist that states there was no significant correlation between LWD and riparian condition in the Willamette Basin. This was followed by a statement that the presence of riparian forests is not a good predictor of salmon abundance.

These statements are misleading and not entirely accurate because large wood was pulled from many low-elevation streams for decades often for navigation purposes. Moreover, harvest of large riparian trees and creation of bank levees along these large rivers has fundamentally altered the natural processes that led to the recruitment of wood into the channels. Therefore, the relationship between LWD and riparian forest cited in the Feist personal communication is confounded by the fact wood was removed and habitat alteration has dramatically reduced the amount of wood in these channels. The relationship in the Willamette River reflects current conditions in a highly altered system. This relationship needs to be evaluated in a low-elevation river where the riparian forest and in-stream wood are not heavily managed.

Recent studies clearly show the importance of floodplain forests in providing wood to large channels (Abbe and Montgomery 1996, Collins et al. 2002). In addition, these studies show how important this LWD is in forming pool-habitat and creating complexity, both of which are important for Pacific salmon (Abbe and Montgomery 1996, Collins et al. 2002, Collins and Montgomery 2002). Collins et al. (2002) examined changes in wood abundance and function in Puget lowland rivers over the past 150 years using historical records and field surveys of a protected reach of lower Nisqually River, and the Snohomish and Stillaguamish Rivers. They found that current wood abundance in the Snohomish and Stillaguamish Rivers, which flow through predominantly agricultural land, is one to two orders of magnitude less than before European settlement, and significantly less than the protected reach of the Nisqually. Wood jams on these rivers are rare because of a lack of very large wood that function as key pieces in forming jams and the low rates of wood recruitment. These changes, in turn, have fundamentally altered the morphology of these rivers. Historically, these lowland rivers had more and deeper pools, and many of these pools were formed by logjams. Large wood had a dominant influence on the geomorphology of large Western Washington rivers: wood formed 61% of the pools in the Nisqually, which is comparable to the study by Abbe and Montgomery (1996) in the Queets. They found that 70% of the pools in the Queets were formed by wood. This is considerably less than the Snohomish and Stillaguamish where wood forms 6 and 12% of the pools, respectively.

Wood formed pools, especially those created by jams, are deeper than those not created by wood. The lack of pools on the more developed Stillaguamish and Snohomish Rivers compared to the Nisqually is likely due to the transition from a freely migrating river with a mature floodplain (Nisqually River) to leveed rivers with little riparian recruitment. This transition has reduced the number of pools by two to three times. Pools created by LWD provide high-quality habitat for salmonids and other fishes because of increased habitat complexity. Beamer and Henderson (1998) found that sub yearling chinook salmon abundance was five times greater along riverbanks with wood compared to where wood was absent.

Further information on the role of wood in large rivers and the importance of floodplain forests in supporting inputs of wood to lowland rivers can be found in the following papers: Abbe and Montgomery 1996; Collins et al. 2002; Collins and Montgomery 2002; Montgomery et al. 1995; Montgomery et al. 1996; Sedell and Froggatt 1984.

Page 10, last para, bulleted items: It is stated that agricultural impacts differ significantly from those due to timber harvest, and can be classified as:

- Soil erosion and sedimentation
- Pesticides and fertilizers
- Animal wastes
- Irrigation/water withdrawal
- Grazing

We agree that these functions are important in agricultural lands, but would also suggest that LWD recruitment and litter input are also important functions of riparian buffers on agricultural lands. Although riparian forests are especially important to shading in small streams, we suggest that riparian trees can also shade large rivers as many mature conifers can reach heights of 100 m. It is suggested in the report that these functions are not important in agricultural lands (see below). We suggest that this conclusion is not supported by the literature.

Page 13-14: No data are presented supporting the statement that cattle grazing in the riparian zone is compatible with a healthy riparian zone, and stream habitat and the term "healthy riparian pastures" is not defined. Without this information, the validity of the statement cannot be determined. To support this conclusion, the term healthy riparian pastures should be defined and peer-reviewed literature cited to support these statements.

Page 15, 1st full paragraph: Inadequate citations were presented to support the conclusion that grazing impacts on riparian ecosystems depends entirely on how the grazing is managed.

Page 15. Again, inadequate references are provided and it is not possible to assess the validity of the statements.

Page 15, 2nd full paragraph: We suggest that the relevant comparison should be between grass buffer strips and forested strips. Historically, floodplains along large rivers were dominated by forests not grass strips. The functional attributes of these floodplain forests are much different from grass strips. Grass strips do not provide large woody debris nor shade protection, and minimal inputs of organic matter. Furthermore, although grass strips remove sediment, there is no mention of concentrations of sediment still entering the stream nor flow rates. Nor is there a mention of the long-term consequences of sediment input. Sediment concentrations may be high enough to impact the river food web.

How relevant are these data to conditions expected on low-elevation streams of Western Washington or Oregon? Sediment dynamics in streams of the PNW are related to a variety of factors such as precipitation and streamflow (Welch et al. 1998); therefore, effort should be made to relate conditions used in studies cited in the Report to environmental conditions in the PNW.

Page 15, last paragraph, top of page 16: It is noted that most of the studies cited were short-term studies that did not address the long-term impacts of chronic inputs of sediment to streams. Two studies were cited that suggest wider riparian buffers (30 to 100 m wide) would be needed to mitigate these long-term impacts. This is an important finding and one we discussed previously. Specifically, many of the impacts discussed should be considered long-term, chronic impacts that over time can have negative effects on stream habitat.

Page 16, Water Quality Protection, 2nd para: It is suggested in the Report that pollutants are removed by riparian buffers. There is no attempt to discuss the relevancy of these studies to conditions in the Pacific Northwest (PNW). Environmental conditions that are critical to evaluating these studies include soil type, organic matter content of soils, flow rate, soil temperature, etc. Without providing this environmental context, it is impossible to determine the relevancy of these studies to the PNW.

Page 16, first bullet, bottom of page: How far into the buffer did these reductions occur?

Page 17, top of page: Grass strips removed only 10 to 40% of atrazine, cyanazine, and metalachlor, and thus were inefficient at removing these contaminants.

Page 17, 1st full paragraph, 1st bulleted item: No documentation of the basis for this recommendation was provided.

Page 17, 2nd bulleted item: These streams were not very efficient at removing solids, phosphorus or nitrogen; therefore, a substantial amount of nutrients and solids will enter the stream under this buffer scenario. This implies high risk for elevated levels of these substances for stream habitat. High levels of nitrogen and phosphorus can lead to eutrophic conditions, which are detrimental to stream organisms (Welch et al. 1998)

Page 17, 4th bulleted item: How much is a "substantial reduction"?

Pages 16-19: Another way to examine the effectiveness of forest buffers in protecting water quality is to examine input-output budgets. Lowrance et al. (1985) compared input-output budgets for a suite of materials in watersheds that were comprised of different proportions of forest and agricultural land. Export of total N from a fully forested watershed (6.9 kg ha^{-1} yr^{-1}) was 2.5 to 8.4 times less compared to watersheds with a mix of forest and agricultural crops (%forest/%agricultural=47/38, 30/54, and 59/36). Therefore, the more the landscape is composed of forests the less export of nitrogen from the ecosystem.

Page 19, Shade protection: The discussion in this section oversimplifies the complex interaction between stream and air temperature and the role that shade has in affecting both of these parameters. A detailed discussion of the interactions is not appropriately discussed here, but briefly, shade is important and helps to both reduce heating of streams and to cool them. In small streams this effect is more pronounced. As streams get larger, the effect of shade on stream temperature diminishes, but is still important.

Page 20, 1st full paragraph: The authors state that the study by Steinblum et al. (1984) defined buffer strip effectiveness in terms of angular canopy density (ACD), and buffer strips of 6 and 31 m yielded ACD's of 17 and 73%, respectively and that a buffer of 17-m would provide an ACD of 90%. These statements are contradictory and inaccurate. According to Steinblum's study, 90% shade is achieved at a buffer width of approximately 38 m. Additionally, the use of ACD to measure shade is a somewhat dated technique. A more recent study (in the PNW) using more sophisticated light measuring instrumentation demonstrated that wider buffers are actually needed to obtain similar amounts of shade (e.g. 90% shade is achieved with a 53 m buffer) (Brosofske et al 1997).

Page 21, Large Woody Debris, 1st full paragraph: It is suggested in the report that LWD is most important in small, forested streams. Several studies show that it is also important in large rivers (Abbe and Montgomery 1996, Hyatt and Naiman 2001).

Page 21, 2nd full paragraph: Recent data suggests that LWD is also important in large rivers, and there is no scientific evidence suggesting that LWD is more important to small rivers compared to large rivers.

Page 22, 4th paragraph: There is no scientific evidence suggesting that LWD is more important in terms of pool formation, velocity refugia, and spawning gravel retention in high gradient streams compared to low gradient streams.

Page 22, 5th paragraph: We agree that less is known about LWD in large rivers, but recent papers have documented the importance of floodplain forests as a source for LWD, the role of LWD in shaping physical habitat of large rivers, and the preference of stream salmonids for habitat associated with LWD (e.g., Abbe and Montgomery 1996; Collins and Montgomery 2002; Collins et al. 2002).

Page 22, 5th paragraph: The Report uses a research proposal by Blake Feist as the "Best Available Science" to show support for the weak relationship between riparian forest condition and in-stream LWD in the Willamette. We have already commented on this statement. To reiterate, this conclusion is flawed because LWD has been removed from many low-elevation rivers for decades. In addition, much of the riparian forests along these rivers are in marginal condition. Therefore, the lack of relationship is more a statement on the condition of the system than the actual relationship between forest condition and instream LWD. To better understand the relationship between forest cover and

LWD requires a study that examines this relationship in unmanaged river systems such as the Queets or portions of the Nisqually River (see studies by Abbe and Montgomery 1996; Collins and Montgomery 2002; Collins et al. 2002).

Page 23, 1st full paragraph: It is mentioned in the report that predictive models of LWD effectiveness and corresponding buffer requirements "do not apply well in agricultural settings, although literature on this topic is severely lacking".

There is no scientific support for this statement, because of the lack of comprehensive research on LWD in large rivers and the recent papers that show the importance of LWD in these systems. Therefore, this statement is highly speculative.

Page 23, 2nd full paragraph: It is noted in the report that "LWD (we presume this statement refers to LWD in low-elevations rivers) originates primarily from forests where velocities and erosive forces would otherwise limit habitat quality and quantity"…There is little to no scientific evidence that supports this conclusion. In contrast, recent papers published in peer-reviewed journals clearly show that historically LWD was orders of magnitude higher than current conditions. Moreover, LWD is considerably higher in the few remaining protected lowland rivers in Washington state than in more developed rivers. These studies have also shown that this wood was critical to shaping the morphology and complexity of lowland rivers. The authors also conclude that "the ecological function of LWD is likely a dominant factor in establishing wide buffer requirements in forests but its need in agricultural areas is not well demonstrated in the literature". We suggest LWD is of critical importance in lowland rivers of Western Washington, and recent papers support this contention.

Page 23, 3rd-5th paragraph: An unpublished study is cited that suggests streams with narrow buffers provided significant improvement in biological metrics compared to control conditions (sites with no buffers). The study was not statistically robust because it did not examine a variety of buffer widths nor have a true control (i.e., a stream in a fully forested landscape). A more rigorous design would have had wider buffers (30-60 m wide) and fully forested controls. With this design, one would be able to gauge how narrow buffers compare to wide buffers and to riparian areas with fully functional forests. For example, studies that have looked at such a gradient have shown that streams with 30-m buffers provide more protection from the effects of logging than narrow buffers (10-m) (Newbold et al. 1980; Murphy et al. 1986; Davies and Nelson 1994).

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