12877 Manzanita Road
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4 August 2011

Planning Commission Members
City Council Members
The Record

Re: Shoreline Vegetated Buffers

The purposes of this packet are to:

- Suggest that some of the functions attributed to tidewater buffers may be irrelevant here,
- Point out a dozen contradictions in statements commonly made about buffer functions,
- Comment on buffer dimensions and diversity,
- Suggest a way to go.

Since the current SMP update venture 9 years ago I've been through nearly 4000 research papers on buffers and related subjects. Previously I supervised studies on forest stream buffers.

Overall, ties between upland residential buffers and tidewater habitats remain to be verified and measured. Scepticism on your part is well-justified.

I apologize for the length of this. There's a full story to be told; more than just Herrera's gratuitous "There is consensus in the scientific community..."[1] Material beyond page 18 is backup.

Donald Flora PhD

[1] Memorandum from Herrera analysts to Bainbridge shore planners dated June 27, 2011. P. 4 et seq.

Manuscript report
July 2011

SOME NOTES ON VEGETATED BUFFERS

FOR BAINBRIDGE COMMISSIONERS AND COUNCIL MEMBERS

You have been given a list of nine functions that buffers perform at some places at some times, mostly along streams. Attributing them to tidal shores is problematic. Certainly a number of contradictions arise. Pages 4-9 in this report.

Although "science" offers little guidance for the Island, a few things are clear. Pages 9-10

Buffer widths proposed to the City[i] and thence to you[ii] are dubious for several reasons. You may be troubled by some of the claimed ties between the upland and the shore. I have found little linkage between the inland nearshore and tideland habitats below. And no research supporting a need for buffering on residential places on the Island. Pages 10-12

Buffer-success claims generally **under**state their efficacy. For that reason and others, 30-foot buffers have no substantive advantage over, say, 20-footers. Buffers narrower than 20 feet are very effective. Beyond that width, gains in efficacy are not proportional to buffer broadening. Pages 12-14

Little has been said, and there is apparently little to say, in favor of 'Shoreline Standard Buffers' wider than the proposed 'Riparian Protection Zone'. Pages 14-15

Mandates for lawnless, native, 3-tiered vegetation are severe; you may want to alter them. Indeed the position against grass runs against significant literature. Pages 15-17

With most of our shoreline home places already attired in vegetation, you may want a functional comparison of landscaped residential land with "unblemished" shores. Page 18

You may wish to consider the effectiveness and outdoor activities gained from alternatives to buffers. Page 18

All of which may draw you toward the status quo. Page 18

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WHAT BUFFERS CAN DO ELSEWHERE; MAYBE HERE

Do vegetated buffers work? Yes indeed, around the world, mostly where bare soil receives runoff across sloping ground.

How well? Very well in some places. A buffer on *deep, absorbent* soil can slow or stop most stormwater and its cargo being carried from feedlots, manure-laden pastures, row-cropped farms, clearcut logging, or construction sites. In western Oregon a 20-foot buffer stopped 100 percent of farm-generated nitrogen.[iii]

Is that useful? Yes, if you want to corral certain nutrients or chemicals that attach to sediment particles, or if you don't want even clean sediment in a creek, pond, or the Sound.

Any other benefits? Yes, albeit iffy and, including the sediment matter, even contradictory. Herrera[iv] has lately given you a list, *all drawn originally from stream-related research literature,* in some of which I've had a part. The list, apart from functions I've already mentioned:

Nutrient delivery and retention
Terrestrial carbon sourcing
Food support for juvenile salmonids
Large woody debris delivery and retention
Microclimate moderation
Hydrologic based slope stability
Fish/wildlife habitat creation, maintenance

This list came from fresh-water literature. Does it imply similar buffer widths among the functions? No. In fact there is vast variation in the presence and need for each of these functions, even along individual streams.

SCIENCE SHALL GUIDE YOU. JA SURE.

Does the literature tell us about relevance of these functions for habitats along *tidewater* shores? Very little, and too much of the limited Puget Sound "science" literature is flawed. I cite in an end note the flawed items appearing in the Herrera memo's text and reference list.[v] Science that is valid for stream and pond watersides is abundant. Having reviewed several thousand abstracts and papers on buffering and related subjects, I summarize below the freshwater functions listed above, their likely pertinence to the Sound's shores and habitats, and a dozen contradictions that infect their tidewater embodiment:

Nutrient retention - This issue is different from sediment control in that dissolved substances are presumed to be taken up by vegetation, sparing the salt chuck from tainted stormwater. Our rapid-response vegetation also means that, absent buffers, vegetation intervenes anyway. But don't count on its working: Stormwater is a winter thing here, when vegetation is largely dormant.

The Herrera memo cites statements that woodlands work better than grass at removing nutrients from passing stormwater. Perhaps elsewhere. Not here, where shallow hardpan and steady rains produce robust surface flows that are better restrained by grass blades that disperse the rivulets. Woody shrubs and trees have inter-plant spaces which channel water into rills that scrub away woodland litter and duff and coalesce into channels whose severity is determined more by slope and hydraulics than by buffer widths.[vi] **Contradiction No. 1:** Vegetated buffers, especially those with native vegetation, are expected to transpire winter stormwater; their real capacity is as spring-summer unwanted water conduits to the sky.

Nutrient delivery - Upstream, volunteers are dumping salmon carcasses into creeks to enhance nutrient loads. Along the way alders are applauded for inoculating streams with nitrogen from root nodules. Jan Newton (UW) has shown that nitrogen is a limiting factor in tidewater plankton production. **Contradiction No. 2:** Nutrient additions from headwater streams are seen as a good thing, essential to fishes' food chains; their addition to tidewater is currently seen as bad.

Beach wrack would be an interesting shore feature if were a more stable and abundant subject. It is a seasonal and transient home to certain inverts that young salmon consume; however those organisms (amphipods) are near-universal even without the wrack. **Contradiction No. 3:** Much is made of the role of wrack, yet nowhere on the Sound is that role quantified.

Terrestrial carbon sourcing - Certain isotope tracers have been shown to be identical between vegetation and stream biota, and between vegetation, tidewater beach biota, and chum salmon, mentioned at page 4 in the Herrera memo.[vii] The memo implies a cross-beach tie from upland to fish, but no vector was found nor suggested. One may suppose that the nearby significant stream brought vegetative material, microorganisms, et al, dispersing them to nearby shores in the same manner as sediment or wrack. Whether this is even important depends on whether this nutrient is a limiting factor in biota welfare. In any case this is a subset of the previous nutrient delivery function. **Contradiction No. 4:** Nutrient additions and carbon sourcing are treated as significant while the ocean provides immense nutrient flows to the Sound. For instance Hood Canal receives 400 times as much nitrogen from the ocean as from human sources.[viii]

Food support for fish – In fresh water there is a clear down-flow gradient, from nutrients entering headwaters via underground seepage, to bacteria and microorganisms dependent on those nutrients, to invertebrates feeding on cones, twigs, leaves and needles, to emergent fish fry feeding on inverts' larvae, to smolts feeding on adult inverts and each other.

The tidewater salmonid typically starts at a hatchery that discharges into a stream, thence a brackish pocket estuary, thence the salt chuck. Diet studies in the Sound have shown that about 1/64th of juvenile salmons' diet biomass is tree-related insects. That proportion appears to be correlated with the size of nearby streams, and fishery scientists speculate that the insect part of juvenile salmon diet originates mostly upstream. Attached is a paper on insects-from-trees-to-fish.

It follows that the notion of overhanging trees dribbling insects onto tidewater for fish consumption is trivial. (Non-insects in tidewater diets range from plankton to clam siphons to sludge worms.)[ix] There is no other research directed to this subject. **Contradiction No. 5:** Despite great interest in this subject there are no quantitative studies relating Puget Sound shore vegetation to fish nutrition.

Large woody debris – Driftwood, a fixture of Sound beaches since steamboats began towing logs, has never had the same functions as blown-down trees beside, across, and in streams. The structure of headwater stream habitats and even stream routes can depend on entrained treetops, trunks, and roots. About 60 percent of LWD in streams comes from trees growing within 15 feet of their banks.[x]

Tidewater logs' principal function has been as de facto bulkheads at beach tops. Within them wood borers and carpenter ants may reside, yielding a slow riddling of their homes. Carbon dating has shown drift logs over 200 years old in the north Sound, implying that any internal biota have been slow to digest the woody tissues.[xi] Depending on logs' postures relative to the tide, barnacles, mussels, and many other invertebrates may attach to drift logs, in lieu of rocks.

Depending on the shoreline for large woody debris can involve a long wait and wan produce. Unless the bank collapses, perhaps impelled by the weight, lopsided branch array, and saturated soils associated with bank-top trees. Herein **Contradictions Nos. 6, 7, 8:** We want trees to fall to the beach but also want them upright, above, for habitat. We want trees to fall naturally onto the beach but neatly placed, not athwart the beach acting as natural groins. We want to conserve moisture yet we want trees, which are voracious, valve-less, spring-summer users of water.

Microclimate moderation - Shade is important to water temperatures in headwater streams; unimportant along Bainbridge shores. If migrating fish were to dodge among upper-beach shady places (on hot days, in summer, during an hour or so of spring tides every couple of weeks) it would take all summer to reach the Strait from here.[xii]

Shade is important in some places to those surf smelt that spawn in summer. Such spawning occurs in only one Island place, on the north side of Eagle Harbor opposite the creosote plant, in front of a Hawley salt marsh that hasn't had beach tree shade for at least 100 years. Yet the smelt return.

Shade does little for tidewater water temperatures. Nor for humidity nor wind along the bayside, important though those things are along backcountry streams. There, mosses and amphibians depend on high humidity and two-way water seepage that is primarily responsible for the kinds of life adjacent to headwater streams, because of bacteria and invertebrates that ride along.[xiii] Into-the-bank seepage would be fatal to upland biota along tidewater shores. **Contradiction No. 9:** Longshore shade and leafy outreach is appealing, yet there is a converse appeal in failing banks and falling bluffs to brace up beaches.

Hydrologic based slope stability - The Herrera memo (p. 4-5) suggests that removing vegetation makes banks more prone to failure. Yes, in the unlikely combination of (1) roots having embraced the bank but not impeding hydraulic flows above the hardpan, (2) the vegetation isn't replaced by landscaping and/or our irrepressible natural veg, and (3) the vegetation isn't trees, given their weight and propensity to lean beachward.

The City's bluff study (Johannessen) did not point to bluffs that failed or are endangered by vegetation's removal. In fact, **Contradiction No. 10:** Those trees again: we want them for their aesthetic appeal yet demand view corridors that require tree removal, as at the Suyematsu farm a few years ago. And **Contradiction No. 11:** Collapsing bluffs are considered important in sustaining beach habitats, yet they also bury inshore habitats, often for decades.

Fish and wildlife habitats - Riparian zones along streams have much to do with fish welfare, mentioned earlier. Brushy reserves above the beach have not been shown to be better for the fish below than residential landscaping.

Upland wildlife species that use beaches go there regardless of shoreline residential occupancy. The Island is a poster case of such uses, including deer, otters, raccoons, rodents, et al. Amphibians shun tidewater shores (unless one includes the otters). Marine mammals do not climb the bank to reach shrubs (excepting, again, otters).

Do buffers offer needed habitat for obligate species? Among animals there seem to be no obligates tied to the upshore. Nor do we seem to need more habitat-regardless of location-for animals that we want to encourage.

Where will the wild things be? About where they are now, perhaps. Which is just about everywhere. With and without shoreline wildlife buffers, the point of this note.

The Island's byways, backyards, and open places provide creature comforts to wildlife from birds to (maybe) bears. Day and/or night the four-legged kinds sally near, as do the aviators.

From where? From hideouts in holes and cavities, under boards and beneath bushes and brambles. From treetops, grassy clumps, fence corners, yard burrows, and shrub lands.

If these be habitat, how do we justify wider wildlife habitat buffers along shorelines, or even the critter buffers we already impose? Presumably (1) we know which species we want to favor with living space; (2) we know how many of each species we have; (3) we've decided how many wild things we want; (4) we've accounted for their prey needs and the welfare of those species, (5) we've adjusted for losses to predators, (6) we're sure that habitat is the limiting factor affecting wildlife welfare; (7) we know how much habitat we have already reserved and expect to emerge from other planning; (8) we understand the alternative uses and costs of candidate habitats; with (9) opportunities to choose those less pricey in private and social terms. That's a lot.

The great levelers here, for small animals and birds, are clearly domestic dogs and, especially, cats. A noted Northwest ornithologist has said seriously that the best way to encourage shrub-nesting birds is to kill cats, not provide more habitat.

Among 51 priority marine birds listed by the Department of Fish & Wildlife are two that nest on the Island: herons and eagles. On densely (70%) forested Bainbridge Island, heron rookeries are found far from the beach, as are eagle nests. Herons show no preference for shoreside nests, and eagles are widely spaced, nesting about 3 miles apart. A marine bird that has gone off the priority list but attracts attention is the osprey, which nests nearshore here on broken treetops or piling. Pigeon guillemots (unlisted) can be seen cruising on protected waters around the Island. They nest in self-pecked burrows in bluffs. **Contradiction No. 12:** There is advocacy for falling bluffs, yet they obliterate a key bird's nesting places.

DECADES OF BUFFER RESEARCH DO POINT IN SOME DIRECTIONS

What might all this imply for buffers? First, buffers may not be the best route to certain ends, relative to current shore husbandry. Indeed, buffers may not work here relative to what they can do in other climes, soil types, and land uses. For example, stormwater, viewed as heinous in the Herrera memo and other advocacy pieces, may be restrained here above a hardpan (till) substrate, with a great and often-seen risk of saturating the upshore.

The Herrera memo cites two reports that together summarize findings from close to 100 buffer effectiveness studies.[xiv] They bring good news and bad. The good news is that narrow buffers can bring substantial rates of pollutant restraint, around 80 percent with 16-foot buffers. The bad news is that total restraint is nearly impossible, regardless of buffer width. The overall implication is that stopping pollution at its source probably beats buffering. This for sediments, nutrients, and some unidentified pesticide(s).

So what can I tell you about buffering that is specific to the Island or to Puget Sound? Not much -

The Island's shore inventory of several years ago revealed that about half of the area within 200 feet of the shore is "naturally" vegetated; about a quarter is "hard" surfaced, including driveways, roofs, et al. Presumably the rest is landscaping and lawns. A quarter of the shoreline has overhanging vegetation. The inventory tallied structures within 30 feet of the shore, but I haven't seen the results. And as far as I know nobody has compared the presence of residences with the welfare of habitat nor biota, above nor below the bank. (It could easily be done.)

Obviously this tells us nothing about the right number, sizes, and locations for buffers. A few things can be inferred. With over 80 percent of shore parcels 'developed', mostly with homes, there is an immense variety of upshore habitat and vegetation, involving large investments of time and expense in maintaining that ecotone, which may or may not be relevant to the beach. Earlier discussion in this letter suggests not.

Another inference is that ecologists' preference for vegetative 'complexity' is well met.

Yet another is that vegetation that does not fare well is briskly replaced by owners, probably with more enthusiasm than would be applied to mandated bushes.

LINKS BETWEEN THE NEARSHORE UPLAND AND "CRITICAL AREAS" BELOW

Do they exist? Are these good or bad, real or just proclaimed? The state has specified these "critical" saltwater habitats[xv]:

Spawning and holding areas for forage fish (e.g. Pacific herring, surf smelt, Pacific sand lance)

Intertidal wetland (read salt marsh) vascular plants

Eelgrass beds

Kelp beds

Commercial and recreational shellfish beds

Mudflats

Areas with which priority species have a primary association

Mentioned earlier is the finding in the North Sound that overhanging trees can hold down upper-beach temperatures during summer days when the tide is low, the sun is high, and the beach faces somewhat southward. We have places like that, but summer-spawning forage fish visit only a site at Hawley, mentioned earlier, and it has been shadeless for a century.

We have several salt marshes (see the City's maps), already under Conservancy protection. In the Sound where such marshes are vast and being expanded, the main concern is goose, not people, invasion, with each goose adding up to 4 pounds of poop per day to the marsh.[xvi]

You may know about my analyses showing that Bainbridge bulkheads are not associated with eelgrass welfare, plus nor minus. The same is true of forage-fish spawning, including herring, as well as kelp beds. Now, if not associated with bulkheads, how can these things be related to conditions above the bank? Not with shade, not with upland insects. Perhaps with sediment discharges via stormwater. But sediment is proclaimed to enhance the beach. If, say, eelgrass welfare is affected by stormwater-borne yard chemicals, with or without buffers, I have not seen the science. It is interesting that nobody has bothered to check beach-sediment chemistry with and without buffering, nor even considered the amounts applied and their half lives. Not here nor, as far as I know, elsewhere on the Sound.

The same comments apply to shellfish beds and mudflats, two other "critical" areas. Shellfish are sensitive to a number of things and the bivalves can't run away. Paralytic shellfish poisoning is one, about which buffers can do nothing. Another is septic pollution, found sporadically and for which moving drainfields is surely less drastic than expropriating homes.

"Areas with which priority species have a primary association" is pretty vague. WDFW includes seabird concentrations as priority habitats. We have many, mostly in transit to and from nesting grounds far northward. Mentioned earlier, above-the-bank places are clearly important to eagles, herons, and that perennial favorite, river otters. Plus pigeon guillemots that live *in* the bank.

Woodsy travel corridors above the beach these and other animals clearly do not require, per the earlier discussion. They travel wherever they like.

In short, you may not find much basis for the claim that "marine riparian" areas are crucial to wildlife. Nor to the welfare of tidal creatures generally, nor even to passing fish.

Again, be aware of vegetation's dormancy here during the season when we want it to perform. It won't ingest much stormwater, won't absorb our unwanted chemistry no matter how plant-friendly it is, and won't pump stormwater up those vegetative conduits to the sky.

So what are we doing to ourselves? We settlers have engaged these shores for 160 years -- woodworkers, loggers, farmers -- close to shores because tidewater tendered transport. By 1890 the Island was logged from shore to shore, burned and stump-ranched in many places. Those were times of degradation, given the exposed soils of overgrazed pastures, logging, and row cropping.

Those times are a century past and vegetation is irrepressible here. Consider the Port Blakely surround. Except for saturated bluffs, which have lately killed some people, it may be hard to find habitat degradation nor impute biota reductions to upshore ecosystem changes. Not the Battelle analysis nor the CGS bluff scoring nor Herrera's reports found a quantitative tie between nearshore welfare and upshore buffering.

BUFFER WIDTHS ARE MORE OF AN ISSUE THAN YOU MAY THINK

Are buffer studies fetched-far? Yes. In the Midwest and East buffer studies have been numerous, with widely varying results that should not dismay you. They reflect different circumstances on the ground rather than bad science. The research has focused on three problems: eroded soil from row-crop farming and overgrazed pastures, nitrogen and phosphorus mostly from livestock operations, and farm chemicals. Another, much smaller tier of buffer-width studies comes from forestry, relating mostly to logging along streams. Buffer studies here, with our special combination of climate and soil conditions, are scant. This may also be because, in central Puget Sound, we do not have problems with sediment loss, feedlots, row cropping, nor heavy use of fertilizers and other chemicals.

Can buffer data be misleading? Yes. There is a hidden bug in this ointment, unmentioned by the City's consultants and perhaps not noticed at City Hall. Not displayed nor mentioned in City documents is that the amounts of pollutants going into research buffers are typically far higher than can be expected from residential sites. In literature surveys the buffer studies are arrayed in terms of Pollutant **Percentage** Removed. An example is a 70-foot buffer that removed 98 percent of fecal nutrients from a Midwest feedlot. Should we use a buffer that wide? Well, unmentioned is that the feedlot held 136 cattle per acre.[xvii] Their per-acre emanations equaled those of 1200 people. At that level of efficacy a buffer of perhaps 3 feet would more than meet our needs.

In short, buffer reports almost always involve pollutant flows much greater than those we might experience, a fact that percentage-performance numbers obscure. There will be more insight into this issue by fall. Meanwhile...

Is a 30-foot "Riparian Protection Zone" better than, say, a 20-footer? That there is no significant protection difference is obvious by inspection of the data arrays in Desbonnet et al and Zhang et al, mentioned earlier in connection with the considerable effectiveness of narrow buffers in reducing stormwater-entrained sediments, nutrients, and pesticides. These "meta-analyses" are based on scores of field studies. There is no *significant difference in* buffer efficacy between 20 and 30 feet (6 and 9 meters) in either of these analyses.

These packages of studies also support the premise of diminishing returns: doubling buffer width doesn't double performance. They show reduced incremental benefit starting at about 20-foot buffer widths.

It may not seem to matter much, but the difference can easily reduce children's play space by half. I've attached a 1-page comment on the outlook for children's space.

Relative to a 20-foot buffer, a 30-foot no-touch zone will <u>not</u>:

Better protect the Sound against stormwater-borne pollutants

Improve shade for surf smelt spawning
Provide more insects for salmon diets

Improve nutrient flows to tidewater prey organisms

Speed the dynamics of intertidal drift zones

Slow the loss of backshore to the sea

Provide more sediment to drift zones

Regulate tidewater temperatures to reduce plankton blooms or increase benthic invertebrate production

Improve the nutrition of passing salmon

Increase eelgrass production

Increase the abundance of juvenile nor adult salmon

Protect ocean-bound fish from predators

Increase marine habitat diversity

Restore marine conditions to beckon lost cod and herring

Enhance the attributes of native plant species

Increase diversity of upland landscapes

Discourage invasive animal species

Provide a better home for small mammals

Enlarge depleted habitat for cavity-nesting birds

Provide more shoreside perches for eagles, kingfishers

Conserve water for infiltration to aquifers

Protect aquifers from water-borne pollutants

Preserve play space for children

Nor perform better than a number of alternatives

I can provide detailed discussions of each of these functions relative to buffer widths.

And what about the proposed 50-150 foot "Shoreline Standard Buffer"? This is the proposed total buffering in residential zones outside urban area.[xviii] Adjacent to the bank, the proposed "Riparian Protection Zone" has been recommended as a minimum of 30 feet and as much as 150 feet "to the contour of existing vegetation"[xix] (whatever that means), "if intact native riparian vegetation were present"[xx].

You can reasonably assume that, just as 30-foot buffers offer negligible gain over 20-footers, a 30-footer will not be inferior to a 50-footer, using the criterion list above. Indeed, if this brushfield zone is envisioned as special for wildlife, is it superior to the status quo? Apparently not, given research elsewhere in the Seattle surround showing that wildlife diversity is greater in exurban areas than in woodlands.[xxi]

IMPLICATIONS FOR BUFFER CONTENT

Are you asked to make major changes in shoreline vegetation and landscaping? Yes.

The June draft from the staff proposes two-part buffering, with a totally non-grass part closest to the bank. The draft proposes substituting shrubs, trees and 'groundcover' for lawns and residential landscaping. A third mandate requires total commitment to native vegetation in the near-bank buffer.

Do you really want to eliminate lawns? The Working Group's June 25 draft is replete with prohibitions of grass lawns. Only 35% of the upper buffer could be planted to new grass lawns. As shown starting on the next page, that could be as little as a 7-foot strip in front of the house. Even zero if there is already native vegetation in that space. Which is a wild card because common grass species used here *are* native fescue and ryes.

The Herrera memo cites a "meta-analysis" that, they say, shows woodland superior to grass in halting pollutants. The paper, in a one-liner, says that trees worked better than grass but curiously provided no foundation, analytical nor otherwise, for the statement.[xxii] The paper acknowledges that maintaining 'sheet flow' is critical in reducing sediment loss and rill erosion, and that this is "typically difficult". Indeed. Without sheet flow, sediment-carried pollutants not only carry right on through the buffer, they erode it along the way. Grass is the only known method of assuring sheet flow, and even that may not work on uneven ground.

A widely-cited paper, also listed by Herrera, says that, for tidewater shorelines:

> [Grasses] are generally able to respond rapidly to increased concentrations of nutrients, grow rapidly and densely, and typically grow well in nearly all climates. Thickly planted, clipped grasses provide a dense, obstructive barrier to horizontally flowing water. This increases the roughness of the terrain, which reduces flow velocity, promotes sheet flow, and increases sediment and adsorbed pollutant removal efficiency.[xxiii]

Obviously shrubs' stems, tree trunks and woodland litter cannot do those things.

Even the State's stormwater manual (generally echoed locally) reflects the relative ability of grass to slow water's above-ground progress.[xxiv]

I've attached a longer discussion of grass and lawns. Whatever the reasons applied by the Working Group, scourging grass is a big mistake for ecologic reasons.

Does nativeness make sense for Island shoreline landscaping? The Work group's draft regs call repeatedly for plants "native to the Central Puget Sound" or plants providing the same functions, approved by the Administrator, whomever that is. And yes, native vegetation does make sense of course, where it's wanted. Beyond that, we're lucky in having a maritime climate that suits plants from afar; though some have been real nuisances. As when Lizzie Gazzam brought back Scotch broom seeds from Victoria.[xxv] Yet what is more demeaning than having verdure's variety dictated to an owner, landscaper, or gardener? Amid all the baggage being loaded onto shore folks, is nativeness really a tidewater imperative? What is the point? I've attached a discussion of the latter matter.

Will front yards become brushfields? Yes, over time. The Herrera memo alludes to "the City's desire to limit the number of non-conforming structures..." (page 6). Shoreline homes are being built at a rate of about 6 per year.[xxvi] If 600 shoreline lots remain undeveloped, wrapping the Island in a vegetative cloak will take a while. Well, not really, because vegetation is, generally, already there. Still, that's 600 windows of vulnerability to new rules.

Assume a front yard between the house and bay. It's probably grass and interesting landscaping. The proposal is to convert 30 feet of it to native "multi-storied, diverse species", including "trees, shrubs and groundcover". Of the rest of the "standard buffer", 65% would be the 3-storied veg; 35% could be lawn. Thus, given a 50-foot standard buffer between house and bank, 7 feet could remain grass.

Is 3-tiered vegetation feasible? Probably not. Even over on the coast, with its abundant rainfall, two ecotypes are common (in otherwise natural settings, decades after logging): either trees and moss or shrubs alone. The notion of a 3-level vegetative complex ignores the reality that usually only two and in some places only one will survive the competition for sun and water. For confirmation, visit Fort Ward Park[xxvii] or your own yard. If you like what you see in the vegetative complex between Fort Ward Drive and the shore, that's what we'll get. Well, maybe not the ivy.

Three DOE publications warn against trees at the brink:

> "In the Pacific Northwest, forested buffers are often "created" as leave-strips around wetlands or along streams when the surrounding forest is cleared for land development. These forested strips are then exposed to winter windstorms, which are common, often resulting in substantial loss of large trees due to blowdown."[xxviii]

> "Large trees should be used on the face of slopes sparingly and with caution. Should these trees collapse because of undermining of the root system by erosion or by windthrow, large volumes of earth can

be disturbed by the tree roots when they pull from the slope. The resulting large, bare areas are opened to further erosion, which may endanger adjacent land and vegetation. New major trees should not generally be established on the face of coastal slopes."[xxix]

"Any process that adds weight to the top of a potentially unstable slope can increase the risk of sliding." "Vegetation growth increases weathering of soils and root action can, particularly in compact units like glacial till, loosen natural fractures and joints in the material, leading to failure. Movement of trees by wind stress may loosen soils, enhancing infiltration, and in some cases, may impart significant loads to the slope itself that may trigger failure."[xxx]

That this nigh-beach no-touch zone will somehow enhance the environment is an hypothesis that runs counter to what we know about buffer efficacy, summarized earlier. In particular, their "protection" role (mentioned in the Herrera memo, page 8) is vacuous without specificity about what is to be protected and how that is greater protection than now exists. Herrera, for example says that this zone's goal is to "protect native vegetation". Well, why, if it is present, does it need special protection? Is it more vulnerable than what would otherwise be there? If yes, why use it? The premier argument for 'native' vegetation is that it is less vulnerable than alternatives.

THREE SUGGESTIONS

Where does all this leave you? With thin gruel and three recommendations.

One, reconnaissance. Have a look at shoreline yards and the abutting beach, especially where Islanders have been living along the shore a long time. What's broken along the way? Ask for a show-me tour. Do beaches with buffers appear to be better served than those without? Does buffer width appear to matter? Upshores have surely changed. In ways that are bad? How much badness is about us now, or in prospect? If badness is not present, might buffers make things still better?

The City has found that, on average, shoreline homes are 70 to 90 feet from the shore, with wide variation.[xxxi] What uses are being made of the space between houses and the shore? Are they sending us into harm's way? Commonly, here and there, or rarely?

What about the nine riparian functions discussed earlier. Are they in play here? Are they important here? Has buffering made them better? Where buffering is absent, how much buffer would it take to create a better place in ways meaningful to you?

Second, consider alternatives to buffers. I've attached a list. What is most cost-effective in achieving whatever seems to be needed? Cost reckoned in terms not just of dollars but also the welfare and displacement of people and their activities.

Third, press the staff to secure data on actual movements of stormwater, nutrients, and pollutants across residential yards. Random sampling, peer-reviewed study plan, grant funding, the works. There is no lack of people willing to do the field work. Lab work would be costly. Analytical expertise is all around us.

Along the way... consider the likelihood, plus or minus, that inshore welfare requires broad upshore buffers.

D. F. Flora

NOTES

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i. Memorandum from Herrera analysts to Bainbridge shore planners dated June 27, 2011.

ii. Bainbridge Draft Regulations for Vegetation Conservation and Management Zones, June 25, 2011.

iii. Davis, Jennifer J., et al. 2007. Mitigation of shallow groundwater nitrate in a poorly drained riparian area and adjacent cropland. Journal of Environmental Quality 36:628-637.

iv. Herrera memo June 27, 2011. P. 4.

v. Flawed studies in the Herrera memo's reference list include:

Herrera 2005
Brennan et al 2009
Romanuk and Levings 2010

I can provide detailed explanations of the unfortunate problems resident in these items.

Because the Brennan et al paper has probably been handed to you, I point out that it extrapolates freshwater findings to tidewater buffers. That is unfortunate:

> Marine life is very different from aquatic fauna. A Scripps Institution professor has remarked, "...seawater is a toxic material to most land organisms and highly inimical to their survival..."
>
> Few marine shore birds stroll the margins of streams.
>
> The effects of trees falling toward other trees are very different from trees falling toward nearshore houses. And trees falling into streams have dynamic roles, while those in tidewater are largely static. Even in the best of windthrow worlds, the roles of downed trees are very different along streams relative to tidal shores.
>
> The biota of stream-held logs are different from those in beach logs.
>
> Most waters in back-country streams are seasonal; those on the Sound are diurnal.
>
> Wind's role along streams is very different from its intertidal activities.
>
> Old-growth forest headwater streams are typically high-gradient and narrow
>
> Fire has played a determining role in backcountry forests and riparian areas; burning bushes along the bay are rare.
>
> Aquatic insects are key players in streams; neither they nor other insects have much to do with tidewater, where they play a minor role in diets of juvenile salmon.

Nutrients are scarce, limiting, and welcome in forest streams; they are (perhaps wrongly) considered hostile in the Sound, where oceanic sources are immense. A noted marine biologist has suggested that primary production in tidewater is constrained by light, not nutrients.

Snow and ice are common arrivals in headwater riparian areas; not so along the Sound.

Eroded tidelands are considered problems along tidal routes; eroding beds are a natural part of the aquatic profile.

No research has shown that humidity, air temperature, windspeed gradients, nor soil-moisture profiles are the same above tidewater shores as those adjacent to streams.

Most of the literature cited by *Brennan et al* on surface erosion is from the East and Midwest, involving row-crop agriculture, overgrazed pastures, and feedlots. The Bainbridge Island shore inventory does not list any of these sediment sources.

Mosses, lichens and amphibians have major presences and are major concerns in managing forest nearshores. They are absent or minor matters along Puget Sound.

Shade is important to water temperatures in streams; virtually irrelevant to tidewater.

The conclusions of the WDFW science panel (Herrera memo page 3) are also misconstrued. The consensus that freshwater riparian buffer research was *conceptually* applicable to marine shorelines was actually limited to the principle of diminishing returns associated with buffer widths. The panel in fact raised questions about the pertinence of certain riparian functions to tidewater. The panel clearly did not choose to draw tidewater buffer-width guidance from streams. They were cautious about ascribing the conditions and dynamics of transitional stream riparia to the abrupt ecotones at marine fringes. They did not subscribe to notions that marine pollutant dynamics are analogous to those of streams (p. 111). They noted that the mechanisms and benefits of shade differ between streams and the marine environment (p. 114). They learned that most marine driftwood comes from distant places, while large woody debris in streams is mostly from adjacent slopes. They agreed that while leaf litter has comparable roles, associated insects dominate fish diets in streams but are minor in tidewater (p. 119). They identified "a strong contrast in natural and anthropogenic sediment issues in freshwater and marine systems" (p. 122).

The Gonor paper (Herrera memo p. 6) pertains to rivers and oceanic beaches, not to Puget Sound.

vi. I can provide a manuscript report on this subject.

vii. This is the Romanuk-Levings 2010 paper. While isotope tracing has lately become common, the vegetation-stream link has been well-quantified for decades. For instance Naiman, Robert J., *et al*. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion. In: Naiman, R. J., ed. *Watershed Management - Balancing Sustainability and Environmental Change*. New York: Springer-Verlag.

viii. Paulson, Anthony J., et al. 2006. Freshwater and saline loads of dissolved inorganic nitrogen to Hood Canal and Lynch Cove, Washington. Scientific Investigations Report 2006-5106.

ix. Flora, D. F. 2007. A perspective on insects eaten by juvenile Puget Sound salmon. Peer reviewed but unpublished; available from the author.

x. Murphy, M. L., *et al.* 1987. The relationship between stream classification, fish, and habitat in Southeast Alaska. Research Paper R10-MB-10. USDA Forest Service, Tongass National Forest;

VanSickle, J. and S. V. Gregory. 1990. Modeling inputs of large woody debris into streams from falling trees. Canadian Journal of Forest Research 20:1593-1601.;

McDade, M. H., *et al.* 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20(3):326.

xi. Tonnes, 2008, above.

xii. A normal swimming rate of 5 miles per day has been found in Hood Canal.

xiii. Montgomery, David R., *et al*, eds. 2003. *Restoration of Puget Sound Rivers.* Seattle: University of Washington Press, p. 261.

xiv. The 1994 source may be out of print; the staff probably has a copy or I can provide it: Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report 2064. Narragansett, RI: Rhode Island Sea Grant Publications, University of Rhode Island Bay Campus.

The 2010 source is on the Web. Search for the journal or get a copy from me: Zhang, Xuyang et al. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84.

Most of the studies compiled in these papers are from farmlands and have no tie to tidewater; they involve soil types, land uses, and climates unlike ours; and they address issues that we may not have: manure, pastures, and row-crop sediments.

There are no counterpart studies for Puget Sound. These farm-oriented studies appear to involve pollutant loadings far greater than can be found here, suggesting that buffers narrower than those studied may work just fine around the Sound, if needed.

xv. Washington Administrative Code 173-26-221(2)(c)(iii).

xvi. The per-capita contribution is from a 22 July 2011 *Kitsap Sun* letter by Dave Kimble, citing wildlife biologists.

xvii. Young, R. A. et al. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Journal of Environmental Quality 9(3):403-407.

xviii. Work group draft regs, June 25, p. 6.

xix. Work group draft regs, June 25, p. 5.

xx. Herrera June 27 memo p. 6.

xxi. Marzluff, John. 2003. Data presented at a seminar on urban ecology, November 7, 2003, University of Washington, College of Forest Resources.

xxii. This is the Zhang paper mentioned earlier. Its regression equations combined trees with grass and thus obscured any meaningful difference.

xxiii. Desbonnet et al, above.

xxiv. Washington Department of Ecology. 2000. Stormwater management manual for the Puget Sound basin [with amendments].

xxv. Related by Ruth Gazzam and reported by Jack Swanson in *Picture Bainbridge*, 2002, p. 92.

xxvi. This is the 2003-2010 rate, provided by the staff for Herrera's 2011 "Addendum to Summary of Science Report", at page 48.

xxvii. This is an easy visit. From Lynwood Center follow Pleasant Beach Drive south to the park entrance/parking area. Walk the road beyond. This is one of the Island's wettest areas rainfall-wise and because of its shallow underlayment of bedrock.

xxviii. Sheldon, Dyanne, *et al*. 2003. Freshwater wetlands in Washington State, Volume 1: A synthesis of the science. Publication 03-06-016. Olympia: Washington Department of Ecology. p. 5-46.

xxix. Myers Biodynamics, Inc. 1993. Slope stabilization and erosion control using vegetation, a manual of practice for coastal property owners. Publication 93-20. Olympia: Washington Department of Ecology. p. 25-26.

xxx. Shipman 2001 above. p. 19, 20.

xxxi. These are the mean distances in the proposed shoreline residential and shoreline residential conservancy zones, from Table 1 in the Herrera memo. Standard deviations are 46 and 56 feet respectively, signaling wide variation.

LAWNS OF GRASS

AN ASSESSMENT

Bainbridge Island's charm flows partly from its lawns. Grassed lawns have played an admirable environmental role. Readers are reminded that, for other reasons too, lawns are and have ever been immensely important places.

These pages report research showing that replacing lawns with non-grass vegetation will not likely reduce alleged potential problems with excess nutrients nor 'pollutants'. Certain heavy-duty chemicals, released steadily and copiously, are likely to sluice through vegetation, regardless of its kind. This because of our stormwater's habits. However no kind of vegetation surpasses lawn grass in absorbing pollutants of all kinds.

Vistas, meadows, and lawns are hallmarks of pleasant lifestyles in every developed region of the world. They are celebrated in centuries of art, poetry and prose. Provincially they are implicit in the state's Growth Management Act and the Smart Growth agenda.

Locally questions have been raised about the laudability of lawns and the goodness of grass. Some have proposed that the City endorse and commit resources to replacement of lawns.[1]

It appears that issues about lawns devolve largely into concerns about what comes from, goes across or flows under lawns. Here are some of those issues with findings from the technical literature. Overall, as with other Island natural systems, lawns are complex places to which simple assumptions may not apply.

Yards, Lawns, and A Children's Place

Why is all this important? Because families coming here look forward to an outdoor place for children.

However, in land-use planning, a children's place is becoming an afterthought. Sad that, with buffering and the condo flood, yards are fading. Without yards and grassy home places what refuge is there for kids? Where will be the places to romp? Where will be the backyard swing sets, sandboxes, Radio Flyer wagons, croquet layouts, tent pitches, and private places to run and dream?

Presumably they'll be wedged among the requisite shrubs, 'native' groundcovers and Astroturf-like surfaces. Because all chemicals are very bad and lawns are surfeited with them.[2] However these underlying declarations of danger are largely false.

Hardpan, Climate, Vegetation, and the Stormwater Story

Across northern states the continental glaciers left a rich legacy of lakes and wetlands, and a belt of farm-poverty-producing soils: bedrock, gravels, and compressed hardpan. Bainbridge got some of all three: 350-plus wetlands, areas of hard rock and gravels, and a heavy harvest of hardpan. Which says much about *where* our stormwater goes.[3]

Our peculiar climate says it all about *when* surface water flows. In contrast to most other U.S. regions we have scant summer rainfall. We lack the brief but intense local "convectional" storms that provide summer runoff.[4] And our prolonged winter rain events add other unusual regional dimensions, not the least of which are leaky buffers and saturated soils.

Our vegetation is special too. It's irrepressible, providing a useful rain softener in almost all places and seasons, in some combination of surface veg, shrubs, and trees. Bare ground is an oddity. However a key fact is that most vegetation goes dormant in winter. For hardwoods and softwoods alike, winter transpiration is as little as one percent of that in summer.[5]

Together these three factors - soils, climate and vegetation profile - make us different relative to stormwater.

Why tell this stormwater story? Because stormwater is the prime mover of nutrients and pollutants, for better or worse, across the landscape including lawns and all other vegetation.

Prolonged (winter) rains soak into upper soil horizons as far as the hardpan, which can be a matter of only inches. The glacier-compacted subsoil accepts water very slowly, perhaps an equivalent of .06 rainfall inches per hour.[6] At that rate, after a week the hardpan is wetted downward only 1-2 feet. Meanwhile rainwater (and other fluids) drain downhill on the hardpan's surface, toward surface seeps at wetlands, ponds, and creeks. This subsurface flow diverts water from aquifers but it is critical to streams.

Vegetation matters. Roots have trouble invading the hardpan, but they impede water sliding along through the surface soil. The root-soil combination can be an effective dam, saturating the soil on the uphill side.

Vegetation aboveground helps in three ways. One is physical obstruction of moving water, typical of grass. Another is absorption, by the settled leaf litter under vegetation, including grass clippings. The third is uptake of water in the course of photosynthesis, a growing-season-only factor.

Lawns and Erosion

Sediment is widely cited as a threat to wetlands and streams[7], going back decades to times of rampant logging, land clearing and farming across America. An active construction area is said to produce about 2000 times as much sediment as a fully vegetated area.[8]

However the erosion concern may be beating a dead horse. I suspect there were three periods in Kitsap history when erosion was prevalent. One was the 1870s and 80s, when logging and burning reached almost everywhere. Another was the era of stump ranching when everybody had livestock and overgrazed pastures were the norm. The third was the time of strawberry farms when much of the island was kept clear for berry culture, with long rows of bare soil exposed to winter rains.

Our present era of abundant vegetation and a cultural aversion to bare dirt mitigate against surface erosion. A few pastures are still with us, but given sensible animal management the Island's risk of rill erosion, the main source of sediment outside construction sites, is probably nil. Certainly woods and subdivision lawns don't carry that risk.

Stormwater in Flood Mode

However, overland flow of the waters not retained by vegetation or floodwater restrainers can wash away the accumulated dead leaves and twigs that make up forest duff, stripping the ground back to the underlying hardpan. Grass bends its head and lets the water flow over[9], but the woodland detritus has almost no capacity to cling.

These sluices through the bushes are junior versions of the woodland debris flows that Northwest scientists have been studying for decades.[10] Such flows are narrow, sudden, and sodden. They surge through wooded buffers into streams. Scoured out along the way are surface vegetative litter and duff and their algae, fungi, and fauna. A legacy is the woody debris that shelters fish and kills kayakers. Small versions of these flows are common in ravines all around Puget Sound.

Aside from trenching against the torrent or routing water into closed conduits, the best protection against erosion is stormwater capture at the top of the slope. No matter what the groundcover, water moving across the ground tends to concentrate, carving out tiny rills that merge into bigger channels. This can be seen in gardens in which shrubs are open-spaced. "...naturally occurring vegetated buffers are generally incapable of inducing sheet flow from storm water runoff ..." and "The natural tendency of water to move in discrete channels may be one of the greatest impediments to successful buffer implementation for nonpoint source pollution control..."[11] Up-slope capture leads to ways to encourage infiltration, mentioned next.

Aquifer Recharge and Yard Vegetation

How best to enhance infiltration of (presumably clean) stormwater? In a land of extremely dense glacial tills, adjusting vegetation would seem to have little merit, unless the till sill is narrow enough that tree roots can break through. Unless the roots block the breakthrough. I know of no Puget Basin research on this matter.

One objective is to delay stormwater long enough to allow it to infiltrate downward. Our winter storms are long enough that stormwater tends to roll over grass, run across bare ground around shrubs, and right on through woodland duff. Especially on steep ground. An option that works, although site-specific and generally expensive, is 'low impact development' (LID), which embraces water gardens, permeable pavements, small structural and roadway footprints, rain barrels - a landscape reminiscent of the 1930s.[12]

A King County analysis concluded that "...if a forested area is replaced with a paved surface for which runoff is collected in a recharge pond, net recharge may be greater than under the original condition in which much of the precipitation is lost to interception and evapotranspiration."[13]

This says little about lawns, except that infiltration (retention) ponds are typically lined with grass and other vegetation is excluded.

Given that our residential open space is invariably covered by some kind of vegetation, and all veg draws water from below, choosing least-thirsty plants has appeal. A woodsy setting transpires perhaps 2,000 to 4,000 tons of water per acre per summer.[14] During that time, a watered lawn might use 1800 tons over four months.[15]

A further advantage of a managed lawn is that water use can be controlled by the turn of a spigot. Trees, those great water conduits to the sky, keep right on doing their thing.

Septic Output and Lawns

Septic systems discharge whatever goes into them, of course, if one includes periodic pumping. Around Puget Sound two septic products, both involving drainfields, generate special concerns. These are coliform bacteria and nitrogen.

Fecal Coliform is a goner in a standard, maintained septic system (tank plus field). EPA reports that 99-99.99 percent removal is common.[16] Recently the Kitsap County Health District surveyed some 50 miles of shoreline along Hood Canal, finding only 13 septic systems needing attention.

A key factor in septic-system success is, of course, free flow of fluids through the drainfield's dispersal pipes. Which accounts for regulators' insistence on grass rather than deeper-rooted plant covers.

Nitrogen, essential to all proteins and thus to all animals and plants, is both nuisance and necessity in the Puget Sound country. Nuisance because in some wild waters nitrogen is a limiting factor to the reproduction of algae. Adding nitrogen can support explosive growth of these marine and freshwater plants that are at the bottoms of many food chains as well as adding oxygen. That's good, but excess algae die, decompose, and the decay organisms use up oxygen, a process to which fish deaths in Hood Canal have been attributed.[17] Some lakes, and probably some West Side wetlands, have been oversupplied with nitrogen, creating an excess of algae in a process called eutrophication.

The necessity side relates to dry-land plants all around, from lawns to forests, and famously to fish, in freshwater streams. So deficient that adding fertilizer to streams has markedly increased invertebrate populations and the numbers and sizes of juvenile salmon.[18] Volunteers have been carrying salmon carcasses from hatcheries to backcountry streams.[19]Wipfli, Mark S. et al. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase the growth rates of stream-resident salmonids. Transactions of the American Fisheries Society 132:371-381. [Results in Southeast Alaska]

Elsewhere, nitrogen abounds. There is four times as much nitrogen as oxygen in air. Ocean upwelling brings huge amounts into Puget Sound.[20] Animal doo and decaying vegetation may be the main sources of nuisance nitrogen on the Island. Alder trees are great nitrogen-fixers, using nodules on their roots.[21] Drainfields are probably trivial troublemakers given recent estimates along Hood Canal.[22]

Septic nitrogen is not well-processed inside a septic tank. Its return to the atmosphere involves a change from ammonia to nitrite, then nitrate, then (via bacterial action) to gas. This needs to happen in the "vadose" (porous, unsaturated) zone in and around the drainfield. So it's no surprise that grass outperforms woodlands by 2 to 1 in protecting aquifers and water places from nitrogen.[23]

Phosphorus Plus Some of the Really Bad Stuff

These are chemicals that cling to sediments. As goes surface erosion so go these things. Some, including phosphorus and many organic chemicals, move from the sediments to roots and up into plants. This assuming the plants are actively taking up water. We are fortunate here in having a long growing season and ground covers that stay green. The bad bit can be saturation. Saturation with the chemicals, harming the plants. Or saturation by stormwater that carries the soil particles on down the hill.

An asset of wetlands here is their abundance of clay-sized bottom sediments. By adsorption these gather phosphates, toxics and metals. Our wetlands' typical low (acid) pH helps too. This may seem a strange function for wetlands, but DOE has said that a function of wetlands is to trap and transform chemicals and improve water quality in the watershed.[24]

You may well disagree. Be of cheer. There's a consensus that, overall, grasses

> "...are generally able to respond rapidly to increased concentrations of nutrients, grow rapidly and densely, and typically grow well in nearly all climates. Thickly planted, clipped grasses provide a dense, obstructive barrier to horizontally flowing water. This increases the roughness of the terrain, which reduces flow velocity, promotes sheet flow, and increases sediment and adsorbed pollutant removal efficiency."[25]

Too, grasses have an advantage over other vegetation in their greater capacity (per square foot) to absorb otherwise unwanted chemicals. This because of their higher "primary productivity".[26]

Fertilizers and Yard Chemicals Generally

Farmers, foresters and landscapers are economically and biologically shrewd. They have a strong incentive to minimize the use of expensive chemical treatments, so most operators do soil testing as part of site- and time-specific fertilizing. Some homeowners resort to soil analyses, but most can readily judge when grass and shrubs have gotten greener and taller and trees are adding new growth.

As with fertilizers, the extent of use of herbicides and insecticides here is unknown. Insecticide use may increase as we see an influx of gypsy moths to decimate flower and vegetable gardens and deciduous trees, perhaps followed by the Asian gypsy moth that will take conifers. Not to mention rusts, wilts, mildews, galls, chewers, girdlers, and wasps. Native plants will presumably be especially susceptible as these (and most other harmful) insects come from abroad. Another challenge to creative chemistry will be mosquito-borne West Nile disease and, with regional warming, malaria.

Grass has advantage over less-dense plantings like shrubs because of its structural integrity. Invaders like Scotch broom, laurel, poison oak and blackberries are better repelled by lawns. And grass establishes that tight cover in weeks rather than the years required by even broadleafed-tree litter.

Concern about yard chemicals should be moderated by the fact that chemicals are applied mostly in seasons in which stormwater will not wash them away before they decompose.

There are yard and buffer chemicals that meet these environmental standards:[27]

Persistence. A half-life of less than 30 days is a recommended objective.

Adsorptivity. The tendency of a chemical to adhere to soil particles rather than passing through to groundwater or horizontally to streams. The coefficient is K, preferably above 300.[28]

Solubility in water. Less than 30 mg/L is considered desirable, especially if persistence is high and adsorptivity is low.

Petroleum Products and Industrial Chemicals

There are heavy-duty chemicals, including organics and heavy metals, in Puget Sound. Familiar names are zinc, lead, mercury, copper, PAHs, PCBs, dioxins, and furans. Most of the Sound's contaminated sediments are associated with industrial areas, and the great majority lie in Elliott Bay.[29]

The weakness of buffers, including lawns, applies also to petroleum products and heavy metals. It is argued that vegetation, by capturing rainwater, also absorbs the chemicals. It does, but only in the growing season and only up to a point: plants have a limited capacity for the chemicals they don't need.

Even woodlands become overwhelmed, especially where soils are dense and slow to absorb water, as on much of the County. The hardpan helps keep chemicals out of aquifers but speeds the chemistry downhill to wetlands and creeks. So pervious are woods that a research compilation points out that 300-foot wooded buffers are no more effective than 6-foot buffers.[30]

Stormwater dilutes these chemicals but they don't dissolve; they just ride the wave of water to wherever they settle. As lawns and other buffers become saturated with water they can also be saturated with the bad stuff.

The primary enduring solution to chemical pollution is cutting off chemicals at the source. This is not an indictment of septic systems, lawns, nor suburban life. Snohomish County, in an assessment of their many lowland lakes, found that the quality of lake water is better where shores are lined with homes than where they are not.[31]

Lawns, Grass, and Native Vegetation

Lawns preserve a heritage of native grass. The key lawn grass species here are fescues, descendants of the grass that predated fir trees in the Puget Lowland. Remnants of the grass-oak savannas remain from Victoria south into California.[32] It is ironic that restoration of those grass-based environments is a key element of conservation these days, while some folks would have grasses diminished.

If Not Grass, What?

Presumably some other vegetative child-friendly groundcover. Ideally, one that provides all the functions and values of grassed lawns with less expense or hassle. A challenge indeed.

D. F. Flora

NOTES

1. CAO Non-Regulatory Citizens Working Group. 2004. Matrix of recommendations for Land Use Committee [of Bainbridge Island City Council] re: Critical Areas Ordinance non-regulatory options. April 27, 2004. On file at Bainbridge Island Department of Planning and Community Development.

2. For example, Cruickshank, Cara. 2002. "Get your lawn off drugs:" the natural landscapes project. Scotch Broom. Autumn.

3. There is a soil-type survey done by the U.S. Department of Agriculture covering all of Kitsap County.

4. Hornbeck, James W., et al. 1984. Forest hydrology and watershed management. In: Wenger, Karl F., ed. Forestry Handbook (Society of American Foresters). New York: Wiley.

Hewlett, J. D. 1982. Principles of forest hydrology. Athens, GA: University of Georgia Press.

5. Baker, Frederick S. 1950. Principles of Silviculture. New York: McGraw-Hill.

6. A calculation based on equations and data in: Washington Department of Ecology. 1992, 2000. Stormwater management manual for the Puget Sound basin [with amendments], Section III. Soil type D.

7. Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center

Technical Report No. 2064. Narragansett, RI: University of Rhode Island Sea Grant.

8. U.S. Environmental Protection Agency. 1976. Erosion and sediment control in surface mining in the eastern U.S., Volume 1, Planning. EPA Technology Transfer Seminar Publication EPA 625/3-76-006. Cited in: Barfield, B. J., et al. 1977. Prediction of sediment transport in a grassed media. Paper No. 77-2023. St. Joseph, MI: American Society of Agricultural Engineers.

9. Ree, W. O. 1949. Hydraulic characteristic of vegetation for vegetated waterways. Agricultural Engineering 30(4):184-9. Cited in: Barfield, et al, above.

10. For example (there are scores of relevant pubs):

Swanson, F. J. Et al. 1982. Material transfer in a western Oregon forested watershed. In: R. L. Edmonds. Analysis of Coniferous Forest Ecosystems in the Western United States. Stroudsberg, PA: Hutchinson Ross Publishing Co.

Swanson, F. J. et al. 1987. Mass failures and other processes of sediment production in Pacific Northwest forest landscapes. In: Salo, E. O. And T. W. Cundy, eds. Streamside management: Forestry-fishery interactions. Seattle: University of Washington.

Swanson, F. J. et al 1998. Flood disturbance in a forested landscape. BioScience 48(9):681-9.

Skaugset, A. E. Et al. 2002. Landslides, surface erosion, and forest operations in the Oregon Coast Range. In: Hobbs, S. D., et al, eds. Forest and Stream Management in the Oregon Coast Range. Corvallis: Oregon State University Press.

11. Desbonnet et al, above, p. 10.

12. An array of such treatments is in:

Hinman, Curtis. 2005. Low impact development - Technical guidance manual for Puget Sound. Olympia and Tacoma respectively: Puget Sound Action Team and Washington State University's Pierce County Extension.

13. King County Department of Natural Resources and Parks et al. 2004. Best available science, Volume 1. P. 6-20, citing:

Bidlake, W. R. And K. L. Payne. 2001. Estimating recharge to ground water from precipitation at Naval Submarine Base Bangor and vicinity, Kitsap County, Washington. Water-Resources Investigation Report 01-4110. U.S. Geological Survey. [Place of publication unk.]

King County also says (same report, p. 6-17), "The routing of storm water into infiltration systems is the preferred method for storm water management in Washington..."

14. 2,000 tons is based on research by Prof. Leo Fritschen at the University of Washington. He measured transpiration for a second-growth Douglas-fir by putting an adult forest tree into a very large pot, called a lysimeter, which measured how much water the tree took up. It corresponded to about 20 inches of rain per year. This in the Cedar River watershed.

4,000 comes from Buell, Jesse H. 1949. The community of trees. In: Trees, the Yearbook of Agriculture.

15. This is based on the common Puget Sound prescription of one inch of water per week. I doubt that most people use that much.

16. U.S. Environmental Protection Agency. 2002. Onsite wastewater treatment systems manual. EPA/625/R-00/008. Cincinnati: National Risk Management Research Laboratory.

17. Fagergren, Duane, et al. 2004. Hood Canal low dissolved oxygen - Preliminary assessment and corrective action plan. Puget Sound Action Team and Hood Canal Coordinating Council. [Processed. Place of publication unknown.]

Paulson, Anthony J., G. L. Turney, et al. 2004. An analysis of nitrogen loading to Hood Canal. Preliminary results, subject to revision. Tacoma: U.S. Geological Survey. Two papers at HTTP://wa.water.usgs/projects/hoodcanal.

18. Ward, Bruce R., Donald J. F. McCubbing, and Patrick A. Slaney. 2003. Evaluation of the addition of inorganic nutrients and stream habitat structures in the Keogh River watershed for steelhead trout and coho salmon. In: Stocker, John G., ed. Nutrients in salmonid ecosystems: Sustaining production and biodiversity. Proceedings of the 2001 Nutrient Conference, Eugene. Bethesda: American Fisheries Society.

19. Bilby, Robert E., et al. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch)* and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, U.S.A. Canadian Journal of Fisheries and Aquatic Science 55:1909-1918.

20. Harrison, P. J., D. L. Mackas, B. W. Frost, et al. 1994. An assessment of nutrients, plankton, and some pollutants in the water column of Juan de Fuca Strait, Strait of Georgia and Puget Sound, and their transboundary transport. In: Proceedings of the BC/Washington Symposium on the Marine Environment, January 13 & 14, 1994. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1948. Ottawa[?]: Fisheries and Oceans Canada.

21. Bollen, W. B. And K. C. Lu. 1968. Nitrogen transformation in soils beneath red alder and conifers. In: Trappe, J. M., et al., eds. Biology of alder. Portland: USDA Forest Service, Pacific Northwest Research Station.

Edmonds, R. L. 1980. Litter decomposition and nutrient release in Douglas-fir, red alder, western hemlock, and Pacific silver fir ecosystems in western Washington. Canadian Journal of Forestry Research 10:327-337.

22. Flora, D. F. 2005. An ocean view from the foot of Hood Canal: A different perspective on the dead zone. Bainbridge Is.[processed].

23. Desbonnet et al, above.

24. Paraphrased from : Sheldon, Dyanne et al. 2003. Freshwater Wetlands in Washington State, Vol. 1: A Synthesis of the Science (Draft, August 2003). Olympia: Department of Ecology. P. 2-5.

25. Desbonnet et al, above.

26. Falk, John H. 1980. The primary productivity of lawns in a temperate environment. Journal of Applied Ecology 17:689-696.

27. Mulla, David J. Et al. 1996. Clean water for Washington - Pesticide movement in soils - Groundwater protection. Extension Bulletin 1543. Pullman: Washington State University Cooperative Extension.

28. K is the 'partition coefficient', the ratio of adsorbed to dissolved pesticide concentrations per 1% of soil organic carbon content. Knew you'd wonder.

29. Map in Puget Sound's Health 2002, published by Puget Sound Action Team [formerly Puget Sound Water Quality Action Team].

30. Desbonnet et al, above.

31. Williams, Gene and Heidi Reynolds. 2003. State of the lakes report. Everett: Snohomish County Public Works, Surface Water Management.

32. Brubaker, Linda B. 1991. Climate change and the origin of old-growth Douglas-fir forests in the Puget Sound Lowland. In: Ruggiero, L. F., et al. Wildlife and vegetation of unmanaged Douglas-fir forests. General Technical Report PNW-GTR-285. Portland: USDA Forest Service, Pacific Northwest Research Station.

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Manuscript Report
July, 2010

SOME NOTES ON VEGETATION NATIVENESS

Vegetation is native if it's from Puget Sound.

The local definition of native vegetation refers to species that are indigenous to the Puget Sound lowlands. This presumably includes recent arrivals like Douglas fir that has been here only 3-4 thousand years, at most eight fir-tree generations. It certainly includes Oregon white oak, which has been here longer. And Oregon grape, Oregon ash, Oregon crabapple, Oregon tea-tree, California rose-bay, all 'natives'.

'Indigenous' includes plants that arrived here before and after a cooling of the climate several millennia ago. Clearly 'native' is a relative term, especially since none were here ten millennia ago. In short, nativeness is an elastic matter.

The Growth Management Act points out that the worth of vegetation depends on its 'functions and values'.

These aren't listed but presumably functions include protection of the ground, control of stormwater movements, stabilizing slopes, and along the shore, providing habitat for shoreline-inhabiting wildlife. Wildlife nurture may be considered a value, albeit both good and bad. Other values are aesthetics and protection of property rights, the latter specifically mentioned in GMA.

Structural functions do not depend on species nativeness.

Stormwater streaming toward the Sound, rolling overland or riding about hardpan soils, is of course indifferent to nativeness. What matters is physical barriers in the form of stems, roots, and grass blades. Native shrubs and grasses do this as well as others presumably. None do it well; this is the subject of another paper.

Stabilizing the shore, attributed to root wads, is either good or bad depending upon whether the occasional failure of 'feeder bluffs' (i.e., all banks and bluffs) is preferred. Some of our better grippers are exotic, e.g. Scotch broom. Others, like Cascara, are regional natives. Unfortunately good grippers, with their dense root networks, also encourage saturation of shore-top soils, leading to slope failures. An advantage of Scotch broom and other shrubs is that they never grow tall, heavy trunks that lever trees and their rootwads over the side.

Nor are Kitsap wildlife very discriminating.

Wildlife depend on native plants. We wish. Like non-native roses, non-native raspberries, and non-native geraniums.

Density, vertical structure, succulence and bugginess seem to favor wildlife, almost regardless of nativity. A ground cover of ivy is seemingly more useful to ground-abiding birds and animals than the alternative, which appears often to be bracken ferns and weeds. True firs from afar attract raccoons, small birds, eagles, and more, as well as native firs.

But landscapers certainly are.

With miles of buffers under discussion, many of those buffers would be in places that would otherwise be landscaped. The prospect of Puget Sound's rather narrow array of species, repeated endlessly, is an affront to homeowners who take pride in designing and maintaining their surrounds. The popularity of diversity is clear during tours of homes and visits to nurseries. Indeed, nurseries would be sorely affected by a nativeness constraint.

Aesthetically many people prefer, say, red maples over native maples; scarlet oaks to native Oregon white oaks; non-native, showy cultivars of rhododendrons over the rather uninteresting native species; tasty and productive apples over the native crabapples; the same argument for non-native plums and cherries relative to natives; redwoods relative to firs; mountain ferns relative to lowland natives, weeping birches over locals, cultivated roses over thorny natives, alien daffodils over native ditchgrass, and so on. Few Kitsap yards have wholly native species. While, with a stretch, one may point to hundreds of native Puget lowland plant species, "exotics" offer us thousands.

The usual arguments against non-natives are these:

<u>Durability</u> - Non-natives aren't attuned to our climate. Generally untrue; meanwhile some of our natives, including oaks and dogwoods, are fading. Many non-natives come from climates similar to ours, and our climate is clearly favorable for plant growth. Owners seem willing to give extra care to seemingly fragile plants, and replace those that fail. That means extra effort and expense, but it is an option that owners should have.

<u>Durability relative to insects and diseases</u>. Actually a concentration of any species invites attack. Native forest trees are having a rough time because of beetles. Gypsy moths are sweeping toward us, attacking all broadleaf species. Native dogwoods are dying. Native bracken ferns are less evident. Counterpart species from elsewhere are chosen, in some cases, for their resistance to pests and pestilence.

Native apples, cherries, and plums have been bred away from their susceptibility to insects and disease. We've been glad to see varieties other than native crabapples, Indian plums, and wild cherries. Aside from appearance and durability, the alternative species save us from having to search T&C's produce bins for worm-free produce and give us a broader array of varieties, while making fruit more economic for both grower and consumer.

Invasiveness - Native plant and animal species are here because of their invasiveness over recent centuries. Indeed, every species on earth is invasive. And every native species is invasive within its province or it is displaced. 3000 years ago the prevailing plant species here were oaks and grasses. Even within its shady domain, the shy trillium presses outward against all comers, and obviously wins with some frequency. Salal and salmonberry, natives both, have become invasive nuisances west of the mountains and especially toward the coast. So using 'invasiveness' as an argument against non-natives seems ironic.

All organisms are invasive, constantly probing, intruding, occupying, or retreating. This has been widely seen in salmon (good) and spartina (bad).

Local nurseries are replete with invasives--plants that, given pleasant environments, enlarge their garden presence.

Invasion includes movement across bare ground. Without invasiveness vegetation would not spread across disturbed areas. By ruling out invasive exotics we foreclose most perennials. And indeed most useful exotics. Landscapers will not be pleased.

Nor will they be pleased if we prohibit invasive natives. Yet the ecologic effect, such as saving mosses from fescues or vice versa, would be comparable.

Meanwhile the State has compiled lists of aggressive plants that are actually harmful. Perhaps citing this list is more useful than forbidding all exotic species.

Don Flora

October 2010

THE PASSING OF A CHILDREN'S PLACE

Families who move to Bainbridge Island look forward to the extra bedroom they can now afford, a garden in a friendly climate, and an outdoor place for children.

Little do they know that, sooner or later, a shadow will probably fall across the back yard--the fence that guards a buffer around some 'critical area'. It's rather probable--the City has an energentic buffering program for wetlands, and 53 miles of shoreline are being committed to brushfields of some dimension.

Kids pay the price, in space lost. This because it's typically the back yard that is inundated. Not by water but by regulation. Parents will be in the odd position of telling their children they can't go beyond the sign, although officials with clipboards and boots can wander through any time, with volunteer groups 'saving' the environment and admonishing residents for too much ivy or too few shrubs. Meanwhile the conscripted space must be allowed to sprout brush, drop limbs, and host a remarkable array of rodents, raccoons, opossums, and the like.

But not children. Forget sand boxes, swing sets, friendly paths, scooters, basketball and badminton courts.

It won't happen at once. Buffers will come sliding in as neighborhoods develop.

Not the least consequence will be creation of competition for what space remains, raising prices and leading to smaller homes sandwiched into denser spaces. So much for the extra bedroom. So much for kids.

Don Flora

November 2010

PROTECTING ISLAND NEARSHORES: ALTERNATIVES TO BUFFERS

Protect the nearshore and you protect its functions. Mostly true. Buffering is prudent protection. Mostly false.

How can this be so? Why is it important? What other protection options are there?

In summary,

Uses foregone make buffers an extravagant land conscription

Options include

for stormwater - ponds, furrows, berms, and even paved routes; Low Impact Development

for sediment - grassy swales and fields

for pesticides and herbicides - lawns, forbearance, and Integrated Pest Management

for toxic chemicals - grass and abstinence

for bacteria - septic systems

for wildlife - yards and their verges, parks, meadows, beaches, and woodlands that also serve as children's places

BUFFERING IS EXTREMELY COSTLY.

Land is fixed in supply and is arguably our scarcest Island resource. As one attorney has noted, buffers instantly turn whole regions of the community into nonconforming uses.[1] And premier landscapes are involved. Over 80 percent of Island shores are developed, almost all with residences and their yards.[2] These lands account for 18 percent of Island families, 1600 owners, and 55 percent of the Island's tax base.[3] So conscripting buffer space here carries uncommonly high community and private costs.

Too, buffers are land-intensive. A proposal to expand tidewater buffers to 150 feet, added to wetland and stream buffers already ordained, would envelop perhaps a thousand acres of mostly-residential shoreline.

THERE ARE USEFUL OPTIONS, AND MOST ARE BETTER THAN BUFFERS.

STORMWATER has been the principal purveyor of water from the Island to the Sound since the glaciers left, either by overland flow or underground seepage. There are concerns about too much and too little.

The "too little" issue relates to holding enough water back to seep into the Island's aquifers. Bluff-top buffers can help or hurt retention. Hurt by sending water up through trees, those great conduits to the sky, that can take up 100 to 150 gallons per day, per tree, during spring and summer. A 150-foot buffer fronting on a 100-foot waterfront can pump away 40 *thousand* gallons per week.[4]

Help by blocking soil's pore spaces with myriad tiny roots from shrubs and, especially, trees. The resulting root wads dam water working its way downhill above hardpan, toward the shore. Of course there's a negative side to this benefit. Prolonged rains turn soils uphill from the dam-like roots to muck, freeing the vegetation to drop to the beach, in an episode locally called a beach plop. The slop typically buries, starves, and asphyxiates intertidal marine life before the muck dissipates in a decades-long process.

'Hydroperiod adjustment' is an elegant phrase for detaining and diverting stormwater, as close to its source as possible. this surge-tank role is applauded by the state Department of Ecology (DOE).[5] **Stormwater collection and dispersal** is a well-developed branch of engineering, well understood and practiced here.

Given buffers' leakage problem[6] stormwater **retention ponds** are in wide use. The captured water dissipates by evaporation and infiltration. **Detention ponds** are a variation, with water released, but slowly. Dispersion of hillside water above the nearshore, using **small furrows**, works. Even better is **grass**, which keeps stormwater from forming into rills. Grass filter strips, a proven technique, are said to be superior to buffers,[7] and are in common use.[8] **Berms and barriers** like curtain drains, laid horizontally, divert and delay waters. Assuming the water is clean, these features can direct surface and ground water into seasonal streams that feed pocket estuaries, of which there are thousands around Puget Sound. King County says that a **paved surface with a recharge pond** can do more for aquifers than a forest on the same area.[9]

Recently devised is a whole program of practices called **Low Impact Development**. LID strategies "focus on evaporating, transpiring, and infiltrating stormwater on-site..."[10] Examples include open swales, permeable and porous pavements, green roofs, planter boxes, soil amendments, sand filters, and inlet retrofits.

SEDIMENT, a common problem in farm areas, does not concern us here.

If it did, **grass** would be twice as effective as woodland at retaining sediment.[11]

If **NUTRIENTS** are a problem in Bainbridge waters it has never been shown. This despite occasional conjecture about eutrophication in the backwaters of bays. Elsewhere nutrients, primarily nitrates and phosphates, are an issue downhill from pastures and especially feedlots. Dogs, deer, and yard care are probably the main Puget Sound sources, with septic systems a source in a few places. Not surprisingly, dog discharge has been found in Bainbridge outfalls. It is written that in Kitsap County there are 15,000 dogs, producing ten *thousand* pounds of poop each day. The Island's quota is probably being met.

Phosphates may be the lesser issue here because they tend to bind themselves to soil particles. Nitrates go with the flow. Here again, **grass** is the solution of choice, if there is a problem. Its success with septic-source nitrates is a given.[12] Grass is twice as effective as forest buffers in corralling nitrogen.[13] As with most other vegetation, grass takes up nitrates best during the growing season. This is good timing considering that fertilizing is a growing-season activity. In the rainy season, anything that retards or diverts stormwater is good, and **grass** is a winner here as well. "Thickly planted, clipped grasses provide a dense, obstructive barrier to horizontally flowing water. This ... reduces flow velocity, promotes sheet flow, and increases sediment and adsorbed pollutant removal efficiency."[14]

PESTICIDES AND HERBICIDES are yet to be reported in Island nearshore waters, though they have long been used here, but little in winter when stormwater to carry them toward mischief is available. Research has shown that a 20-30 foot band of grass can stop 70-100 percent of herbicides.[15] **Lawns** work.

Forbearance in application, including following label instructions, and using chemicals specific to the problem, are known solutions. Modern chemicals are designed to lose their potency quickly. Choosing chemicals with a half-life less than three weeks has been recommended. **Physical control of vegetation**, rather than spraying, has been adopted by Bainbridge Island's road staff.

Integrated pest management, adapted from farming, boils down to using plants adapted to the site, keeping them well nourished, avoiding treatments that harm predators of the pests, mowing instead of spraying unwanted vegetation, and using chemicals sparingly and only when really needed.

PERSISTENT TOXIC CHEMICALS, including metals like lead, typically from industrial activity, generally elude capture as they move in pulses of stormwater, or adhere to sediments above and below ground. The Island has had upland experience with such chemicals, in addition to our famous waterfront creosote site.

If the sediments are free to travel (e.g. zinc and copper)[16] they are prone to saturate buffers, residing there with their toxic passengers until dislodged by surges of surface water.[17] The ability of vegetation to draw in and use these chemicals is very small and generally fatal to the plants. Not to mention effects on living things all along the food chain. The upshot is that, where buffers accumulate sediments they correspondingly warehouse chemicals.[18] This is the sump role of buffers.[19]

So, for some persistent toxics, buffers work temporarily where sediment is the vector, and **grass**, mentioned above, is the best filter. But industrial chemicals tend to arrive in the landscape continuously, racing downhill past sediments, saturating everything including Puget Sound.[20] Against these enemies of nature the obvious weapon is **control at the source**. Heavy metals and industrial chemicals don't belong in Island buffers; for them buffering is not a solution.

The simplest sort of source suppression is **abstinence and prohibition**, and there are lists of target industries. However the problems and their solutions lie with individual processes and are often place- and stage-specific. A solution may be as simple as installing and servicing a filter. Industrial engineering is the expertise of choice here, not buffer command.

BACTERIA emerging from septic systems are a non-issue assuming reasonable design and care (and crippled systems declare themselves loudly, via odors). "Normal operation of **septic tank**/subsurface infiltration systems [**drainfields**] results in retention and die-off of most, if not all, observed pathogenic bacterial indicators within 2 to 3 feet of the infiltrative surface....most bacteria are removed within the first 1 foot vertically or horizontally from the trench-soil interface."[21]

WILDLIFE WELFARE is generally not specific to nearshores nor their buffers. Larger landscapes are involved and available. Which is why wildlife habitats are treated separately from other 'critical areas'.

Alternatives to wildlife buffers are already in place. They are the **residential shoreline places** already landscaped, plus wetland buffers already proclaimed, plus parks and other already-dedicated open spaces. Together they total about 30 percent of the Island's area. All of these are in regular use by upland species for nesting, burrowing, hunting, feeding, and breeding.

As is most of the Island's other 70 percent. The wild things are with us almost everywhere. Byways, backyards, and open places provide creature comforts to wildlife from birds to voles. Day and/or night the four-legged kinds sally near, as do the aviators.

Shoreside yards clearly share that abundance, by day, night, or both. Indeed some nearshore transients, including raccoons, river otters and deer, are increasing,[22] despite the fact that 4/5 of the Island's tidewater shore is developed.

From where do they come? From hideouts in holes and cavities, under boards and beneath bushes and brambles. From treetops, grassy clumps, fence corners, yard burrows, and shrub lands.

Repeated studies along Northwest forest streams have shown that birds, small mammals, invertebrates and fish prosper in the absence of buffers.[23] **Bainbridge back yards and verges** are surely far more hospitable than streamside forest clearcuts.

The State's Department of Fish and Wildlife has listed 'priority species' across the state. Among the 51 priority marine birds are 17 that visit Puget Sound. Most are passing through toward nesting sites to the north and east. Five may nest on Bainbridge island.[24] Of those, one is oriented to fresh water, leaving bald eagles and great blue herons.

Plus two: pigeon guillemots and terns which, if here, nest in self-dug holes in bluffs. For these, best protection may be **shore protection**. A collapsing bluff would not help these priority birds.

The growing inventory of bald eagles comes at the expense of herons. This because eagle predation of heron eggs and chicks is causing herons to abandon rookeries, even where herons have long ignored nearby human disturbances. Such tradeoffs may be far more significant to wildlife welfare than the Island's long-existing nearshore development. In any case, while herons pace the water line, eagles perch on dock railings and piling as well as the Island's million treetops.

People see the Island, its institutions and its landscape, as an environment for families. Countryside **treatment as a children's place** is not much different from ensuring habitat for wild things. **Lawns, parks, meadows, beaches, and woodlands** are serving wildlife well.

Overall, the Island may be a poster place for compatibility of nearshore development with wildlife.

Meanwhile, habitat may be irrelevant, with wildlife free-ranging virtually everywhere. Wildlife welfare may well depend not on living space but rather pressures elsewhere, predation, lack of prey, disease, normal cyclic changes, seasonal weather and states of vegetation, or cycles in predators or prey abundance.

D. F. Flora

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Manuscript Report
February 2009

TREE-DEPENDENT INSECTS AND JUVENILE PUGET SOUND SALMON

Donald F. Flora, PhD

Commonly listed among the functions and values of tidewater buffers are insects, said to fall from overhanging shoreline trees, to be eaten by young salmon and forage fish swimming close to shore. Whether that nutrition mechanism is significant or trivial relative to other sources is the general question addressed here.

Examined specifically are four issues, relying on research publications cited later. The questions and their short answers are:

Do young salmon ingest insects? Yes. Puget Sound studies indicate that insects account for about 12 percent of juvenile salmon biomass intake. For adult salmon and forage fish the figure is near zero.

Where does the insect biomass come from? Mostly from aquatic sources (freshwater streams and wetlands) and estuaries. Some derives from tidewater beaches. Some comes from upland vegetation. Little comes from trees.

What share of salmons' diets comes from insects dependent on trees? Between 1 and 2 percent.

Would doubling the number of shoreside trees make a difference for young salmon? Given the several local studies of salmon diets, a considerable science on aquatic and near-tidal insects, and clear knowledge of the insect inhabitants of marine riparian tree species, the answer appears to be 'nearly none'.

Juvenile salmon practice predation across a broad spectrum of prey.

Young salmon are avid consumers (as are many other predators) of aquatic insects as the fish hatch upstream and, growing along the way, the salmon move down toward estuaries and tidewater. In Puget Sound their diet shifts toward marine organisms and smaller fish. By adulthood, cruising in deep water, their menu comprises mostly fish, notably herring. Until then, insects will have played a steadily declining role in salmons' intake.

In a recent Sinclair Inlet study[1] kinds[2] of prey, all from the animal (versus plant) kingdom, were compiled from juvenile salmon stomachs. Over a hundred kinds were marine creatures, either connected to the bay's bottom or drifting or moving under their own power. Typical were fish eggs, shrimps and tiny shrimp-like creatures, sand fleas, pileworms, young crabs, and barnacle larvae. Remarkably, Chinook salmon ate juvenile octopuses and squid. Not surprisingly they also ate perch, bottom fish and (smaller) chum salmon.

Insects have been found in all tidewater juvenile-salmon diet studies.

Perhaps more surprising is that insects, few of which survive in saltwater, are present in the salt chuck. Yet, in Sinclair Inlet and other studied places, insects have not been rare in the fare of juvenile salmon. Arriving from various places beyond the tidal reach, they have ranged from tiny mites to hulking wasps. Rather a let-down after an octopus presumably, though some of the insects' quantities were large.

Three other Puget Sound studies have yielded published results in sufficient detail to analyze biomass consumption, a better measure of salmon welfare than numbers of creatures consumed. Biomass is what drives both energy and growth of fish.

Brennan et al (2004)[3] worked off Snohomish and King County shores, including Vashon and Maury Islands. Fresh et al (1981)[4] worked near Anderson Island in the South Sound and off Bainbridge Island. Duffy (2003)[5] collected in the Whidbey basin and the Fox Island-Steilacoom area south of the Tacoma Narrows.

In all four studies the capture sites were close to shore because the emphasis was on juveniles.[6]

The weighted-average[7] insect-biomass share of the stomach biota of all young salmon examined (Chinook, coho, chum and pink) in these four studies was about 12 percent. That share ranged widely, from 0 (frequently) to 50 percent (rarely) in particular times and places.

A few kinds account for most of insects' dietary contribution.

Although 61 biologic types of insects were recognized by the analysts, and several were numerous, few of them carried much heft biomass-wise.

The significant groups are described here, including their general habitats. Together these five groups accounted for over 85 percent of the insect biomass consumed by salmon:

Ants and termites (Members of Hymenoptera and Isoptera) -- These may seem unlikely visitors to saltwater, but they outweighed every other eaten group by far, contributing 58 of the 85 percent just mentioned. Ants were prominent in Sinclair Inlet and along central Puget Sound shores.

Carpenter ants live in dead and rotted wood. Winged adults emerge from nests yearly in swarms to mate in the air; males then die. Aerial swarming echoes the mating behavior of many aquatic insects and, if trees don't interfere with wind, may explain the presence of ants afloat on tidewater.

Most ants, the workers, don't have wings. These versions are common in shoreline wrack, dissecting plant tissues and other invertebrates live and dead. Anthills and portals to underground nests are common along Puget Sound backshores. A single nest's hunting ground can reach out hundreds of yards. So unwinged ants may well come to salmon, accidentally, from the marine margin.

Brennan's group published monthly diet detail. Ants were found in Chinook taken throughout the two summers studied. This suggests wandering surface ants rather than episodic flyers. Ants were prominent in Sinclair Inlet and along central Puget Sound shores.

Dampwood termites, found in Sinclair Inlet, occupy dead wood including snags, stranded drift logs, and branches in the wrack. They parallel ants with their unwinged workers and winged flyers. The winged ones emerge to fly annually at mating time. As with ants, annual swarming may bring them to the shore. Termites do not tumble from trees; in fact they have no use whatever for live trees.

Curiously, in the first of two years' assessment, the Fresh team in Sinclair Inlet found a considerable biomass of termites - more than any other prey organism except fish and worms. The next year virtually none. Yet, like ants, termites swarm every year, in late summer. Perhaps birds got'em.

Flies (Dipterans) -- Three kinds of flies were found in numbers great enough to be worth tallying, all of them well-known to fly fishermen and stream biologists.[8] They were midges, dance flies, and fungus gnats. The analysts concluded that the flies had floated downstream into tidewater. Fungus gnats and midges are found in marine settings as well. They were about 13 percent of the insect biomass.

Saltmarsh leafhoppers and aphids (Among the Homoptera) -- Most leafhoppers, planthoppers and their cousins live and dine on land plants. Enough are aquatic that they are mentioned in texts on aquatic invertebrates. Several families were found in Sinclair Inlet. Some species are specific to streamsides and salt marshes, where they live along the margins. Others hang out on grasses just above the wrack line along marine beaches. A popular fishing fly is tied to mimic leafhoppers.

Every rose gardener deplores the earthly habits of aphids (plant lice), that suck juices from the leaves of shrubs, annuals, perennials, and trees like birches that have succulent leaves. Some are winged and may be blown about. Some live on emergent vegetation in fresh water. And some live on bay-side plants.

Aphids are one of the two groups significant to this review that are likely to have come, in mating swarms, from non-aquatic vegetation. About 3 percent of the insect biomass came from aphids.

Bark lice (Part of Psocoptera) -- Aphid-like and winged, these insects are vegetation-dependent, living on the surfaces of shrubs and trees. They feed on lichens and fungi. They were found in significant numbers and biomass in Puget Sound studies, apparently at swarm-and-mate time.[9] They are the second group that probably came from non-aquatic vegetation. About 8 percent of the insect biomass was bark lice.

Some moths and aquatic caterpillars (Lepidopterans) -- This group is huge across the Northwest. The analysts weren't able to report whether terrestrial or aquatic species were found, and there are many possibilities of both. Those found were presumably winged adults. Their larvae are famous miners and shredders of foliage, from trees to shrubs to stream vegetation. About 4 percent of the insect biomass was of these kinds.

An example of tree-based caterpillars in salmonid stomachs occurred during the 2001-03 tent caterpillar outbreak. I collected 2000 larvae (caterpillars) from one birch tree and estimated that 6000 more were too high to reach. Billions of adults must have flown from trees and shrubs around the Sound. A handful were found in salmonid stomachs by the Brennan team. Clearly most of these terrestrial moths had business away from tidewater.

Diet proportions recited here should be considered rather general, for three reasons. They are based on biologic and environmental conditions that vary immensely over space and time. Identification of partly-digested invertebrates is not easy. And many of the numbers were reported in charts rather than tables, so some crude scaling was required.

Stream deltas, estuaries, and their marshlands may have much to do with insect supplies.

Many kinds of aquatic insects, well-known to fish, were consumed by these studies' salmon, though in small numbers in the central and lower Sound. Examples not discussed above include many other freshwater fly families, diving wasps, water bugs, aquatic beetles, fishing spiders, and water mites.

The Sinclair Inlet analysts wondered at the low occurrence of aquatic insects, especially midges, in their part of the Sound. They reasoned that such insects favor deltas and salt marshes, scant in the Inlet.

Duffy, on the other hand, found that prey comprised mostly insects in the deltas of the Whidbey Basin, fed by three rivers carrying 60 percent of the freshwater entering Puget Sound. The combination of down-river drift and a mosaic of deltaic estuaries and marshes there may deliver multitudes of aquatic insects and board lingering salmon nicely. The researchers seem to agree that aquatic insects loom much larger than this summary suggests.

Most of the salmonids' insect prey groups have links to fresh water...

Of 61 insect kinds found in the several studies (albeit sparsely in most cases) 42 are strongly represented among freshwater obligates: Some parts of their lives depend absolutely on streams or standing water.[10]

...While a few have ties to trees.

These are bark lice, some aphids, and certain moths. The source of bark lice is puzzling, as they are not associated with alders, firs, cedars nor our other common shoreline trees.[11] Aphids, on the other hand, are ubiquitous and could be coming from many terrestrial plants.

Moths, too, were mentioned earlier. Alders (our most abundant shoreline trees) host (rarely) a leafroller, a webworm, and a tussock moth plus (every few years) those rascally, cyclic caterpillars. Cedars attract tussock moths and a leaf tier. That's about it for our nearshore tree-dependent moths, and moths of all venues were minor in salmon stomachs. Of the tree-related moths, only the tent caterpillar was identified in the studies.

Those insects most likely to be dependent on trees, aphids and bark lice, accounted for about 1½ percent of the total invertebrate biomass found in salmon stomachs.

All other eaten insects were heavily related to non-tree upland vegetation or to freshwater environments.

Herring and similar fish eaten by salmon are not insect consumers.

Predators all, salmon start young at eating other fish, even other salmon. Herring, sand lance, and surf smelt, collectively called baitfish or forage fish, up to half the lengths of attacking salmon, were found in salmon stomachs.

If insects were consumed by forage fish they would be contributing to the greater welfare of salmon. However Fresh's 1981 team netted and examined nearly 400 forage fish and reported no insects in their diets.

The key insect groups described here all have and use wings.

All these fulsome contributors to salmon nutrition have legs, which they use continually for local motion across leaf and beach surfaces and through dead-wood tunnels. With certain exceptions they also have wings, reserved for major migration, meeting and mating.

Aside from downstream drifting, aerial swarming may be insects' prime route to tidewater.

Mating and migration flights, and related swarming, may account for the seemingly spontaneous, irregular appearance of many insects, controlled by temperature and other environmental factors. That they arrive upon tidewater is presumably nocturnal mischance.

Tidewater trees do little to assist beach-related insects.

Freshwater biologists often report seeing insects falling from trees into streams or ponds below. These are mainly aquatic insects that have emerged from puberty in the water to mate in flight or on any nearby surface. Males then typically die at once, dropping back into the water. Females usually expire post-partum, in the water. Thus both sexes can be seen heading waterward.

There are some intertidal and near-tidal insects that may follow the fly-and-die protocol, including some midges, certain flies, springtails and a beetle, but none needs trees to copulate. Some of these are numerous along the shore though none provides significant biomass to salmon.

In addition to swarm-and-die there is a presumed accidental, incidental drizzle of insects from saltwater shoreline trees' foliage, or with leaves as they fall. However insects commonly associated with Puget Sound trees do not lose their grips easily.[12] And leaf fall comes in later months than salmon feeding.

Elsewhere trees have not been essential conduits for tidewater insects.

The salmon-diet studies reviewed here do not identify specific vectors for the observed insects. However other studies have noted insect swarms blown out to sea, and the abundance of woodland insects arriving in streams adjacent to pastures and forest clearcuts. From western Oregon to southeast Alaska research has shown that clearcuts can generate more invertebrate supply in adjacent streams than does oldgrowth.

In all places where insects have been trapped beside tidal beaches, there has been a baseline catch of insects regardless of inshore vegetation. An example is an unvegetated condominium site in the Georgia Basin of B.C., which provided a low but significant census of aquatic flies.[13] In Puget Sound Sobocinski captured large numbers of insects on shorelines encumbered by bulkheads and scant vegetation.[14]

Shoreside trees may be an impediment to inshore insects heading salmon-ward.

A line of shoreside trees may be a barrier to insect swarms, trapping them inshore. The windbreak stops or slows air currents whose ability to carry insects varies with windspeed. The insects won't really care: They have no affinity for saltwater, and most die after mating in any case.

Doubling the extent of shoreside trees probably would not materially affect diets of juvenile salmon in saltwater.

The key reason for this surmise is the very low fraction of tree-obligate insects in tidewater salmonid diets. That percentage is estimated at between one and two.

This low ingestion rate occurs despite the relative abundance of wooded shores. For instance 21 percent of the shore in Sinclair Inlet, a seemingly industrial inlet, is wooded,[15] and most of the juveniles found there came down a woodland stream. Around nearby

NOTES

1. Fresh, Kurt L., et al. 2006. Juvenile salmon use of Sinclair Inlet, Washington in 2001 and 2002. Technical Report No. FPT 05-08. Olympia: Washington Department of Fish and Wildlife. The study included 258 inshore Chinook, 77 offshore Chinook, 41 inshore chum and 34 inshore cutthroat.

2. "Kinds" is meant as the biologist's "taxa". Anna Jones, James Jones, and Other Joneses comprise three taxa.

3. Brennan, James S., et al. 2004. Juvenile salmon composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. Seattle: King County Dept of Natural Resources and Parks. A 2-season catch of 819 Chinooks, 89 cohos, and 56 cutthroat trout.

4. Fresh, Kurt L., et al. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Progress Report No. 145. Olympia: Washington Department of Fisheries. 210 Chinook, 166 coho, and 287 chum were examined from nearshore habitats less than 20m deep. They ran studies elsewhere as well, and covered other fish species.

5. Duffy, Elisabeth J. 2003. Early marine distribution and trophic interactions of juvenile salmon in Puget Sound. Master of Science thesis. Seattle: University of Washington, School of Aquatic and Fishery Sciences. This study involved 697 Chinook, 195 coho, 292 chum, and 156 pink salmon. These figures include juveniles from nearshore and offshore (surface) captures. Her report did not include biomass findings.

6. Excluded from the figures are adult salmon tallied in the 1981 Fresh study. No insects were found in adults.

7. Weighted by numbers of salmon examined in each study/species group.

8. To be acknowledged, a species or group had to occur in more than 1 percent of stomachs (Fresh et al 1981) or more than .1 percent (Fresh et al 2006), or exceed occurrence, count, and biomass thresholds (Brennan et al).

9. Brennan et al 2004, and Fresh et al 2006, both above.

10. This is a tighter criterion than the "primary association" test commonly used by naturalists. It was applied presumptively to studies' listed taxonomic families when a family includes some non-aquatic members but the family is well-known for its aquatic siblings, as determined from the taxonomic literature. References included:

McCafferty, W. Patrick. 1998. *Aquatic Entomology*. Boston: Jones and Bartlett.

Merritt, R. W. and K. W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America*. Dubuque: Kendall Hunt.

Thorp, James H. and Alan P. Covich, eds. 2001. *Ecology and Classification of North American Freshwater Invertebrates*. New York: Academic Press.

Furniss, R. L. and V. M. Carolin. 1977. *Western Forest Insects*. Miscellaneous Publication No. 1339. US Forest Service. Washington, DC: Superintendent of Documents.

11. Furniss and Carolin, above.

12. Furniss and Carolin, above.

13. Romanuk, T. N. and C. D. Levings. 2003. Associations between arthropods and the supralittoral ecotone: Dependence of aquatic and terrestrial taxa on riparian vegetation. Environmental Entomology 32(6):1343-53.

14. Sobocinski, Kathryn L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master of Science thesis. Seattle: University of Washington, School of Aquatic and Fishery Sciences.

15. Fresh et al 2006, above, p. 70.

16. Williams, G.D., et al. 2004. Bainbridge Island nearshore habitat characterization & assessment, management strategy prioritization, and monitoring recommendations. Sequim: Battelle Memorial Institute. Table A-2.

17. Romanuk and Levings 2003, and Sobocinski 2003, both above.

18. Gregory D. Williams, Battelle Memorial Institute's Marine Sciences Laboratory.