Supplemental best available science supporting recommendations for buffer widths in Jefferson County, Washington

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1. Background. In June, 2006, Jefferson County's Planning Commission held a public hearing in preparation for adopting what has become known as the May 17 draft of a revised Critical Area Ordinance. Hundreds of Jefferson County residents attended the meeting expressing outrage with the draft's onerous and prescriptive contents that attempted to micromanage private property throughout the county. In response, the county organized a Jefferson County Critical Area Ordinance Review Committee (CAORC), which first met in September 2006.

My initial efforts were directed at developing critical area management recommendations that were specific to Jefferson County's rural character using the Department of Ecology's *Best Available Science* (Sheldon *et al.*, 2005). Twenty-six scientific papers cited in Sheldon *et al.* (2005) were requested from DOE for review by Jefferson County. That request was denied by Ecology in an email from Dr. Tom Hruby dated August 31, 2006. In the absence of cooperation on the part of the Department of Ecology, the papers were then obtained from private sources.

Based on nearly 30 years of experience in assessing and managing natural resources and 20 years of experience in delineating wetlands, planning and implementing wetland mitigation projects, and conducting scientific studies involving benthic invertebrates in wetlands, it was apparent that Sheldon *et al.* (2005) had selectively reviewed papers and that significant additional documentation was available. Additional peer reviewed and published literature was then obtained from the Washington State Extension Service through Jefferson County's Conservation District.

That literature was used to define minimum buffer widths necessary to protect wetland functions and values in what has been subsequently been called *Supplemental Best Available Science* (Brooks, 2006). These results were coupled with a strategy to use the Washington State Department of Ecology Rating System for Western Washington (WDOE, 2004) together with numeric factors to define wetland function and hazard specific buffers for use in Jefferson County. This was considered an expansion of the third option for defining buffers included in Granger *et al.* (2005). These minimum buffers were combined with emphasis on monitoring and a local stewardship program to promote win-win management of critical areas in a way that forms a stewardship partnership between land owners and local government. Brooks (2006) and the recommendations of the Committee were then sent to a number of scientists for review. One of those reviewers was the Department of Ecology (Hruby *et al.*, 2007). Based on Ecology's BAS, their reviewers state at page 12:

> "We disagree with Dr. Brook's [*sic*] assertion that the review in Sheldon et al [*sic*] (2005) is lacking documentation of the degree to which species are affected when its [*sic*] range is limited. Section 4.11 addresses the impacts of fragmentation of a wide range of species. Fragmentation directly limits the ranges of species by creating a landscape matrix through which species have difficulty passing. There is much empirical evidence that fragmentation results in lower species richness. This is another way of saying that fragmentation is linked to the local extinction of species that were once

present, and this represents the highest degree to which a species can be affected (The empirical studies describing reduced species richness for plants, amphibians, and birds are summarizes [*sic*] in Section 4.11 Vol. 1 BAS)."

At page 4-57 (Section 4.11.5.1), Sheldon *et al.* (2005) state, "Among these factors, there is evidence that increasing isolation of wetlands due to wetland loss may play a significant role in declining amphibian populations." and that, "Other landscape-based studies also conclude that the distances between wetlands, as well as the suitability of terrestrial habitats, are key factors in amphibian distribution." In their conclusions (Section 4.11.8 on page 4.-62) Sheldon *et al.* (2005) state, "Increased isolation of wetlands appears to be a **major factor** in reducing species richness and abundance for most taxonomic groups." (emphasis added)

It became evident that additional scrutiny of the citations provided in Sheldon *et al.* (2005) was necessary in order to better understand the conclusions they reached. Fourteen papers cited by Sheldon *et al.* (2005) that deal with the effects of habitat fragmentation on amphibians and birds were obtained from private resources. Those papers were reviewed and the results of that review added to Brooks (2006) to create this expanded version of the *Supplemental Best Available Science*. The following reviews of Sections 2.6.1, 2.6.2, 2.6.3., 4.11.5 and 4.11.7 in Sheldon *et al.* (2005) find that:

a) Ecology's BAS is incomplete in that it ignores a significant body of literature supporting smaller buffer widths than are currently recommended in Granger *et al.* (2005) for protection of water quality and hydrologic functions associated with wetlands and surface waters.

b) Ecology's BAS is inaccurate in that a review of the papers cited by Sheldon *et al.* (2005) do not support, and in fact contradict, several of the conclusions reached regarding the effects of fragmentation on the biodiversity of amphibians and birds.

The findings contained in Section 3.1 (Hydrologic and water quality functions) and Section 3.2 (Wildlife functions) suggest that Sheldon *et al.* (2005) does not represent Best Available Science and that their document requires independent critical review by credible scientists who are known to disagree with Ecology's approach to managing wetlands and stream corridors. This statement is made in full knowledge that Ecology sent the document to reviewers nominated by the authors and to the general public. However, as evidenced by the findings contained herein, that process does not appear to have resulted in a document that is sufficiently robust to be considered Best Available Science.

1.1. ***Responsibility for setting buffer requirements.*** In their introductory section, Castelle *et al.* (1994) state that, "Resource agencies are most often responsible for setting buffer requirements." Later, in the section entitled **Agency Applicability** the authors state "Many regulatory agencies rely predominantly on wetland and stream rating systems (a measure of functional value) to establish buffer sizes."

These statements are somewhat misleading. I serve on two Food and Agriculture Organization (FAO) committees under the auspices of the United Nations. Our small Group of Expert Scientists Addressing Marine Pollution (GESAMP-31) has been working for six years to develop risk assessment recommendations for member nations with respect to environmental assessment and management of nearshore aquaculture. Over the last ten years I have also participated in numerous international meetings dealing with the assessment and management of the environmental effects associated with nearshore aquaculture. These meetings have been convened by the U.S. National Marine Fisheries Service, the Canadian Department of Fisheries and Oceans, and Environment Canada. They generally involve 12 to 14 internationally known scientists. A CV is provided in Appendix 1. In every meeting, there has been unequivocal consensus that the setting of performance standards associated with human activities is the responsibility of elected representatives.

What constitutes an allowable cost is not a matter solely of science. These deliberations require multi-faceted consideration of all of the consequences of the decision to include the effects on natural resources **and** the legal, social, political and economic consequences of the decision. Resource agencies must follow legislative mandates and rigorous rule making procedures before environmental criteria are codified in regulatory (RCW) or administrative (WAC) codes.

Natural resource agencies such as the Department of Ecology and the Department of Fish and Wildlife are not generally charged with making multifaceted appraisals, they are charged with protecting fish and wildlife, water, air, soil and sediment quality, etc. These one-dimensional tasks lead to one-dimensional thinking that is evident in the *Best Available Science* (Sheldon *et al.*, 2005) written by WDOE and even more so in the WDFW recommendations of (Knutsen and Naef, 1997) describing perceived wetland and stream buffer requirements for protecting water quality and wildlife.

Federal and state agencies that are land users and managers in addition to being resource regulators frequently have very different perspectives with respect to what constitutes needed land use restrictions. This is well stated in the review of Mr. Frank Easter (National Resource Conservation Service (NRCS) State Resource Conservationist) included as Appendix (2). Mr. Easter, who has 36 years of experience with NRCS in Washington and Oregon:

- "That science typically used by regulatory agencies is conservative and one dimensional."
- "That balanced documents and decisions made by regulatory agencies related to the Growth Management Act and Critical Areas Ordinance are very hard to find."

Balanced documents always include authorship by both resource using and resource regulating agencies and I always encouraged my students to look at the authorship of government reports to insure they contain a variety of perspectives. Sheldon *et al.* (2005), *Wetlands in Washington State, Volume 1: A Synthesis of the Science* was written by a consultant to the Department of Ecology and seven WDOE staff. The *Core Team* contributing to this synthesis of the *Best Available Science* includes only resource regulating agencies (WDOE, WDF W and the US EPA). Similarly, the WDOE document *Wetlands in Washington State, Volume 2: Guidance for Protecting and Managing Wetlands* was written by six Department of Ecology staff; a consultant to Ecology and a member of the Washington Department of Community, Trade and Economic Development.

Absent from the list of authors for either document is representation from the Department of Natural Resources (DNR), US Department of Agriculture, Natural Resource Conservation Service (NRCS), Bureau of Land Management (BLM), Washington Association of Conservation

Districts (WACD), Washington State University Extension Service (WSU) and/or other federal and state agencies that would have provided a broader perspective of the science.

As will be seen in following sections of this paper, there is a good deal of additional science that provides a different perspective with respect to the sensitivity of wetlands and what is needed to protect them. I always cautioned my students to read every paper with skepticism, whether it was published in the peer reviewed literature or was gray literature. As will be seen in Section 3.2 dealing with the effects of fragmentation on amphibian and bird species, failure to critically review cited publications can lead to significant errors in their interpretation. The best reports are those that include authorship by both resource using and resource regulating agencies.

1.2. Putting peer review into proper perspective. Peer review implies that a paper has been reviewed by (usually) three anonymous reviewers known only to the editor who acts as a referee. A paper is published if the editor feels that the reviewers have seen enough value in the contents to warrant publication. Reviewing articles proposed for publication is a tedious task for which no compensation is provided and publishers frequently find it difficult to entice qualified scientists to review work proposed for publication. For that reason, and to help in selecting reviewers who are familiar with the subject of the paper, editors frequently ask the author(s) to nominate potential reviewers. Thus, publications that appear in journals are those that most frequently have been anonymously reviewed by several of the authors' associates who share their point of view.

Scientists do have points of view and that is why there are reputable scientists on opposing sides of many issues – particularly environmental issues. The authors of many government documents frequently send drafts to colleagues for comment. While that review is valuable, it does not constitute anonymous peer review. This procedure lacks rigor because the weight given the comments is determined by the authors and not by an independent editor acting as referee.

Lastly, lay readers must realize that publication in a journal is not certification that the information is accurate or the opinions valid. True peer review occurs over time as others attempt to duplicate results and additional information accumulates to either support or refute the published work. If peer review and publication represented a stamp of correctness, then we would all be basking in the warm glow of cold fusion. That work was peer reviewed and published. Unfortunately, no one has been able to duplicate it – including the original authors.

1.3. Purpose of this paper. This paper is not intended as a replacement for Sheldon *et al.* (2005). Rather, the following discussion is intended amplify the *Best Available Science* produced by Sheldon *et al.* (2005) in an effort to voice the opinions of scientists and government agencies that are not devoted solely to regulating resource uses. This is considered necessary if Jefferson County's Board of County Commissioners are to be able to make balanced decisions with respect to the level of protection needed for the county's wetlands and surface waters - particularly those lying on private property where overly intensive regulation may result in unnecessarily restricting the ability of Jefferson County's citizens to enjoy and benefit from their properties. As previously noted, an unintended consequence of this review has been the detection of significant omissions and errors in Sheldon *et al.* (2005), bringing into question the validity of the buffer recommendations made by Granger *et al.* (2005).

2.0. Wetland functions.

2.1. Hydrologic functions necessary for removing total suspended solids (TSS) from surface flows. One of the functions of wetlands is to store stormwater. This reduces downstream flows during storm events (flood flow desynchronization). In addition, the stored water can slowly percolate downward, recharging shallow and deeper ground water where subsoils are permeable. The stored water is also important to wildlife during the dry season if it does not seep downstream, evaporate or percolate downward too rapidly. The quantity of water semi-permanently stored in a wetland is called its *live hydraulic capacity.* This depends on the landscape's morphology. Wetlands can also store water by reducing the rate at which water flows through them. The time that water spends traveling through a wetland is called the residence time. Residence times are dependent on the hydraulic path and resistance to flow.

Dillaha *et al.* (1986) concluded that the most significant factor affecting vegetative filter strip performance was the flow regime. Higher sediment removal was observed with overland flow as opposed to channelized flow. These authors recommended mowing filter strips two to three times per year to improve grass density and control weeds. Wildlife habitat filter strips planted to woody vegetation were judged to be ineffective for filtering contaminants because the vegetative conditions at ground level were too sparse for effective filtering **or flow retardance**. These same principles apply to managing the hydraulic functions of wetlands. One simply needs to maintain the wetland's live hydraulic capacity and water residence time by:

- Not filling the wetland – including the removal of TSS from stormwater inflows;
- Not changing the elevation of the wetland's outlet; i.e. don't drain the wetland;
- Retaining or increasing the water's hydraulic path as it passes through the wetland;
- Maintain a healthy plant community to slow water's movement through the wetland.

The first two items are easy to manage and relatively easy to monitor and regulate (no fill; manage TSS; no lowering of the discharge; no draining using drainpipes, curtain drains, etc.). The third item is subtler. The hydraulic path can be shortened if wetlands are ditched to collect and move water quickly through the landscape, decreasing the value of their hydraulic function (Edwards, *et al.,* 1996). In contrast, the hydraulic path can be increased by meandering the flows in a torturous path or by maintaining sheet flow without channels across the wetland.

Maintenance of a healthy plant community to preserve wetlands' hydrologic functions requires more consideration. When considering only hydraulic functions, dense vegetation will control and slow water flows more efficiently than woody vegetation such as salmon berries, spirea, skunk cabbage, willow or crabapple thickets (Schmitt *et al.*, 1999). Sedges, rushes and reed canary grass are excellent ground-covers for retarding the flow of water through wetlands where live hydraulic capacity is not the primary factor affecting their hydraulic function. Rumsey (1996) found that stubble height was important and should be keyed to anticipated rainfall. Short herbaceous stems and leaves trap more sediment than taller vegetation, which bends over and offers less resistance to overland flow. More sediment was deposited in Kentucky bluegrass clipped to one-half inch compared to 3 or 8-inch heights. When rainfall was heavy, 8" to 12" stubble continued to trap sediments while the shorter height stubbles were overwhelmed. Rumsey (1996) found no difference in sediment deposition among unclipped sites and sites clipped to heights of one, three and six inches.

Rainfall in Jefferson County varies from over 120 inches in the West End to 80 inches along the Hood Canal to <20 to 25 inches in some areas of eastern Jefferson County. Therefore, maintenance of wetland vegetation to optimize its contribution to hydraulic functions requires different approaches. In general, mature grass, sedges and rushes will be more effective than woody vegetation in all environments. In addition, grass might be clipped to maintain dense structures in the lower rainfall areas of eastern Jefferson County and clipped to higher heights in southern and western portions of the county (Young, *et al.,* 1980, Schmitt *et al.*, 1999).

2.2. Fish and wildlife habitat functions. Department of Ecology BAS (Sheldon *et al.*, 2005) and the recommendations of WDFW (Knutsen and Naef, 1997) rely on publications generally emanating from the conservation biology literature. This literature, including Habitat Suitability Indices, describes the optimum needs of wildlife and the ranges over which species can exist.

It is difficult or impossible to find literature describing the minimum habitat needs necessary to sustain most populations of wildlife. In part that is because it is relatively easy to document the maximum extent of the habitats used by wildlife. It is far more difficult to document the minimum habitat needs required to sustain populations of individual species or communities.

In general, most wildlife is adaptable and many species can maintain viable populations in minimal habitats – especially when there are larger core habitat areas available. In Jefferson County, 95% of the landscape is devoted to Washington State, Federal, Industrial and Tribal forestlands, parks and wilderness areas. These vast habitat areas provide the core habitat needs of most wildlife in this county. The remaining five percent of Jefferson County's landscape is devoted to agriculture and low density residential uses (Wheeler, 2006). There is little commercial or industrial development outside the county's only Urban Growth Area (UGA) located in Port Townsend.

Near the top of page 2-61 of Sheldon *et al.* (2005), the authors assert, "The **presence of buffers and undisturbed uplands and forest cover leading to other wetlands or to upland habitat is critical**" (emphasis added). This statement is not substantiated by empirical evidence provided in the document. Under certain circumstances, wildlife corridors may facilitate the recovery of animal populations diminished by natural or anthropogenic disturbance. However, the citations provided by Sheldon *et al.* (2005) do not empirically demonstrate that the overall survival of any species is jeopardized by the absence of undisturbed wildlife corridors. See Section 3.3 for a discussion of the effects of fragmentation on species of amphibians and birds.

Populations of any given species expand and contract in response to the multitude of variables that influence their numbers including available habitat, food, predators, disease, weather, etc. As populations increase, species expand their occupation of the landscape from optimum habitats to the fringes of sub-optimal and marginal habitats in order to exploit as much of the landscape as possible. The spatial limits of species excursion from optimum habitats can be an order of magnitude greater than the minimum habitat needs necessary to sustain the species.

For instance consider marine mussels (*Mytilus trussulus*) and barnacles (*Balanus sp. and Cthalamus sp.*). On vertical surfaces, such as rocks and piling, communities of these mollusks and crustaceans compete with each other for habitat at tidal elevations between ca. –3.0' MSL and +8.0' to +10' MSL. At the lower extreme, these species fall prey to numerous echinoderms and crustaceans, particularly decapods. At the upper tidal heights these communities are controlled by desiccation and lack of feeding time. Mussels and barnacles at the upper extent of their habitat are typically small and have low reproductive capacity because of a lack of food and thermal and osmotic stress. In Puget Sound, these populations are sustained by that portion of the community resident between ca. –1.0 and +3.0' MSL. Both communities are frequently extirpated at higher intertidal elevations by exposure to freezing temperatures during nighttime low tides in January and February. However, both taxa remain viable in Puget Sound and they expand into marginal habitats at higher elevations whenever conditions allow (cool summers and warm winters) and into lower intertidal areas where low salinity excludes stenohaline predators (Brooks, 1991).

The recommendations of Sheldon *et al.* (2005) and Knutsen and Naef (1997) provide local governments with the maximum distances at which species might be found from their preferred habitats and they provide buffers necessary to exclude all anthropogenic influence on a species. However, the observations of Richter (1996) and Richter and Azous (2001a and 2001b) that habitat buffers of 1,640 to 3,280 feet are used by birds and amphibians in Puget Sound cannot be construed to infer that survival of the avian or amphibian species is jeopardized by buffers of only a few feet or by discontinuously distributed wetland environments.

In fact, wildlife adapt very nicely to human activity. For instance, the University of Washington administration is continually confronted by demands to disband the flocks of wild geese and ducks that take up residence on grassy areas of the campus (to the annoyance of students and faculty who cannot find a place to sit among the feces).

The adaptability of wildlife and their ability to live in harmony with humans is clearly evidenced in the report of Edge (2001) who found that agricultural habitats in Oregon and Washington support diverse wildlife communities. Agricultural habitats in the two states are used by 342 species – more than any other habitat. This high species richness is a function of the broad distribution of habitat types found in agricultural landscapes across the two states, but more importantly, it is a function of the wide variety of habitat conditions, land uses, and crops that are included within this habitat classification.

From a wildlife point of view, homogenous stands of old-growth hemlock and cedar represent some of the most unproductive landscapes found in North America. Consider that Sheldon *et al.* (2005) reported that on the Westside of Washington State only 195 wildlife species are closely associated or associated with herbaceous wetlands and 219 species are similarly associated with riparian wetlands. From this, one might conclude that agricultural habitats, which support of 342 species in Oregon and Washington, are more important to wildlife than are wetlands. It may very well be that the increased habitat diversity and edge effects associated with sensitively managed multiple use wetlands and wetland buffers in residential areas could function just as effectively for wildlife as has been demonstrated for agricultural habitats.

Hruby *et al.* (2007) have argued that a large number of species are associated with agriculture because of the diversity of crops and environments where it is practiced. However, it can be argued that wetlands are equally or more diverse. Wetlands occupy marine environments, potholes in Eastern Washington and environments from sea level to at least six or seven thousand feet where agriculture is not found.

As seen in Section 5.1 of Brooks (2007b), the northeastern portions of Jefferson County have low rainfall (<20 to 30 inches/year). Edge (2001) notes that, "Water is scarce in many of these areas, and water developments become an important habitat feature for wildlife.. . . Spring developments, reservoirs, and precipitation catchments or guzzlers are water developments used for livestock production that also benefit wildlife." Excavated ponds may be especially important in Eastern Jefferson County where most of the rainfall occurs in winter and early spring and where dry summers limit water availability to wildlife. In this author's experience delineating over 400 wetlands in Western Washington, constructed farm and residential ponds provide some of the most significant habitat and water for wildlife during the months of June or July through October in Western Washington.

According to Edge (2001), unimproved pastures that are grazed rather than hayed offer some of the best habitat among agricultural landscapes, especially if fall regrowth is sufficient to offer winter and early spring cover. Fruit and nut orchards provide excellent long-term habitat structure in agricultural landscapes. They are a source of food for many species including black bears, raccoons, skunks and coyotes. Orchards are also used for nesting and foraging by many songbird species.

Edge (2001) provides numerous recommendations for enhancing agricultural lands for wildlife including management of odd areas, creation of food plots, shelterbelts and windbreaks, hedge and fence rows, field borders and management of roadsides by leaving a five meter wide uncultivated strips seeded to grass-legume mixtures. He also recommends reducing pesticide impacts. While these recommendations were made with respect to agriculture, the importance of habitat diversity and edge effects likely applies to low and moderate density residential landscapes as well.

Hruby *et al.* (2007) have argued that agricultural environments can act as "environmental traps" for wildlife. However, the same is true of natural environments. Amphibians that lay eggs in ephemeral wetlands in Western Washington during March or April may waste their reproductive potential when those wetlands become dry in June or July before aquatic larvae metamorphose. Coho salmon fry and cutthroat trout that explore too far into headwater Type 4 or 5 streams may become stranded and die as these annual streams dry up in late spring and summer in eastern portions of Jefferson County lying in the rain shadow of the Olympic Mountains.

2.3. Water quality functions. The ability of wetlands to store inorganic contaminants such as common metals like copper, chromium, zinc is well established as is their ability to process organic contaminants like polycyclic aromatic hydrocarbons. In addition to sequestering organic contaminants, the shallow water depths and rich microbial communities associated with some wetlands facilitates the photochemical and microbial mineralization of organic contaminants.

Wetlands also act as a sink for nutrients – particularly nitrogen and phosphorus. The organically enriched sediments in some wetlands coupled with seasonally changing water levels leads to variable redox potentials in surficial sediments. These conditions initially encourage nitrification ($NH_4^+ \rightarrow NO_2 \rightarrow NO_3$). Below the surface, where redox potentials are negative, microbes denitrify nitrate resulting in the release of nitrogen gas (N_2) into the atmosphere. This process is important in some areas of the country where nutrients are flushed from upland areas into marine surface waters during late spring and summer when algae are rapidly growing.

As will be seen in a following section of this report, most of the rainfall in Jefferson County occurs during the winter months when cloud cover and the county's high latitude (48^o N) causes primary production to be light limited – not nutrient limited. Many wetlands in Jefferson County no longer have saturated soils by the end of June because of reduced rainfall. In addition, outside of Hood Canal, the marine waters of Jefferson County are naturally enriched with nitrogen during spring and summer in association with coastal upwelling driven by northwest tradewinds.

The point being that in summer, outside of Hood Canal, Jefferson County's marine environments are not nutrient limited at any time of year. It is sunlight that drives primary production in most of the coastal waters of Jefferson County – not nutrient inputs from upland areas. However, Jefferson County's lowland freshwater streams, ponds and lakes can and do suffer from eutrophication. However, because our rainfall occurs primarily in winter when these waterbodies are light limited, wetland function with respect to the sequestering of nutrients is not as important is it might be in other areas of the country. Brooks (2000, 2003 and 2006) provide discussions of nutrients in Puget Sound marine waters.

An exception to these temporal patterns of rainfall and illumination occurs when farmlands in Jefferson County are fertilized during summer and then irrigated. Under these circumstances excessive primary production can and does occur in lowland streams, ponds and lakes receiving irrigation runoff. Having said that, wetlands function to process nutrients and contaminants at the same time and the contaminant function remains a potentially significant function of wetlands in Jefferson County at all times of the year.

The maintenance of the Jefferson County's wetland water quality functions requires many of the same considerations as does the maintenance of hydraulic functions. Many common contaminants, including metals and phosphorus are adsorbed to clay particles and are sedimented in depositional areas (like wetlands). Therefore the water quality function requires long hydraulic paths and dense vegetation to slow water movement through the wetland. However, optimal water quality function also requires vigorous plant growth and organically enriched sediments that provide the cometabolites necessary for the microbial catabolism (mineralization) of some refractory organic contaminants.

3.0. Supplemental information regarding wetland functions. The analysis presented in Sheldon *et al.* (2005) appears designed to protect wetlands on a worst-case basis. As will be seen in the following supplemental information, there is no consensus supporting the statement of Castelle *et al.* (1994) that minimum buffer requirements for effective sediment removal from storm water is ca. 10 meters (33') or that, "From the literature, it appears that buffers less than 5 to 10 m (16 to 33') provide little protection of aquatic resources under most conditions. Nor does the following analysis support their conclusions that minimum buffers of 15 to 30 m (49 to

98') width are necessary under most circumstances. In fact, as will be seen, there is a significant body of literature supporting minimum buffer widths less than 5 meters (16'). Lastly, the detailed review of citations in Sheldon *et al.* (2005) provided in Section 3.3 indicates that empirical evidence does not support assertions made by Ecology that habitat fragmentation has significant adverse effects on amphibians and birds.

The approach taken in these recommendations for defining buffer widths appropriate to Jefferson County is to start with minimum buffer widths necessary to protect water quality and hydrologic functions. A reasonable water quality monitoring program such as that undertaken by Jefferson County's Conservation District would then be expanded to identify exceedances of Washington State water quality criteria (WAC 173-201A). Where exceedances are observed, the CAO should require adaptive management, to include increased buffer widths where that is deemed necessary, to bring surface water quality into compliance.

It is quite possible, that Jefferson County citizens with an interest in natural resource conservation could become an integral part of a water and sediment quality monitoring program. There is a long history of successful citizen monitoring programs in the United States (Latham, 2007; Clark, 2007; Hughbanks, 2007) and the US EPA provides guidance for monitoring by *Streamkeepers* and other local groups (EPA, 1992; Shackleford, 1988). This approach is considered consistent with traditional American values in that it does not allow degradation of public resources, such as surface or ground water. The proposal imposes minimum buffers that should protect water and sediment quality under most conditions followed by a requirement for adaptive management in response to a local monitoring program when there is evidence that the minimum buffers or management of those buffers is not adequately protecting water quality.

3.1. Hydrologic and water quality functions. These two functions are considered together because they both depend on a wetland's live hydraulic capacity, water residence time, vegetation, and the magnitude of inputs from adjacent uplands. In Figure 1 of Castelle *et al.* (1994), the authors assert that the minimum buffer requirements for effective sediment removal from storm water are ca. 10 meters (33 feet). In the section entitled **Agency Applicability** they state that, "From the literature, it appears that buffers less than 5 to 10 m provide little protection of aquatic resources under most conditions. Based on existing literature, buffers necessary to protect wetlands and streams should be a minimum of 15 to 30 m in width under most circumstances."

Table 5-1 of Sheldon *et al.* (2005) summarizes data from eight studies describing sediment control buffers and Table 5-2 lists results from 13 studies describing buffer widths for nutrient removal. Summary statistics describing the values given in the two tables are provided in Table 1. The average buffer width recommended for nutrient removal in Table 5-2 of Sheldon *et al.* (2005) is 90.8 $\pm$ 67.6 feet (28 m) and for sediment removal it is 103.8 $\pm$ 59.1 feet (32 m). A casual or naive reader might assume that buffers between 91 and 104 feet are necessary to control sediments and nutrients. Well-trained scientists understand that numerical results presented in publications can only be understood in terms of the methods used to determine them. That is why scientific papers include a Materials and Methods section – to allow appropriate interpretation and experimental duplication of the results.

Table 1. Summary of buffer requirements asserted as necessary to protect hydrologic and nutrient removal functions listed in Sheldon *et al.* (2005)

Variable	Descriptive Statistics (Rainfall 2001 through 2006)						
	Valid N	Mean	Confidence -95.000%	Confidence +95.000%	Median	Minimum	Maximum
Nutrient Removal (feet)	26.0	90.8	23.2	158.3	36.0	12.5	853.0
Sediment Removal (feet)	15.0	103.8	44.7	162.8	80.0	6.6	400.0

The need to understand the context within which it is appropriate to apply an author's data is emphasized by considering that both tables referenced a buffer width of 80 feet attributable to the work of Young *et al.* (1980). These authors' measured total suspended solids (TSS), nitrate (NO_3-N) and phosphate (PO_4-P) in runoff from a feedlot containing 310 cattle fed within an area that was 111.25 m long x 94.86 m wide (1.06 hectares or 2.61 acres). That is a density of **119 cattle/acre**. During the first year, the buffer strips were plowed and planted to corn and a mix of sorghum and sudangrass with herbicide applications to control weeds. A third plot was planted to orchard grass, a typical forage grass in Jefferson County.

Why is the type and maturity of vegetation in the buffer important? Most of the pastures that I have examined in either Clallam or Jefferson Counties in the last 18 years have been covered with mature grasses older than at least five years. Schmitt *et al.* (1999) found that compared to sorghum grass, 2-yr-old grass; 2-yr-old grass-shrub-tree, and 25-yr-old grass filtered more of the adjacent pasture's contaminants. 25-yr-old grass was far more effective than the other treatments in controlling pollutants and 2-yr-old grass was more effective than the grass/shrub/tree VFS. Figures 1a (mature grass) and 1b (newly planted grasses) are provided to give a more intuitive understanding of why these differences are important to understanding the conditions under which the Young *et al.* (1980 study was conducted and where it can appropriately be applied.

a) Mature pasture in December, 2006

b) Immature pasture in December 2006

Figure 1. Photographs of a) mature Jefferson County pasture in December 2006 describing the organic matrix functioning to slow overland water flow and to filter suspended solids and sediment bound nutrients and, b) grass, seeded in September 2006 in Clallam County, as it appeared in December 2006.

The Young *et al.* (1980) study was conducted on a landscape having a slope of 4%, which is typical of many Jefferson County pastures. Artificial rainfall was applied at a rate of 6.35 cm/hour (2.5 inches/hour) for 71 minutes, which is more intense than the predicted 24-hour, 25-year storm event for Jefferson County (2.5 – 3.0 inches/24 hours). Under these worst-case conditions, the authors reported that the newly planted buffer strips reduced suspended solids by 67 to 79% and nitrogen by 84% and P by 83%.

The report of Young *et al.* (1980) indicates that if a farmer were to put 119 cows on a single acre and plant an 80 foot buffer with corn or sorghum and then experience a storm more intense than Jefferson County's 25 year event, the buffer would reduce TSS by 74% and nutrients by 83.5%. However, that is not the typically animal husbandry operation in Jefferson County and in 2006, an intensive animal feeding operation such as this would require an NPDES permit from the Department of Ecology – it would not be regulated by a local Critical Area Ordinance.

The point in this discussion is that the 80' buffer described in Tables 5-1 and 5-2 of Sheldon *et al.* (2005) has little or no applicability to current animal husbandry practices in Jefferson County or to animal practices that would be regulated solely by the CAO. None of this detail is included in Sheldon *et al.* (2005) and it is essential to understanding whether or not the data is appropriate to the question being asked. Are other studies available suggesting that narrower buffers are sufficient to protect wetlands and surface waters from excessive nutrient and TSS inputs?

Buckhouse and Gifford (1976) concluded that low density grazing (one AMU/2.0 ha. or one AMU/5 acres) did not constitute a public health hazard in terms of fecal pollution indicators. At a distance of 1.0 m from individual cow feces (a cow pie) the average fecal coliform (FC) count was 23/100 ml of runoff. They cited Stuart *et al.* (1971) and Bissonette *et al.* (1970) who found that a wildlife refuge where people had been excluded for 40 years had consistently higher bacterial counts attributable to the wildlife than did an adjacent watershed which was open to the public. Low density grazing did not significantly increase fecal coliform counts in comparison with adjoining ungrazed areas. The authors concluded that there were no apparent negative public health hazards associated with grazing at a rate of one AMU/2.0 ha (one AMU/4.9 acres).

Edwards *et al.* (2000) found that runoff concentrations of N and P from manure treated grass pastures were low and generally not consistently different from control plot concentrations. Runoff FC concentrations from manure-treated plots were higher than from control plots. NH_4^+-N, NH_3-N, NO_3-N, NO_2, P and FC decreased exponentially as a function of time. The authors concluded that manure deposition on well-managed pasture grazed at 3.7 AMU/ha (1.5 AMU/ac) had a negligible impact on nutrient content of runoff – with no buffers included in the study.

Desbonnet *et al.* (1994) concluded that, "From the values presented in Table 7, **a multiple-use vegetated buffer of five meters could be considered a reasonable minimum-buffer-width standard.** A five-meter-wide buffer will provide approximately 50 percent sediment and nutrient removal (except for nitrate). While a vegetated buffer of this width may not provide good overall wildlife habitat, it may be sufficient to provide resting and feeding areas for both resident and migratory species." (Emphasis added).

Mosley *et al.* (1997) in developing the Idaho Forest, Wildlife and Range Policy concluded that based on Doyle *et al.* (1975) and Oskendahl (1997), a vegetated filter strip (VFS) of at least 12.5 feet on each side of a stream was adequate to protect water quality from coliform bacteria and effectively filter nutrients. Soil type, slope, vegetative cover, fecal concentration, and runoff levels are determinants of the width of buffer needed on a site-specific basis. Mosley *et al.* (1999) concluded that the impact of cattle grazing on riparian ecosystems depends on how the grazing is managed. The important variables were timing, frequency, and intensity of grazing. Each situation was hypothesized to be unique; requiring its own creative, locally tailored solution. The authors concluded that the best way to know whether a particular management strategy was suitable for a particular site at a specific point in time was to implement the strategy and then monitor its effectiveness and adjust the practice as needed (adaptive management).

Neibling and Alberts (1979) used a rainfall simulator on grass plots with a slope of 7% to show that 0.6 to 4.9 m (2 to 16') long grass buffers reduced sediment discharge by over 90%. Clay transport was reduced by 37, 78, 82 and 83% for the 0.6, 1.2, 2.4 and 4.9 m buffers. Significant solids deposition was found upslope of the buffer zone and 91% of the TSS was removed within the first 0.6 m (2') of the VFS.

Owens *et al.* (1983) examined a 26-ha (64 acre) pasture with a perennial stream and extensive wetlands that was fallowed for two years followed by summer grazing at a stocking rate of 0.26 AMU/acre for 3 years. "The concentrations of most of the measured chemical parameters (NO_3-N, mineral N, NH_3, HN_4^+, P, K, Ca, Mg, Na, S, Cl, HCO_3 and Total Organic Carbon) in the storm water discharge water from the pasture to the stream were low and changed very little as a result of grazing. The stormwater discharge of the same parameters from the ungrazed 17.7 ha (44 acre) wooded watershed were greater than or equal to those from the unimproved pasture during the grazing period."

Pizzimenti 2002) summarized buffer widths reported in a number of studies.

Ahola (1990) - 2 to 10 m (7 to 33') for stream habitat protection.
Dillaha *et al.* (1989) - 4.6 m (15') removed 70% of TSS; 61% TP and 54% TN.
Doyle *et al.* (1975) 12' adequate
Doyle *et al.* (1977) 12' for forested buffers and 13' for VFS.
Ghaffarzadeh *et al.* (1992) - <9 m (30')
Hubbard and Lowrance (1992) - 7 m (23')
Madison *et al.* (1992) - 4.6 m (15') removed 90% N and P.
Neibling and Alberts (1979) - 82% TSS removal in 2.4 m (8') and 90% removal in 4.6 m (15')
Reneau and Pettry (1976) 94% P removal from shallow groundwater over 3 m (10')
Xu *et al.* (1992) - 100% Total Nitrogen removal in 10 m (33')

Gary *et al.* (1983) conducted a two-year study in two pastures containing 185 acres and 210 acres with a small perennial stream flowing at an annual average rate of 2.9 cubic feet/sec (cfs). Stocking rates ranged from 0.18 to 0.75 AMU/ac. Suspended solids and NO_3-N did not increase significantly and NH_3 increased significantly only once under these moderate rates of grazing. Fecal coliform bacteria counts in the stream were significantly higher when at least 150 cattle were grazing. Significant FC increases were not observed at any time with 0.18 AMU/ac. These conditions were observed with no buffers on the streams.

Larsen *et al.* (1994) found that bovine feces landing near a stream had a much smaller potential impact than feces deposited directly in the water. The number of bacterial escaping during a 30-min rainfall event was reduced 83.4% by a 0.67 (two foot) VFS and bacterial loading was reduced 95% with a 2.13 m (7') VFS. However, differences in bacterial counts were not significantly reduced at 1.37 or 2.13 m distances in comparison with concentrations at the edge of the 0.67 m VFS suggesting that a buffer strip of 2.0 feet was adequate.

Doyle *et al.* (1977) found that both grass and forest buffer strips of approximately 4 m (13') were effective in reducing levels of fecal bacteria and concentrations of total soluble NH_4-N, NO_3-N, P and K in surface runoff from manure treated plots (90 mT/ha) on soils similar to many found in Jefferson County (18% sand, 55% silt and 16% clay). Rainfall was heavy at 2.8 to 8.0 cm (1.1 to 3.15") over periods of 11.5 to 18.5 hours. Nearly all of the nutrient removal occurred in the first 3.8 m (12.5') of buffer. Decreases at distances >4.0 m (to 30.5 m) were not statistically significant ($\alpha = 0.05$).

Lim *et al.* (1998) treated the upper 12.2 m (40') of pasture plots with cattle manure, while the lower 18.3 m (60') acted as a VFS. Runoff produced by simulated rainfall was sampled at VFS lengths of 0.0, 6.1, 12.2 and 18.3 m and analyzed for NO_2, NO_3, NH_3, NH_4^+, P, TSS, FC and other parameters. Contaminants were reduced quickly in the VFS and the mass transport of most endpoints was represented by first-order exponential decay functions. Approximately 75% of incoming total N, P, ortho-P and TSS were removed in the first 6.1 m (20') of the vegetated buffer.

Strivastava *et al.* (1996) examined the effectiveness of 6.1, 12.2 and 18.3 m long VFS below poultry litter-treated uplands. Simulated rainfall of 1.97 inches/hour was applied to vegetated filter strips newly planted with fescue (*Festuca arundinacea*) on a 3% slope. NO_3-N, TKN, NH_3-N, PO_4-P, Total P and TOC declined exponentially with VFS length. The authors concluded that a relatively large proportion of the mass removal occurred within the first 3 m (10') of the VFS. An examination of their individual graphs suggests that nearly all of the removal occurred in the first 6 to 9 meters (20 to 30 feet) of VFS and that the efficiency was low beyond that.

These results are summarized in Table 2. Note that with the exception of Desbonnet *et al.* (1994) and Doyle *et al.* (1977), none of the references are cited in Sheldon *et al.* (2005). These citations indicated that light to moderate grazing in riparian areas had no significant effect on water quality with respect to nutrients, TSS and/or bacteria. Nutrients, bacteria and TSS generally declined exponentially in overland stormwater flows with the most efficient filtering occurring in the first 0.6 to 6.1 m (2 to 20') of vegetated buffer. In general, 60 to 90% of the material was filtered in the first 0.6 to 4.6 m (2 to 15').

In general, these studies were specific to agricultural practices. However, their finding that suspended solids, bacteria and nutrients (fertilizers) were effectively filtered in the first 2 to 15 feet of VFS could equally be applied to residential hazards associated with landscaping as well. However, it should be noted that Schmitt *et al.* (1999) found that while most nutrients and TSS were effectively filtered in narrow strips, ionic pesticides dissolved in stormwater, such as atrazine and alachlor, declined linearly rather than exponentially. These pesticides must be applied in compliance with the EPA label to insure adequate protection of wetlands and surface waters.

3.2. Stream temperatures. Salmonids are public resources that are sensitive to high temperatures and Washington State's Administrative Code (WAC 173-201A-030) defines thermal criteria for surface waters. For AA waters, allowable anthropogenically induced thermal increases are restricted to $\leq 0.3\ ^{o}C$ when the stream's maximum temperature exceeds $16\ ^{o}C$. For Class A waters the maximum is $18\ ^{o}C$ and for Class B it is $21\ ^{o}C$. Stream temperatures are affected by both solar insolation and air temperatures.

In addition, Crittenden (1978) determined that water temperature in small streams was also influenced by heat loss to the stream bed and to evaporative cooling while heat can be exchanged with groundwater by conduction through the stream bed. Shade reduces solar insolation, but does little to mitigate air temperatures or these other factors. The following literature provides additional perspectives on this issue not discussed in Sheldon *et al.* (2005).

Larson and Larson (2003). Landowner monitoring of stream temperature and bottom sediments on the North Fork of the John Day River showed that stream temperature was related to elevation and not to uses. Cattle grazing had no effect on temperature.

Headwaters of this river are at 7,000' MSL declining to 1,875' at its confluence with the John Day River. The headwaters are located in lodgepole pine forest and are derived from springs and marshy seeps. Mid-elevation sites are mixed conifer forests comprised of grand fir, Douglas fir and Ponderosa pine. Low elevations are covered with sagebrush steppe and agricultural croplands in the floodplain and terraces adjacent to the river. Similar to Jefferson County, average annual precipitation at 4,000 feet is 18.5 inches with 62% occurring between November and March and 22% from April through June. Precipitation is lower at lower elevations (10 to 15 inches).

Five test plots were either grazed or left ungrazed at four elevations. The data in the three-year study did not detect thermal or sediment pollution between sites used for grazing or hay production and sites without grazing. They determined that existing water quality conditions within the watershed were strongly influenced by weather and elevation and served to illustrate the need to establish natural or background conditions before drawing conclusions with regard to pollution or management activities. **Stream temperature change was correlated primarily with thermal gradients associated with elevation changes and not with management practices.** (Emphasis added.)

Moore and Miner (1997) emphasized that shade can come in the form of tall grass, shrubs and brush which is very effective in shading small, narrow streams. Taller trees, further from the edges of wider streams also provide shade, except during midday, when the sun is overhead.

Monoham (2004) found that, "As such, there is considerably less woody debris recruitment in the floodplain environment compared to the forested upper portions of the watershed. Therefore, lowland riparian buffers probably should not be designed to meet large woody debris in-stream quotas that were developed in mature and/or old growth upland forests."

However, he did not demean the importance of shade and also noted that, “The elevation-based differences in temperature mean that the role of riparian buffers play in temperature regulation along lowland agricultural streams is potentially of great importance to the maintenance of a habitable temperature regime for salmonids, but appropriate widths may not be predicted by models developed in forested regions.”

These comments suggest that shade is important along Jefferson County lowland streams, but that the type of plants providing that shade will likely be different than found at higher elevations where stream banks are most often dominated by conifers. Most agricultural and residential development in Jefferson County occurs in lowlands. In undisturbed lowland riparian areas, alder, salmonberry and willows are often dominant plants and these have a potential to effectively shade small streams.

Monoham (2004) also found that riparian buffers comprised of red alder can act as a net source of nitrate rather than a sink, which means that the nitrate-retention attributes of riparian buffers studied elsewhere may not be relevant for riparian buffers in the agricultural areas of the Pacific Northwest. Monoham’s preliminary results showed that in-stream total nitrogen increased with buffer width and density (in red alder riparian zones). Thus in nutrient sensitive stream reaches, such as the middle reach of Chimacum Creek, planting red alder may provide shade, but it may also exacerbate problems with eutrophication.

The bottom line is that appropriate riparian vegetation is site specific and needs to consider all of the functions being managed – not just temperature.

Steinblums *et al* (1984) evaluated 40 buffer strips in conifer forested Oregon Cascades at elevations of 2,000 to 4,000 feet. Figure 2 of their paper describes *angular canopy density in percent (ACD)* as a function of buffer-strip width. One buffer that was ca. 28’ wide had an ACD value within the range of values reported for all wider buffers. In general, Log ACD was related to buffer-strip width (feet). However, there was a distinct discontinuity at ca. 50’ width, with generally lower values between 40 and 50’ and higher values at ≥58’ buffer widths.

Pizzimenti (2002, 2005) concluded that, “In summary, after reviewing numerous peer-reviewed studies related to agriculture, we conclude that riparian buffers, based on site potential tree heights of up to 300 feet wide, often greatly exceed what is required to protect water quality and the ecological function of aquatic habitat on agricultural lands.”

Pizzimenti also found that, “Riparian buffer zones are ecologically beneficial; however, the width and composition of a buffer zone should be tied to specific management objectives.”

Based on their literature review, Pizzimenti (2005) recommended a minimum lowland buffer width of 25’ for streams where salmon listed under the Endangered Species Act are found. The minimum buffer width assumed that agricultural BMPs were implemented for irrigation water application, pesticide and fertilizer application, or animal management. Their model ordinance recommends an increase in buffer width to 35’ in areas receiving >18” of rainfall/year and where the banks have gradients >7%. If landowners refuse to incorporate BMPs, then Pizzimenti (2005) recommend a buffer width of 60’.

Figure 2 describes a section of Matriotti Creek in Clallam County Washington having a measured buffer of 25’ either side of the stream. The alder trees completely shade the stream regardless the position of the sun.

Figure 2. Twenty-five foot buffer on either side of Matriotti Creek in Clallam County, Washington.

3.3. General wildlife functions of wetlands. Wildlife species compete with each other for nesting and rearing habitat and for food. This competition is mitigated to some extent because different species comprising a community of animals are each adapted to specific habitats or niches. As the number of individuals in a species expands, the species need for additional habitat will inevitably exceed the preferred niche. Populations then expand into less desirable habitats where they encounter increased competition from other species. Eventually, all species will expand their range to include even the most marginal habitats in which they can survive.

It is relatively easy to document the maximum range from preferred habitat at which a species is found. It is more difficult to document the **minimum habitat needs** necessary to sustain a species. The fact that an amphibian is found at some significant distance from a body of water does not mean that the species cannot thrive when restricted to a much smaller area. What is missing from the review of Sheldon *et al.* (2005) is documentation of the degree to which a species is affected when its range is limited. Also missing from the discussion in Sheldon *et al.* (2005) are the following:

- The fact that the attention of birds is directed toward human intruders is an *effect per se.* No empirical evidence is presented demonstrating that the species are put at significant risk because they are interested in the nature of the intrusion. The attention of birds is also diverted by predators, wind rustling in trees, etc. Their survival depends on this alertness.

- The interconnectedness of habitats, such as wetlands, may or may not increase the potential for repopulation of a disturbed habitat. In addition, interconnections may increase gene flow between adjacent populations or it may not. On another scale, evolution is enhanced by the isolation of communities of animals forced to adapt to isolated environments. The federal government is currently regulating salmon as threatened or endangered based on the need to preserve the genetic identity of particular stocks of fish that have evolved subtle differences in their genomes as a result of relatively short term isolation associated with their natal watersheds. On the one hand, conservation biologists wish to impose significant restrictions on society in an effort to stop gene flow between salmon stocks and on the other hand, Sheldon *et al.* (2005) argue for increased restrictions on society in order to maintain gene flow between populations in adjoining wetland environments. This issue will be discussed in more depth in Section 3.3 of this report.

- Many wildlife species are highly adaptable. As noted by Edge (2001), 342 species of wildlife are associated with farmlands in Washington and Oregon. That is 50 percent more species than are associated with wetlands (Sheldon *et al.* (2005). In my experience, there are few landscapes that are as depauperate as old growth forests. Wildlife is far more abundant in scrub lands and/or mixed stands of vegetation having several seral stages. As previously noted, agricultural lands may be diverse, but wetlands are equally or more diverse.

- There is no recognition in Sheldon *et al.* (2005) of the fact that in some areas, such as the Olympic Peninsula, most of the landscape is already devoted to state and national parks that provide enormous core habitat areas sustaining wildlife populations. As documented by Wheeler (2006), only 5% of Jefferson County's area is devoted to agriculture and residential landscapes. If 95% of Jefferson County was devoted to human activity and only 5% was available in an undisturbed state to wildlife, there might be some rationale for public resources to be spent to purchase private property in an effort to increase the area available to wildlife. The presence of these forested core habitat areas is emphasized in Figure 2 describing zoning prescribed in Jefferson County's Comprehensive Plan . The dark green areas are zoned *Commercial Forest*, the brown areas are *Commercial Agriculture* and the light yellow areas are *Rural Residential with 20 acre minimums (RR20).* In general, outside Port Townsend, Port Ludlow and Hadlock-Irondale, the maximum allowed density is one residence per five acres (RR5).

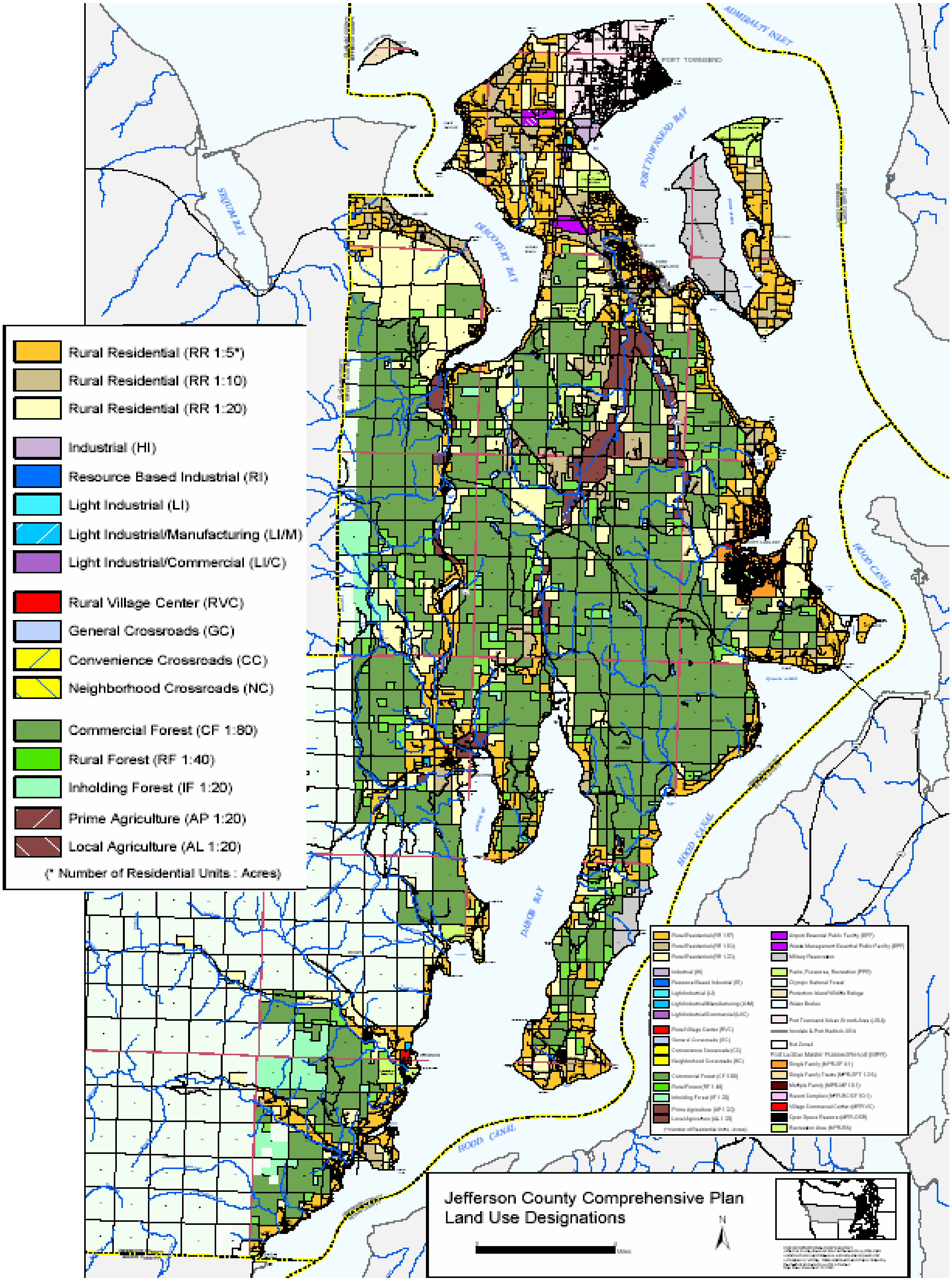

Figure 2. Jefferson County Comprehensive Plan – Land Use Designations.

3.3. The effects of habitat fragmentation on amphibians and birds. In their review of the draft *Supplemental Best Available Science* (Brooks, 2006), Hruby *et al.* (2007) stated at page 12 that:

> "We disagree with Dr. Brook's [*sic*] assertion that the review in Sheldon et al [*sic*] (2005) is lacking documentation of the degree to which species are affected when its [*sic*] range is limited. Section 4.11 addresses the impacts of fragmentation of [*sic*] a wide range of species. Fragmentation directly limits the ranges of species by creating a landscape matrix through which species have difficulty passing. There is much empirical evidence that fragmentation results in lower species richness. This is another way of saying that fragmentation is linked to the local extinction of species that were once present, and this represents the highest degree to which a species can be affected (The empirical studies describing reduced species richness for plants, amphibians, and birds are summarizes [*sic*] in Section 4.11 Vol. 1 BAS)."

In response to this comment and because of the emphasis in Sheldon *et al.* (2005) on the perceived negative effects of fragmentation, a careful review of references cited in Sections 4.11.5 and 4.11.7 of Ecology's BAS was undertaken. Fifteen papers were reviewed in an effort to understand the conclusions reached by Sheldon *et al.* (2005) leading to the Department of Ecology's recommendations for wildlife buffers provided in Volume II of Wetlands in Washington State. The purpose of reviewing these 15 papers was not to thoroughly examine every point in WDOE's BAS, but rather to determine the fidelity with which Sheldon *et al.* (2005) had interpreted the literature. This is considered important because the discussion, conclusions and management recommendations included in the *Conservation Biology* literature frequently ignores the empirical evidence documented by the author in favor of commonly held beliefs. The following paragraphs will describe what the author(s) actually observed; what they concluded; and how Sheldon *et al.* (2005) interpreted the paper.

Adams (1999). The author examined red-legged frog occurrence at habitat and wetland spatial scales in 17 wetlands. Evaluated endpoints included shoreline aspect (with respect to south), shoreline slope; firmness of the substrate; dominance of reed canary grass; wetland permanence; presence of emergent vegetation; distance to the nearest wetland with a reproducing population of red-legged frogs; water temperature; abundance of predaceous invertebrates; and the presence of salamanders.

Results. Red-legged frogs and bullfrogs were present in 59% of the sites. Forty-one percent of sites had exotic fishes. Neither of these predators was significantly related to the abundance of red-legged frogs at the habitat scale. Shallow slopes and a southerly orientation were the only significant endpoints – explaining 63% of the variance. Importantly, distance to the nearest population was not significant (X^2 (P) = 0.250) indicating that *patchiness* of the environment was not demonstrably a factor.

Baker and Halliday (1999) noted that in Great Britain, 5.5% of the landscape is suburban. Agriculture covers 48.7% of the landscape. In Britain, creation of new ponds is encouraged by government grants for their construction. The authors surveyed 49 old and 78 new (range of ages = 1 to 20 years) ponds dispersed over 3,000 km^2. Forty-one percent of new ponds were constructed primarily for fish or waterfowl. Some were constructed for other purposes such as wildlife and aesthetics. Three old and 16 new ponds had been intentionally inoculated with frog spawn. The purpose of this study was to compare ponds that have been recently constructed in agricultural areas with older ponds as amphibian breeding sites. The study sought to ascertain those characteristics of new ponds that made them suitable amphibian sites by investigating the effects of land use around newly created ponds, the presence of fish, water fowl and vegetation, pond age, the distance between ponds, and local pond density. Evaluated endpoints included urbanization, presence of woodland, other riparian habitats, pond density within a one km radius and the distance to the nearest neighboring pond, presence of fish and waterfowl, presence of amphibians, and the presence of submerged vegetation.

Results. There was no significant differences in the proportions of frog presence/absence between old (39% presence) and new (26% presence) when only those new ponds that had not been intentionally inoculated were included in the database. However, two species of frogs were found in fewer (23%) of new ponds when compared with old ponds (39%). Frogs and toads tended to be found more frequently in fish ponds, while smooth newts were found less frequently and great crested newts were never found to co-exist with fish. Differences in frog occupancy were similar with respect to waterfowl use, but the differences were not significant. Frogs occupied new ponds that were not inoculated independent of the distance or density of ponds. Newts were found more often in new ponds where the distance to the nearest neighboring pond was small. Terrestrial habitat quality (buffers) was not a significant factor for any of the amphibians. However, the author noted that, “It is possible that terrestrial habitat effects were not detected because the quantification technique used in the present study was not sufficiently sensitive. Alternatively, the mixed farm land surrounding the new ponds may have provided sufficient habitat diversity such that land surrounding all new ponds was equally likely to support amphibian populations.”

Fahrig (1997). This is a computer model simulation devised to study the relative importance of habitat loss and fragmentation on the probability of extinguishing a metapopulation.

Results. The author concluded that the amount of breeding habitat had a much greater effect than fragmentation did on extinction probability. Fragmentation effects were expected only when the amount of habitat was less than about 10 to 30% of the landscape (Andren, 1994). She concluded that, “This study suggests that in fact ‘details of how habitats are arranged’ (Kareiva and Wennergren, 1995) are unlikely to mitigate the risks of habitat loss. . . . . and, “To significantly improve survival prospects of endangered species we must therefore stop habitat loss and increase efforts in habitat restoration. Current emphasis in conservation biology on habitat spatial pattern (e.g., Fahrig and Merriam, 1994) may be misplaced.”

Fahrig (2003). This study compares the effects of habitat loss and habitat fragmentation on biodiversity by reviewing 100 recent fragmentation studies, 17 of which contained empirical data. Interestingly, in Figure 3, this is one of the few authors to use non-linear regression instead of the more commonly applied linear techniques in the analysis of data.

Results. The following are excerpts considered important to understanding minimum habitat requirements.

- Page 500: "Individual species have minimum patch size requirements (Diaz *et al.*, 2000).

- Page 500: "If small patches occur in areas with less forest, the reduced reproductive rate may not be the result of patch size, but may result from larger populations of nest predators and brood parasites that occur in landscapes with more open habitat."

- Page 501. "There have been very few direct empirical tests of the extinction threshold hypothesis (but see Jansson & Angelstam, 1999). . . . " However, the occurrence of the extinction threshold is a response to habitat loss, not fragmentation per se."

- Page 502. In reviewing all of the 17 empirical studies on fragmentation effects available at the time of writing her paper, Lenore Fahrig concluded that, "The empirical evidence to date suggests that the effects of fragmentation per se are generally much weaker than the effects of habitat loss. Unlike the effects of habitat loss, and in contrast to current theory, empirical studies suggest that **the effects of fragmentation per se are at least as likely to be positive as negative**." (Emphasis added.) Note that of 17 empirical studies reviewed in her paper, no effect of fragmentation on biodiversity was found in three papers; positive effects of fragmentation were observed in 11 studies; and negative effects were found in five studies. Four studies observed both positive and negative effects on biodiversity associated with fragmentation. The paper includes an informative discussion describing why positive effects are associated with fragmentation.

- In her conclusions, Fahrig (2003) notes that, "Empirical evidence to date suggests that the loss of habitat has large negative effects on biodiversity. On the other hand, the breaking apart of habitat, independent of habitat loss, has rather weak effects on biodiversity, which are as likely to be positive as negative." She goes on to state that, **"It also suggests that research in support of particular conservation problems should focus on determining the amount of habitat required for conservation of the species of concern. The fact that effects of fragmentation per se are usually small and at least as likely to be positive as negative suggests that conservation actions that attempt to minimize fragmentation (for a given habitat amount) may often be ineffectual."** (Emphasis added.)

- The last sentence of her paper should be noted by landscape managers, "Therefore, landscape patterns that maintain the required habitat amounts, but intersperse the different habitat types as much as possible, should produce the largest positive biodiversity response (Law & Dickman, 1998)."

Fairbairn and Dinsmore (2001). This study examined bird species richness and individual species densities in wetland complexes. The authors' note that more than 37,600 wetland hectares (92,912 acres) have been (or are being) restored on private land in Iowa. Large wetland complexes ranging from 44 to 144 ha (109 to 356 acres) that included from 4 to 15 wetlands were surveyed. Upland areas were grasslands. Fourteen endpoints were evaluated describing the geography and physicochemical properties of the wetlands.

Results. The most important endpoints explaining the variation in species richness were the total amount of wetland habitat in a complex (Area) and the percentage of the wetlands within a complex that was covered by emergent vegetation. On an individual bird species basis, the most frequently included variable in significant models was the ratio of the wetland's perimeter within the complex divided by the complex's wetland area. Some species were more abundant with high perimeter/area ratios (mallards, swamp sparrows, and red-winged blackbirds) and five species (pied-billed grebes, least bitterns, American coots, marsh wrens and yellow-headed blackbirds) were more abundant when the perimeter/area ratios were low (reduced edges). The amount of open water was not a factor in the abundance of any of the 15 bird species. Interestingly, the coefficients of determination for the best models explained between 0.20 and 0.76 of the variation with an average of 50.9 ± 8.0 percent. Note that total wetland area (TOTWET) within 3 km of the site was a significant factor only for one of the birds (Gadwall), but that the coefficient was extremely low (0.00000003*TOTWET (m^2)). Total wetland area within 3 km was also significant for total species richness. However, the coefficient was also very small (0.0000004*TOTWET). The coefficient implies that to increase the number of species by one, the total wetland area within 3 km would have to increase by 2,500,000 m^2. The total area in a 3 km circle is 28,274,333.9 m^2 and therefore the increased wetland area would be 9% of the total area to increase the species richness from 12 to 13.

Fore *et al.* (1996). This paper was difficult to read because the hyperbole in the very first sentence revealed a bias that was evident throughout the paper. Statements like, "The Pacific Northwest region of the USA is on the brink of losing its salmon" and "Salmon and other aquatic organisms are disappearing because dams, timber harvest, agriculture, urbanization, and other human actions alter watersheds and degrade rivers that support populations of aquatic species" are not substantiated by facts.

Salmon returns for the Columbia River were accessed at WWW.dfw.state.or.us/OSCRP/CRM/reports/status_report/2002 on March 25, 2007. Figure 3 provides total salmon and steelhead returns to the Columbia River between 1938 and 2002. Returns had declined in 1996 when Fore *et al.* (1996) wrote this paper, but those declines appear to be part of a periodic cycle of anadromous fish returns. As has happened in previous cycles, salmon returns increased in subsequent years and were at a record 3,259,900 fish in 2001 and they were also exceptionally high in 2002 as well (2,558,300 fish).

There is no indication that Columbia River salmon are about to be lost. It is increasingly recognized that rearing conditions in the open oceanic areas of the Northeast Pacific have as much or more to do with the health of Pacific salmon returns in the Pacific Northwest than does the condition of our watersheds. The reader should not misinterpret these comments.

This author is not suggesting that reasonable efforts to improve salmon spawning and freshwater rearing areas of our watersheds are not appropriate. I am suggesting however, that this kind of unsubstantiated hyperbole does not belong in rigorous scientific publications and its presence in this paper detracts from the authors' credibility and the credibility of the journal's peer review process.

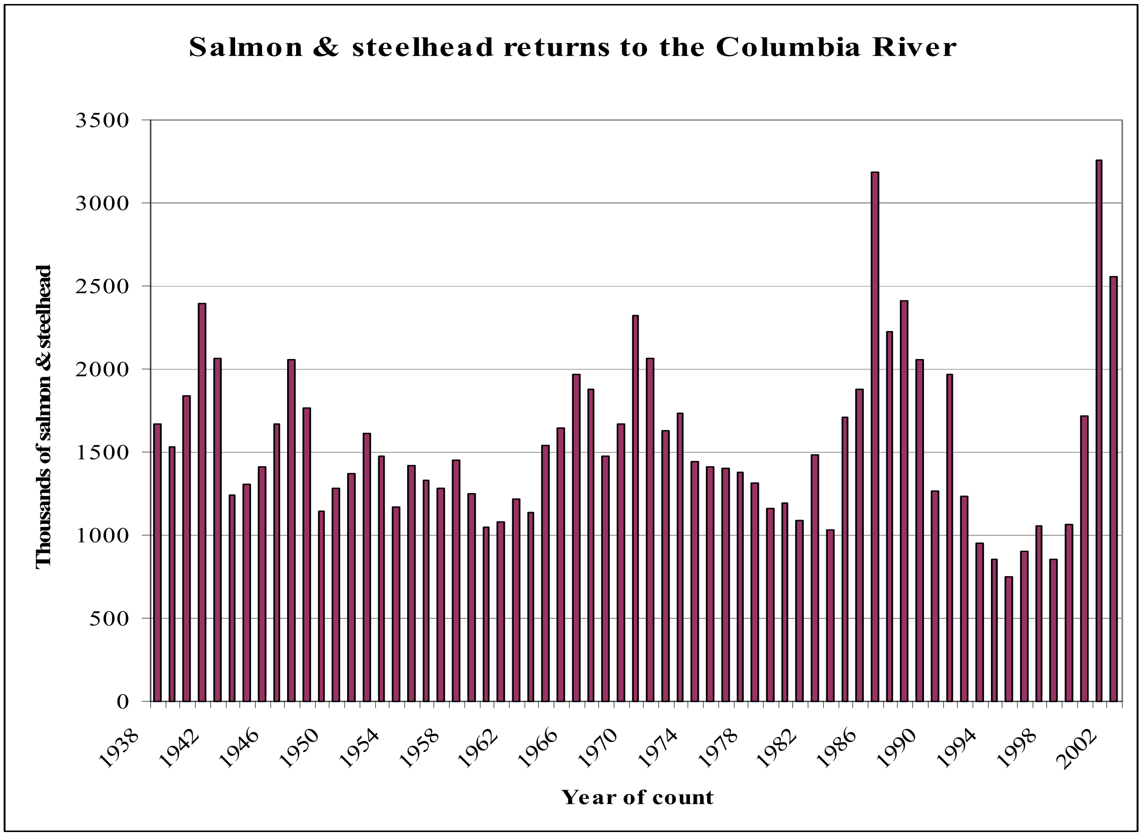

Figure 3. Chinook salmon returns to the Columbia River between 1938 and 2002.

The paper selectively used data from southwestern Oregon in areas that had been modified by timber harvest, grazing, agriculture and urbanization. Data from stream pools was excluded and only riffle data was used. The chosen metrics evaluated aquatic insect community richness and composition, invertebrate tolerance and intolerance to disturbance, feeding ecology and population attributes. The analysis relied primarily on graphs and few determinations of significance were made. The paper is difficult to use in assessing the width of required buffers because the adjacent landscape was not evaluated other than to conclude that it was logged, farmed, urban, etc. No effort was made to assess conditions, such as the width of riparian buffers remaining, adjacent to the evaluated streams. However, the authors noted that they did not consider pristine control sites or highly urbanized areas.

Results. The authors noted that the presence or absence of roads adjacent to the channel, or percent of the area logged most accurately reflected the impact of human activities on the biota. Figure 3 of their paper contains lines "drawn by eye" that do not appear to represent the datapoints at all. The authors argue that points suggesting high watershed condition and poor instream condition were outliers. From an analytical point of view, Figure 3 does not demonstrate any significant trends. Figure four relates the number of taxa to the percent of an area that was logged. No trends are evident until >60% of an area was logged. At the two points where 80% of an area was logged, riffles contained 21 to 35 taxa versus 45 to 55 taxa in riffles where <20% of the area was logged. If non-linear regression were used on the data in Figure 5, it would likely reveal a peak in the number of taxa in all feeding groups when between 20 and 40 percent of an area had been logged. In their conclusions, these authors make many assertions regarding the superior performance of the Benthic Index of Biological Integrity in comparison with Rapid Bioassessment Protocols. However, even a casual reading of this paper suggests that the claimed improvements were the result of inadequate analysis. Under any circumstances, Fore *et al.* (1996) provides no information that would help determine the buffer widths necessary to protect wetlands and/or surface waters.

Knutson, *et al.* (1999). The authors examined landscape-level habitat relationships for frogs and toads by measuring associations between relative abundance and species richness based on survey data derived from anuran (frogs and toads) calls observed in spring and early summer and features of land-cover maps for Iowa and Wisconsin. One hundred eighteen (118) sites were evaluated in Iowa and 260 in Wisconsin. Fourteen species were identified. Nineteen independent variables describing the ponds and their surrounding landscape were evaluated.

Results. In Wisconsin, many anurans were associated with permanently flooded wetlands, whereas in Iowa some anurans were negatively associated with deep-water variables. They noted that Wisconsin has many more natural lakes than Iowa and that most open water in Iowa is in the form of reservoirs created by damming rivers and streams for water control or recreational purposes. They observed that natural lakes typically have more extensive, shallow wetland complexes than do reservoirs. Other results include:

- Anurans were preferentially associated with high patch diversity having long edges and numerous pools. The presence of forested edges also enhanced anuran populations.

- There was no indication that environmental fragmentation negatively affected anuran populations. They cite Bonin *et al.* (1997) finding that fragmentation of forests in Quebec did not affect anuran species.

- The study failed to find strong negative associations between anurans and agriculture. Agricultural area was positively associated with anurans in Wisconsin but not in Iowa.

- Anuran populations were adversely affected by urbanization.

Knutson, *et al.* (2004). The authors studied small, constructed, agricultural ponds in southeastern Minnesota to assess their value as amphibian breeding sites. They compared endpoints assessing amphibian reproduction from April to August in 2000 and 2001 by searching the littoral zone of each pond for amphibian eggs and by conducting larval and metamorph dip-net and visual encounter surveys. Twenty-six (26) habitat variables were assessed describing geomorphology of the ponds, wetlands and adjacent uplands. The area of permanent and temporary wetlands within 500, 1000 and 2500 m was determined as was the distance to the nearest adjoining wetland and forest. The pond's depth, area and vegetation were determined as was the presence of fish and invertebrate predators. The shoreline's vegetation (trees, brush or emergent vegetation) was mapped. Water quality endpoints included DIN (dissolved inorganic nitrogen), turbidity, conductivity and phosphorous. A total of 1,644 visits to ponds were made during the two years of the study.

Results. The following statements summarize the results:

- Landscape variables did not appear in the final model for either species richness or multispecies reproductive success.

- The final model for species richness included pond area, presence of fish, the abundance of tiger salamander larvae and total nitrogen.

- The final model for multispecies reproduction included negative coefficients for total nitrogen, fish and emergent vegetation cover.

- Gray tree frog reproductive success was higher in nongrazed and agricultural ponds than in natural ponds and grazed ponds. Spring peeper reproductive success was higher in non-grazed and agricultural ponds than in grazed ponds. In contrast, the leopard/pickerel frog enjoyed higher reproductive success in natural ponds.

- Models for individual species included differing landscape variables. In this study, the presence of fish had a negative effect on species richness and multispecies reproduction. Fish were not a factor in any of the single species models.

- The authors describe the adverse effects of livestock grazing and loafing in wetland ponds available in other citations. They found that increased nitrogen was a negative effect on reproductive success in three of the nine species models and increased turbidity had a negative effect in one of nine models.

- The authors expected that submerged vegetation would increase amphibian reproduction success – but found the opposite was true.

- The final models did not indicate that the density of surrounding ponds or nearest neighbor pond distance were significant factors. In other words fragmentation was not a negative factor.

Lehtinen, *et al.* (1999). This study investigated the significance of habitat loss, fragmentation and within-wetland conditions on amphibian assemblages in 21 glacial marshes located within urban and agricultural regions of central and southwester Minnesota characterized as grasslands and forests. They assessed 21 seasonal to semipermanent wetlands in central and southwestern Minnesota. Eight sites had high proportions of agricultural or urban land use. Six sites were studied in small remnant habitats within an agricultural or urban matrix. The seven least impacted sites were located in extensive areas of natural habitat. All sites were surveyed using larval sampling, chorusing surveys and visual encounter searches. Amphibian larvae were sampled using minnow and aquatic activity traps in water depths ≤ 1.0 m. Predators (fish and invertebrates) were sampled using minnow traps and aquatic activity traps. Leeches were trapped in plastic jars baited with chicken liver. The study evaluated ten landscape variables including the distance from a wetland to the nearest adjacent wetland, grassland, the presence of adjacent cultivated fields or forest. Road density and the proportions of the landscape defined as wetland, grassland, forest, cultivated field or urban land within 500, 1,000 and 2,500 m of the wetland were determined.

Results. Eleven species of anurans along with 11 species of fish were observed at the 21 sites. Other results include:

- The only landscape variable that significantly influenced the occurrence of any species was the presence of forests at the 500 and 2,500 m scales with respect to the occurrence of the American toad (*Bufo americanus*).

- In the deciduous forest area, species richness was strongly influenced only by urbanization. Note that in the urban areas studied houses, roads, commercial landscapes, etc. covered 25% of the landscape.

- In the prairie area, the presence of the predatory tiger salamander, and fish were significant negative factors regarding species richness as was the distance to the nearest neighbor wetland, which explained 47% of the variation in the model. However, the coefficient was small (-0.00297) suggesting that the number of species would be reduced by one when the nearest neighbor wetland was located 336 m away (1,094 feet).

- At page 9, the author states that the observed negative coefficient on distance to the nearest neighbor is evidence supporting the fragmentation hypothesis. However, in the other models presented in Table 6, the distance to the nearest neighbor explained between 19 and 28% of the variance.

- Lehtinen *et al.* (1999) used linear regression in Figure 5 to suggest that the number of species was equal to -0.0058*distance to nearest neighbor + 5.2 ($R^2 = 0.47$). A non-linear regression analysis would have indicated little decrease in the number of species until wetlands were separated by at least 450 meters. At distances greater than 450 m, there was a significant decrease in the number of species observed, but there are only two data points.

On page 11, Lehtinen *et al.* (1999) suggests that, "The data presented here suggests that decreases in landscape connectivity via fragmentation and habitat loss play an important role in explaining these phenomena." However, the actual data presented does not support that assertion. Rather, as Lehtinen *et al.* (1999) note at page 9, "Our study provides evidence that landscape-level variables that estimate connectivity **may be** important factors affecting amphibian assemblages in wetlands." (emphasis added). With respect to application of this study's results to Jefferson County, note that assuming a home and the associated landscape occupies one quarter acre. A zoning density of RR5 would result in 5% of the landscape being devoted to residential uses. Figure 4 of Lehtinen *et al.* (1999) indicates a predicted decline of 0.21 species associated with 5% urbanization.

Lehtinen and Galtowitsch (2001). This study examined 5 reference and 7 recently restored wetlands in central and southern Minnesota during the 1998-breeding season to assess colonization of recently restored wetlands by amphibians and to identify factors influencing colonization. The wetlands studied generally varied in age between 5 and 12 months. One of the seven restored wetlands was 20 months old. Eight were agricultural and four were urban. Some wetlands had mixed landscapes. One problem with the natural wetlands is that they had previously been studied and therefore were not a random sample of available natural wetlands. All of the wetlands were seasonal to semipermanent ranging in size from 0.1 ha to 8.6 ha (0.25 to 21.2 acres). Sites were surveyed for amphibians on five occasions between April and July using chorusing surveys, larval sampling and visual encounter surveys conducted 25 m either side of the pond's edge. Seven independent endpoints were evaluated including dissolved oxygen, alkalinity, conductance, pH vegetative cover, wetland size and distance to the nearest neighbor.

Results. Wetlands had similar physicochemical characteristics. However, the concentration of dissolved oxygen was significantly lower in the reference wetlands when compared to the restored wetlands. This was likely due to increased biological oxygen demand in the reference wetlands, which were more heavily vegetated than the restored wetlands. The only other significant difference was the 28% vegetative cover in restored wetlands compared with 50% in the natural wetland. The following summarize other results:

- Lehtinen and Galatowitsch (2001) make the same error of using linear regression in their Figure 1 to relate the number of species to the distance to the ten nearest source ponds. Their linear regression suggests that the number of species is predicted to be equal to 6.9 - 0.005*distance (m). A non-linear quadratic fit (Figure 4) explains 82 percent of the variation rather than 65% with the linear fit and it suggests that there was little effect on the number of species associated with distance to the nearest neighbor until that neighbor was 900 m away.

- The authors noted that the two wetlands restored in urban areas had the lowest species richness of all sites sampled. The distances coincide with points 6 and 7 in Figure 4. The authors made no attempt to segregate effects associated with urban environments from those associated with distance. If one eliminates urban points 6 and 7 in Figure 4, then only the intercept is significant. The probability of the coefficient on distance being zero is 0.43. In other words, excluding the urban sites, distance between wetlands within the range 220 to 900 m (721' to 2,953') was not a factor determining anuran diversity.

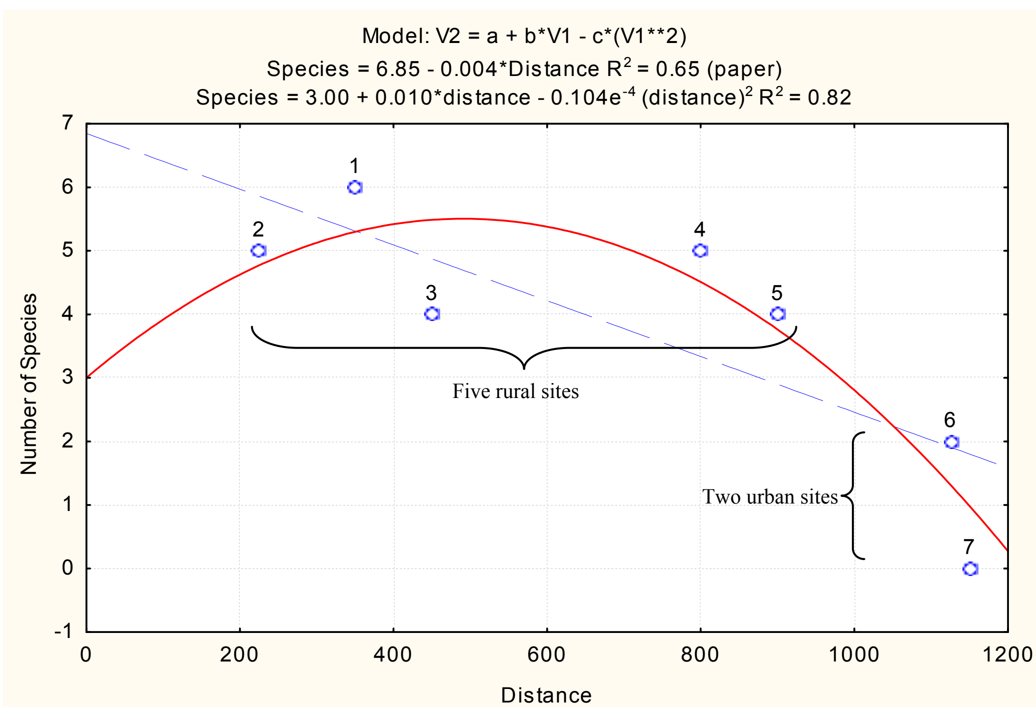

Figure 4. Non-linear (quadratic) model predicting the number of amphibian species observed in restored wetlands by Lehtinen and Galatowitsch (2001) as a function of the mean distance to the nearest ten wetlands (R^2 = 0.82) . The linear regression of Lehtinen and Galatowitsch (2001) is provided in dashed blue (R^2 = 0.65).

Minton (1968). This paper is based on the memoirs of the author who collected reptiles as a child near his home between 1949 and 1958. It is not a scientific study and it is uncertain why it was included in Sheldon *et al.* (2005). Having said that, the anecdotal evidence provided by Minton (1968) suggests that loss of habitat area associated with urbanization had a significant negative effect on amphibians.

Naugle, *et al.* (2001). This computer simulation examined the importance of wetlands in eastern South Dakota to waterfowl and non-game birds. Eight hundred thirty-four (834) semi-permanent and seasonal wetlands that had been surveyed for birds in 1995 and 1996 were included in the model. Wetland basins were classified as temporary, seasonal, semi-permanent or permanent by the water regime of the most permanent wetland they contained. For some reason that was not adequately explained, the authors excluded all isolated excavated or impounded semi-permanent wetlands. The densities of the remaining natural wetland areas were then determined. Two seasonal and two semi-permanent wetlands were randomly selected within each cell giving a total of 418 seasonal and 416 semi-permanent wetland surveys. The percent vegetated wetland area and the types of emergent vegetation representing >10% of the wetland's area was estimated along with grazing intensity and the percent of the wetland's perimeter that was wooded. Adjacent land-use was classified as tilled or untilled. Evaluated landscape variables included total wetland area and the density (number/unit area) of temporary, seasonal, semi-permanent and permanent wetlands was determined using GIS. The area and proportion of untilled upland within each 25.9 km^2 cell was also determined. Four wetland-obligate bird species were analyzed (mallards, northern pintails, black terns and eared grebes). The analysis of only open-water dependent species brings into question the exclusion of excavated and impounded surface waters from the analysis because these features may have been important to these types of waterfowl. Wetlands $\leq$ 0.20 ha (~0.49 acres) were excluded from the study.

Results. Wetlands comprised 9.4% of the land area of eastern South Dakota. Natural semi-permanent wetlands comprised 31.5% of all semi-permanent wetlands. An additional 50.7% of wetlands were shallow wetlands with excavations imparting a semi-permanent water regime and 15.1% of all wetlands were impoundments. The median size of semi-permanent wetlands was 0.92 ha (2.27 acres) and it was 0.20 ha (0.49 acres) for seasonal wetlands. The authors identified 14,840 easement and fee-title protected tracts comprising 13.9% (3,140,919 acres) of eastern South Dakota. Existing programs had protected 15.8% of temporary, 25.6% of seasonal and 32.3% of semi-permanent wetlands in the region. The following conclusions were reached:

- The authors selectively excluded some interesting data – such as species area sensitivities. No **adequate** explanation was given for this exclusion.

- When wetland area was included in the model, the percent-vegetated wetland area was the most common variable related to species' occurrences in semi-permanent and seasonal wetlands.

- The authors included 20 species of game and non-game birds in their report.

    i. Total wetland area (available habitat) was positively correlated with 18 of the 20 species.

    ii. The semi-permanent wetland area was a positive factor for four species and a negative factor for one.

    iii. The percent vegetative cover in the wetland was negatively correlated with three species and was a positive factor for six species.

    iv. The proportion of shoreline with trees was negatively correlated with two species and it was not favorably correlated (positive) with any species.

    v. Grazing was a negative factor for one of the 20 species of birds and it was not a positive factor for any species.

    vi. The proportion of the surrounding landscape in ungrazed grassland was a positive factor for four species and a negative factor for one bird species.

- Seasonal wetlands were inundated for only a portion of the year. The authors used logistic regression analysis to assess habitat variables for 14 bird species found in these wetlands.

    i. 30% fewer bird species were observed in seasonal compared with semi-permanent wetlands.

    ii. Total wetland area remained the dominant factor and was included in 10 of the 14 models.

    iii. The percent vegetative cover in the wetland was a positive factor for five species and a negative factor for three dabbling duck species.

    iv. In these seasonal wetlands, grazing was a negative factor for two of the 14 species and it was not a positive factor for any species.

    v. Percent shoreline that was treed was a negative factor for one species and was not a positive factor for any species.

- Of the four species of birds analyzed in depth, none of the seasonal wetlands having a size ≤ 1.0 ha (2.47 acres) were suitable for any of the species (Table 8 in their report). Thirty eight to 39.4% of semi-permanent wetlands covering ≤2.47 acres were suitable only for black terns. They were not suitable for the other birds.

Conclusions. The author's conclusions do not necessarily reflect the results of their study. For instance Table 8 in their study suggests that seasonal wetlands covering ≤ 1.0 ha (2.47 acres) did not provide suitable habitat for any of the four evaluated species. And yet, the author (page 14) concludes that, "When viewed as components of a larger landscape, however, small wetlands are critical landscape elements that influence the suitability of larger wetlands." This appears to be an opinion rather than a conclusion based on the study's results. In the conclusion *Importance of Temporary Wetlands* on page 15, the author notes that bird surveys were not conducted in temporary wetlands, the most abundant wetland type in all domains, because the brief duration of ponding in spring precluded breeding by wetland bird species in most years. He goes on to note "Temporary wetlands in agricultural landscapes also provide foraging habitat for migrating waterfowl." These are opinions that are not supported by the study's results.

Richter and Azous (1995). These authors studied amphibian distributions in 19 Puget Sound wetlands in King County between 1988 and 1991. Amphibian richness was compared to wetland size, vegetation classes, presence of bullfrog and fish predators, water flow through the wetland, permanence of water, water level fluctuations and upland land uses. Wetland sizes ranged between 0.4 and 12.4 hectares (1.0 to 30.6 acres). The authors noted that most of the wetlands lost to development have ranged in size from 0.2 to 2.0 ha (0.5 to 5.0 acres). Land uses included agriculture, single and multiple residential housing, commercial and industrial development, transportation corridors and any other development within a watershed that had reduced second growth forest cover. Wetlands were classified as semi-permanent if they had no standing water for one month or more in the summer and all others were classified as persistent. Low flow wetlands had currents <5.0 cm/sec during March and April. Amphibians were surveyed using pitfalls, spring breeding censuses and by encounter surveys. This is the only study reviewed that included rainfall and temperature data during the periods of observation.

Results. Seven lentic (still water), one lotic (running water), and two terrestrial breeding amphibian species (10 species total) were observed in the 19 wetlands surveyed. The following results were reported:

- Amphibian species richness was not dependent on the size of the wetlands within the range inventoried (1.0 to 30.6 acres).

- Moderate to high richness (4 to 7 species) was observed in wetlands covering areas of 1.0 to 5.0 acres.

- No significant relationship was found between species richness and the distance to the nearest favorable wetland or to the nearest favorable breeding wetland.

- Species richness was not dependent on the number of vegetation classes.

- A possible positive correlation was found between species richness and the presence of an aquatic bed – which is likely a measure of the depth and permanence of the water.

- Amphibian species richness was not related to the presence of fish or other amphibian predators regardless of wetland size. Fish included rainbow trout, cutthroat trout and coho salmon.
- Equally high numbers of lentic breeding species were found in semi-permanent and persistent wetlands.

- Three species of anurans (*Ambystoma gracile, Rana aurora and Pseudacris regilla* were significantly more likely to be found in low flow than in high flow wetlands.

- Amphibian species richness was negatively affected by high water fluctuations (i.e. > 20 cm).

- Wetlands with watersheds in which more than 40% of the land area was urban were significantly more likely to have low amphibian richness of <4 species than wetlands with less urbanization.

The study appears to be well done and the reported results are consistent with the actual data. However, in the last paragraph on page 309 and the first on page 310, the authors make several assertions that may or may not be true, but that are not supported by data in their report.

Semlitsch (2000). This paper was reviewed in depth. However, an in-depth critique of the numerous assertions made is beyond the scope of this effort. The bias brought to the work by the author is evident in statements like "or connections made with fish-infested lakes, rivers or canals." The author focuses on the need to protect wetlands covering <4.0 hectares (9.9 acres). Discussions regarding *Global Climate Change* are obviously premature and the discussion regarding chemical contamination on page 618 is hyperbole despite the author's acknowledgement that, ". . . . direct evidence of population declines due to contamination is rare." Statements such as "All insecticides are neurotoxins and do not necessarily break down quickly, but instead are sequestered either in sediments or animal tissues" Is generally not true. Some insecticides are molt inhibitors and others break down quickly. Despite the findings of Richter and Azous (1995) and others sited herein that fish do not necessarily adversely affect amphibian populations, Semlitsch (2000) states emphatically "Fish are considered the most critical and wide-spread problem because they can be both competitors and predators of amphibian larvae."

The studies containing actual empirical evidence that were reviewed herein do not generally support the view that habitat fragmentation is a factor adversely affecting amphibians. And yet, Semlitsch (2000) asserts that, "Field and experimental studies indicate that both local population dynamics and ecological connectivity of amphibian populations at the landscape level must be considered in any effective management plans." Furthermore, there is no compelling overall evidence that "filling and drying on an annual basis" is necessary for viable amphibian populations. Semlitsch (2000) emphasizes the need for drying to control amphibian predators – like fish. If that is the case, then why are there amphibians associated with perennial Pacific Northwest lotic systems that have salmon fry in them for much of the year? A small book could be written examining and rebutting many of the points made by Semlitsch (2000) in his diatribe against nearly all forms of life other than amphibians. However, that task is beyond the scope of this review.

Summary. Table 2 summarizes the results of this review of the effects of habitat fragmentation on amphibians and Table 3 is for birds. Papers by Fahrig (1997), Minton (1968) and Semlitsch (2000) did not contain empirical data and are not included in the tables. Fore *et al.* (1996) deals with aquatic insects and is also not included.

Table 2. Summary conclusions reached by authors addressing amphibian populations based on empirical evidence.

Author	Did predators (fish and bullfrogs) affect amphibian populations?	Were wetland attributes a factor?	Was distance to the nearest amphibian habitat a factor (i.e. fragmentation)?	Were natural ponds more productive than constructed ponds?	Were anurans adversely affected by urbanization?	Were anurans adversely affected by agriculture?	Was the depth and permanence of water a factor?	Were adjacent upland landscapes a factor?
Adams (1999)	No	Yes	No					
Baker & Halliday (1999)	No	Frogs no Newts yes	No	No		No		
Knutson *et al.* (1999)		Yes	No		Yes	No	Natural lakes no Impoundments yes	
Knutson *et al.* (2004)	Yes	Yes	No			Yes		
Lehtinen *et al.* (1999)	Yes		Yes @ >450 m		Yes			Yes
Lehtinen *et al.* (2001)			Yes @ >900 m		Yes			
Richter & Azous (1995)	No	Yes	No		Yes		Yes +	

Table 3. Summary conclusions reached by authors addressing bird populations based on empirical evidence.

Author(s)	Did the presence of forest affect bird reproduction?	Was overall habitat size a factor?	Is habitat fragmentation a factor?	Is the affect of fragmentation positive or negative?	Were wetland attributes a factor?	Was the ratio of edge/area a factor?	Was the amount of open water a factor?	Was grazing a factor
Fahrig (2003)	Yes +	Yes +	Small	+ & -				
Fairbairn & Dinsmore (2001)		Yes +	Small		Yes	Yes ±	No	
Naugle *et al.* (2001)	Yes -	Yes +			Yes		Yes +	Yes -

There are several threads in these papers dealing with the effects of habitat fragmentation on amphibians and birds indicating that:

For anurans (frogs and toads):

- Predation on amphibian larvae was a significant factor in two of five studies;
- Landscape attributes of individual wetlands consistently affected anurans;
- Fragmentation was generally not a factor except in two cases where separation by 450 to 900 meters had a negative affect on near term colonization of wetlands;
- Constructed and/or restored ponds were as suitable for anurans as were natural ponds;
- Anurans were negatively affected by urbanization in all studies that included this factor;
- Agriculture had a negative effect in one study and no effect in two other studies;
- Permanent and semipermanent ponds appear to support more anuran species than seasonal ponds;
- Other than urbanization, upland landscape was documented as a significant factor in only one study.

For birds:

- The presence of adjacent forest had positive and negative effects;
- Overall availability of habitat was a significant factor in all studies;
- Habitat fragmentation had a minor affect on bird populations and it was positive in more cases than it was negative;
- The effects of urbanization were both positive and negative;
- Wetland attributes were a factor in two studies;
- Edge effects (ratio of edge/area) was a factor in one study with mixed effects;
- Increased areas of open water had a positive effect on bird species diversity in one paper;
- Grazing adversely affect bird species diversity in one report.

3.5. Development of a defensible wildlife program. Assertions by Sheldon *et al.* (2005) and Hruby *et al.* (2007) that habitat fragmentation presents a significant challenge to the viability of populations of amphibians and birds were reviewed in the previous section. That review indicates that the primary factor affecting both amphibian and bird species diversity is the total amount of wetland habitat available and not fragmentation of that habitat. Unfortunately, no information useful to determining minimum wildlife habitat buffer widths necessary for sustaining the viability of non-listed species was revealed. Pizzimenti (2002) concluded that,

> "Although wildlife corridors may be worthy conservation objectives, it is not the legal or management objective of agriculture" and "The proposals to develop buffer widths to fully establish riparian habitat preserves or wilderness corridors (Knutsen and Naef, 1997) probably go beyond the needs of salmon habitat restoration. A scientific basis for salmon habitat restoration will match form to function: that is, buffers will be one tool to restore identified habitat deficiencies along specific stream reaches when preferred alternatives are ineffective. In some cases, riparian buffers will be the preferred alternative, but the width of each riparian buffer should be established to meet site-specific criteria based on BAS that is specific to agricultural lands."

These comments are consistent with the comments of Easter (2007 provided in Appendix 2) who concluded that prescriptive buffers do provide a sound approach to managing wetlands or surface waters from either a social or environmental perspective. Todd (2000) in Figure 2 on page 447 of his report concluded that minimum wildlife habitat buffers of about 9 m may be appropriate and that the maximum needed width is 90 m. Similarly, Desbonnet *et al.* (1994) noted that while a vegetated buffer of 5 meters width may not provide good overall wildlife habitat, it might be sufficient to provide resting and feeding areas for both resident and migratory species. The question of government's constitutional authority to impose restrictions on property owners for the general benefit of wildlife is addressed in more depth in the report of Tracy (in-prep). If it is determined that government can impose restrictions on private property for the general enhancement of wildlife then there are several questions that should be answered by the legislature and courts:

- **What degree of wildlife protection is required?** Do restrictions on private property need to provide for all of the needs of all species of wildlife that might be found in the landscape in question or is the degree of protection only that required to insure that a species or community is sustained and not extirpated?

- **On what scale is protection required?** Is it necessary to sustain species everywhere they were found during the pre-European settlement era or is it sufficient to insure that they have adequate habitat at the present time? Does each city need to insure sufficient habitat to support mink, elk, deer, mountain lions, etc.? Does each county have such a responsibility? Jurisdictional boundaries have no biological meaning and if the legislature and courts decide that the federal and state constitutions allow government to impose restrictions on private property for the general benefit of unlisted wildlife, then it might be deemed more appropriate to insure that adequate habitat is available in each ecotope (kind of habitat).

- **Which habitats require protection?** Do to the competition for space, wildlife occupies virtually all of the habitat niches available – not just those associated with wetlands and their immediately adjacent uplands (buffers). Deer and elk have a preference for edges where shrubs and young trees provide the types of forage they require. Hibernating animals require upland dens that are dry and protected from wind and snow. Waterfowl require open areas of water – not wetlands that are merely saturated during winter months. If general protection of wildlife is required by private property owners, then all particularly sensitive landscapes must be protected – not just stream channels and wetlands, which are representative of one type of habitat that is important to wildlife.

- **What restrictions on private property are necessary to sustain wildlife.** Response curves describing the effects of various human activities on wildlife need to be known in order to **fit the restrictions to the required degree of protection** (emphasis added**).** This requires identification of the degree of effect that human activities have on wildlife and an understanding of the response of differing species and communities of animals to these human effects. The literature reviewed in this report dealing with amphibians suggests little effect on species richness associated with agriculture or low density rural development and larger effects associated with higher density (>20%) urban development. Are the same restrictions necessary in urban and low density rural environments? There is no empirical evidence indicating that low density rural development in Jefferson County (RR5 to RR20) has been detrimental to wildlife.

o **Do different species require different restrictions?** The report of Edge (2001) clearly documents that many species of wildlife are adaptable to, and coexist with, agricultural. I am unaware of documentation describing the communities of wildlife coexisting with the scale of residential development allowed in rural Jefferson County. However, I do know that on my farm, we have had raccoons, deer, elk, raptors, quail, rabbits, coyotes, mountain lions, black bears, herons, cormorants, Canadian geese, over a dozen species of ducks, dozens of species of song-birds and literally thousands of amphibians foraging and living in our neighborhood. Granted, I have not seen a mink or a beaver. My point is that there is a menagerie of wildlife living in the low density residential area comprising Eaglemount in Jefferson County, Washington. Are there some species of wildlife that are excluded from this environment? If there are, then these should be identified and the reasons for their exclusion determined and mitigated. In the absence of some showing of harm, there is simply no reason to create no-touch buffers on residential properties.

The questions asked of the legislature and state and federal courts in this Section are intended to clarify what the Growth Management Act actually requires with respect to maintaining the *Functions and Values of Wetlands.* The act is too vague with respect to the requirements for buffers to provide local jurisdictions with the direction they need in developing recommendations for protecting unlisted wildlife. In general, government should at least be required to demonstrate the existence and severity of a problem before imposing restrictions on property through regulation.

3.6. Development of wildlife protection performance standards. Regulatory agencies such and the U.S. Environmental Protection Agency and Washington State's Department of Ecology typically define performance standards designed to protect resources. Sheldon *et al.* (2005), Granger *et al.* (2005) and Hruby *et al.* (2007) do not define performance standards and Ecology has not demonstrated that their prescribed buffers protect wildlife against any particular level of risk.

For instance, the assertion by Hruby *et al.* (2007) that the prescribed buffers are in the "mid-range" of the distances at which wildlife responds to human activity or at which species have been observed from their core habitats is meaningless. For wildlife, consider the conceptual representation of upland buffer habitat needs for population viability in Figure 5. In reality there is a family of curves and these three are only conceptual examples. The dashed blue line is appropriate for species that have minimal habitat needs outside their core area. No buffers or upland buffers of only a few feet may meet all of this population's needs. The exponentially increasing solid black line represents a population that is partially dependent on uplands, but whose core reproductive potential is maintained by small buffers.

Ecology's approach of assuming a linear response curve and choosing median values is represented by the solid red line. The fact is that individual taxa undoubtedly elicit different response curves and for unlisted species, we don't know what those curves are. There is no basis in the literature for Ecology's choice of median values on a linear response curve. My professional experience with aquatic invertebrates suggests that the exponential increase is more likely to represent the buffer requirements for many species. Many species are primarily dependent on a core habitat, such as open water, and have a need for minimum upland buffers (the dashed blue line). Sheldon *et al.* (2005) and Granger *et al.* (2005) fail to address these facts for the benefit of County Commissioners, who subsequently must develop ordinances with incomplete information.

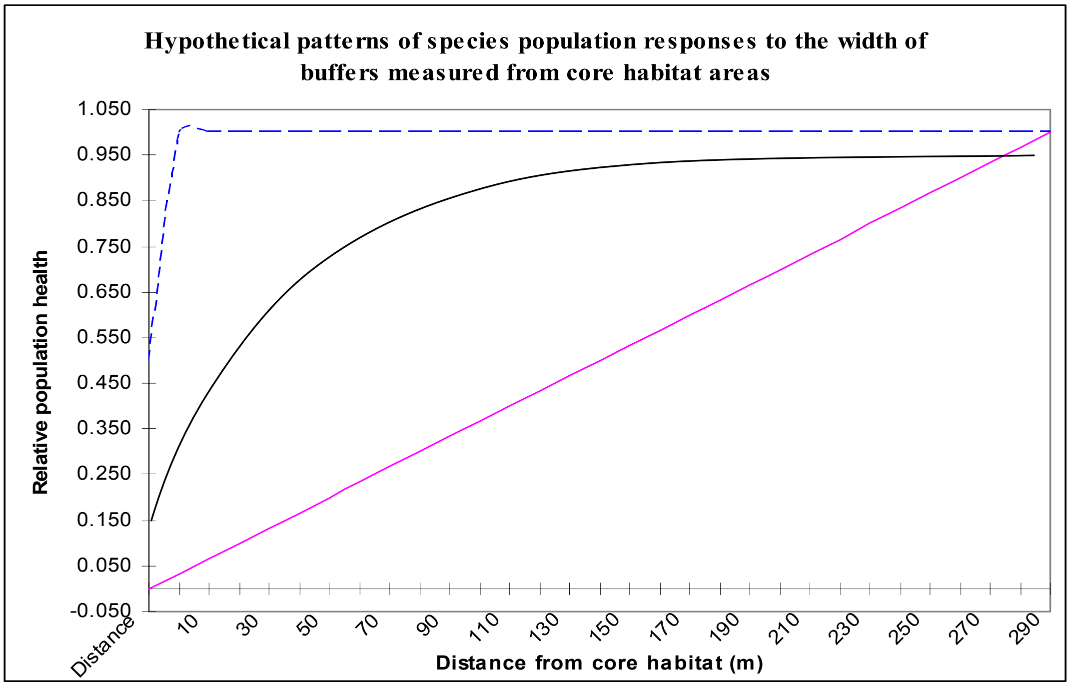

Figure 5. Conceptual response of a species of animals to the amount of upland habitat (buffer) available adjacent to their core habitat. A value of one on the Y-axis indicates that buffer width per se no longer affects the viability of the population.

One of several points made in Figure 5 is that each species and/or community of species has specific habitat needs and those needs have not been adequately established for unlisted taxa. There is good precedent for the performance standard based approach recommended above. The Sediment Management Unit of the Department of Ecology has developed Sediment Quality Criteria (SQC) defined in WAC 173-204. Those criteria are based on *Apparent Effects Thresholds* that clearly define the level of allowed biological effect. Empirical evidence supporting development of the SQC is available in the form of suites of sediment bioassay results and macrobenthic community responses for the contaminants included in the code. Hruby *et al.'s* (2007) assertion that this task is too difficult and complex when applied to wildlife is unacceptable.

An example of how other jurisdictions have approached this issue is provided in Figure 6 copied from Brooks and Mahnken (2003). In British Columbia the macrobenthic performance standard applied to the Marine Netpen Waste Regulation is based on an allowable 50% reduction in species richness found at local reference locations. A similar biological performance standard based on macrobenthic abundance is codified in Washington State's Biological Effects Criteria contained in WAC 173-204-320 (3).

"(c) Benthic abundance: The test sediment has less than fifty percent of the reference sediment mean abundance of any one of the following major taxa: Crustacea, Mollusca or Polychaeta, and the test sediment abundance is statistically different (t test, $p \leq 0.05$) from the reference sediment abundance."

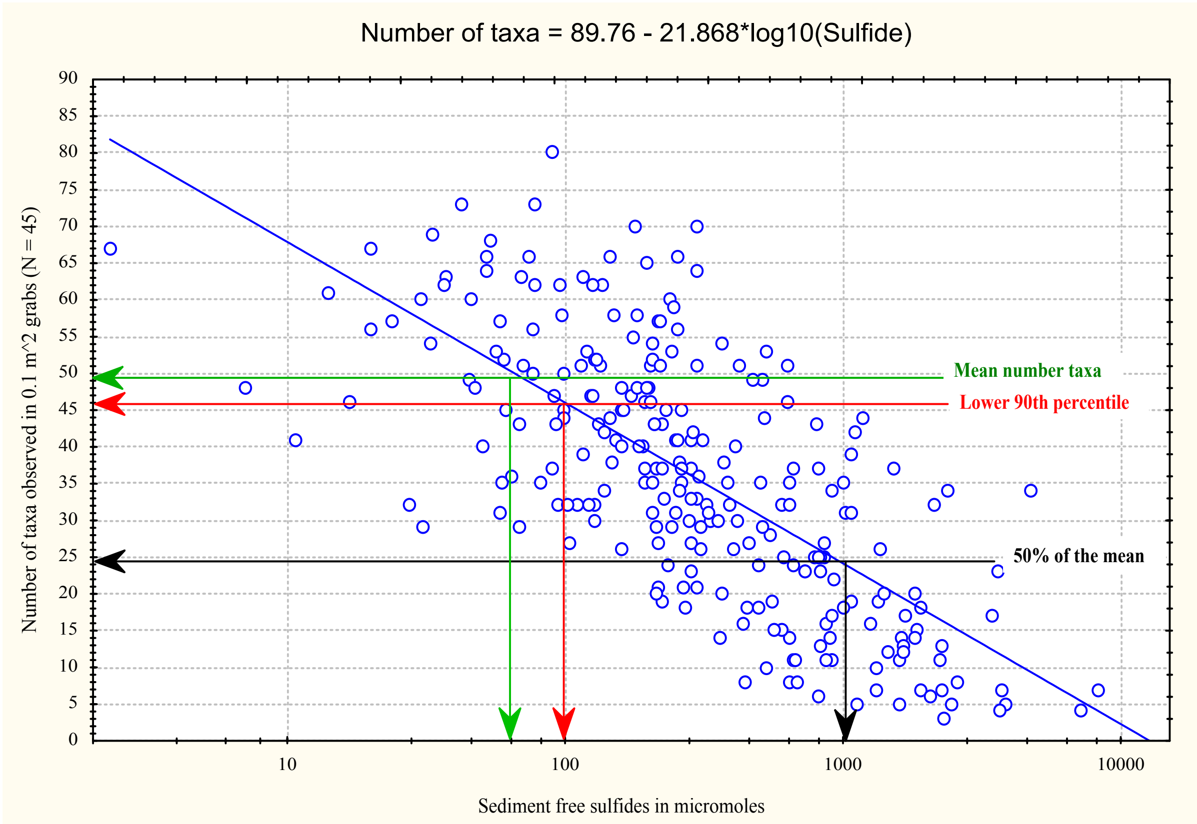

Figure 6. Number of macrobenthic taxa observed in marine sediments as a function of the concentration of free sulfides in micromoles.

The point is that Hruby *et al.*'s (02007) assertion that the task of coupling wildlife needs for upland buffers demonstrated by empirical evidence with allowable effects determined by the legislature or other elected body is not acceptable. Ecology has taken the more rigorous approach discussed above in dealing with other anthropogenic effects and in the absence of this type of rigorous approach showing a demonstrable effect (harm) coupled with an allowable level of effect, the prescriptive buffers recommended by Ecology are not justifiable.

The Endangered Species Act requires this rigorous approach for listing and managing species and Jefferson County's Critical Area Review Committee's recommendations for designation of species of local concern and wildlife corridors requires a process including these considerations. Those processes anchor requirements for restrictions on private and public lands in *fact* and not in *opinion* as appear to be the case with Ecology's and WDFW's recommendations for prescriptive wildlife buffers that do not identify the species being protected or their specific habitat needs.

4.0. Summary and conclusions. This *Supplemental Best Available Science* was undertaken in an effort to use Sheldon *et al.* (2005) and Granger *et al.* (2005) in assisting development of a Critical Area Ordinance that is sensitive to the environmental, social, economic and regulatory conditions existing in rural Jefferson County. However, the results presented in this paper are applicable wherever local jurisdictions are struggling with implementing Washington State's Growth Management Act.

The review of peer reviewed papers not included in Ecology's BAS dealing with buffer requirements to protect wetlands and surface waters from total suspended solids, nutrients, bacteria and pesticides has indicated that the agency ignored a significant body of information supporting smaller buffers for protecting hydrologic and water quality functions in agricultural and low density residential areas than was recommended by the agency (Granger, *et al.*, 2005). Hruby *et al.'s* response to Brooks (2006) continued to ignore this information and instead focused on perception to object to the CAORC's recommendations for managing wetlands and surface waters. Their continued refusal to acknowledge the additional dimensions brought to this issue by these papers are troubling.

In preparing a response to Hruby, *et al.* (2007), it was necessary to retrieve and review another 181 pages of peer reviewed documents in an effort to understand their recital of assertions made in Chapter 4 and 5 of Sheldon *et al.* (2005) regarding the effects of habitat fragmentation on amphibians and birds. The additional review finds that the documents cited by Sheldon *et al.* (2005) do not generally support the importance of habitat fragmentation on the diversity of either birds or amphibians. In fact in numerous cases, the cited literature contradicts claims made by Sheldon *et al.* (2005) and Hruby *et al.* (2007). It appears that the agency misused the cited literature and that the authors either didn't critically review the documents or they misinterpreted what they read.

In any case,1 the examination of additional documents regarding buffer requirements to protect hydrologic function and water quality and the papers reviewed dealing with wildlife buffers suggests that there are significant omissions and flaws in Sheldon *et al.* (2005) and that it does not provide a rigorous scientific basis for the recommendations made in Volume 2 by Granger *et al.* (2005). All of this has been a significant disappointment to this author.

Given the omissions and flaws in the analysis of Sheldon *et al.* (2005), it is strongly recommended that the Washington State Legislature commission a panel of truly independent experts who are known to disagree with Ecology's approach to critical area management to conduct an independent and critical review of both Sheldon *et al.* (2005) and Granger *et al.* (2005). The review panel should submit its findings to an independent referee. It may be that the hydrology, water quality, amphibian and bird sections reviewed herein are exceptions and that the remainder of the BAS is acceptable. However, the review to date is not encouraging and because these documents form the basis of significant restrictions on private and public property in Washington State, the citizens deserve and should demand that the credibility of these documents be properly reviewed.

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Appendix 1. Brooks CV

Dr. Kenneth M. Brooks
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EDUCATION

- Bachelor of Science in Physics (Cum Laude), Naval Postgraduate School (NPS), 1973
- Master of Science in Physics (With Distinction), Naval Postgraduate School, 1974
- Doctor of Philosophy, University of Washington, 1991

EMPLOYMENT

1959-1979	United States Navy Officer, retired in 1979.
1979-2001	Own a 185 acre farm in Port Townsend, WA.
1982-1992	Washington State - Environmental mediation and Chairman, Washington State Conservation Commission.
1986-1988	Doctorate, College of Ocean Sciences and Fisheries, University of Washington
1988-1990	Battelle Marine Science Laboratory, NORCUS grant
1993-1997	Director, Fisheries Technology Program, Peninsula College
1989-2005	Owner, Aquatic Environmental Sciences

ANALYSIS OF EXPERIENCE

Research: Biological studies focus on understanding organismal, population and community effects associated with natural and anthropogenic changes in aquatic ecosystems. Dr. Brooks has completed a number of benthic ecology studies examining the impact of organic loading and potentially toxic contaminants on invertebrate communities in marine and freshwater environments for government and industry. He has a broad range of mathematical tools, is competent in biometrics analysis, and has experience in developing analytically descriptive computer models.

Pressure treated wood. Ongoing research includes investigations of the aquatic risks posed by polycyclic aromatic hydrocarbons (PAH) and metals lost to aquatic environments in association with the use of treated wood under contract with the U.S. and Canadian governments and the wood treating industry. These studies are documented in a series of risk assessments, which include computer models predicting the environmental transport and fate of the preservatives. He has completed five major environmental scale risk assessments describing the environmental response to the use of pressure treated wood for the Canadian Government, the U.S. Forest Service, U.S. Environmental Protection Agency and industry.

Aquaculture. Dr. Brooks has seventeen years experience in evaluating the environmental effects associated with organic and inorganic waste and exotic species introductions in support of intensive aquaculture. His laboratory monitors ten of the 13 active salmon farms in Washington State and one-third of the farms in British Columbia. In addition, he has completed a series of intensive studies documenting the environmental effects associated with Atlantic salmon culture in British Columbia and is currently completing a series of similar studies describing the environmental response to intensive mussel culture in Totten Inlet, Washington. He has been under contract to the U.S. National Marine Fisheries Service since 1999 as part of a team conducting environmental risk assessments for various aspects of marine aquaculture. Dr. Brooks has been a member of the United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) since 2001 and is currently a member of two working groups evaluating the environmental risks associated with coastal aquaculture; developing management recommendations for member nations; and comparing the environmental costs associated with aquaculture with capture fisheries and terrestrial agriculture.

Shellfish enhancement. A five-year study evaluating intertidal shellfish resources in South Central Alaska and developing hatchery and growout protocols for native little neck clams and cockles to enhance Native American subsistence shellfish resources was completed in 2001 with funding from the *Exxon* Valdez Trustees. Additional shellfish research involves long-term genetic and epizootiological studies of Washington State mussel populations to evaluate the potential for cultured *Mytilus edulis galloprovincialis* to displace *M. e. trossulus* and other intertidal organisms and an investigation into the disappearance of razor clams from traditional harvest beaches near Cordova, Alaska with funding from the U.S. Fish and Wildlife Service.

Wetland science. Dr. Brooks has 18 years experience delineating wetlands in Western Washington and designing and construction wetland mitigation projects. He inventoried all wetlands (211 wetlands) for the City of Ocean Shores with funding from the Department of Ecology. Over the last 18 years, he has delineated and rated nearly 400 wetlands in Western Washington and designed, constructed and monitored seven wetland mitigation projects, most of which were approved by the U.S. Army Corps of Engineers. In 1995 and 1996, he included a three week course on wetland functions and delineation as part of the Freshwater Ecology Course at Peninsula College.

Resource Management: The management skills developed in numerous management positions have been valuable in fulfilling the duties associated with the following resource management positions held in Washington State:

- Chairman - Washington State Conservation Commission 1987 through 1989
- Chairman - Washington Agriculture Natural Resource Forum (ANRF) 1988 through 1990
- Chairman - Puget Sound Association of Conservation Districts 1984 - 1989
- Chairman – Jefferson County Conservation District 1982 - 1987

These positions demanded creativity to generate new programs such as the Agriculture-Natural Resources Forum, leadership to encourage participation in voluntary programs and fiscal responsibility to manage budgets approaching two million dollars per year. The Conservation Commission includes the directors of the various state natural resource agencies and holds a legislated mandate to help coordinate their efforts to improve natural resource management. The commission elects the chairman annually. During this period, Dr. Brooks provided environmental mediation services for Governor Gardner's administration. He successfully mediated several natural resource issues of state-wide significance.

Teaching: Professor Brooks was the Director of the Fisheries Technology Program at Peninsula College for five years. In addition to administering the program, he taught courses in Freshwater and Marine Ecology, Biostatistics, Mathematical Assessment of Populations I and II, Fish Physiology, Life History and Ecology of Fishes, Taxonomy of Fishes; Invertebrate Taxonomy; Invertebrate Physiology; Communications; and Computer Skills for Biometricians. Several of these courses were accepted for upper division credit at the University of Washington.

Professional Affiliations:

- National Shellfisheries Association
- Sigma Xi
- Society of Environmental Toxicologists and Chemists

HONORS

- Recognized by the Daughters of the American Revolution as the outstanding U.S. Navy Pilot in 1961.
- Awarded a gold watch by President John F. Kennedy as the Outstanding U.S. Naval Aviator in 1962.
- Faculty Merit Award for Academic Achievement (Presented to the graduate student with the highest academic achievement during the previous year) - University of Washington, 1991.

- Chapman Scholarship - University of Washington, 1988.
- All degrees awarded with honours, Naval Postgraduate School, 1973 and 1974.
- Mewborne Research Award - Presented annually by the Secretary of the Navy for the "most scholarly and significant research conducted at a naval institution." 1975.
- Dr. Edward Teller Program Award for the first imaging of the laser induced thermonuclear burn, Lawrence Livermore Laboratories, 1976.

Certified to be a true copy

Dr. Kenneth M. Brooks, January 17, 2005

Selected Publications:

Brooks, K. M. and Elston, R. A. 1989. Epizootiology of hemic neoplasia in *Mytilus trossulus* in Washington State, Part I. *J. Shellfish Res*., 8:411

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Appendix 2. Review comments from Mr. Frank Easter, NRCS State Resource Conservationist

REVIEW COMMENTS - SUPPLEMENTAL BEST AVAILABLE SCIENCE SUPPORTING RECOMMNEDATIONS FOR MINIMUM BUFFER WIDTHS IN JEFFERSON COUNTY WITH EMPHASIS ON A VOLUNTARY WILDLIFE ENHANCEMENT PROGRAM

MY REVIEW AND COMMENTS ARE BASED ON THE FOLLOWING PRINCIPLES

- That science typically used by regulatory agencies is conservative and one dimensional.
- That balanced documents and decisions made by regulatory agencies related to the Growth Management Act and Critical Areas Ordinance are very hard to find.
- That "one size fits all buffers" will not work socially, economically or environmentally on private lands.
- That examining the purposes for and functions of buffers is paramount to understanding how effective they will work on the landscape.
- That buffers do not and will not mitigate all anthropogenic impacts that influence hydrologic, water quality and wildlife functions of surface waters and wetlands.

After spending the last 36 years in Washington and Oregon in this business my comments are also heavily influenced by my experience in watershed planning, on farm conservation planning, designing and installing conservation practices in both western and eastern Washington, being responsible for the technology contained in the Field Office Technical Guide used by all NRCS and CD employees and killing myself for two years over this very "buffer width issue" in the Agriculture, Fish and Water (AFW) Process.

I must say you started your paper out with excellent information on back ground, purpose, functions and values, literature citations and very good information on GMA and CAO. However, when you got to the supplemental science, I think you fell into the same trap that has happened to allot of agencies and organizations. Taking the position that a specific sized buffer is all that is needed to protect surface water and wetland functions and values is not the solution. Attempting to prove there is science out there that can justify why a 36 foot buffer is as effective as a 40 foot buffer at filtering silt is a never ending challenge. The debate soon looses sight of the real reasons why we need to protect resource values.

NRCS recognized in the 1970's that trying to address multiple resource concerns with single conservation practices really did not work. Even though our infamous planning process could identify the problems; we were not totally solving them with the singlet practice approach. This was very evident with the old Agricultural Conservation Program administered by ASCS. During this same time period the passage of the Clean Water Act and the Endangered Species Act left both the regulatory agencies and resource management agencies struggling with developing guidance on "ecosystems management" and "best management practices" What WDOE and EPA came up with was the single practice concept for solving water quality problems! After a few years of dealing with single practices it became apparent something else needed to be done. SCS (NRCS) took the bold step into a more holistic systems approach called "resource management systems". NRCS defined a Resource Management System (RMS) as a combination of conservation practices and resource management, for the treatment of all identified resource concerns for soil, water, animals, plants and air that meets or exceeds the quality criteria in the Field Office Technical guide for resource sustainability. This unique concept, though complex, is really the proper way of reading the land and understanding the basic ecological interactions that take place when an action results in an interaction or reaction with multiple resources. Here is a classic western Washington example that we learned in the early 1980's. NRCS had been designing waste storage structures on dairies and installing them using the old ACP cost sharing program but it was not helping the producers comply with the CWA. Manure was still finding its way to streams and wetlands. No matter how big the storage structure was or how long the producer stored their manure, when it was full it had to go on the fields or in the streams. NRCS was not addressing all of the issues with one practice. We needed to plan a system that would work together and address the production, collection, transfer, storage, application and utilization of the waste. Today, this is called a Comprehensive Nutrient Management Plan (CNMP).

Anthropogenic impacts on hydrology, water quality or wildlife functions of surface waters and wetlands are no different. NRCS plans resource management systems for site specific planning units and can also use this concept on a watershed scale. Included in these RMS plans are specific buffer practices. The type, size and locations of conservation buffers (including riparian forest buffers, riparian herbaceous buffers, filter strips, grassed waterways, field borders, contour grass strips and hedgerow plantings) will vary depending upon the other supportive practices in the RMS Plan. Example, we know that on sloping cropland that if we can divide the slope length we can reduce sheet and rill erosion and reduce the size of the filter strip at the bottom of the slope next to the creek. We also know that if we can get the producer to leave more crop residue on the surface and save trips over the field the soil will accept more water and the soil will have less compaction thus reducing erosion. So rather than designing a huge filter strip that takes up a bunch of land, we develop a plan that includes conservation tillage, contour grass strips and a filter strip designed with parameters that take into account the upland treatment.

NRCS has developed an extensive conservation system guide data base that is specific to different land uses, ecoregions and resource concerns. These can be used by NRCS, CDs and the general public to build conservation plans. There are currently 24, 000 conservation system guides developed nation wide and 10,400 specific to the west. They have all been developed and tested in the field. Are they perfect? No, but they can be adjusted as they are being implemented to obtain the desired results. The key here is that improvements made to the conservation systems based on field knowledge is what makes the systems work.

The concept can work with protecting critical areas in western Washington. Get away from the paradigm of placing one practice on the landscape and saying ok. Develop a conservation system plan.

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