State of Oregon Department of Environmental Quality

Written Comments

Upper Yaquina TMDL Rulemaking

This document is a compilation of written comments received related to the first two meetings of the advisory committee for the Upper Yaquina TMDL Rulemaking held Aug. 25 and Oct. 19, 2022.

Comments

WALTZ David * DEQ

From: REDICK Daniel
Sent: Wednesday, October 19, 2022 11:28 AM
To: WALTZ David * DEQ; LIVERMAN Alex * DEQ
Cc: VERRET Greg J
Subject: RE: EXTENSION: Upper Yaquina TMDL RAC input due Sept 26

Hi David and Alex,

Here are my previous comments.

Thank you,

Daniel Redick *he/him*
Solid Waste & Water Quality Program Coordinator
Community Development
Phone: 541-766-6819
Email: daniel.redick@co.benton.or.us
www.co.benton.or.us

Community Development has moved to the Kalapuya Building at 4500 SW Research Way, 2nd Floor.
Come see the new space; we are officially open for business!

From: REDICK Daniel
Sent: Thursday, September 22, 2022 3:48 PM
To: 'WALTZ David * DEQ'
<alex.liverman@deq.oregon.gov>
Cc: VERRET Greg J
Subject: RE: EXTENSION: Upper Yaquina TMDL RAC input due Sept 26

Hi David and Alex,

Thank you for the opportunity to respond to the draft Statement of Fiscal and Economic Impact. Here are the primary considerations for Benton County's fiscal and economic impacts associated with the TMDL:

- TMDL Implementation Plan Development
- Plan Approval Process
- Ongoing TMDL Implementation
- Annual TMDL Reporting

The full economic impact to Benton County from the Upper Yaquina TMDL will largely depend on the TMDL implementation requirements. If the county's Upper Willamette TMDL implementation plan (pgs. 8-20) meets the requirements for the Upper Yaquina TMDL, the implementation plans and annual reports can mirror one-another, reducing the additional economic impact of developing the Upper Yaquina TMDL implementation plan, ongoing implementation, and annual reporting.

The county has not completed a fiscal impact study of current TMDL implementation for the county's Upper Willamette TMDL implementation plan, so there are not clear indicators of actual fiscal and economic impacts for the county's

Upper Yaquina TMDL implementation across the considerations listed above. Several county departments participate in a variety of implementation strategies detailed in the existing TMDL implementation plan, requiring staff time to implement, as well as some additional financial resources for outreach efforts. While some costs and efforts can be shared between the Upper Willamette TMDL and Upper Yaquina TMDL implementation, others like those associated with the Plan Approval Process are unique to each TMDL implementation and require staff time.

Please let me know if you have any questions.

Thank you,

Benton County OREGON

Daniel Redick *he/him*
Solid Waste & Water Quality Program Coordinator
Community Development

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www.co.benton.or.us

WALTZ David * DEQ

From: Joe Steere
Sent: Wednesday, November 2, 2022 1:30 PM
To: WALTZ David * DEQ
Cc: LIVERMAN Alex * DEQ; HUMMON Cheryl * ODA;
Subject: TMDL fiscal statement review.

David: Really not much help on any actual numbers. I do not see an actual requirement to establish a timbered 100' streamside buffer being forced on ag. land owners.
In my case this requirement would really take any profit out of my operation, combined with what looks like a 50% take on existing timbered ground from new rules. It would all go to blackberries and scrub grasses (sedges) as the cost of establishing timber on pasture ground, with no dollar benefit, is higher and harder than just replanting to recently harvested ground. Cost to benefit we need more actual numbers. Having seen stream side buffers for over 35 years as a requirement and no supposed uptick in Salmon numbers, the problem is not upstream on timbered or small ag ground.

Sincerely

Joe Steere

914 SW Coast Hwy - Newport, OR 97365 - Phone 541.265.2631 - www.LincolnSWCD.org

26 September 2022

Oregon Department of Environmental Quality
ATTN: David Waltz, Mid-Coast Basin Coordinator
165 E. 7th Ave., Suite 100
Eugene, OR 97401

CC: Alex Liverman, Watershed Management Program Analyst

RE: Upper Yaquina TMDL Fiscal Impact Statement

Dear David,

Thank you for extending the comment period for the Upper Yaquina RAC. In past days I've been able to review our meeting presentation, notes, and discuss process and expected impacts with local stakeholders. I appreciate the opportunity to provide comment early in the rulemaking and participate in that process.

Based upon DEQ's recently-presented analysis, and in order to meet criteria, the Upper Yaquina Basin will require Maximum Reductions of 83% *E. coli*, 76% Solar Radiation, and 50% Phosphorous.[1] These are ambitious objectives and will require considerable investment on the part of landowners, agencies, and partners. Management Plans and Strategies specific to the Upper Yaquina have not been fully developed at this time, nor has the Full Draft Rule been published for consideration. Both would inform a forward-looking and thorough fiscal and economic analysis from relevant perspectives.

According to OR-DEQ's report, *Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon (2010)*, BMP implementation costs for rural riparian forest averaged $4695.00/acre for the duration of a 15-year USDA Conservation Reserve Enhancement Program (CREP) contract.[2] Implementation within Urban Growth Boundaries (UGBs) averaged more, about $14,247.00.[3] Implementation of Best Management Practices (BMPs) in the context of livestock, requiring riparian exclusion fencing, cost $6,307.00/acre for a 100-foot buffer.[4]

[1] Waltz, David, "Upper Yaquina River Watershed TMDL – Rule Advisory Committee Meeting #1," (Virtual, August 25, 2022).
[2] Michie, Ryan, "*Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon (2010)*," Oregon Department of Environmental Quality, pg. 17.
[3] Michie, 18.
[4] Michie, 19.

Applying an inflation adjustment factor based on U.S. Consumer Price Indices from nominal 2007-2008 levels to the present (1.385) yields the following:

Implementation Context	Cost per Acre 2022
Rural Riparian Forest	$6,502.58
Rural Riparian Fencing	$8,735.20
Urban Riparian Forest	$19,732.10

Significant portions of the Upper Yaquina basin proximal to monitored streams are rural residential properties not operating agriculture or forestry. Costs to implement on these properties would vary widely based on current and historic landscaping practices, but could be expected, due to lot size variability and higher density built infrastructure, to cost somewhere between Rural Riparian and Urban Riparian, perhaps in the $10,000.00/acre range.

Several problems and uncertainties arise when applying these figures to the Upper Yaquina today. While this publication used restoration cost data in the context of CREP contracts, CREP agreements have been used sparingly in the Mid-Coast Basin, partly due to landowner concerns about the long duration of contracts (10-15years). As the author suggests, incentive payments and rents may not be sufficient to attract participation. While providing access for restoration, rents also increase the total cost of implementation. DEQ anticipates, correctly, that landowners are likely to utilize OWEB grants and other programs, like EQIP, to accomplish restoration and enhancement goals. These agreements are typically shorter duration and may have significantly different project costs but are designed using similar BMPs.

Furthermore, the Willamette Basin study assumes restoration sites with little or no vegetative cover (hence the need for restoration).[5] Regardless of land use, coastal basins are likely to have dense riparian vegetation. In open areas, this is often dominated by Himalaya Blackberry and Reed Canary Grass, well-adapted and rapidly invasive species that choke out native vegetation and do not perform riparian shading or erosion protection well. These types of sites are difficult to restore, often involving multiple years of site preparation and after-planting maintenance to ensure success. Elsewhere, I have advised land managers and restoration professionals to plan for higher project costs in these areas.

A glance at the map suggests the relative spatial distribution of land uses, with predominantly public and private forestland tax lots and rural residential/agricultural tax lots concentrated in bottomlands. Recently, as part of their Mid-Coast Strategic Implementation Area (SIA), ODA analyzed 383 tax lots within the Upper Yaquina Basin. 233 tax lots were evaluated as hosting forestry and 150 tax lots were evaluated as agricultural. 64% of the total tax lots in the Upper Yaquina SIA were evaluated as having agricultural activities, held by ~100 individual landowners.[6] These lots represent 37,888 acres and 160 stream miles.[7]

[5] Michie, 14.
[6] Ryan Beyer, ODA Compliance Specialist, e-mail message to the Author, 26 September 2022.
[7] ODA, "Overview of the 2020 Upper Yaquina Strategic Implementation Area – Lincoln County"

While forest riparian buffer dimensions are generally prescribed by the Oregon Forest Practices Act or Private Forest Accord legislation, agricultural buffer requirements recognize a broader range of effective designs. However, when applied to smaller agricultural and rural residential tax lots in Upper Yaquina bottomlands, riparian shading and filtering practices occupy a larger proportion of ownership parcels.

ORS 183.333 specifically asks DEQ and advisory committees to consider adverse impacts on small businesses. However, DEQ's business registry search does a poor job of capturing the actual business relationships and allocation of responsibility between deeded acres represented in the tax rolls and small businesses operating in the basin. Definitions of "Small Business" used by Oregon agencies variy, but elsewhere DEQ cites U.S. code language, in part, of "independently owned and operated by an individual employing fewer than 100 employees."[8] Except for a few large industrial timber owners, or exempt state and tribal landowners, a very high proportion of the Upper Yaquina Basin's tax lots fit this definition. Insofar as rural agricultural and forestry lands, as well as rural residential lands, are "investments" on behalf of their holders, they also could be considered "business," whether or not they are registered with the Oregon Secretary of State or headquartered within the basin. Traditional small businesses likely hold land lease agreements or land management contracts within the basin as well.

All this to say that DEQ should be circumspect in concluding that a tax lot or group of tax lots within the basin are not the interest of small businesses and that costs of implementation won't fall disproportionately to these entities. As it is unclear at this time what, if any, additional compliance requirements will be drafted for different classes of land ownership to meet water quality criteria objectives, we should assume that both in relative number and acreage/stream mile estimates, the greater costs and restoration opportunities within the basin shall accrue to small businesses. While grant assistance and technical assistance is available, at some level of funding, and through several avenues, those are voluntary programs and landowners are not required to use them. Extended compliance timetables for certain classes of entities disproportionately affected by the Rule may be warranted.

ODA's recent analysis for the Upper Yaquina SIA speaks to the need for voluntary implementation partnerships in order to achieve water quality criteria. Of the 150 ag tax lots examined, ODA staff identified zero potential violations of Ag Water Quality Management Plan (AWQMP) Area Rules. 88 tax lots were determined to be "likely compliant," with little opportunity for further BMP implementation. 62 tax lots were designated as "Restoration Opportunities" or "Compliance Opportunities." These results are in-line with previous SIA analyses statewide.[9]

Applying the restoration cost estimates to just the agriculture side of the basin, restoration opportunities exist on an estimated 66 stream miles (41.3% of ag stream). Conservatively assuming a 30-foot forested buffer and no livestock fencing, the 240-acre aggregate project would require investment of $1.56 million. More extensive buffer establishment to the 100-foot mark would increase that to $5.20 million. If exclusion fencing were required for the same 100-foot buffer, costs would rise to $12.19 million.

[8] https://www.oregon.gov/deq/aq/aqPermits/Pages/BAP.aspx

[9] Ryan Beyer, ODA. Presentation, Upper Yaquina SIA Open House. Eddyville, OR. 12 September, 2022.

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Regardless of the source of funding, these are significant levels of investment for local smallholders and conservation partners. While I am optimistic that agencies and partners are well-positioned to provide funding and technical assistance for individual rural landowners in the basin, a fiscal analysis should recognize that, even in less-developed basins, restoration and enhancement opportunities require resources in excess of ready local resources. Accessing those resources and coordinating them is an upfront and ongoing cost for landowners and conservation partners.

Respectfully Yours,

--Alan Fujishin
Chairperson, Lincoln Soil and Water Conservation District
Member, Upper Yaquina RAC

WALTZ David * DEQ

From:	HUMMON Cheryl * ODA
Sent:	Wednesday, November 2, 2022 11:54 AM
To:	WALTZ David * DEQ; LIVERMAN Alex * DEQ
Cc:	ALLEN Marganne * ODA; JASPER Olivia * ODA
Subject:	Upper Yaquina TMDL - ODA comments on 2nd draft of Fiscal Impact Statement
Attachments:	UpperYaquinaTMDLm2FIS.ODA-Comments.pdf

Hello David and Alex,

We are submitting ODA's comments on the current draft of the Fiscal Impact Statement for the Upper Yaquina TMDL.

Please see attached .pdf for corrections needed in the actual document:

- Page 2, info on CREP
- Page 4, ODA Ag WQ Program authority
- Page 7, ODA-ODF sentence about regulatory and voluntary practices

As requested, we are also providing ODA's input on the three questions that DEQ asked the Rules Advisory Committee to address, during the second RAC meeting:

1. Does the RAC find these TMDLs **will** or **will not** have a significant adverse impact on small businesses in Oregon?

   ODA finds it difficult to answer this question, without having had an opportunity to review the draft rules (draft TMDL and WQMP). ODA believes there may be a fiscal impact for some agricultural landowners; the potential new fiscal impact would be for improvements needed to achieve conditions consistent with TMDL load allocations that are above and beyond compliance with the existing Ag WQ Rules. Fiscal impacts could include taking some land out of production for riparian improvements and/or cost-share or match for implementing changes. ODA is unable to say whether any fiscal impact would be "significant" or "adverse".

2. How could DEQ reduce the rules' fiscal impact on small business?

   ODA requests increased funding / capacity for implementation of restoration projects and management changes needed to achieve conditions consistent with TMDL load allocations.

3. Input on how the rule will affect racial equity in Oregon?

   ODA supports the current language in the draft Fiscal Impact Statement. ODA suggests also recognizing that some underserved communities may not have (or may not have had) equal access to technical and financial assistance or other resources.

Thank you for the opportunity to provide input.

Cheryl – WQ Specialist
Marganne – Program Manager

Cheryl Hummon, Regional Water Quality Specialist - NW Oregon
Oregon Department of Agriculture – Water Quality Program
635 Capitol St NE, Salem, OR 97301
PH: 503.986.4791 | CELL: 971.599.8327 | WEB: Oregon.gov/ODA
EMAIL: Cheryl.Hummon@oda.oregon.gov **(new – please update contacts!)**

Upper Yaquina Watershed TMDLs

Summary

Rule Advisory Committee Meeting #2

Oct. 19, 2022, 9 a.m. to 11:30 a.m.
Zoom meeting

Watershed Management
700 NE Multnomah St.,
Suite 600
Portland, OR 97232
Phone: 503-229-5696
800-452-4011
Fax: 503-229-6124
Contact: David Waltz

www.oregon.gov/DEQ

DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

List of RAC member attendees

Name	Affiliation
Joe Steere	Small Woodlands Association/Lincoln County Farm
Roy Kinion	Bureau Lincoln County
Rebecca McCoun	Oregon Department of Forestry
Mark River	Weyerhaeuser Co.
Cheryl Hummon	Oregon Department of Agriculture
Russ Glascock	Local landowner
Daniel Redick	Benton County
Randy Hereford	Starker Forests
Paul Engelmeyer	Wetlands Conservancy
Evan Hayduk	MidCoast Watersheds Council
Glen Spain	Pacific Coast Federation of Fishermen's Associations

Not attending: Mike Kennedy (Confederated Tribes of Siletz Indians), Alan Fujishin (Lincoln Soil Water Conservation District), Frankie Gonzales or Matt Koon (Genesee & Wyoming Inc.)

List of DEQ team attendees

Name	Role
David Waltz	Mid Coast Basin Coordinator
Alex Liverman	Watershed Management Program Analyst
Michele Martin	Facilitation/Rulemaking process support
Gene Foster	Watershed Management Program Manager

List of handouts

- Draft agenda
- Second Draft Fiscal Impact Statement

Post-meeting: DEQ Presentation Slides

Meeting Summary

DEQ staff used a PowerPoint slide presentation to convey information and guide discussion with RAC members during the meeting. Most of the information presented in the slides is not repeated in this summary. Rather, the focus of this summary is on clarifying information provided by DEQ staff and capturing the key points of discussion associated with the materials in the presentation and other topics. The slides will be posted as an Adobe pdf file on the Upper Yaquina TMDL Rulemaking webpage as a companion to this summary of comments and discussion by the Rule Advisory Committee members.

DEQ staff asked RAC members to identify themselves in the Zoom application to include the initials AC ahead of their names to indicate RAC membership and addressed meeting logistics. Following introductions of DEQ staff and RAC members, Alex Liverman provided an overview of the meeting agenda.

David Waltz noted that this week is the Clean Water Act's 50th anniversary and that watching the documentary film "Pollution in Paradise" by journalist and former governor Tom McCall provides an interesting reference point.

David provided an update on two related topics relevant to the Upper Yaquina River watershed TMDLs that occurred since the first RAC meeting: Oregon's final 2022 Integrated Report/303d list was approved by U.S. EPA on Sep. 1, 2022, resulting in a change to Section 303d listing in the watershed and subsequent adjustments in spatial scope for effective shade allocations to address dissolved oxygen impairments. This information is summarized in the presentation slides. Discussion with the RAC members followed these updates.

Paul Engelmeyer asked about sequencing of TMDLs and why DEQ would assume the portions of the watershed without data do not meet standards and given the significant effort [to develop the DO TMDL], whether there a discussion about doing quick evaluation for the unassessed portions, or whether this will have to wait until monitoring is done in the future. He added that it would be simpler for everyone to obtain the information now rather than potentially revisit other sixth field HUCs in the future.

David responded that DEQ evaluated several model scenarios and reached the conclusion is that there is insufficient data to link effective shade conditions on the tributaries with dissolved oxygen conditions in the mainstem. Therefore, the spatial scale of the dissolved oxygen TMDL shade allocations were revised to align with the IR 2022 status and focus on the mainstem. Based on the TMDL analysis, the dissolved oxygen criteria will be met with effective shade on the mainstem and the phosphorus allocations that will be applied to the watershed as a whole. For temperature, changes to the FPA are intended to address shade deficiencies for small and medium size streams.

Alex reiterated that DEQ is currently developing DO and bacteria TMDLs, but temperature impairment will be addressed in a future TMDL.

David provided a table clarifying that the distance used in the riparian effective shade model was approx. 100-feet from each bank, rather than 120-feet shown in the presentation for RAC meeting #1. These distances were based on the approximate riparian zone width that results from using the stream centerline as the starting point for the assessment. Since the stream width varies over the modeled portion of the mainstem, the modeled width also varies somewhat.

Glen Spain asked whether the revised 100-foot will meet the 87% effective shade (loading capacity) target shown in the slide. David responded that a 100-foot riparian zone of overstory vegetation will meet the 87% effective shade target.

David briefly recapped the overall TMDL implementation steps to clarify roles of DEQ and designated management agencies and responsible persons (DMAs/RPs) in developing the WQMP, implementation plans and performing site specific assessment needed to identify where additional management strategies, BMPs or protection strategies are needed to meet load allocations.

Cheryl Hummon asked about the site-specific assessment for DMAs and when additional information (tools and analysis) for implementation planning will be made available. David indicated that several subsequent presentation slides show the status of development of the tools at a high level.

Russ Glascock summarized riparian planting projects completed on his property that are now providing shade on the river in the last 20 years. David responded that type of information supports the need for site-specific assessment before investing significant resources.

David showed the draft outputs of the shade gap analysis, figures with DMA/RP responsibility within the riparian zone and the average shade gap over the modeled segment. David summarized the results, including the acres or stream miles and the effective shade gap in percent (difference between analyzed current shade and modeled effective shade) that is aggregated into bins or ranges.

Cheryl indicated she was uncertain from the figure where the highest shade gap. She asked for the averaging distance of the shade gap. David indicated that he believed it is over 500-meter segments but would check with Analysts to identify the appropriate scales and get back to Cheryl and others. Cheryl's follow-up question was whether the GIS layers will have the shade gap bins or actual shade gap. David responded this layer will contain the bins.

David explained DEQ wants to provide information at a scale that is useful to Designated Management Agencies, other responsible persons and local restoration partners. One approach is to provide GIS layers to DMAs. At one extreme, the raw Light Detection and Ranging (Lidar) data is publicly available for use by DMAs and others. DEQ is trying to find a balance between DEQ evaluation and DMA site specific assessments. David reiterated that the TMDL scale is based on cumulative reductions at the watershed or segment-scale load allocations, rather than site-specific allocations.

Rebecca McCoun noted that the amendments to the Forest Practices Act will mandate 110-foot riparian buffers for the Yaquina River and Little Elk Creek starting in January 2024, if the Board of Forestry adopts them in November 2022.

Joe Steere asked whether DEQ looked at smaller buffers, such as 30-feet. David responded that DEQ did look at a 35-foot conservation buffer and showed a figure with that distance within the larger buffer. David expressed that DEQ would not discourage a strategy starting with a conservation buffer as part of phased implementation approach to achieve the shade allocations. David reiterated that a 100-foot riparian zone of overstory native vegetation would meet the effective shade targets (or once it reaches maturity), but that the site-specific assessment is needed to determine topographic shade and other factors.

David presented the shade gap analysis tables by jurisdictional acres or stream miles of vegetation height ≤ 3 feet. Shows current condition and relative responsibility and deficit for streamside shade.

Joe requested confirmation that the shade allocations only address mainstem. DEQ confirmed the modeled segment is Clem Rd to Trapp Ck Rd and shade allocations also apply to Little Elk Creek.

Rebecca asked whether the riparian zone includes "channel migration zone" and stated that the revised Forest Practices Act rules will require identification of this feature. David responded that this feature was not directly considered in modeling and DEQ performed no separate analysis of channel morphology. For effective shade, a set distance from the stream centerline was used (131 feet), recognizing that there are relations between channel stability and ability to support vegetation needed to provide shade.

Russ asked whether DEQ has mapped logs placed in tributaries for shade (and clarified this question applies to large wood directly providing shade or to improve channel condition).

David responded that DEQ has not mapped large wood placements or analyzed the effects on shade but understands that this activity should improve channel conditions and support vegetation needed to provide shade and improve other riparian zone function. This is a site-specific shade assessment. David added that DEQ encourages large wood placement in appropriate locations to provide stream functions.

David confirmed that DEQ is deferring to the OR Coast Coho Conservation Plan habitat targets developed by OR Department of Fish and Wildlife and the restoration community to address channel morphology.

Following a break, Alex presented an overview of the revised draft fiscal impact statement prepared to incorporate committee input and posted on the rulemaking website.

Alex reiterated the three primary questions that the FIS must address (see Slide 19)

Alex covered the questions asked in DEQ's first request for RAC input on FIS (see Slide 20)

Alex summarized the Input received during first RAC meeting (see Slide 21)

Alex summarized the written input received during a 4-week period from Russ, Cheryl, Rebecca, and Alan Fujishin (see Slide 22).
Daniel Redick noted that he had provided written input and resent that in response to Alex's request.

Alex summarized DEQ's FIS revisions thus far based on the input received from RAC members (see Slide 23).

Alex requested discussion from the RAC during this second meeting, as well as documentation or other written information to help inform DEQ's fiscal impact statement (by Nov. 2).

Paul asked whether the fiscal and economic analysis will acknowledge the ecosystem or downstream benefits of buffers and indicated that he will be providing written comment in the next round. Paul indicated that there is information on the benefits of buffers and links between cold clear water and the estuary and issues with ignoring the saltwater wedge and that he will share documentation by an author (Dr. Ernest Niemi).

Glen expressed agreement with Paul on including an assessment of economic benefits to fishers and coastal communities of restored salmon runs.

DEQ asked the RAC members to forward any information to DEQ staff for distribution to avoid communicating in numbers that would represent a quorum of the committee, as this would be considered a meeting which requires a two-week public notice in compliance with Oregon public meetings law.

Alex pointed to the inclusion of costs of ongoing impairment as a consideration in the draft fiscal impact statement and noted DEQ's lack of available information to explicitly analyze these watershed-wide and downstream costs.

The committee did not provide a finding in the meeting whether or not the rule will result in significant adverse impacts to small businesses, or how it could be changed to reduce those impacts.

Joe stated that the economics of fisheries are aggregated in the fiscal impact statement at the coastal scale instead of being specific to what the Upper Yaquina watershed supplies to fisheries (or could provide) and should be adjusted to that watershed.

Alex noted that these figures are the ones that were available and are aggregated at large scale and DEQ is seeking watershed-specific information from the committee. Joe indicated that DEQ should assess agricultural and timber economics at the same scale as the fisheries information.

Alex asked whether members had other comments on the revisions in the draft FIS and reminded that DEQ needs to summarize the RAC members' decision on whether there is or is not a significant economic impact on small business (using the definition in the revised draft FIS).

Regarding the key question whether there is or is not a significant adverse impact on small business:

Rebecca stated that it is hard to say if there are impacts to small businesses because there isn't enough information to determine the economic impacts of TMDLs requirements or evaluate cause and effect, considering the intersecting programs of Depts of Agriculture and Forestry, and changes to the forest practices rules.

Glen emphasized that if a benefit or cost cannot be quantified, or there is no data, it does not mean the external impact is zero (in economic analysis) using clean air or clean water as the example.

Alex indicated that the fiscal impact analysis indicates some impacts to some small businesses, but there is not enough information to quantify those impacts to determine that they would "significantly adversely impact small businesses."

Daniel commented that for Benton County, if the TMDLs implementation requirements do not differ much from the Upper Willamette TMDL requirements, then the cost impacts to the County is minimized.

Joe asked for clarification of spatial scope of load allocations and Alex reiterated that the shade allocations will apply to the mainstem Yaquina River and Little Elk Creek, whereas the phosphorus and bacteria load reductions will apply watershed wide.

Alex asked for input from the members on how to minimize impacts to small businesses.

Russ asked whether a distinction will be made between the livestock sources and elk. David responded that one goal of the water monitoring that will be conducted under both the ODA's Strategic Implementation Area process and the TMDL implementation is to attempt to distinguish among sources including wildlife and livestock, but that it can be difficult to accomplish.

Russ indicated that issue is a small business impact and Alex asked him to please elaborate in written comments.

Cheryl asked for clarification of small business. Alex responded that DEQ considered potentially affected small businesses beyond the definition required for rulemaking (50 employees or fewer and registered with the state as a business) to include entities that report income on individual income tax returns. However, DEQ was not able to specifically identify or quantify the number of these entities. The question for the committee is to inform DEQ whether this represents a significant economic impact and if so, how to alleviate those impacts.

Paul indicated that list of opportunities for county-wide state and federal funding programs (including CREP) will help alleviate impacts. He referred to a California co-benefit analyses that quantifies ecological benefits beyond salmonids and that he will provide that information in written comments.

Joe commented that the draft fiscal impact statement doesn't quantify costs of loss of land taken out of agricultural production, which could include tax impacts to landowners.

Alex described the draft Racial Equity statement and environmental justice and asked whether the committee has input on these considerations.

Cheryl thanked DEQ for providing the redlined version of the draft fiscal impact statement and asked whether it will be part of the draft TMDL documents that go out for public comment and open for revision. Alex confirmed it would be part of the package and can be revised as appropriate to respond to input provided.

Cheryl noted that the revised language on ODA programs in the draft fiscal impact statement can be used as a template for fiscal impact statement in future TMDLs that go through rulemaking.

Cheryl reiterated that ODA has no authority for aquatic habitat and noted this change was not made in response to her input on the draft fiscal impact statement. David explained that the language reflects summary information from the Oregon Plan for Salmon and Watersheds and OR Coast Coho Conservation Plan documentation describing each state agency's role and that DEQ will review that source and adjust language as needed.

Cheryl appreciated clarifications around compliance costs with TMDL requirements which ODA found confusing. Alex explained that the phrase "cost of compliance" is a required section of the FIS, so DEQ clarified that compliance with TMDL requirements is being considered, not compliance with other state agency's rules.

Cheryl emphasized that Agriculture Water Quality Program rules do not require voluntary measures. Alex indicated the language aligns with the updated Memorandum of Agreement between ODA and DEQ, but it can be discussed further, if needed.

Joe suggested referring to both Schedule D and F for reporting farm income on tax returns. DEQ suggested generalizing language further to leave out mention of any schedules.

Alex reiterated that DEQ is asking for another round of comments on verbal input from the RAC now, and written input by Nov. 2.

Alex recapped the rulemaking process and schedule.

Cheryl asked for specific dates for public comment and other milestones. Alex provided additional details - public comment period: Dec. through Jan; DEQ briefing to EQC in Jan. 2023; then public hearing on the draft TMDL rule; and first opportunity for EQC to adopt TMDL by rule: March 2023 (acknowledging that certain factors could change that).

Rebecca asked whether committee members will see the water quality management plan before the public comment period. Alex pointed back to the committee charter which indicates committee input will be used to refine the TMDL and WQMP prior to public comment. But DEQ will be sharing specific sections of the WQMP with some DMAs for additional input between now and the public comment period.

DEQ will present conclusions on source assessment, load allocations, management strategies, fiscal impacts and the input considered to the EQC.

Michele Martin offered a final opportunity for committee discussion.

Joe requested a more in-depth map, focused on the Upper Yaquina watershed assessment unit removed from the 303(d) list. David asked Joe to clarify what specific scale or detail is requested, such as larger scale or specific area. DEQ agreed to evaluate the approaches to address broad range of needs. (NOTE: David emailed a link to the committee members on 10/26/22 to the Integrated Report mapping application which provides a range of features and capabilities, including zooming.)

Russ asked whether the Forest Practices Act amendments are a piggyback on the TMDL. Alex reiterated the revisions DEQ made to the fiscal impacts statement in response to ODF and ODA comments that their existing rules are already required and should not be "double-counted" as costs of the TMDL rule.

Alex thanked the committee members for participating and noted that DEQ will post the meeting presentation slides and summary on the rulemaking website as soon as possible. Please send questions and comments to both David and Alex as listed on the final slide.

DEQ adjourned the meeting at approximately 11:30 a.m.

Alternative formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.

State of Oregon Department of Environmental Quality

Draft Fiscal Impact Statement

Upper Yaquina River Watershed Total Maximum Daily Loads for Bacteria and Dissolved Oxygen

Introduction

Consistent with Oregon Revised Statute 468B.110 and OAR chapter 340 division 42, DEQ prepared Total Maximum Daily Loads and a Water Quality Management Plan to address bacteria and dissolved oxygen impairments in the Upper Yaquina River Watershed. The TMDLs and WQMP will be proposed for adoption by Oregon's Environmental Quality Commission, by reference, into OAR 340-042-0090. The TMDLs and WQMP are supported by DEQ's Upper Yaquina River Watershed TMDL Technical Support Document. These draft documents will be available for public review during the comment period and hearing that will precede proposing the rule for adoption by the EQC.

Fee analysis

This rulemaking does not involve fees.

Statement of fiscal and economic impact

Fiscal and Economic Impact

Issuance and subsequent implementation of the proposed TMDLs and WQMP may have fiscal or economic impacts on current and future operators of some: farms and ranches; forestlands; a railroad right-of-way; and federal, state and county lands or operations within the Upper Yaquina River Watershed. However, fiscal or economic impacts and costs of compliance would not be different than if the TMDL was issued as a department order.

This fiscal impact statement does not quantify the costs of on-going water quality impairment to beneficial uses of waters of the state. Implementation of these TMDLs is intended to address water pollution, as required by the relevant sections of the federal Clean Water Act. The negative economic and health impacts of water pollution potentially affect all those who live, work and recreate within the watershed, as well as those downstream, including commercial, recreational and subsistence fishing communities. The externalized costs of water pollution may disproportionately negatively affect poor, rural, indigenous and minority communities in Oregon.

In contrast, costs of TMDL implementation ~~compliance costs~~ are borne only by those entities contributing sources of pollutants to waterways. These costs can be reduced by these entities by choosing pollutant control or reduction strategies or options that align with their particular circumstance, perspective and/or business needs.

Statement of Cost of Compliance

Costs of compliance with this TMDL rule can include administrative and implementation costs. DEQ does not have specific information for potentially affected operations within the watershed to determine economic impacts to particular landowners or business operators. Such impacts are expected to vary by pollutant sources, sizes and locations of activities and affected lands and the extent of any existing and effective, site-specific controls.

Members of the Upper Yaquina TMDL Rule Advisory Committee recommended DEQ use available information to quantify total costs of full implementation of the pollution controls of riparian restoration and livestock access limitations estimated to be needed by the TMDL. In 2010, DEQ estimated costs for riparian restoration in the Willamette Basin, equivalent to standard buffers in the Natural Resources Conservation Service conservation reserve program[1]. One RAC member estimated that extrapolating these costs to the Yaquina River Watershed and applying inflation adjustment factor (1.385) to better estimate 2022 costs, yields anticipated costs of approximately $6500 to $10,000 per acre for riparian vegetation or fencing[2]. DEQ concluded that these figures represent a reasonable range of riparian restoration costs and notes that individual site costs would range from $0 to $10,000 per acre, depending on the existing condition of riparian areas, which may already have adequate pollution controls in place.

DEQ estimated that approximately160--acres along certain streams in the watershed require restoration to effectively implement the TMDL. Using the $10,000 per acre figure, DEQ conservatively estimated approximately $1.60 million will be needed for establishing the needed riparian vegetated buffer. These estimated costs are not distinguishable between public and private investment and costs cannot be refined to a site-specific level (for the reasons listed below).

For each cost of compliance section below, potential fiscal or economic impacts for implementing pollutant controls are highly variable for the following reasons:

- Locations and seasonality of pollution sources and activities can vary from locations and seasonality of bacteria and dissolved oxygen impairments.
- Pollution controls or activities may already be in place in some locations that prevent or reduce exceedances of water quality standards.
- Pollutant control strategies required in the WQMP vary by pollutant and source sector.
- Multiple pollution controls may be needed as some locations.
- The presence of buildings or transportation infrastructure may preclude pollution controls in some locations.
- DEQ does not have exhaustive information to determine all potential sources or what actions are currently occurring that could be modified or enhanced to prevent

[1] DEQ's Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. 2010.

[2] Lincoln Soil Water Conservation District. Input on Upper Yaquina TMDL Fiscal Impacts Statement. Sep. 26, 2022.

exceedances of water quality standards. Pollutant source assessment and allocations are identified by source sector, not individual property or activity.

- Varying ~~sizes~~ acreages and locations of pollutant sources and significance of pollutant contributions.
- A range of organizational capacity exists for implementation plan development and there are varying levels of complexity are needed in plans.

Where investments are necessary to meet TMDL targets and implementation requirements, DEQ identifies funding resources in the WQMP and online that include, but are not limited, to state and federal grants (including Clean Water Act Section 319 nonpoint source implementation grants) and below-market interest rate loans (that can include principal forgiveness) through the Clean Water State Revolving Fund program. Other state and federal opportunities are provided on DEQ's water quality funding resource webpage: https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-Funding.aspx

Members of the Upper Yaquina TMDL Rule Advisory Committee recommended quantifying previous investments in watershed restoration in the Upper Yaquina River Watershed. Over the past two decades, grants from the Oregon Watershed Enhancement Board to the Mid Coast Watersheds Council have been applied in cooperation with, and investments from, agricultural and small woodlot landowners to improve riparian conditions, reduce livestock access to streams and improve instream habitat. In addition, one landowner enrolled 60 acres in the US Department of Agriculture's Conservation Reserve Enhancement Program. Restoration projects can require multiple decades to improve water quality and DEQ does not have current information on the status, success or costs of most restoration projects. However, Oregon Watershed Enhancement Board reports that several funded projects were not fully implemented and a 2021 taxlot-level survey by Oregon Department of Agriculture confirms that some watershed areas do not have proper riparian function. The combination of past or existing riparian improvement or protection projects may offset a portion of the costs of restoring riparian vegetation required by the TMDL.

State and federal agencies

Several state and federal agencies will be assigned responsibility for developing plans and implementing management strategies to achieve cumulative pollutant load reductions, specified in the TMDL and WQMP. Compliance costs are not different for implementing TMDLs issued by department order or TMDLs adopted as rules. Grant and low interest loan funding is available to support implementation of pollution controls and watershed restoration actions required ~~for compliance with~~to meet TMDL requirements.

DEQ implements pollutant waste load allocations through NPDES permits. Because allocations are applied in permits upon evaluation for renewal or initial applications, this does not represent additional fiscal impact to DEQ for TMDL implementation.

Oregon Department of Forestry is responsible for developing plans for management strategies and overseeing implementation of ~~practices~~ state Forest Practices Act rules to achieve nonpoint source pollutant load allocations and meet water quality standards on non-federal forestlands (state, county, and private) within the watershed, perform annual reporting and participate in monitoring and periodic progress reviews. Per ODF authorities described in state statues and rules, a mix of existing practices, programs and voluntary measures are promoted for implementation to improve or protect water quality, land condition and aquatic habitat on non-federal forestlands. Administrative costs for implementing these existing rules and programs are not dependent on TMDLs, but ODF will incur administrative costs for development of a TMDL implementation plan. Administrative and Complianceimplementation costs for ODF and individual forestland owners/operators will be not different for implementing TMDLs issued by department order than TMDLs adopted as rules. Financial incentives and technical assistance programs are available through federal, state and local agencies and organizations to assist private forest landowners/operators to support implementation of site assessment, pollution controls, watershed restoration activities or forestlandscape condition improvements that may be necessary for compliance withto meet TMDL requirements.

Oregon Department of Agriculture is responsible for developing plans for management strategies and overseeing implementation of practices to achieve nonpoint source pollutant load allocations and meet water quality standards on private lands for all agricultural activities within the watershed, perform annual reporting and participate in monitoring and periodic progress reviews. Per ODA authorities described in state statutes and rules, a mix of existing practices,regulatory programs and voluntary measures are promoted for implementedation on agricultural lands or related to agricultural activities, in partnership with local Soil Water Conservation Districts and Local Advisory Committees, to improve or protect water quality, land condition and aquatic habitat and land condition that impacts water quality on agricultural lands, in partnership with local Soil Water Conservation Districts and Local Advisory Committees. Administrative costs for implementing these existing rules and programs are not dependent on TMDLs, but ODA will incur administrative costs for development of a TMDL implementation plan. Administrative and Compliance implementation costs for ODA and individual landowners/producers are not different for implementing TMDLs issued by department order than TMDLs adopted as rules. Financial incentives and technical assistance programs are available to assist private landowners. Grant and low interest loan funding is available to ODA, SWCDs, and individual landowners/operators to support implementation of assessment, pollution controls and watershed restoration actions or landscape condition improvements that may be necessary for compliance withto meet TMDL requirements.

Oregon Department of Transportation is responsible for implementing practices to achieve pollutant allocations related to highways within the watershed. ODOT is required to comply with its DEQ-issued MS4 stormwater permit, including development of a statewide TMDL implementation plan. The plan must include practices to achieve TMDL allocations related to both stormwater discharges and nonpoint sources of excess solar radiation. Compliance costs are not different for ODOT for implementing TMDLs issued by department order than TMDLs adopted as rules.

Oregon Department of State Lands protects and conserves state waterways and wetlands through administration of Oregon's Removal-Fill Law, Scenic Waterways Law and the

Wetland Conservation Program. DSL will not incur additional ~~costs for~~administrative or compliance costs in administering its aquatic resource management programs.

~~**Oregon Department of Fish and Wildlife** is charged by statute to protect and propagate fish and to manage wildlife in the state. ODFW will not incur additional costs for compliance with administering its fish and wildlife management programs. Development of a TMDL implementation plan will incur certain short-term administrative costs. However, DEQ concluded that most implementation strategies are covered under existing plans, including the Oregon Coast Coho Conservation Plan (2007).~~

US Bureau of Land Management is responsible for developing plans for management strategies and implementing practices to achieve nonpoint source pollutant load allocations on forest land owned by the federal government, which makes up approximately one percent of the land area within the watershed. The BLM's current Resource Management Plan dictates how Riparian Reserves are managed. Administrative costs for implementing these existing rules and programs are not dependent on TMDLs, but BLM will incur administrative costs for development of a TMDL implementation plan. ~~Compliance~~ These costs are not different for implementing TMDLs issued by department order than TMDLs adopted as rules.

Local governments

Lincoln and Benton counties are responsible for developing plans and implementing practices to achieve pollutant load allocations for rural residential planning and development, building code administration and enforcement, onsite septic system permitting and compliance and operation of the county transportation systems within the watershed. The counties will incur administrative costs for development of a TMDL implementation plan. Administrative and implementation ~~Compliance~~ costs are not different for these entities for implementing TMDLs issued by department order than TMDLs adopted as rules. Financial incentives and technical assistance programs are available to assist local governments and private landowners. Grant or low interest loan funding are available to support implementation of assessment, pollution controls and watershed restoration actions or landscape improvements that may be necessary ~~for compliance with~~ to meet TMDL requirements.

Public

The proposed rule does not have a direct economic cost to the public at large. As a result of the proposed rule, DEQ expects that currently impaired beneficial uses of waters in the Upper Yaquina River Watershed will be restored. These improvements would provide an overall positive direct economic impact to the public who live, work and recreate in the watershed.

The proposed rule supports the Oregon Plan mission: *Restoring our native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.*

The Oregon Plan is a comprehensive partnership between government, communities, private landowners, industry and citizens funded by the Oregon Legislature. Efforts under the Oregon Plan include regulatory and non-regulatory programs designed to restore native salmon runs, improve water quality and maintain healthy watersheds and human communities throughout Oregon. TMDLs are the primary regulatory approach to addressing water bodies that do not meet water quality standards.

Commercial and recreational fishing is a major driver in the Oregon economy, especially in smaller rural communities. Water quality is a limiting factor that imperils the Yaquina population of Oregon coastal coho, which is significant in the culture and employment of the Oregon central coast that is severely depleted[3]. The proposed rules support state and federal conservation or recovery plans to restore or maintain healthy fisheries and will also help improve water contact recreation and livestock watering opportunities. Small Oregon coastal communities downstream of the watershed, which once relied heavily on commercial salmon fishing for their income, may experience a positive economic impact due to the proposed rules, if salmonid populations increase.

The statewide economic contribution of recreational anglers to Oregon's economy as of 2018 was $1.5 billion dollars, supporting 13,120 jobs. It was estimated that 569,600 Oregon recreational anglers spent $871.8 million in 2018.[4] The proposed rules may have a positive economic impact on income from recreational anglers if salmonid populations increase. Improvements in recreational salmon fishing may also have a positive economic impact on the public who can use the salmon as a food source.

Commercial salmon fishing generates thousands of jobs in smaller coastal Pacific Northwest communities. The Oregon Department of Fish and Wildlife, estimates that Oregon's coastal commercial salmon fisheries generated an average of 396,728 landed pounds of salmon from 2010-2017 in its multiple coastal ports, an average of approximately $2,073,481. This was estimated to have created more than $5,000,000 in net economic impacts to Oregon's coastal communities through commerce.[5]

Large businesses - businesses with more than 50 employees

The large businesses that operate within the watershed are private industrial timber companies and one railroad company. These entities do not have captive locations in the watershed with greater than 50 employees but manage significant tracts of land and/or operate extensive transportation networks. The rule could impose costs associated with achieving required reductions in pollutant contributions to waterways from these lands or operations. Within several years, ~~the majority of~~ compliance costs for natural resource protections for industrial forestland owners may be associated with Fforest Ppractices Act rules currently being developed from legislation associated with the Private Forests Accord rather than this rule. ~~Compliance~~ Administrative and implementation costs ~~for~~ will be

[3] Oregon Coastal Coho Conservation Plan. Oregon Department of Fish and Wildlife, in partnership with state and federal natural resource agencies. March 16, 2007. https://www.dfw.state.or.us/fish/crp/docs/coastal_coho/final/coho_plan.pdf.
[4] https://www.psc.org/download/333/special-reports/9337/economic-impacts-of-pacific-salmon-fisheries.pdf
[5] https://www.dfw.state.or.us/MRP/docs/Backgrounder_Comm_Fishing.pdf

incurred by the railroad ~~are estimated to be administrative (~~for implementation plan development, ~~and~~ periodic reporting~~)~~ and periodic assessment of riparian conditions in the railroad right-of-way. DEQ does not anticipate different economic impacts to any large businesses as a result of the rule, compared to costs for ~~implementing~~ administration or implementation of TMDLs issued by department order.

Small businesses – businesses with 50 or fewer employees

The rule could impose costs associated with achieving required reductions in pollutant contributions to waterways from five small agricultural and timber-related businesses (non-industrial private forestlands), as well as an unquantified number of small woodlands owners and small livestock and farm operations, which are not identified as small businesses in Oregon's database. The rule could also impose costs on four small businesses unrelated to agriculture and forestry if repairs or upgrades to septic systems are needed.

Although the proposed rule does not place specific requirements on small businesses in aggregate, the proposed rule identifies management strategies and practices for the agricultural and forestry sectors that are necessary to reduce pollutant loads. These activities may require changes in certain management practices or improvements in land conditions that could result in capital costs for small landowners. Both Oregon Department of Agriculture and Oregon Department of Forestry have rules in place that require a mix of regulatory and voluntary practices by agricultural and forest landowners to protect or improve water quality. ODF is currently updating its rules based on the 2022 Private Forest Accord report and passage of Senate Bills 1501 and 1502 and House Bill 4055 during the 2022 legislative session. The authors of the Private Forest Accord anticipated the new rules would have a greater, but unquantified fiscal impact on small forest landowners. Compliance costs for implementing ODA and ODF rules are not dependent on TMDLs. Some of these costs may be offset by preventing erosion or improving the productivity of certain agricultural and forest lands. However, ~~compliance~~ administrative and implementation costs are not different for implementing TMDLs issued by department order compared to TMDLs adopted as rules. In addition, grant and low interest loan funding are available to support implementation of pollution controls and watershed restoration actions required for compliance with TMDL requirements. The U.S. Dept of Agriculture, Natural Resource Conservation Service[6] offers a variety of programs to help farmers, ranchers, family forests, Tribes and conservation partners perform voluntary conservation on private lands funded through the Farm Bill. Small rural landowners and agricultural operators are eligible for NRCS Financial Assistance, grant and cost-share programs through, including Environmental Quality Incentives Program, Conservation Innovation Grants, Voluntary Public Access and Habitat Incentives Program, Voluntary Conservation Stewardship Program, Regional Conservation Partnership Program, Conservation Easements, and Agricultural Conservation Easements Program. The Oregon Watershed Enhancement Board offers ~~several~~ multiple grant ~~opportunities~~types, including Oregon Agricultural Heritage Program grants, the only grant type specific to agricultural lands.

ORS 183.336 Cost of Compliance Effect on Small Businesses

[6] https://www.nrcs.usda.gov/wps/portal/nrcs/main/or/programs/

1. Estimated number of small businesses and types of businesses and industries with small businesses subject to proposed rule.

DEQ searched the Oregon Employment Department database (2021) list of all businesses registered in Oregon, using NAICS codes and zip codes for the watershed and nearby. DEQ identified one registered small agricultural business (non-cattle), four registered small timber or logging businesses and four registered small businesses unrelated to forestry or agriculture within the watershed. Based on this review and input from the Upper Yaquina TMDL Rule Advisory Committee, there are small agricultural producers and small woodlot operations that do not appear to be identified as "small businesses" as defined in ORS 183.310, but instead report their farm or forestry income on Schedule D for federal tax reporting.

2. Projected reporting, recordkeeping and other administrative activities, including costs of professional services, required for small businesses to comply with the proposed rule.

The proposed rule does not place specific administrative activities or requirements on small businesses because implementation plan development and annual reporting responsibilities are assigned to state and local governments as Designated Management Agencies. Therefore, DEQ does not anticipate any significant costs of these types to small businesses.

3. Projected equipment, supplies, labor and increased administration required for small businesses to comply with the proposed rule.

Although the proposed rule does not place specific requirements on small businesses in aggregate, the proposed rule identifies management strategies and practices for the agricultural and forestry sectors that are necessary to reduce pollutant loads. These activities may require changes in certain management practices or improvements in land conditions that could result in costs to small agricultural or timber-producing operations. Although compliance costs for implementing ODA and ODF rules are not dependent on TMDLs, aAddressing TMDL requirements may require additional supplies, labor or administration for these businesses, including those that provide in-kind match to publicly funded restoration grants. Some capital costs may be offset by preventing erosion or improving the productivity of certain agricultural and timber lands through grant funded conservation projects.

4. Describe how DEQ involved small businesses in developing this proposed rule.

DEQ included individual landowners and representatives from agricultural and forestry interest groups on the Rule Advisory Committee to advise DEQ on economic impacts and costs of compliance for small businesses. DEQ also provided rulemaking notice to a statewide list of individuals and organizations interested in TMDLs and nonpoint source actions. These groups included small businesses.

Documents relied on for fiscal and economic impact

Document title	Document location
DEQ's Oregon Administrative Rules 340-042-0080 Implementing a Total Maximum Daily Load	https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1459
Economic Impacts of Pacific Salmon Fisheries	https://www.psc.org/download/333/special-reports/9337/economic-impacts-of-pacific-salmon-fisheries.pdf
Oregon's Ocean Commercial Fisheries	https://www.dfw.state.or.us/MRP/docs/Backgrounder_Comm_Fishing.pdf
Oregon Coast Coho Conservation Plan for the State of Oregon - Oregon Department of Fish and Wildlife, in partnership with state and federal natural resource agencies	https://www.dfw.state.or.us/fish/crp/docs/coastal_coho/final/coho_plan.pdf.
Natural Resource Conservation Service programs page	https://www.nrcs.usda.gov/wps/portal/nrcs/main/or/programs/
DEQ's Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon (2010)	https://www.co.benton.or.us/sites/default/files/fileattachments/community_development/page/2516/willametteripcost030310.pdf
Oregon Employment Department Small Business database (2021)	Note: We are confirming whether this list contains confidential business information or can be released.
Oregon State University - Small Farms Program	https://smallfarms.oregonstate.edu/
Oregon Department of Forestry-Forest resources: Helping landowners	https://www.oregon.gov/odf/working/Pages/helpinglandowners.aspx
Oregon Department of Agriculture - Grants, Loans, and Technical Assistance	https://www.oregon.gov/oda/agriculture/Pages/Grants.aspx
Oregon Watershed Enhancement Board (OWEB) - Grant Programs	https://www.oregon.gov/oweb/grants/Pages/grant-programs.aspx
Private Forest Accord Report (2022)	https://www.oregon.gov/odf/Pages/private-forest-accord.aspx
Resource Management Plans for Western Oregon (U.S. Bureau of Land Management)	https://eplanning.blm.gov/public_projects/lup/57902/79046/91311/NCO_ROD_RMP_ePlanning.pdf
Agricultural Statistics – ODA, USDA Census of Agriculture	https://www.oregon.gov/oda/agriculture/pages/statistics.aspx
Written input from Upper Yaquina TMDL Rule Advisory Committee	Available from DEQ, upon request

Advisory committee fiscal review

DEQ appointed an advisory committee.

As ORS 183.33 requires, DEQ will ask for the committee's recommendations on:

- Whether the proposed rules would have a fiscal or economic impact,
- The extent of the impact, and
- Whether the proposed rules would have a significant adverse impact on small businesses; if so, how DEQ can comply with ORS 183.540 to reduce that impact.

The committee will review the draft fiscal and economic impact statement and its findings will be stated in the approved minutes.

The committee determines if the proposed rules would or would not have a significant adverse impact on small businesses in Oregon.

[To be completed following input after 2nd RAC meeting]

Upper Yaquina TMDL Rule Advisory Committee members provided the following additional information for consideration regarding impacts to small businesses:

- There are many small farms in the watershed that are not registered as small businesses and report farm income on Schedule D of an individual federal income tax return.
- An unquantified number of investments in rural land ownership, land lease agreements or land management contracts in the watershed could also be considered to be small businesses.

If a significant impact is identified by the committee, as ORS 183.333 and 183.540 requires, the committee will consider how DEQ could reduce the rules' fiscal impact on small business. Committee ideas included:

[To be completed following input after 2nd RAC meeting]

Housing cost

As ORS 183.534 requires, DEQ evaluated whether the proposed rules would have an effect on the development cost of a 6,000-square-foot parcel and construction of a 1,200-square foot detached, single-family dwelling on that parcel. DEQ determined the proposed rules would have no effect on direct or indirect development costs.

Racial Equity

ORS 183.335(2)(a)(F) requires state agencies to provide a statement identifying how adoption of this rule will affect racial equity in this state.

Tribal nations were made aware of the rulemaking process and invited to consult on this matter. Representatives from the Confederated Tribes of the Siletz Indians participated in the local and technical advisory groups convened in 2012 and on the Rule Advisory Committee.

DEQ also engaged extensively with agricultural, forestry, fishery and conservation communities through the local and technical advisory groups convened in 2012 and the Rule Advisory Committee.

The proposed rules are expected to have a positive impact on and help promote racial equity, particularly in benefitting tribal interests. The externalized costs of water pollution often negatively affect poor, rural, indigenous and minority communities in Oregon. The proposed rules will help restore and maintain healthy and abundant fisheries (including subsistence salmonid fisheries common to poor, rural, indigenous and minority communities) and will also restore and protect beneficial uses including water contact recreation and livestock watering.

Alternative formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.

WALTZ David * DEQ

From: MCCOUN Rebecca L * ODF
Sent: Monday, September 26, 2022 2:25 PM
To: WALTZ David * DEQ
Cc: LIVERMAN Alex * DEQ
Subject: RE: Correction -Input: Upper Yaquina TMDL RAC

Corrected acronym in third paragraph.

From: MCCOUN Rebecca L * ODF
Sent: Monday, September 26, 2022 2:22 PM
To: WALTZ David * DEQ <David.WALTZ@deq.oregon.gov>
Cc: LIVERMAN Alex * DEQ <Alex.LIVERMAN@deq.oregon.gov>
Subject: Input: Upper Yaquina TMDL RAC

Hello David and Alex,

Below you will find my comments on the draft Upper Yaquina TMDL fiscal impact document:

Given the DEQ information received and external fiscal information available regarding the details associated with the draft Upper Yaquina Watershed TMDL Plan, I do not have enough information to make an informed assessment on the overall potential fiscal impact of the proposed new TMDL rules for the Upper Yaquina Watershed.

Beginning in 2022, ODF for the first time in its history begun the process of developing a basin specific TMDL implementation plan. As a result, ODF does not have historic fiscal documentation to reference in determining agency costs associated with the process of developing and implementing an ODF Upper Yaquina TMDL implementation plan.

ODF is in the process of revising its Forest Practice Act (FPA) rules based on the 2022 Private Forest Accord (PFA) report and passage of Senate Bills 1501, 1502 and House Bill 4055 during the 2022 legislative session. The new draft water protection, road, and harvesting on steep slopes rules, based on the PFA report and state statutes, will provide greater protection to waters of the state. Implementation of these new ODF rules will be the way in which ODF, as a Designated Management Agency for non-federal forest lands, will administer its TMDL implementation plans. The authors of the Private Forest Accord anticipated the new rules would have a greater fiscal impact on Small Forest Landowners and as a result included the development of ODF Small Forest Landowner Office and incentive programs to assist small forest landowners with the potential impact of the new ODF rules.

Please let me know if you have any questions.

Thank you for the opportunity to provide comment.

Regards,

Rebecca

Rebecca McCoun
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"STEWARDSHIP IN FORESTRY"

WALTZ David * DEQ

From: MCCOUN Rebecca L * ODF
Sent: Thursday, October 6, 2022 11:49 AM
To: WALTZ David * DEQ; LIVERMAN Alex * DEQ
Cc: WHITTINGTON Thomas * ODF; COBLE Adam * ODF
Subject: ODF Section of the draft Fiscal Impact Statement - Revision request

Greetings,

I wanted to follow up with you regarding some of the language under the ODF section in the current fiscal impact statement for the Upper Yaquina TMDL. I was talking with Thomas Whittington and the sentence I bolded below does not necessarily fit ODF's model. The sentence as it is written follows more of the ODA model.

A better fit might be something along the line of

"ODF in administering the FPA rules provide landowners and operators with technical assistance and guidance on forest operations rule implementation."
If we write this as if the new PFA rules have passed (after Oct/Nov 2022) we could then go on to note:
"The recently revised ODF Water Protection Rules, Road Rules and Steep slope rules will provide greater protections to the waters of the state. ODF is in the process of developing a Small Forestland Owner program and office to assist small forestland owners with the new rules. The ODF SFO program will offer incentives for small forest landowners to improve stream crossings, roads and increase stream buffers. The new rules and incentive programs will not go into effect on January 1, 2024. Possibly provide a link.
Additional information on SFO below.

Currently, ODF does not have a lot of financial incentives other than the incentive to not get a violation for failing to follow rules. Most financial incentives that are available are through other organizations. How it is written now makes it sound like ODF offers financial incentives to implement restoration.

When it comes to TMDL requirements, ODF is responsible for developing TMDL implementation plans and tracking and reporting effort towards meeting the designated reduction targets through the implementation of the FPA rules, monitoring of forest activities, and public education/outreach. The way it is worded below does not seem to be reflective of how ODF is operating. Again, we would like to revise the paragraph. Ideally, to be reflective of pending new rules and to clearly explain how ODF will be carrying out its DMA obligations through FPA rule implementation, enforcement, compliance monitoring, and reporting.

Current Language:
Oregon Department of Forestry is responsible for developing plans for management strategies and overseeing implementation of practices to achieve nonpoint source pollutant load allocations and meet water quality standards on non-federal forestlands (state, county, and private) within the watershed, perform annual reporting and participate in monitoring and periodic progress reviews. Per ODF authorities described in state statues and rules, a mix of existing practices, programs and voluntary measures are promoted for implementation to improve or protect water quality, land condition and aquatic habitat on non-federal forestlands. Compliance costs for ODF and individual forestland owners/operators will be not different for implementing TMDLs issued by department order than TMDLs adopted as rules. **Financial incentives and technical assistance programs are available to assist private forest landowners /operators to support implementation of assessment, pollution controls, watershed restoration activities or landscape improvements that may be necessary for compliance with TMDL requirements**

Regards,

Rebecca

____

Small Forestland Owners – One Pager

Summary:

The Private Forest Accord (PFA) recognizes that small forestland owners (SFO) are inherently different from industrial landowners in their capabilities, property locations, and size. SFO's value and manage their properties for a variety of benefits, including but not limited to timber production.

The defining criteria of an SFO are provided in statute and in the proposed FPA rules as follows:

- Owns wholly or in part less than 5,000 acres of forested land in Oregon
- Has harvested no more than 2 million board feet per year on average of timber in the last three years
- Does not expect to harvest more than 2 million board feet per year over the next 10 years

When submitting a Notification of Operation, landowners may self-certify that they meet the above criteria.

Assistance for Small Forestland Owners:

Senate Bill 1501 directed ODF to establish a Small Forestland Owners Assistance Office to aide small forestland owners in understanding and following forest practices regulations. The SFO Assistance Office will provide technical assistance, supporting services, and administer incentive programs—including two new incentives: the Small Forestland Investment in Stream Habitat (SFISH) and the Forest Conservation Tax Credit.

Small Forestland Investment in Stream Habitat:

This program is managed by SFO Assistance Office in consultation with Oregon Department of Fish and Wildlife. The program prioritizes high value conservation sites, including areas of chronic sedimentation, fish passage blockages, stream diversions and perched fill.

The program provides the financial means via grants for road improvement projects for the greatest species and natural resource benefit. SFO would apply for state funds to complete voluntary projects through the SFISH program for road repairs to meet the new forest road standards in Forest Practices Act rules.

Forest Conservation Tax Credit:

This is a tax credit program to financially incentivize SFO to adopt the standard practice riparian area prescriptions over the SFO minimum option when conducting a timber harvest. The tax credit amount is for the stumpage value of the forest conservation area—the strip of riparian area between the standard practice and minimum option buffer zones. The forest conservation area is filed as a deed restriction at the county office by the SFO. Once filed and a tax credit has been issued, the current SFO and any future owners are restricted from harvesting in the forest conservation area for a 50-year period. If the forest conservation area is removed, the original owner would need to repay the amount of credit utilized. If the property changes ownership, the new landowner would need to repay the original (full) amount of the credit.

The credit is applied to the SFO's tax liability, is transferable to their heirs, and can be applied year after year until it has been depleted. Forms for filing with the county office and the Department of Revenue will be available from the Small Forestland Owner Assistance Office.

Let me know if you would like to set up a meeting to discuss further.
Thank you.

Rebecca

"STEWARDSHIP IN FORESTRY"

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WALTZ David * DEQ

From: MCCOUN Rebecca L * ODF
Sent: Friday, October 28, 2022 2:25 PM
To: WALTZ David * DEQ; LIVERMAN Alex * DEQ
Subject: ODF_ Upper Yaquina FIS Suggested Revisions 10-28-22

Hello David and Alex,

Below are my edits/input for the FIS version 2. The document provided was a PDF. I had a hard time adding comments to it. Edits highlighted.

Note: The Board of Forestry passed the new and revised FPA rules on Wednesday 10-26-22. The stream buffer rules go into effect for the large landowners (>5000 acres) July1, 2023. All the other new & revised rules will go into effect for everyone January 1, 2024.

Link to adopted FPA rules: https://www.oregon.gov/odf/board/documents/laws-rules/forest-practices-act-rule-revisions.pdf
Possibly add link to table.

Suggested Revisions – R. McCoun p 6
Within several years, the majority of compliance costs for natural resource protections for industrial forestland owners may be associated with the recently revised Forest Practices Act rules developed from legislation associated with the Private Forests Accord rather than this rule. The new stream buffer rules go into effect for the large landowners (>5000 acres) on July1, 2023. All other new & revised FPA rules will go into effect January 1, 2024 .

Suggested Revisions- R. McCoun p 7
Both Oregon Department of Agriculture and Oregon Department of Forestry have rules and programs in place that require a mix of regulatory and voluntary practices by agricultural and forest landowners to protect or improve water quality. In October 2022, the Board of Forestry passed new and revised FPA rules based on the 2022 Private Forest Accord report and passage of Senate Bills 1501 and 1502 and House Bill 4055 during the 2022 legislative session. The new FPA rules will go into effect January 1, 2024. The authors of the Private Forest Accord anticipated the new rules would have a greater, but unquantified fiscal impact on small forest landowners. Compliance costs for implementing ODA and ODF rules are not dependent on TMDLs. Some of these costs may be offset by preventing erosion or improving the productivity of certain agricultural and forest lands. However, compliance administrative and implementation costs are not different for implementing TMDLs issued by department order compared to TMDLs adopted as rules.

It would be nice to have some sort of administrative process included in the FIS and/or TMDL rule making process that would allow the fiscal impact to be re-evaluated after so many years of implementation. Values and cost of water for the Upper Yaquina River Watershed. Here is an example of a "economic value" assessment of a give geography: http://northsantiam.org/wp-content/uploads/Economic-Importance-of-Water-in-NSW_FINAL_2019.pdf

One last comment, p 11

“The proposed rules will help restore and maintain healthy and abundant fisheries (including subsistence salmonid fisheries common to poor, rural, indigenous and minority communities) and will also restore and protect beneficial uses including water contact recreation and livestock watering.”

Above statement seems overstated: Rules will reduce sediment, reduce nutrient loading, provide more shade, hopefully increase DO. which are limiting factors to the recovery of fish, etc. These are things DEQ can measure over time. So many factors play a role in recovery of fish and improved water quality. Climate change may have an impact that negates the benefits or make the TMDL goals unattainable. Having more direct statements may help with future fiscal impact assessments.

Thank you for giving me the opportunity to provide input.

Rebecca

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"STEWARDSHIP IN FORESTRY"

Importance of Water in the North Santiam Basin

An Economic Description

January 30, 2019

Prepared for:

North Santiam Watershed Council

Final Report

ECONorthwest
ECONOMICS • FINANCE • PLANNING

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Acknowledgments

For over 40 years ECONorthwest has helped its clients make sound decisions based on rigorous economic, planning, and financial analysis. For more information about ECONorthwest: www.econw.com.

ECONorthwest prepared this report to the North Santiam Watershed Council and the Oregon Business Council. We received substantial assistance from the many individuals and organizations who live in or make their living in the North Santiam Watershed, and we appreciate their willingness to share data, stories, and provide thoughtful feedback.

This project is funded by resources from the Meyer Memorial Trust, Marion SWCD, Marion County, North Santiam Watershed Council.

That assistance notwithstanding, ECONorthwest is responsible for the content of this report. The staff at ECONorthwest prepared this report based on their general knowledge of the economics of water, and on information derived from government agencies, private statistical services, the reports of others, interviews of individuals, or other sources believed to be reliable. ECONorthwest has not independently verified the accuracy of all such information, and makes no representation regarding its accuracy or completeness. Any statements nonfactual in nature constitute the authors' current opinions, which may change as more information becomes available.

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Summary

People have enjoyed relatively clean, reliable flows from the North Santiam Watershed (NSW) for many generations. In the last 100 years, the intensity of demand for water has increased, and the NSW has met those demands. However, larger trends affecting water resources in the NSW and throughout Oregon are generating concern that the NSW may in the future not be able to meet the full range of demands without changing the way the people who depend on the watershed's resources think about its management. Climate change, population growth, and declining populations of threatened salmon are among these pressing trends.

It is against this backdrop that the North Santiam Watershed Council and the Oregon Business Council approached ECONorthwest to compile economic information about water use and value in the NSW. Assembling this information will help watershed managers, water users, and other stakeholders identify and prioritize actions intended to improve the quantity, quality, and distribution of water or water-related goods and services in the NSW. It may also help managers secure resources for and justify investments in the watershed's water-related built and natural infrastructure.

This report presents the results of research in which we compiled important findings from other studies, interviewed over a dozen stakeholders, and engaged many more in providing information. The goal of this report is not to produce a single value of the water flowing out of the NSW. The demand for and value of water varies depending on time, place, and character of use. The data we have compiled reflects some, but almost certainly not all of this variability. The information provided here is appropriate for informing planning-level decisions to identify opportunities for better management outcomes, understand potential tradeoffs, support priorities for future investments, and to serve as a starting point for more detailed study of the economic outcomes of specific projects.

The table below summarizes the economic information available to characterize the value associated with each category of demand included in the analysis. The categories reflect the major uses designated by OWRD on water rights, and the demands for water that do not require a water right but benefit from water available instream. In all cases, ***the estimates represent the general scale of value associated with each use of water***, rather than precise estimates. Wherever possible, we used assumptions that likely yield conservative estimates of value, and describe factors that may indicate the likelihood of additional, unquantified value. For this reason, we discourage readers from summing these values into a total. Instead, we provide these values to illustrate the general magnitude of value water users derive from different uses of water from the NSW.

Table S1. Summary of Demand for and Associated Economic Value of Water from the NSW

Description of Use[1]	Percent of Total Surface Water Rights	Scale of Quantified Economic Value (2018 Dollars) and Unquantified Economic Importance
Instream Flows for Aquatic Species and Habitat[2]	42%	The value Oregon households place on recovery of Upper Willamette River Chinook across their range within 50 years is estimated at **$621 million**. Recovery in the NSW is necessary but not sufficient for delisting. Research shows that households outside of Oregon also value recovery and delisting of the species, and to the extent their value is included in the estimate, it would be higher. Recovery of salmon is likely to some extent a proxy for people's value of healthy ecosystems that sustain life in many forms.
Water-Related Recreation	No Right Required[3]	Estimated annual visitation at recreation sites throughout the NSW is at least 500,000 visits per year, with an estimated value (not including spending on trip-related expenses) of **$36.5 million.**
Aesthetics	No Right Required[4]	Property value uplift from proximity to waterways varies by characteristics of the property and waterway, with higher contributions in urban areas and lower contributions in rural areas. An important aesthetic value supported by the NSW is flow augmentation of Mill Creek, which runs through Salem and would otherwise be dewatered during the summer months when workers, residents, and visitors are most likely outdoors enjoying it. Research indicates that riverfront views may add between **10 and 30 percent** to the value of property in places where there is differentiation in quality of scenic character across properties.
Electricity Generation	26%	The estimated value of hydropower generated at Detroit and Big Cliff Dams in 2017 was **$7.8 million**. This amount varies somewhat from year to year based on flows. The estimated value of the avoided CO_2 emissions associated with the power generated in 2017 was **$19.8 million**. Smaller hydropower facilities in the NSW generated electricity, the value of which is not included in these totals.
Municipal and Industrial	19%	The estimated value, in terms of the annual amount invested in water supply infrastructure and water availability by the users of water in the NSW communities and Salem is **$66 million.** This does not include the value associated with diversions from the Santiam River for Jefferson, Albany, and Millersburg, or direct diversions for industrial use. The value of the goods and services produced with this water is likely much higher, but that production is the product of many more inputs in addition to water. The value to residential households of avoiding shortages of water in the future that would impose mandatory curtailment for outdoor use ranges from **$2.0 to $3.6 million** per year that shortages are avoided.
Irrigated Agriculture	8%	At least 23,867 acres of land in Marion and Linn Counties are irrigated with water from the NSW. The estimated annual value of crops produced on these acres is **$59.8 million.** The actual value is almost certainly higher because this does not include acres of irrigated land outside of the two districts for which we had data.
Cultural and Tribal	No Right Required[5]	Cultural values for natural resources held by members of Tribal nations are distinct from instream values, recreational use, and aesthetic use. Tribal cultural well-being is the product of intensive and complex uses of resources, knowledge and relationships with the natural environment. Interaction with water resources in the NSW provides goods and services and additional cultural services including a sense of place and the sharing of cultural experiences between generations. This value is unquantifiable in monetary terms, but considered in this report of significant importance.
Public Health and Well-being	No Right Required	Ecosystem-mediated effects link water to public health and well-being through air quality improvement and access to "green" and "blue" spaces, generating improvements in mental and physical health and enhancements to individual and community identity and cohesion. While these are not distinct "uses" of water, they are effects not captured in other categories. Limitations in data and methods prevent quantification of most of these benefits at a watershed scale at this time, but the research suggests positive economic effects likely exist that are not otherwise accounted for in this report.

Notes: [1]We derived these categories from the use codes in OWRD's database of water rights (WRIS) and organized into these groupings based on similarity of demand, to simplify the analysis. [2] Includes Instream, Fish, and Wildlife use codes from OWRD's database of water rights. [3] Recreation is identified as a use in OWRD's database and has a small amount of flow associated with it, but most recreation demand does not require a water right, and derives from instream flows. [4] Aesthetics is identified as a use in OWRD's database and has a small amount of flow associated with it, but most aesthetic demand does not require a water right, and derives from instream flows. [5] While a water right is not required, tribes do have trust responsibility for natural resources and treaty rights.

Towards a Regional Water Management Plan

The information we provide here can inform decisions about future water policies and investment decisions. By having a better understanding of how water is used today and how important trends may impact the value of water from the NSW in the future, managers can look for opportunities to protect and enhance the value people derive from water. The case studies in Section 5 of this document illustrate some of these potential opportunities. Several themes emerged from these case studies that may have implications for future regional planning efforts and management decisions in the NSW:

- Many of the uses of water from the NSW are inherently complementary, meaning increasing demand for one will not increase scarcity or reduce the value of the others. For example, instream flows for fish also support recreation demands and aesthetic values. Because of the way infrastructure is currently designed, instream flows also facilitate efficient operation of Salem's diversion and treatment systems.
- Identifying how water use generates economic value helps to illuminate how economic sectors that demand water for different purposes are dependent on each other. For example, demand for irrigation water produces crops that are processed by companies that demand water for cooling and sanitation. Both sectors are dependent on water for different purposes, and dependent on each other to remain productive. Similarly, demand for municipal water in the canyon communities supports services for recreation users, who demand water for swimming, boating, and enjoy water near recreation areas.
- The distribution of costs and benefits arising from changes in management of the NSW over the years have not necessarily been equitable, meaning the beneficiaries of the actions have not borne the same share of costs as they have enjoyed in benefits. Many of the challenges the communities in the NSW face are the result of increased costs resulting from management actions taken to provide benefits to communities downstream. Future trends and actions may reinforce or even increase the disparity. Understanding who enjoys the benefits and who bears the costs of actions is critical to addressing many of the economic challenges facing the communities in the NSW, and this report helps to document this.

The "baseline" values reported here provide information about the relative magnitude of demand from different sectors and the general scale of value under current conditions. This information is useful for supporting regional planning efforts and developing high-level strategies that require some level of common understanding and shared purpose across a broad set of interrelated stakeholders. Additional analysis would be required to understand how specific policies or management actions affect specific users and the value they derive from water at a specific time and place. That is a different undertaking, which would yield more precise estimates of the net economic value (benefits minus costs) of actual changes in the timing and availability of water for specific users. Additional economic analysis may be warranted to understand implications of decisions on the jobs, incomes, and tax revenues arising from changes in supply of and demand for water. Thus, the information and conclusions provided here should be taken as a starting point toward deeper understanding of a complex system.

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1 Introduction

1.1 Background

The North Santiam watershed (NSW) is a tributary within the Willamette River Basin in western Oregon. The North Santiam River flows through the watershed east-west for approximately 100 miles, draining an area approximately 766 square miles (almost 500,000 acres). Its headwaters are located in the central Oregon Cascades, much of which is part of the Willamette National Forest on the western slopes between Mount Jefferson and Three-Fingered Jack. Its confluence with the Willamette River is at the Willamette Valley floor.

Highway 22, a primary transportation route connecting population centers in the Willamette Valley with those in central Oregon, follows the North Santiam for much of its length. Small communities are located along Highway 22 and the river. Popular recreation sites and access points connect people to the river and its tributaries. In the heart of the watershed is Detroit Dam, managed by the U.S. Army Corps of Engineers, which provides flood control and energy production, and offers recreation opportunities. As the river reaches the western half of the watershed, farmland of orchards, pastures, and annual field crops largely replace forests. Here, several smaller dams divert water into pipes and canals conveying it north, west, and south for irrigation, municipal, and aesthetic uses. Twelve miles before its confluence with the Willamette River, the North Santiam is joined by the South Santiam, forming the Santiam River. The NSW includes this portion of the Santiam River.

Within this portrait of the NSW, people have enjoyed relatively clean, reliable flows for many generations. In the last 100 years, the intensity of the demands for water has increased, and the NSW has met those demands. However, larger trends affecting water resources in the NSW and throughout Oregon are generating concern that the NSW may in the future no be able to meet the full range of demands without changing the way the people who depend on the watershed's resources think about its management.

- Salmon recovery efforts have mandated actions to improve habitat and remove barriers to migration and survival, including minimum dedicated streamflow, fish passage improvements, and investments in temperature control measures at Detroit Dam that could result in temporary drawdowns of Detroit Lake.
- Climate change has the potential to change the timing and form of precipitation the NSW receives, shifting more precipitation from snow to rain. This loss of snowpack could shift the quantity and timing of runoff, with implications for how water is stored, and the potential to increase the frequency and magnitude of water scarcity, especially during the summer months.
- Patterns of population and development have shifted, as communities in the lower reaches of the NSW and downstream on the Willamette River grow, and communities in the upper reaches of the NSW experience declines and shifts in economic opportunities

away from timber-dependent industries. Combined with climate change-induced physical changes, increasing population demands from downstream communities may increase the economic importance of the North Santiam to the whole Willamette Basin.

It is against this backdrop that the North Santiam Watershed Council and the Oregon Business Council approached ECONorthwest to compile economic information about water use and value in the NSW. Assembling this information will help watershed managers, water users, and other stakeholders identify and prioritize actions intended improve the quantity, quality, and distribution of water or water-related goods and services in the NSW. It may also help managers secure resources for and justify investments in the watershed's water-related built and natural infrastructure.

1.2 Methods

This report describes the economic importance of water originating in the NSW. Understanding the economic importance of water entails identifying the many ways water is used, both directly (e.g., for drinking or boating) and as an input into other goods and services people find valuable (e.g., food production or habitat for species that people care about). Water has economic importance to the extent that it contributes to things that people care about.[1] To describe the economic importance of water, we step through an analysis in three parts.

- In the first step, we identify the characteristics of the supply of water in the North Santiam Basin: how much water is available at what times? What is the quality of the water?
- In the second step, we identify the ways people use water from the NSW, or allocate water to specific uses (e.g., for instream flows). In economic terms, these uses represent demand for water. The amount of water demanded is specific to water with a specific characteristic (e.g., quality) at a particular time, place, and price. To the extent possible, we identify information relevant to understanding these dimensions of demand.
- In the third step, we provide information to help understand the value of water associated with each demand. For some uses of water, the economic value can be quantified in monetary terms. For other uses, the value may not be quantifiable in monetary terms, but can be described qualitatively. Where local information about value is not available, we use an economic technique called benefit transfer to apply relevant values from studies of similar uses elsewhere.

The goal of this report is not to produce a single value of the water flowing out of the NSW. To do so in an academically rigorous and defensible way would require a much more comprehensive and analytical exercise involving original data collection that is beyond the

[1] Some people may argue that water has intrinsic value, independent of how people use or value it. This project takes an anthropocentric view that water is important because people use it or otherwise care about things dependent on it. For example, water for habitat has importance because people care about the habitat and the things it produces (e.g., fish, a place to relax, an opportunity for experiencing connection to nature). This framework employs a broad definition of "use" or "things dependent on it," including intangible "things," such as experiences.

scope of this project. Instead, we compile available information about the quantity of use and the general magnitude of value based on observed prices or values quantified in other studies. The information provided here is appropriate for planning-level decisions to help weigh certain tradeoffs, identify opportunities and priorities for future investments, and to serve as the basis for more detailed study of specific projects. To illustrate how information may be used in the context of specific challenges the NSW is currently facing, the last section of this report provides brief examples of how the information may be relevant to specific topics.

A Note about Jobs: From an economist's perspective, while labor is an important input in the production of goods and services, jobs are not a measure or indicator of the economic value of goods and services. Thus, when we talk about "benefits" or "value" of water, we do not include jobs in that discussion. While employment outcomes can be one dimension of the economic importance of water to a community—and we discuss the topic in several places within this report—it is not the focus of this report.

This report is the culmination of Phase 2 of a two-phased project. In the first phase, ECONorthwest staff reviewed relevant data and reports on the NSW, and discussed with staff and stakeholders of the North Santiam Watershed Council their priorities and needs to support future planning and management efforts. Out of that process, we collectively concluded that a baseline economic description of water uses was missing among the information currently available, and ECONorthwest developed the Phase 2 scope of work to develop this information.

To complete this report, ECONorthwest, Oregon Business Council, and the North Santiam Watershed Council convened a stakeholder meeting to present the project plan and identify potential sources of information missing from the Phase 1 review.[2] During that meeting, numerous individuals offered, on behalf of their organizations, to provide specific data. ECONorthwest followed up with these individuals, and conducted additional interviews to compile a more complete picture of water use in the NSW. The results of those interviews are folded into the sections that follow. A list of individuals contacted in the scope of the research is included in Appendix A.

[2] Phase 1 deliverables are available upon request from the North Santiam Watershed Council.

1.3 Organization of this Report

This report begins in **Section 2** with a description of the NSW: its physical characteristics, including water supply and water quality, socioeconomic setting (land use, political jurisdictions, demographics), and the regulatory/policy landscape as it applies to water resources. This information provides context for the rest of the report.

Section 3 describes the demand for water and estimated economic value associated with each use. This section also describes current and expected future trends that may affect the demand and value of water in the NSW.

Section 4 provides illustrative case studies of three water-related issues that NSW stakeholders and water users have expressed concern about during our initial reconnaissance efforts in Phase 1 and interviews in Phase 2.

The **Summary** at the beginning of this document summarizes the major findings of the report and offers suggestions about how the information might be used in the future as part of the ongoing planning and management efforts underway in the NSW.

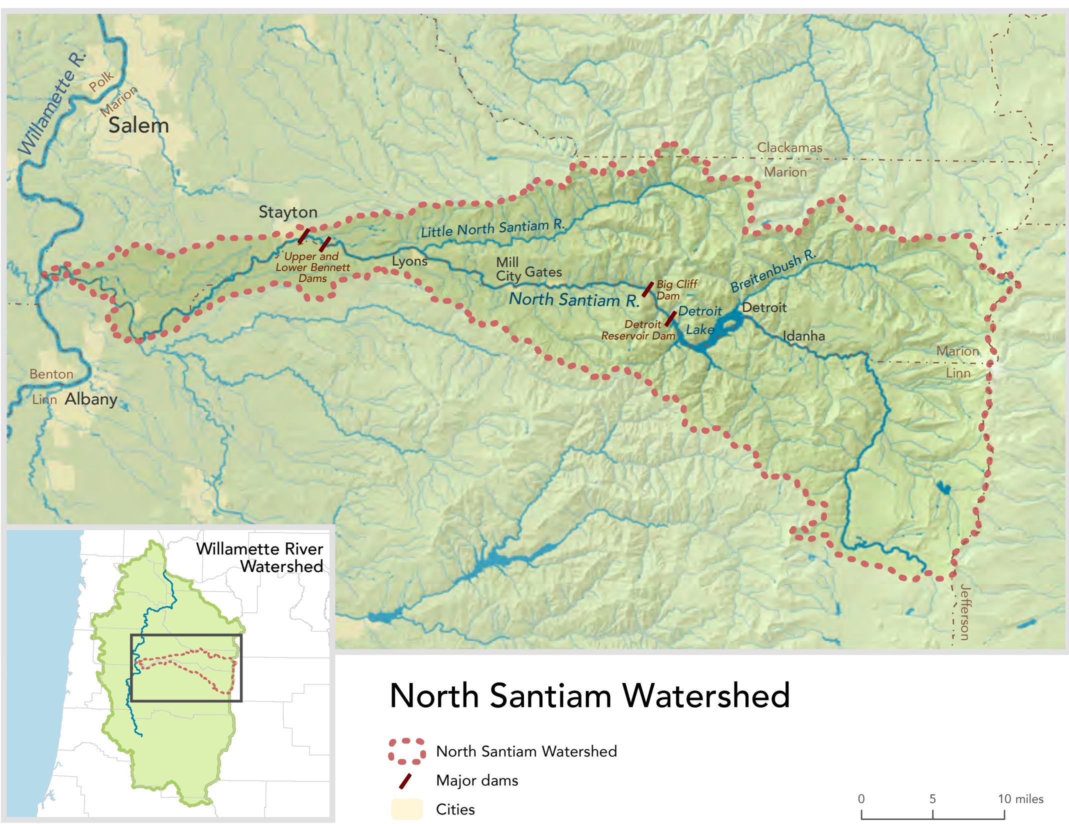
2 Description of the North Santiam Watershed

In this section, we describe the characteristics of the NSW that are relevant to understanding its economic importance. This includes physical characteristics that both support and limit the economic productivity of the watershed, and the socioeconomic systems that interact with and depend on the resources produced within the watershed.

2.1 Physical Description

The NSW occupies about 490,000 acres within the larger Willamette Watershed, located in the heart of northwestern Oregon. It represents about 6.6 percent of the total area of the Willamette Watershed. The NSW headwaters flow from the flanks of Mount Jefferson and Three Fingered Jack, in the Willamette National Forest and the Jefferson Wilderness Area. The North Santiam River traverses about 100 miles as it flows to the west, joining the Santiam River about 12 miles before the Santiam's confluence with the Willamette River between Salem and Albany. Figure 1 shows the boundaries of the NSW, and the major hydrologic and political features.

Figure 1. Map of the North Santiam Watershed



Source: ECONorthwest

2.1.1 Precipitation

Reaching from the Willamette Valley (nearly sea level) to the peaks of the Cascade Mountains (3,200 meters above sea level), the NSW receives precipitation in the form of both rain and snow.[3] Average annual precipitation ranges from 40 inches at the Valley floor, to 90 inches at Detroit Dam.[4] Average annual snowpack in the mountains is 91 inches; much of the precipitation that falls in the upper watershed is stored as snowpack and released as meltwater, contributing runoff to streams and infiltrating to groundwater with the spring thaw. The U.S. Geological Survey (USGS) estimates that up to one-half of the precipitation in the high Cascade Mountains seeps into the groundwater system.[5]

2.1.2 Water Storage

At least four significant dams serve multiple purposes within the NSW (Figure 1). These dams change the natural flow regimes of the North Santiam River by storing water and discharging it later in the year, and by diverting water for consumption and use within and outside of the NSW.

In the middle of the NSW sit two U.S. Army Corps of Engineers (USACE) dams: Detroit Dam and Big Cliff Dam. Constructed in 1953 as part of the larger Willamette Valley Project (Willamette Project),[6] the U.S. Congress authorized these dams and several fish hatchery projects within the NSW with a primary purpose to store spring runoff and mitigate downstream flooding.[7] Both dams also generate hydropower. Detroit Dam has a hydropower generation capacity of 100 megawatts; Big Cliff Dam has a capacity of 18 megawatts. Big Cliff dam is a re-regulation dam and is directly downstream of Detroit Dam to adjust water levels.[8] Behind Detroit Dam sits Detroit Lake, which has a storage capacity of 455,000 acre-feet when full and 281,600 acre-feet when drawn down in the summer, with a useable storage capacity of 321,000 acre-feet.[9] In addition to providing flood control and hydropower, the Bureau of Reclamation manages some of the water for irrigation and the lake itself provides opportunities for flat-water recreation. The recreation infrastructure associated with Detroit Lake is discussed in more detail below. Finally, the USACE built Minto Dam (not shown in Figure 1), a 10-foot

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[3] U.S. Geological Survey. 2017. *North Santiam River Basin, Oregon.* Retrieved September 24, 2018, from https://or.water.usgs.gov/proj/or00311/detroit_lake/nsantiam_basin.html

[4] U.S. Geological Survey. 2007. *Description of the North Santiam River Basin.* Retrieved September 24, 2018, from https://pubs.usgs.gov/sir/2007/5178/section3.html

[5] Ibid.

[6] Congress authorized Detroit Dam as part of the Willamette Valley Project in the Flood Control Act of 1938.

[7] U.S. Army Corps of Engineers. 2018. Detroit Dam and Lake. Retrieved May 3, 2018 from: http://www.nwp.usace.army.mil/Locations/Willamette-Valley/Detroit/.

[8] U.S. Army Corps of Engineers. 2018. Big Cliff Dam and Reservoir. Retrieved May 3, 2018 from: http://www.nwp.usace.army.mil/Locations/Willamette-Valley/Big-Cliff/.

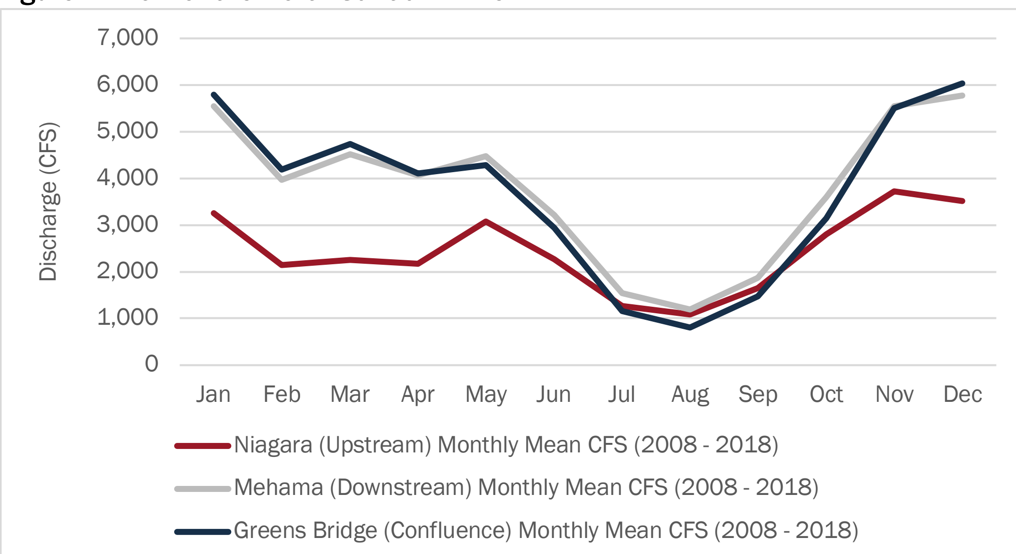
[9] Risley, J.C. et al. 2012. *An Environmental Streamflow Assessment for the Santiam River Basin, Oregon.* U.S. Geological Survey and U.S. Army Corps of Engineers. Open-File Report 2012-1133. Retrieved October 3, 2018, from https://pubs.usgs.gov/of/2012/1133/pdf/ofr20121133.pdf

fish diversion structure, to support the fish hatchery operations that mitigate the effect on fisheries from the Willamette Project.[10] In addition to the USACE dams, there are two dams used for water diversion that are owned by the City of Salem and Santiam Water Control District at river miles 29 and 31.5: Lower Bennett Dam (5.3-feet high) and Upper Bennett Dam (5.7-feet high).[11] These dams also divert water used by the Santiam Water Control District.

2.1.3 Water Supply

The water that accumulates in the North Santiam River and its tributaries is a combination of runoff from precipitation and snowmelt, and seepage from groundwater springs. This, coupled with flow-regulation provided by the dams, ultimately results in an average rate of streamflow in the North Santiam River of between 1,086 and 6,036 cubic feet per second (CFS), depending on the season and location. Figure 2 shows the discharge at three stream gages on the North Santiam River.

Figure 2. Flow of the North Santiam River



Source: ECONorthwest, with data from U.S. Geological Survey. 2018. *National Water Information System: Mapper.* Retrieved September 24, 2018, from https://maps.waterdata.usgs.gov/mapper/?state=or

The Niagara gage is located just downstream of Big Cliff Dam. The Mehama gage is located mid-way along the river course toward its confluence with Willamette River, after joining with the Little North Santiam, which is the largest tributary to the North Santiam. The Greens Bridge gage is located just upstream of the confluence with the South Santiam River.[12] Streamflow declines and reaches its lowest levels during the dry season between July and September.

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[10] Ibid.

[11] U.S. Army Corps of Engineers. 2018. North Santiam Subbasin Fish Operations Plan.

[12] U.S. Geological Survey. 2018. *National Water Information System: Mapper.* Retrieved September 24, 2018, from https://maps.waterdata.usgs.gov/mapper/?state=or

These streamflow measurements are all below Detroit and Big Cliff Dams. Since they began operating in 1953, these dams have regulated the flow regimes in the North Santiam River, providing baseflow during the summer months that is higher than pre-dam flows, and reducing the flow levels during the winter and spring.

2.1.4 Groundwater

Groundwater resources are most plentiful in the lower reaches of the NSW, in alluvial aquifers. Aquifers in the upper reaches of the NSW are volcanic in nature and are highly variable in supply and productivity.[13] The Oregon Water Resources Department has classified areas near the North Santiam Basin as groundwater restricted areas. These classified designations include South Salem Hills, Kingston, and Stayton-Sublimity. There are limitations to new groundwater uses in these areas to protect against groundwater level declines.[14] Marion County also has a Sensitive Groundwater Program which it uses when reviewing land use applications within the monitored areas.[15]

2.1.5 Water Quality

As required by the Clean Water Act, the Oregon Department of Environmental Quality (DEQ) assesses water bodies statewide for water quality issues through its Integrated Water Quality Assessment process.[16] This process identifies water bodies in which regulated pollutants may adversely affect water quality. Impaired water bodies are listed on the 303(d) list, and DEQ must develop a Total Maximum Daily Load limit for the relevant pollutant to improve water quality. In the NSW, there are 24 listings requiring TMDLs, shown in Table 1.

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[13] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

[14] Oregon Water Resources Department. 2018. *Groundwater Restricted Areas.* February 23. Retrieved September 27, 2018, from http://apps.wrd.state.or.us/apps/gis/gis_map_library/gis_view_image.aspx?gis_library_image_id=1136

[15] Marion County. 2015. *Sensitive Groundwater Program.* Retrieved September 27, 2018, from https://www.co.marion.or.us/PW/Planning/zoning/Pages/Sensitive-Groundwater-Program.aspx

[16] Oregon DEQ completed the most recent water quality assessment in 2012. Data collection efforts are underway for the 2018 Integrated Assessment, but result are not yet available. See Oregon Department of Environmental Quality. 2018. *Water Quality Assessment.* Retrieved September 24, 2018, from https://www.oregon.gov/deq/wq/Pages/2018-Integrated-Report.aspx

Table 1. Waterbodies in the NSW Listed by DEQ for Pollutants in 2012

Pollutant	Criteria	Water Body	Status
Temperature	Core cold water habitat: 16.0 degrees Celsius 7-day-average maximum Salmon and trout rearing and migration: 18.0 degrees Celsius 7-day-average maximum Salmon and steelhead spawning: 13.0 degrees Celsius 7-day-average maximum	Bear Branch Big Creek Chehulpum Creek Elkhorn Creek Little North Santiam River Marion Creek North Santiam River Santiam River Sinker Creek Stout Creek	TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved TMDL Approved
Biological Criteria	Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.	Blowout Creek Breitenbush River South Fork Breitenbush River	TMDL Needed TMDL Needed TMDL Needed
Aquatic Weeds Or Algae	The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or which are injurious to health, recreation or industry may not be allowed.	Marion Creek/Marion Lake North Santiam River/ Detroit Reservoir	TMDL Needed TMDL Needed
Dissolved Oxygen	Spawning: Not less than 11.0 mg/L or 95% of saturation	North Santiam River Santiam River	TMDL Needed TMDL Needed
Mercury	Human Health Criteria for Toxic Pollutants	Santiam River	TMDL Needed
Sedimentation	The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed.	South Fork Breitenbush River	TMDL Needed

Source: ECONorthwest, with data from Oregon Department of Environmental Quality. 2012. *2012 Integrated Report*. Retrieved September 24, 2018, from https://www.deq.state.or.us/wq/assessment/rpt2012/results.asp

Although DEQ has identified six pollutants that impair waters to an extent that a TMDL is required, it has only developed allocations for a TMDL for temperature.[17] The temperature criteria set depends on the water bodies, but ranges from 13.0°C (55.4°F), which is based on salmon and steelhead spawning needs, 16.0°C (60.8°F), which is based on core cold water habitat needs, or 18.0°C (64.4°F), which is based on salmon and trout rearing and migration needs. The Willamette Basin Biological Opinion, which assessed the effect of the Willamette Project's effects on survival of several anadromous species, set monthly temperature targets for the North Santiam River below Big Cliff Dam, ranging from 38°F to 42°F in January and February to 52°F to 55°F in July and August.[18] These targets are driving the temperature control tower retrofit plans at Detroit Dam, discussed in more detail elsewhere in this report.

[17] Oregon Department of Environmental Quality. 2006. "North Santiam Subbasin TMDL." *Willamette Basin TMDL*. Retrieved September 24, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[18] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion*. Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion/

DEQ has listed Detroit Lake for algae, but has not yet developed a TMDL. Like many other water bodies in Oregon, blue-green algae is a persistent issue at Detroit Lake. When levels of cyanotoxins resulting from the algae blooms reach a high level, generally in the summer months as water temperatures increase, the Oregon Health Authority will issue advisories to avoid drinking or contacting the water, especially for children and pets.[19] Before 2018, only recreational advisories had ever been listed. In the summer of 2018 both a recreational and drinking water advisory were issued. It is unclear what is causing the algae blooms in Detroit Lake, but increased phosphorous and temperatures are known to lead to algae blooms.[20] Much of the phosphorous in the lake is naturally occurring, but some is anthropogenically introduced from runoff due to timber harvest activities and road construction.[21]

Despite a TMDL for bacteria being in place for the Willamette River, there is not currently an allocated TMDL for bacteria on the North Santiam. Through the Willamette TMDL, DEQ established targeted reductions for fecal bacteria from agricultural areas, ranging from 66 to 83 percent, and urban areas, ranging from 80 to 94 percent relative to current concentrations. According to the DEQ, the North Santiam River is "relatively uncontaminated" with fecal bacteria and serves as a dilution mechanism for the relatively more contaminated Willamette River.[22]

2.1.6 Terrestrial and Aquatic Habitat and Species

The North Santiam Watershed Council's *Watershed Restoration Action Plan* identifies the types of habitat within the NSW that provide conservation opportunities for terrestrial and aquatic species consistent with the Oregon Department of Fish and Wildlife's Conservation Strategy. These range from the aquatic and riparian habitat provided by the North Santiam River and its tributaries, to the oak savannah and woodlands in the uplands of the lower and middle reaches of the watershed, to the late successional Douglas-fir forests in the upper portions of the watershed. These habitats support a range of species, including fish and amphibians, birds, and plants.

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[19] Wang, A. 2018. "Detroit Lake Residents, Visitors Warned of Toxic Algae Bloom." *The Oregonian.* May 18. Retrieved September 24, 2018, from https://www.oregonlive.com/pacific-northwest-news/index.ssf/2015/05/detroit_lake_algae_bloom.html

[20] Personal communication with Kurt Carpenter, Hydrologist, U.S. Geological Survey, on June 1st, 2018.

[21] Ibid.

[22] Oregon Department of Environmental Quality. 2016. "Chapter 2: Willamette Basin Bacteria TMDL". *Willamette Basin TMDL.* September.

Table 2. Key Habitats and Species within the NSW

Location within the NSW	Key Habitat	Key Species
Lower NSW and NS River	Aquatic Floodplain and forests Riparian Wetlands and Wet Prairie	Riparian Birds Oregon Chub (fish) Winter Steelhead (fish)
Lower NSW	Grassland and Oak Savanna Oak Woodlands	Western Meadowlark (bird) Bradshaw's Lomatium (plant) Oregon Larkspur (plant) White-topped Aster (plant) Willamette Valley Daisy (plant)
Upper NSW	Aquatic Late Successional Douglas-Fir Forest Montane Grasslands Wetlands and Wet Meadows	Cascade Torrent Salamander (amphibian) Cascades Frog (amphibian) Coastal Tailed Frog (amphibian) Oregon Slender Salamander (amphibian) Oregon Spotted Frog (amphibian) Black Swift (bird) Bufflehead (bird) Northern Goshawk (bird) Sandhill Crane(bird) American Marten (bird) Fisher (bird) Great Gray Owl (bird) Northern Goshawk (bird)

Source: North Santiam Watershed Council. 2011. *Watershed Restoration Action Plan.* Retrieved September 27, 2018, from http://northsantiam.org/wp-content/uploads/policy-general/2011-02-North-Santiam-Watershed-Council-Watershed-Restoration-Action-Plan-Review-Draft.pdf

The NSW is home to sensitive, threatened, and endangered species that depend on high-quality riparian and aquatic habitat for survival. Within the NSW there are two federal endangered species, which were listed in the 1990s: Upper Willamette River (UWR) winter steelhead and UWR spring Chinook salmon.[23] The listing of these species triggered recovery planning efforts that drive water management and use throughout the NSW (see discussion of the Biological Opinion later in this Section). Oregon chub is also present in the basin, and was the first fish ever to be delisted in 2015 due to significant population increases.[24]

2.1.7 Future Trends in Water Supply and Quality with Climate Change

Climate scientists expect that future trends in climate (including temperature and precipitation) likely will affect the water supply availability, streamflows, and ecosystems in the NSW. Projected future climate scenarios that were developed as part of the Willamette Water 2100 project[25] suggest that by 2100 the average surface temperature in the Willamette River Basin

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[23] U.S. Army Corps of Engineers. 2018. *North Santiam Subbasin Fish Operations Plan.*

[24] https://www.fws.gov/oregonfwo/articles.cfm?id=149489414

[25] Willamette Water 2100 was a multi-year, interdisciplinary study on future water in the Willamette River Basin. More information can be found at https://inr.oregonstate.edu/ww2100.

could be between 1°C (2° F) to 7°C (13° F) warmer than current temperatures.[26] With warmer ambient air temperatures, annual snowpack levels are expected to decline, with snowfall converting to rain more often at lower elevations. Researchers predict that the North Santiam River subbasin, along with the McKenzie River subbasin, likely will experience the largest total loss of snowpack relative to the rest of the Willamette River basin.[27] Warmer temperatures and less snowpack are also expected to impact stream temperatures in the North Santiam River, and Detroit Lake is expected to see temperature rises between 1.1°C (2° F) and 1.5°C (3° F).[28]

Expected changes in temperature, precipitation, and snowpack have the potential to affect water supply and water quality indirectly as well, by changing the ecosystem in ways that increase the risk of wildfire and toxic algae blooms, and potentially other as-yet unforeseen effects. Increased wildfire incidence and intensity has the potential to change runoff patterns and infiltration capacity, and increase sediment loading and nutrient deposition to waterbodies.[29] Increased water temperature, changes in precipitation patterns, and increased nutrient deposition may increase the frequency and magnitude, and change the timing of toxic algae blooms compared to historical conditions.[30]

2.2 Political Boundaries, Ownership, and Land Use

As the NSW stretches from the Willamette Valley floor to the crest of the Cascade Mountains, patterns of land ownership and land use vary from west to east. This variation reflects the underlying physical features of the landscape, and drives variation in demand for water, discussed in more detail in Section 4.

2.2.1 Political Boundaries

Native Americans populated the area prior to settlement by Europeans and others. Indigenous people lived on and frequented the area to fish, harvest food, collect materials, and engage in activities throughout the year. Based on research collected by the NSWC, the Kalapuya people inhabited and land and utilized the resources in the NSW. Other indigenous people in the Willamette Valley, including the Mollala, frequented the area and interacted with the Kalapuya.[31] Both the Confederated Tribes of the Grande Ronde and Confederated Tribes of the

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[26] Oregon State University, Institute for Natural Resources. No Date. *Future Climate.* Retrieved September 24, 2018, from https://inr.oregonstate.edu/ww2100/analysis-topic/future-climate

[27] Oregon State University. *Snow*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1291.

[28] Buccola, N. L., Risley, J. C., & Rounds, S. A. (2016). Simulating future water temperatures in the North Santiam River, Oregon. *Journal of Hydrology*, 535, 318-330.

[29] Turner, D. P., Conklin, D. R., & Bolte, J. P. (2015). *Projected climate change impacts on forest land cover and land use over the Willamette River Basin, Oregon, USA*. Climatic change, 133(2), 335-348.

[30] O'Neil, J. M., Davis, T. W., Burford, M. A., & Gobler, C. J. (2012). "The rise of harmful cyanobacteria blooms: the potential roles of eutrophication and climate change." *Harmful Algae*, 14, 313-334.

[31] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

Siletz continue to rely on the water in the NSW and are actively involved in management and restoration of the lands in the NSW.

The NSW intersects primarily with Marion and Linn Counties, and to a very small extent with Clackamas County. Table 3 shows that over half of the NSW is in Marion County and just under half is in Linn County, while less than one percent is in Clackamas County. It also shows that of the total county area, about one-third of Marion County is located within the NSW, while only about 15 percent of Linn County is in the NSW.

Table 3. Counties in the North Santiam Watershed

County	Total County Acres	Acres of County in Watershed	Percent of County in NSW	Percent of NSW in County
Clackamas	1,204,596	1,071	0.1%	0.2%
Marion	762,037	254,213	33.4%	52.0%
Linn	1,475,545	233,575	15.8%	47.8%

Source: ECONorthwest GIS Analysis

There are eight cities and census-designated places within the NSW.[32] In addition to the communities within the NSW, four cities outside the watershed rely on water from the NSW. Figure 1 shows both the communities within the NSW and the communities outside its boundaries that depend on its water. Table 4 shows the water source and the most recent population estimates.

Table 4. Communities Within and Outside the NSW that Use Water from the NSW

Community	County	Water Source	2017 Population Estimate[1]
		Communities within the NSW (Listed West to East)	
Jefferson	Marion	Santiam River (Below confluence of N. and S. Santiam)	3,235
Stayton	Marion	North Santiam Intake (below Salem's intake)	7,770
Mehama[2]	Marion	North Santiam River	
Lyons	Linn	North Santiam River	1,180
Mill City	Marion	Well	1,860
Gates	Marion	North Santiam River	485
Detroit	Marion	Mackey Creek, Breitenbush River	210
Idanha	Marion	Spring, Rainbow Creek, Mud Puppy Creek	140
		Communities that Use Water from the NSW	
Salem[3]	Marion	North Santiam River	163,480
Turner	Marion	North Santiam River (Purchases water from Salem)	2,005
Albany	Linn	Santiam River (Santiam-Albany Canal)	52,710
Millersburg	Linn	Santiam River (Santiam-Albany Canal)	1,835

Source: ECONorthwest, with data from Oregon Drinking Water Data Online, Personal Communications, and Portland State University
Notes: [1]2017 Population estimates come from the Portland State University Population Research Center, Certified Population Estimates, July 1, 2017; [2] Mehama population estimate is included with Lyons. [3] The Salem water service area is larger than the city limits of Salem, including also the areas east of Salem. Salem's city website estimates that they serve over 178,000 customers (https://www.cityofsalem.net/Pages/public-works-department.aspx)

[32] In addition to the cities and census-designated places, there are several unincorporated communities within the NSW, including Talbot, Marion, West Stayton, Fox Valley, Niagara, and Marion Forks.

2.2.2 Land Ownership

Across the entire NSW, the federal government is the largest landowner, at about 65 percent of the land area. The U.S. Forest Service (USFS) manages most of the federal land, or almost 60 percent of all land in the NSW. Private land owners hold the next largest share, at 28 percent. Other federal agencies (the Bureau of Land Management [BLM], Bonneville Power Administration [BPA], and the U.S. Army Corps of Engineers [USACE]), the state, county and other local governments, and the tribes own or manage the rest. Table 5 shows the distribution of ownership by acres and percent of the NSW land area.

Table 5. Land Ownership in the North Santiam Watershed

County	Acres	Percent of Land Area
Total Federal Government	**320,677**	**65.6 Percent**
U.S. Forest Service	292,627	59.8 Percent
U.S. Bureau of Land Management	20,499	4.2 Percent
Other (BPA, U.S. Army Corps of Engineers)	7,551	1.5 Percent
Total Private	**136,833**	**28 Percent**
Total State of Oregon	**29,874**	**6.1 Percent**
Department of Forestry	29,216	6 Percent
Other (State Parks, ODFW)	658	0.1 Percent
Total County and Local	**880**	**0.2 Percent**
Total Tribal	**716**	**0.1 Percent**

Source: ECONorthwest, with data from Oregon Bureau of Land Management USDI edited by the Oregon Department of Forestry, 2015

The distribution of land ownership varies considerably from the lower reaches of the NSW to the upper reaches. In the lower reaches, private ownership dominates, making up almost 90 percent of the land area. The middle portion of the NSW is more diverse, with private land still comprising over half of the acreage, but state land (both Oregon Department of Forestry [ODF] and State Parks [OSP]) and federal land managed by the BLM making up almost a quarter of the ownership. In the upper reaches of the NSW, the U.S. Forest Service manages the majority of the area, primarily within the Willamette National Forest, but also in the Mt. Hood National Forest in the northern portion of the NSW. About 8 percent of the upper reaches are in private ownership occurring in close proximity to Highway 22 and along the North Santiam River.[33]

2.2.3 Land Use

Land ownership and land use are closely correlated, and land use throughout the basin is patterned after geography. In the upper, higher elevations of the NSW, forest land cover dominates, and land use is consistent with the Forest Service's multiple use objectives. There are over 50,000 acres of wilderness in the upper reaches of the watershed, where uses and management activities are more restricted.[34] Public forested land is dedicated to timber harvest,

[33] Oregon Department of Environmental Quality. 2006. *Willamette Basin TMDL: North Santiam Subbasin.* September. Retrieved September 26, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[34] U.S. Forest Service, Willamette National Forest, Detroit Ranger District. 2007. *Upper North Santiam Watershed Revision.* September, Retrieved September 27, 2018, from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5435084.pdf

recreation, and wildlife habitat. Private land interspersed with public forested land is used for rural residential and commercial/industrial development. In the middle reaches of the NSW, USFS and BLM-managed forest land becomes more interspersed with private land. Private land in this stretch of the watershed is dedicated to rural residential, urban development, and some agriculture. As the elevation declines, private land in agricultural use dominates the landscape.[35,36]

2.3 Population Characteristics

Data are unavailable to estimate the population of the NSW directly. Table 6 shows that almost 15,000 people live in the incorporated cities within the NSW. The population of the NSW is undoubtedly higher because these estimates don't capture populations living in unincorporated areas of Marion or Linn Counties within the watershed. The population of communities that depend on water from the NSW is an order of magnitude higher, at about 220,000, as shown in Table 6. Adding these numbers together, about 6 percent of Oregon's population obtains drinking water from the NSW.

This population that depends on water from the NSW is likely to grow. The population in Marion County has grown by 64 percent since 1980, while the population of Linn County has grown by 37 percent during the same period. The population of both counties is predicted to continue to increase, as Figure 3 shows.[37]

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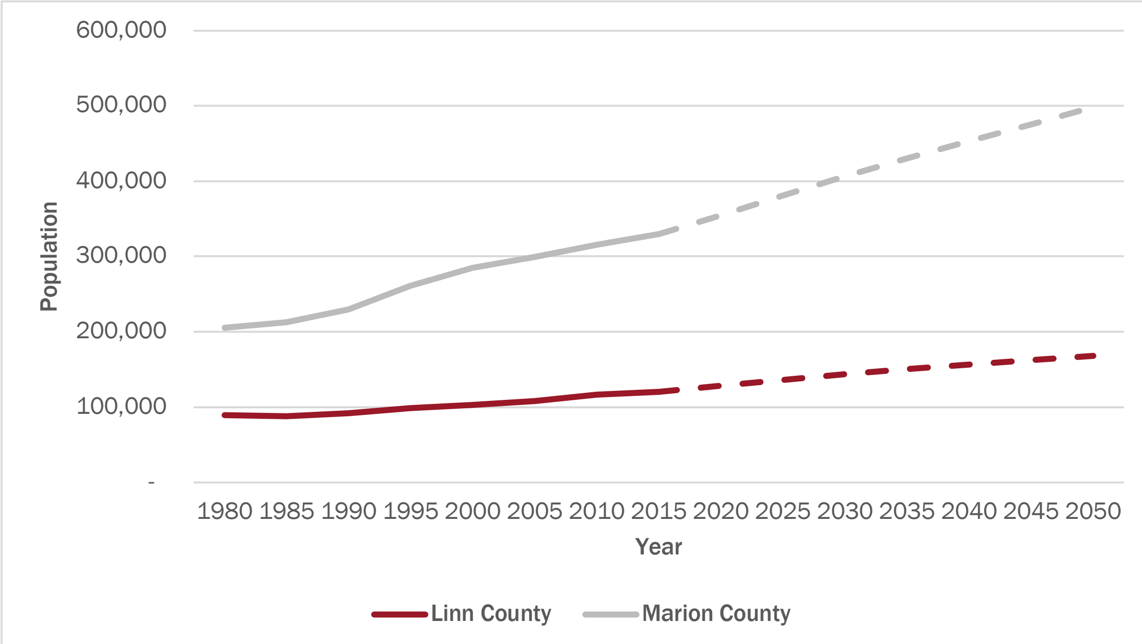
[35] Oregon Department of Environmental Quality. 2006. *Willamette Basin TMDL: North Santiam Subbasin.* September. Retrieved September 26, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[36] U.S. Geological Survey. 2016. "Description of the North Santiam River Basin." *Scientific Investigations Report No. 2007-5178.* Retrieved September 26, 2018, from https://pubs.usgs.gov/sir/2007/5178/section3.html

[37] Oregon Department of Administrative Services. (2013). "Oregon's long-term county population forecast, 2010-2050". Retrieved from https://www.oregon.gov/das/OEA/Pages/forecastdemographic.aspx

Figure 3. Population Growth and Projections in Marion and Linn Counties, 1980-2050



Source: ECONorthwest, with data from the U.S. Census Bureau, American Community Survey 2012-2016, and the Oregon Office of Economic Analysis, 2013.

This growth is driven by increases in urban and suburban areas—areas that are primarily outside of but obtain water from the NSW. The data in Table 6 show that population has increased since 1990 in all communities inside and outside the NSW, except for in Gates, Detroit, and Idanha. It has increased fastest for those communities closest to the larger population centers of Salem and Albany.

Table 6. Population of Communities within the NSW and Outside that Use Water from the NSW, 1990-2017

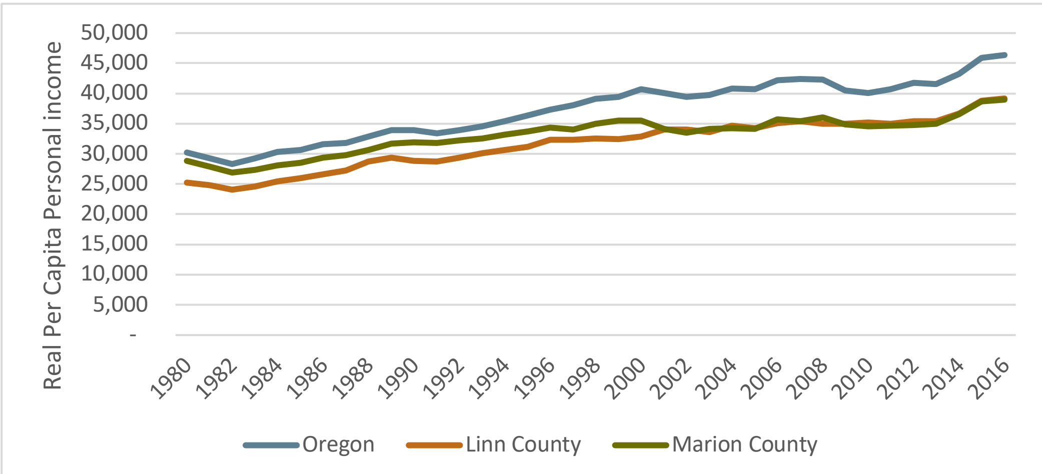
Community	1990	2000	2010	2011	2012	2013	2014	2015	2016	2017	Change 2010-2017	Change 1990-2017
Communities within the NSW (Listed West to East)												
Jefferson	1,792	2,480	3,115	3,135	3,140	3,150	3,165	3,165	3,195	3,235	3.9%	80.5%
Stayton	5,003	6,840	7,645	7,660	7,660	7,685	7,700	7,725	7,745	7,770	1.6%	55.3%
Lyons[1]	938	1,008	1,160	1,160	1,160	1,160	1,160	1,160	1,165	1,180	1.7%	25.8%
Mill City	1,555	1,537	1,855	1,865	1,870	1,870	1,875	1,855	1,860	1,860	0.3%	19.6%
Gates	499	471	475	475	485	485	485	485	485	485	2.1%	-2.8%
Detroit	331	262	205	205	205	205	210	210	210	210	2.4%	-36.6%
Idanha	289	232	135	135	135	135	140	140	140	140	3.7%	-51.6%
Communities that Use Water from the NSW												
Salem	109,651	137,659	155,100	155,710	156,455	157,770	159,265	160,690	162,060	163,480	5.4%	49.1%
Turner	1,287	1,206	1,855	1,860	1,865	1,865	1,900	1,920	1,945	2,005	8.1%	55.8%
Albany	33,424	41,134	50,325	50,520	50,710	50,720	51,270	51,670	52,540	52,710	4.7%	57.7%
Millersburg	670	668	1,345	1,375	1,375	1,430	1,505	1,620	1,730	1,835	36.4%	173.9%

Source: ECONorthwest, with data from Portland State University Population Research Center, Certified Population Estimates, July 1, 2017, and the U.S. Census Bureau
Notes: [1] Includes the population of Mehama

2.4 Economic Characteristics

In 2016, the estimated real per capita personal income for Marion County was $38,981 (2018 dollars) and for Linn County was approximately $39,182 (2018 dollars).[38] Both Marion County and Linn County have lower per capita personal income levels than the statewide average (Figure 4). Real per-capita income has risen since 1980 in all three geographies, but grew faster for Oregon as a whole than for people in Linn and Marion counties.

Figure 4. Historical real per capita personal income for Linn County, Marion County, and the State of Oregon



Source: ECONorthwest, with data from the Bureau of Economic Analysis

The economic characteristics of the population within the NSW and in communities that use water from the NSW are shown in Table 7. As of 2015, the median household income of communities within the NSW ranged from $29,083 in Idanha to $61,848 in Mehama. Median household incomes are generally higher in communities in the western portion of the watershed, and lower to the east. The median household income in 2016 for Marion County was $50,775, and for Linn County was $46,782. These values fall within the middle of the range of household incomes represented in the communities associated with the NSW. Both are lower than the same for the state of Oregon, at $53,270.[39]

The proportion of employed persons in communities within the NSW is higher to the west and lower to the east, and unemployed persons the opposite. Percent of the population collecting social security is higher in the eastern portion of the NSW, which correlates to a lower portion of the population in the labor force.

[38] U.S. Department of Commerce, Bureau of Economic Analysis. "Personal Income, Population, per Capita Personal Income (CA1)". Retrieved from https://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=4#reqid=70&step=1&isuri=1

[39] U.S. Census Bureau. 2012-2016. *American Community Survey.* Table DP03. Results for Marion County, Linn County, and Oregon.

Communities outside the NSW that use water from the NSW tend to have higher rates of employment, lower rates of unemployment, higher median household income, and a lower percent of the population dependent on social security income compared to communities within the watershed, particularly those to the east.

Table 7. Economic Characteristics of the Population of Communities within the NSW and Outside that Use Water from the NSW, 2015

Community	Population (16 Years and over)	Population in Labor Force (%)	Employed (%)	Unemployed (%)	Median Household Income	Social Security (%)	Retirement Income (%)	Cash Public Assistance (%)	SNAP Benefits (%)
Communities within the NSW (Listed West to East)									
Jefferson	2,320	60.9%	56.2%	4.8%	$47,849	31.8%	15.4%	8.9%	24.9%
Stayton	5,837	67.8%	58.8%	9.0%	$43,636	30.6%	15.8%	12.2%	34.4%
Mehama	126	76.2%	69.0%	7.1%	$61,848	27.0%	20.3%	0.0%	0.0%
Lyons	968	62.1%	55.4%	6.7%	$57,750	35.8%	20.4%	2.1%	13.5%
Mill City	1,419	55.1%	44.0%	11.1%	$38,438	45.9%	18.4%	7.0%	36.1%
Gates	409	47.2%	41.1%	6.1%	$35,833	44.1%	25.8%	13.1%	26.7%
Detroit	89	51.7%	49.4%	2.2%	$36,000	59.5%	19.0%	0.0%	14.3%
Idanha	148	58.1%	42.6%	15.5%	$29,083	38.4%	19.2%	24.7%	45.2%
Communities that Use Water from the NSW									
Salem	124,459	61.7%	55.0%	6.5%	$47,191	28.8%	19.5%	6.6%	24.4%
Turner	2,026	65.7%	56.5%	9.2%	$57,850	39.5%	24.2%	4.4%	14.2%
Albany	40,083	62.4%	54.9%	7.3%	$47,150	31.2%	20.8%	5.9%	22.9%
Millersburg	1,287	62.1%	61.3%	0.8%	$72,778	30.1%	24.5%	2.4%	19.6%

Source: ECONorthwest, with data from the U.S. Census Bureau, American Community Survey 2011-2015, Table DP03
Note: In the smaller communities, the percent margin of error in the ACS data may be larger than the percent reported (for example, with unemployed population). For this reason, caution should be taken in drawing precise conclusions from the data, and instead, are shown to illustrate general trends across the study area.

The Mid-Willamette Council of Governments conducted an Economic Opportunity Study for the North Santiam Canyon communities in 2014, which stated that "inadequate infrastructure and basic community facilities prevent businesses from expanding or locating in the area and creating a diverse economic base."[40] The economies of the North Santiam canyon communities were dominated by logging and wood product manufacturing and declines in these industries in recent decades have had direct economic impacts on these communities. Table 8 shows the number of establishments, employment, and percent of total employment for each of the sectors represented in the North Santiam Canyon communities in 2016. The manufacturing sector (primarily wood-products manufacturing) was the largest employer in the region, with 46.1 percent of jobs; other major sectors for employment include government (17.2 percent), leisure and hospitality (16 percent), and trade, transportation, and utilities (8.4 percent).

[40] Mid-Willamette Council of Governments. 2014. *North Santiam Canyon Economic Opportunity Study.* Pg. 4.

Table 8. Employment by Industry for North Santiam Canyon Communities (Detroit, Gates, Idanha, Lyons, Mehama, Mill City)

Industry	Establishments	Average Employment	% of Total Employment
Manufacturing	15	679	46.1%
Government	22	253	17.2%
Leisure and Hospitality	28	236	16.0%
Trade, Transportation, and Utilities	20	124	8.4%
Natural Resources and Mining	9	58	3.9%
Other Services	36	40	2.7%
Education and Health Services	6	27	1.8%
Professional and Business Services	12	25	1.7%
Construction	16	21	1.4%
Financial Activities & Information	5	10	0.7%
Total	**169**	**1,473**	**100.0%**

Source: Created by ECONorthwest with data from Oregon Employment Department. "Employment and Wages by Industry (QCEW)". Retrieved from QualityInfo.org

Compared to the NSW communities in the canyon (i.e., communities within the NSW, east of Stayton), employment in Marion and Linn counties is more heavily weighted towards education and health services, followed by trade, transportation, and utilities (Table 9). Agricultural employment is included in the natural resources and mining category, and makes up about 80 percent of all employment in the category in Linn County and 90 percent in Marion County. Food processing is included in the manufacturing category and includes about 35 percent of jobs in the manufacturing sector in Marion County and just under 10 percent of the jobs in the category in Linn County. Additional jobs closely linked to agriculture and food processing are in warehousing, which is a sub-sector of trade, transportation, and utilities. Together, agriculture-related and food-processing employment make up 8 percent of total employment in Marion County and 5 percent in Linn County.

As expected since Salem is the capital of Oregon, there is a higher portion of jobs in Public Administration in Marion County. Manufacturing, which is the largest sector in the NSW canyon communities, ranks third in Linn County and even lower in Marion County.

Table 9. Proportion of Total Employment by Industry for Linn and Marion Counties, Oregon, 2018

Industry	Marion County	Linn County
Education and health services	24%	23%
Trade, transportation and utilities	18%	22%
Public administration	12%	5%
Professional and business services	9%	7%
Leisure and hospitality	9%	8%
Construction	7%	6%
Manufacturing	7%	17%
Natural resources and mining (including agriculture)	5%	5%
Financial activities	4%	3%
Other services	4%	4%
Information	1%	1%
Unclassified	0%	0%

Source: Created by ECONorthwest with data from Oregon Employment Department

Marion County collects property taxes to fund county government and operations. As part of the Fiscal Year 2017-2018 budget, Marion County identified the 10 largest taxpayers in the county.[41] Of these large taxpayers, NORPAC Foods, Inc. is the eight largest tax payer, and directly relies on water from the North Santiam for food production by its cooperative of farmers.

2.5 Built Infrastructure

As the Land Use discussion above shows, people use the land and water resources within the NSW in a diverse array of ways. Many of these uses require human-built capital to fully utilize the available natural capital (e.g., the water, forests, and soils). Human-built capital includes anything that people construct or modify, including structures (e.g., buildings, dams), routes of conveyance (e.g., roads, pipelines, transmission lines), and equipment or technology not affixed to the land. The most relevant of these forms of built capital within the watershed to the economic analysis in Section 4 is infrastructure related to water conveyance and recreation. Roads and electricity transmission and distribution infrastructure are also important to facilitate access to water resources, but are used for many other purposes as well, so are not discussed here. The dams in the NSW also count as built capital, and are discussed above in the physical description because of their direct relationship to the quantity of water available in the watershed.

2.5.1 Water Supply Infrastructure

As described above, many types of users use water from the NSW. All of these users have developed infrastructure that facilitates their use, including water intakes, pipelines and distribution systems, and treatment facilities. The scale of these varies, but all represent significant investment and require routine maintenance. Water in the NSW would not be available to support the production of goods and services without these forms of human-built capital. There are at least eight major water intakes throughout the watershed, and likely many more small, private intakes, which typically include at various scales and in different combinations, water control structures (e.g., diversion structures and dams), pumps, and pipes.

The most significant of these investments in terms of overall investment and scale is the City of Salem's water system. The City of Salem and the Santiam Water Control District jointly own both Upper and Lower Bennett Dams, which serve several purposes to control and divert flows to water intake structures. Transmission pipelines convey treated water from the water treatment facility at Geren Island—located in the North Santiam River upstream of the City of Stayton—to the City of Salem, a distance of over 20 miles.[42]

The Santiam Water Control District (SWCD) also depends on built infrastructure to convey water to its agricultural customers. SWCD uses a combination of live flow from the North

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[41] Marion County. *Marion County Annual Budget Fiscal Year 2017-2018*. Retrieved September 27, 2018, from https://www.co.marion.or.us/FIN/budget/Documents/FY%2017-18%20Budget/FY17-18%201-Table%20of%20Contents%20and%20Introduction.pdf

[42] GSI Water Solutions, Inc. 2014. *Water Management and Conservation Plan.* The City of Salem. Retrieved September 27, 2018, from https://www.cityofsalem.net/CityDocuments/water-management-conservation-plan.pdf

Santiam River and stored water from the Detroit Lake Reservoir system to serve its customers. Water is diverted and then flows through a network of 90 miles of canals and ditches. On the 24,000 acres that the district occupies, approximately 17,000 acres are irrigated using 53,000 acre-feet of water. Hydropower is also produced by the district, currently by one hydropower plant; approximately 236,000 acre-feet of water was used in 2015 for hydropower production by SWCD.[43]

2.5.2 Recreation Infrastructure

The NSW hosts a variety of infrastructure that supports water-related recreational pursuits throughout the watershed. Water-related recreation in the NSW includes motor boating and personal motorized watercraft use; canoeing, kayaking, and rafting; fishing; swimming and soaking in hot springs; camping nearby waterbodies; hiking nearby waterbodies; and enjoying nature through watching, photographing, etc. Infrastructure provides access and facilities that allow people to engage in these activities, and thus in part dictates the supply of recreational opportunities available to people. Some infrastructure (e.g., campgrounds) provide harder limits on participation at any given time than others (e.g., trails). Table 10 summarizes the quantity of several types of recreation infrastructure in the NSW. Figure 5 shows the location of major recreation facilities.

Table 10. Supply of Recreation Infrastructure in the NSW

Recreation Infrastructure	Quantity
Boat Ramps	15
Marinas	2
Campgrounds	17
Picnic Areas	6
Developed Hot Springs	1
Hiking Trails	Unknown number of miles

Source: ECONorthwest, based on GIS analysis and personal communications with land and park managers.

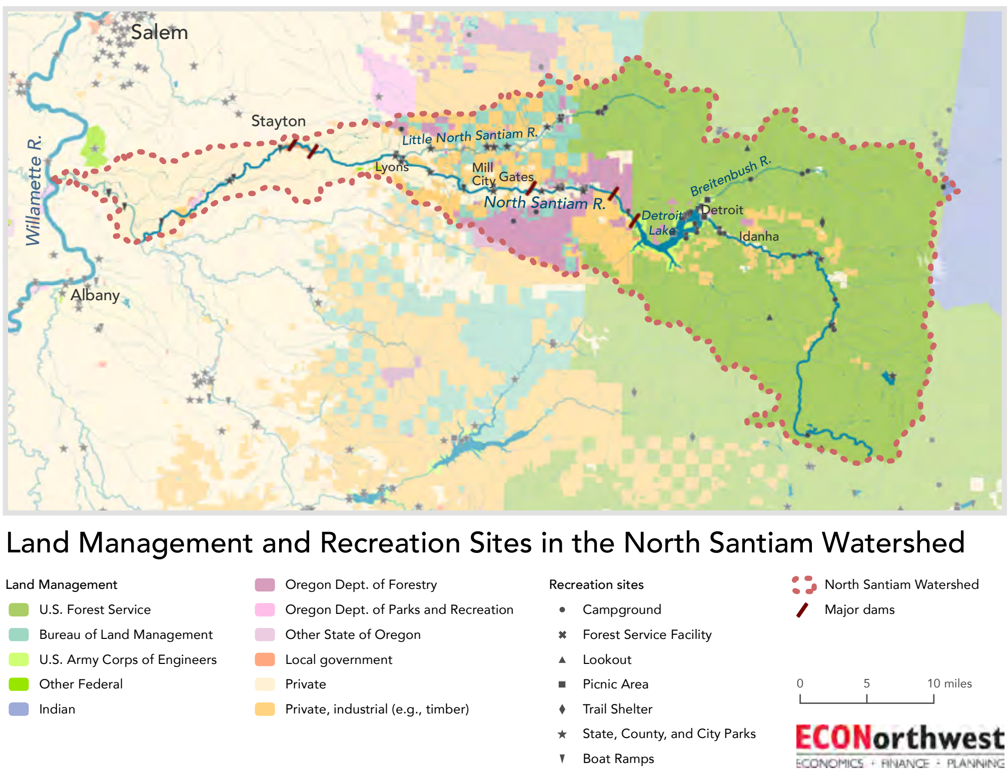
Most of the recreation infrastructure in the NSW is located adjacent to the watershed's water bodies.

- Detroit Lake, the reservoir created by Detroit dam is a popular recreational spot for boating, fishing, and camping.
- Breitenbush Hot Springs Retreat and Conference Center is located on the Breitenbush River, a tributary to the North Santiam, and offers resort-like amenities and access to hot springs.
- There are three state parks, two on Detroit Lake and one on the North Santiam River, which offer boat access, shore access, campground, restroom, as well as hiking and biking.

[43] Santiam Water Control District. (2015). *Application for U.S. Bureau of Reclamation 2015 Drought Contingency Planning Grant.* Prepared for U.S. Bureau of Reclamation.

- There are six Marion County parks, all of which are adjacent to the North Santiam or a tributary.
- Multiple private recreation facilities are located on the mainstem Santiam and tributaries, including Camp Taloali, a facility adjacent to the North Santiam River that provides summer camp opportunities for deaf and hard of hearing and disabled youth and adults in the region.[44] The camp facility is also available for private events throughout the year, and attracts thousands of people annual for camp and private events.

Figure 5. Map of Land Ownership and Recreation Facilities in the NSW



Source: ECONorthwest, with GIS data

In addition to these facilities, the public land throughout the watershed (described above in Table 5) offers dispersed recreation that isn't directly associated with developed infrastructure (except, perhaps, hiking trails which may or may not be maintained regularly). People engage in hiking, dispersed and developed camping, fishing, exploring, biking, hunting, and other activities on these lands.

[44] Camp Taloali. No Date. *About Us.* Retrieved January 10, 2019, from http://www.taloali.org/about-us

2.6 Policy Landscape

Regulations and policies shape and limit how water is used, distributed, treated, and discharged in the NSW. While it is beyond the scope of this study to identify all of the ways that regulations potentially limit or expand how water can be put to economic use, three policies are particularly relevant for understanding the current supply and demand for water in the NSW. One governs how water is regulated to protect endangered anadromous fish and sets limits on future appropriations within the NSW, another influences potential allocation of stored water in the NSW, and the third addresses water quality and sets limits on wastewater discharge into the NSW.

2.6.1 Endangered Species Management and the Biological Opinion

As discussed above, there are two species of anadromous fish in the NSW that are listed as threatened. In response to these listings, public and private land owners have changed the way they use and manage water to avoid causing further harm to the population. In 2008, the National Marine Fisheries Service (NMFS), which is responsible for oversight of anadromous fish under the federal Endangered Species Act, issued a Biological Opinion (Bi-Op) that outlined a set of management actions governing operations for the entire Willamette Project that it deemed would be protective of the threatened species. Within the North Santiam Subbasin, NMFS stated that "Habitat loss due to blockages has been especially severe in the North Santiam…" and found the risk of losing the North Santiam population subgroup of Upper Willamette River Spring Chinook to be "very high," while the risk of losing the Upper Willamette River Steelhead NMFS identified as "moderate."[45] In response to the Bi-Op the USACE developed the Willamette Fish Operations Plan (WFOP), and revises it annually as necessary. The WFOP outlines minimum streamflows, sets monthly temperature targets downstream of Big Cliff Dam, and describes hatchery and fish passage operations plans.[46] The Bi-Op also established a limit on future contracts for water within the North Santiam subbasin in tributaries below project dams, to ensure adequate streamflows.[47]

2.6.2 Willamette River Basin Stored Water Reallocation

In 2015, the U.S. Army Corps of Engineers restarted a joint effort with Oregon Water Resources Department to review the feasibility and options for stored water in the Willamette River Basin reservoirs to be reallocated for municipal and industrial use, irrigation, and endangered species. The first attempt at the reallocation process, which was not completed, was in 1996. Detroit

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[45] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion.* Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion/, Pgs. 8.13-4, 8.13-10, 8.14-9.

[46] U.S. Army Corps of Engineers. 2018. *Willamette Fish Operations Plan, Willamette Valley Project.* Retrieved September 28, 2018, from http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/WFOP/2018/final/2018%20WFOP%20Final.pdf

[47] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Executive Summary, Willamette Project Biological Opinion.* Page. 13.

Lake and Big Cliff dam are two of the thirteen reservoirs, called the Willamette Valley Project (WVP), being considered in the study for reallocation potential.[48] Ultimate approval of the reallocation will require authorization from Congress, and due to this requirement and other uncertainties the timeline and certainty of approval is unknown.

- Of the 1,590,000 acre-feet of WVP conservation storage, approximately 75,000 acre-feet of stored water (roughly five percent of total WVP conservation storage) is currently contracted through Reclamation for irrigation.[49]
- While the Corps has been operating the WVP to meet flow objectives since the year 2000 for ESA listed fish, releases of WVP stored water are not protected instream. Reallocation would allow for legal protections of the water for instream purposes.
- Currently no portion of the WVP stored water is authorized for municipal and industrial uses. The reallocation would obtain authorization to allow for storage agreements for municipal and industrial water use.

The reallocation is being considered for the entire Willamette River Basin and Detroit Lake represents about 300,000 acre-feet of the 1.6 million acre-feet of conservation storage.[50] Although Detroit Lake is a relatively large portion, it is unclear to what extent the reallocation will affect water rights and permits for this specific reservoir at this time because not all reservoirs are expected to be reallocated equally. The reallocation for Detroit Lake is also complicated by the 2008 Bi-Op, which does not allow for new stored water contracts to be issued in the NSW. This limitation would need to change in order for new contracts for stored water to be issued within the NSW as part of the reallocation, but could potentially be issued for users downstream in the Willamette Basin.[51]

2.6.3 Three-Basin Rule

The three-basin rule went into effect January 29, 1994 and stipulates that there can be no new or increased wastewater discharges in the North Santiam, Clackamas, and McKenzie River subbasins. This rule applies to NPDES permit, Water Pollution Control Facility for discharge to groundwater, and 401 Certifications. Effectively this means that no new NPDES permits can be issued, meaning a new Wastewater Treatment Plant that would discharge into the North Santiam cannot be built, regardless of the quality of the water being put back. There are exceptions to the three-basin rule for wastewater discharge to groundwater for domestic sources less than 5,000 gal/day.

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[48] Additional information about the WVP reallocation study can be found on the U.S. Army Corps of Engineers website: http://www.nwp.usace.army.mil/willamette/basin-review/

[49] U.S. Army Corps of Engineers. 2017. *Willamette Basin Review Feasibility Study: Integrated Feasibility Report and Environmental Assessment.* November.

[50] Ibid

[51] Personal communication with Mike McCord, Oregon Water Resources Department, on July 19th, 2018.

3 Demand for Water and Value

In this section, we describe the demand for water from the NSW. We begin with an assessment of the water rights in the NSW. While an imperfect relationship exists between water rights and demand for water,[52] the comprehensive database maintained by Oregon Water Resources Department (OWRD) provides a snapshot of the ways that water is used in the NSW, and serves as a starting point for the economic analysis.

Our assessment of demand includes demand from populations within the watershed (e.g., the communities in the canyon and agricultural users who draw water out of the North Santiam and its tributaries), and demand from populations that live elsewhere but derive value from the water resources in the NSW. This includes people traveling to the watershed to enjoy recreational opportunities, and people outside of the watershed who use water that originates from the North Santiam, Santiam, and tributaries within the NSW.[53] For each of these types of demand, we describe the economic value the users place on the water under current conditions. In some cases, we are able to estimate the economic value in monetary terms. In other cases, we describe the economic value qualitatively, because of limitations in the available data.

The analysis provided for each of these sources of demand together illustrates the economic importance of water in the NSW under current climate and population conditions. Where data permit, we describe the expected trends in demand that may affect the value of water in the future: in most cases, the data suggest that the value of water likely will increase as the population grows, as preferences for the types of goods and services produced from water in the North Santiam increase among the population, and as the overall availability and distribution of water and water-related goods and services changes throughout the Willamette Basin with climate change.

3.1 Water Rights

The OWRD oversees the system that governs and authorizes the right to use water in Oregon. Most uses of water in Oregon must have a water right, which identifies the point of diversion,

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[52] This statement cannot be emphasized enough. One of the strongest criticisms of the legal system governing water allocation in the west is that it does not adequately take into account economic considerations, such as demand and price, and results in economically inefficient allocations of water.

[53] It does not include demand from downstream users who withdraw water from the Willamette River, which may be of incrementally better quality or more plentiful because of the contributions of the Santiam River as it flows into the Willamette River. Agencies have identified in several cases that some water quality parameters in the Willamette River may improve after its confluence with the Santiam south of Salem. It also does not include the value of flood control, which is a benefit not of the water itself, but of the infrastructure designed to control the water. This value is important and described elsewhere as providing annual benefits between $0 and $23.5 million. See, for example, U.S. Army Corps of Engineers and Oregon Water Resources Department. 2011. *Small-Scale Water Supply Allocation Process in the Willamette River Basin.* Retrieved September 28, 2018, from https://www.oregon.gov/OWRD/WRDPublications1/2011_01_Small_Scale_White_Paper.pdf

place of use, type of use, and priority date (i.e., the date when the right was granted, which assigns priority for who gets water during times of scarcity). Thus, understanding how water is used in Oregon's water basins (i.e., the sources of demand for water) begins by examining water rights. These records, however, do not reflect current demand, for several reasons. The most important issue for this analysis is that the water rights certificates on record (sometimes referred to as paper water) do not reflect actual quantity water used or demanded (in some cases, demand may be higher than actual use, or lower and the user takes the water to preserve the option to use more water in the future). In some cases, owners of water rights in OWRD's database may not have exercised their right (i.e., withdrawn water) in many years, and their rights are no longer legally valid (i.e., they could not be renewed if the owner decided to start using water again). In some cases, especially at the urban fringe, a water right certificate associated with a particular property can no longer be used because development has occurred on the land, rendering the point of diversion and/or point of use unavailable.

Thus, the picture assembled for water use in the NSW from OWRD's database of water rights certificates likely overestimates the actual quantity of use, and does not accurately serve as a measure actual use of water. This situation is not unique to the NSW due to the reasons cited previously. In the aggregate, however, we believe the water rights records provide a reasonable picture of the types of demand for water that occur in the basin, and the relative magnitude of demand across different types of users. The overview of water rights that follows comes from the OWRD's online Water Right Information Search Query (WRIS).[54]

3.1.1 Surface Water

Surface water rights refer to live flow in the North Santiam or its tributaries. There are 827 surface water rights certificates in the database for the NSW. Table 11 shows the types of uses, ranked by quantity of water authorized under the water rights certificates (but not necessarily actually used). The largest use represents rights granted for instream purposes (36 percent). Surface water rights for the North Santiam River have the largest variety of uses; uses on tributaries are more limited.

[54] ECONorthwest confirmed with Mike McCord at Oregon Water Resources Department that this was the most comprehensive way using available data to summarize the water rights in the NSW, and within reason, accurately represented the types of use in the NSW. ECONorthwest used the "search by stream function" in the WRIS to isolate rights for the NSW. We then cleaned the data to remove duplicate values and any rights that were not within the North Santiam basin. Based on our interviews, we understand that some rights may be missing from the database, and we did not attempt to resolve issues related to individual rights. The Water Rights Information Query is available at: https://apps.wrd.state.or.us/apps/wr/wrinfo/Default.aspx?t=0

Table 11. Surface Water Rights by Type in the NSW

Description	Number of Rights	Quantity of Water Permitted (CFS)[1]	Percent of Total
Instream	9	2167.0	36%
Power	17	1562.2	26%
Industrial	34	822.3	14%
Irrigation	456	478.5	8%
Municipal	26	301.8	5%
Fish	24	236.3	4%
Wildlife	3	139.5	2%
Miscellaneous	20	132.6	2%
Domestic	168	57.1	1%
Livestock	51	40.0	1%
Recreation	11	27.5	<1%
Agriculture	8	3.7	<1%
Total	**827**	**5968.4**	**100%**

Source: ECONorthwest analysis of WRIS data
Note: [1]This is the variable "PODMaxRate" from the WRIS

3.1.2 Groundwater

A water right for groundwater is required for most wells providing water for agricultural and municipal/industrial purposes. The State of Oregon has identified certain uses as exempt from requiring a permit to use groundwater, and most domestic wells fall under this exemption.[55] Due to the hydrologic connection between groundwater and surface water, wells must be a minimum of one-quarter mile away from surface water.[56] According to the WRIS, there are 294 groundwater rights in the NSW. The overall quantity of water in groundwater permits is less than one percent of the quantity in surface water rights. The distribution is very different as well: the majority of groundwater rights are for irrigation (61 percent), followed by industrial uses (29 percent). Given that irrigation is the largest use and has many landowners who irrigate, private users overall are the largest users of groundwater (59.31 percent). The largest individual users are the City of Salem, followed by the City of Stayton, and Mill City.

As described in Section 3, the OWRD has classified areas in the lower (western) portions of the NSW as groundwater restricted. There are limitations to new groundwater permits in these areas to protect against groundwater-level declines.[57]

[55] See ORS 537.545 for more information on exempt groundwater uses. In general, these represent small volumes of water for agricultural and domestic purposes. Examples include domestic purposes not exceeding 15,000 gallons per day, water lawns not exceeding one-half acre in area, and stockwatering,

[56] Personal conversation with Mike McCord, OWRD, on Thursday, July 19th, in Salem, Oregon.

[57] Oregon Water Resources Department. 2018. *Groundwater Restricted Areas.* February 23. Retrieved September 27, 2018, from http://apps.wrd.state.or.us/apps/gis/gis_map_library/gis_view_image.aspx?gis_library_image_id=1136

Table 12. Groundwater Rights by Type in the NSW

Description	Number of rights	Quantity of Water Permitted (CFS)[1]	Percent of Total
Irrigation	257	126.2	61%
Industrial	10	61.0	29%
Agriculture	10	13.6	7%
Industrial	13	5.4	3%
Miscellaneous	2	0.6	0%
Fish	1	0.0	0%
Domestic	1	0.0	0%
Total	**294**	**206.9**	**100%**

Source: ECONorthwest analysis of WRIS data
Note: [1]This is the variable "PODMaxRate" from the WRIS

3.1.3 Storage Water

Storage water rights refer to the right to store water and are important in the context of the dams on the North Santiam River. There are 187 storage water rights in the NSW, and the vast majority of these are rights stored by the U.S. Bureau of Reclamation in Detroit Reservoir.

Table 13. Storage Water Rights by Type in the NSW

Description	Number of rights	Maximum Acre-feet[1]	Percent of Total
Miscellaneous[2]	67	95463.1	98.8%
Industrial	12	436.7	0.5%
Fish	31	349.4	0.4%
Wildlife	17	159.0	0.2%
Recreational	18	116.0	0.1%
Livestock	37	111.0	0.1%
Industrial	3	5.1	0.0%
Agriculture	2	2.3	0.0%
Total	**187**	**96642.5**	**100.0%**

Source: ECONorthwest analysis of WRIS data.
[1] This is the variable "POD Max AF" from the WRIS. Storage water rights are measured in terms of acre-feet rather than CFS, as surface and groundwater rights are reported in the other tables. Direct comparisons cannot be made against the other tables for this reason.
[2] The majority of the Miscellaneous rights, 95000 AF, are held by the U.S. Bureau of Reclamation

We organize the following sections roughly to reflect the uses identified in Table 11. The order of these sections follows the relative level of use of water in each category (recall, in the best professional judgement of OWRD and ECONorthwest staff, although the quantity identified in the water right and used in Table 11 does not indicate the actual quantity of water use at any given time, the relative proportions likely approximate the distribution of water across uses in the NSW). Furthermore, some categories of demand do not require a water right to use the water. These include uses that are not consumptive and don't require diversion of water—primarily recreation and aesthetics. These demands are satisfied by water flowing instream, and represent "co-users" of the largest category of water rights: water for aquatic life (instream) and anadromous and resident fish habitat (instream). Thus, we address these three uses first, sequentially.

3.2 Instream Flows for Aquatic Species and Habitat

In this section, we describe the demand for and value of maintaining aquatic and riparian habitat at a quality and quantity sufficient for supporting and ensuring the continued survival of threatened fish species in the NSW. Maintaining this habitat produces ecosystem service benefits for other species as well, but a large share of its economic importance derives from its capacity to protect the populations that are at the greatest risk. Thus, we focus on benefits arising from instream flows to protect ESA-listed species. We describe the value associated with the water in terms of the value people assign to recovering the threatened fish populations that live in the water and depend on water-related aquatic and riparian habitat.

3.2.1 Current Demand

Demand, in this case, is indicated by regulatory requirements set by federal and state agencies acting in their capacity as trustees of endangered species, as outlined in state and federal Endangered Species Acts. In theory, these legal obligations reflect demand by Oregonians and the people of the United States to protect species for future generations.[58] The quantity of water demanded (reserved for fish populations) is defined through regulatory processes in which scientists and managers identify the amount of water needed to maintain conditions that are consistent with fish survival at different life stages throughout the year, and put the species on a trajectory for recovery.

In Section 3, we identify two fish species that are protected under the ESA: Upper Willamette River Chinook (threatened) and Upper Willamette River steelhead (threatened). Table 14 shows the counts of adult fish from both species returning to the NSW between 2014 and 2018. The number of adult fish returning fluctuates over time, and is a function of many factors in the ecosystems they pass through during their migratory lifecycle, including the Willamette and Columbia Rivers, and the Pacific Ocean. Thus, the counts in Table 14 reflect population levels influenced by factors that impact survival within and outside the NSW. The trend in population is generally downward, with more dramatic declines in 2017 that may be short-term in nature, reflecting the cyclical nature of the populations. It is these population levels in the NSW and throughout their range that continue to qualify the species for listing under the ESA.

[58] This construction is consistent with Footnote 1, which requires that demand originate from anthropogenic (human) needs and desires. In this case, the fish do not demand water, people demand water for the ongoing survival of fish populations. Water for fish has value that derives from the ways that people "use" the fish, by directly interacting with them through consumption or observation (use value), desiring to potentially interact with them in the future (option value), desiring that future generations may experience them (bequest value), or simply knowing that they exist (existence value).

Table 14. Fish Counts at Upper and Lower Bennett Dams for 2014 - 2018

Species	2018 Count[1]	2017 Count	2016 Count	2015 Count	2014 Count
Hatchery Steelhead	1634	590	5362	905	4202
Wild Steelhead	401	185	866	865	943
Hatchery Chinook	2934	4223	3945	6687	5421
Wild Chinook	411	987	838	1074	1630

Source: Oregon Department of Fish and Wildlife (https://myodfw.com/upper-and-lower-bennett-dams-fish-counts)
Note: [1]Year-to-date as of August 2018.

To protect the species from extinction, the ESA dictates that any water management action, public or private, be evaluated against its potential to "jeopardize the continued existence" of these species. Any state or federal permit (for a public or private action) related to water management where species live is subject to scrutiny under the ESA. Through this mechanism, the NMFS, which has jurisdiction to review actions for potential harm to anadromous fish, issued a Biological Opinion (Bi-Op) in 2008, in response to consultation with the USACE, USBOR, and BPA regarding their operation of the Willamette Project.[59] Among other actions to set the species on a path to recovery, the Bi-Op requires the USACE to set flow targets protective of the species in several locations that impact management of the North Santiam River.

The goal of the regulatory standards established in the Bi-Op is to protect existing populations of Upper Willamette River Chinook and Upper Willamette River steelhead, and to eventually support their recovery and removal from the ESA list. Instream flow targets are a necessary, but partial, component of the overall recovery strategy. To this end, the Bi-Op also requires that USACE manage aquatic resources for specific temperature targets, and manage hatchery operations consistent with species recovery efforts.

3.2.2 Economic Importance

Over several decades, economists have developed and refined methods to estimate the value people are willing to pay to fund actions that protect species from extinction and recover their populations. These approaches are the only way to measure the "non-use" or "existence" values for natural resources. These methods (including contingent valuation, contingent choice, and conjoint analysis) rely on carefully designed and implemented surveys to elicit responses from representative samples of the population about their willingness to pay for specific actions and outcomes that generate public benefits. The responses are statistically assessed to yield mean values applicable to the sampled population. These methods have undergone extensive scrutiny and have evolved over time to address critiques.[60]

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[59] The legal history of this Biological Opinion is far more convoluted and complicated. For a detailed description, see the 2008 Biological Opinion: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion.* Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion

[60] For a broad overview of the history and best practices for these types of studies, *see* Johnston, R.J., K.J. Boyle, W. Adamowicz, et al. 2017. "Contemporary Guidance for Stated Preference Studies." *Journal of the Association of Environmental and Resource Economists* 4(2): 319-405. Retrieved October 2, 2018, from

In 2012, NOAA economists published the results of a national survey that measured the values for recovery of several marine species, including the Upper Willamette River Chinook salmon.[61] This study used state-of-the-art techniques and a large sample of households across the U.S. to estimate their willingness to pay for recovery of each species. The researchers designed the survey to estimate nonconsumptive values, such as the value members of a household placed on being able to observe the species, or to know that they exist now and for future generations. The survey design specifically attempted to examine only these nonconsumptive values, and excluded the value households place on consumptive or other direct-use values, such as being able to fish. The study found that U.S. households were, on average, willing to pay $45.75 (in 2018 dollars) per year for 10 years for additional protection actions that would result in the recovery of the Upper Willamette River Chinook and delisting from the ESA in 50 years.

Applying this mean household value to the household population in Oregon, and adjusting it using the parameters described in the study, yields a per-household willingness-to-pay value over 10 years of $401.96.[62] There are about 1.5 million households in Oregon. Applying this average value to these households yields a total willingness to pay to recover the Upper Willamette River Chinook salmon of $621 million. Applying the value to the estimated 117 million households in the U.S. yields a value of $47 billion.

These values should be viewed as demonstrative of the scale of non-use values people place on species recovery resulting from the ESA-mandated instream flow requirements, assuming these requirements ultimately will allow the species to recover and be delisted. While the recovery efforts in the NSW may be necessary for Upper Willamette River Chinook salmon to be delisted,[63] they may not be sufficient for recovery of all genetically distinct units. This value applies to efforts taken across the Willamette Basin to further the recovery of the Upper Willamette River Chinook salmon. These values are consistent with economic theory and include considerations of the household budget constraints and the full set of public and private goods that a household can consume over a 10-year period of time.

Furthermore, these values are consistent with the results of other large-scale and well-designed surveys conducted at a national level to estimate the value of species protection and recovery in Oregon. In 2010, researchers estimated households' willingness to pay each year over 20 years for actions that would result in a 30-percent increase in wild Chinook salmon and steelhead

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https://aaec.vt.edu/content/dam/aaec_vt_edu/people/faculty/URLs/boyle/boyle-kevin-contemporary-guidelines-2017-jaere.pdf

[61] Wallmo, K. and D. Lew. 2012. "Public Willingness to Pay for Recovering and Downlisting Threatened and Endangered Marine Species." *Conservation Biology* 26(5): 830-839.

[62] Adjusting the annual study value from 2011 to 2018 dollars using the CPI and discounting the value over 10 years at 3 percent.

[63] NOAA Fisheries, Protected Resource Division. 2005. "Appendix C: CHART Assessment for the Upper Willamette River Chinook Salmon ESU." In *Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams For 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead*. August. Retrieved October 5, 2018, from https://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/critical_habitat/chart_report/2005_chart_uwr_chinook.pdf

trout in the Klamath River (Oregon and California). The study found that households in Oregon and California would pay over $10 billion (in 2018 dollars) and households in the U.S. would pay about $96 billion (in 2018 dollars) to achieve this outcome.[64] Just as in the NOAA study, these represent nonuse values.

In addition to instream flows for threatened salmon, the NSW produces fish that are not protected under the ESA, and contribute value to the economy. The Minto Fish Hatchery is part of the mitigation required for operation of the Willamette Project. It produces stocks of spring Chinook and summer Steelhead. The hatchery stocks intended to help restore wild populations of fish, but are available for harvest in tribal, commercial, and recreational fisheries in the Pacific Ocean, Columbia, and Willamette Rivers on their return to the NSW. The production of these hatchery fish is controversial, and some have suggested they continue to pose risks to the recovery of native fish.[65] Other native and non-native resident and migratory fish live in the NSW, including rainbow trout, cutthroat trout, mountain whitefish, lamprey and Coho.[66] These species support primarily freshwater recreation opportunities discussed in greater detail in the next section. Some of these species are also important to the Native American people who traditional lived in the area, and support subsistence, cultural, and spiritual values described in later sections.

3.2.3 Expected Future Trends in Demand and Value

Achieving species recovery goals advanced by the 2008 Bi-Op framework will take decades. Values derived from survey research of willingness to pay are typically only valid for a period of a few years, as the risk that the population's preferences diverge from survey responses increases with time.[67] Results from the Oregon Population Survey between 1996 and 2002 found that the importance Oregonians place on salmon recovery fell—that is, Oregonians became less supportive toward salmon recovery, were less likely to say salmon recovery is important, and chose lower willingness to pay responses in 2002 than in 1996. The study found that attitudes appear to correlate with economic conditions and demographic composition. Specifically, local unemployment rates and rural county residence were significantly negatively correlated with

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[64] Mansfield, C., et al. 2012. *Klamath River Basin Restoration Nonuse Value Survey.*

[65] National Marine Fisheries Service, West Coast Region. 2018. *Draft Environmental Impact Statement (DEIS) to Analyze Impacts of NOAA's National Marine Fisheries Service Proposed Approval of Hatchery and Genetic Management Plans for spring Chinook salmon, steelhead, and rainbow trout in the Upper Willamette River Basin Pursuant to Section 4(d) of the Endangered Species Act*. March. Retrieved October 5, 2018, from https://www.westcoast.fisheries.noaa.gov/publications/nepa/hatchery/upperwillamettehatcheries_deis_march2018.pdf

[66] Native Fish Society. 2018. *North Santiam River.* Retrieved October 5, 2018, from https://nativefishsociety.org/watersheds/north-santiam-river

[67] Lew, D.K. 2015. "Willingness to pay for threatened and endangered marine species: a review of the literature and prospects for policy use." *Frontiers in Marine Science.* 16 November. Retrieved October 2, 2018, from https://www.frontiersin.org/articles/10.3389/fmars.2015.00096/full#B148

expressed support for salmon recovery and education level positively correlated with support. Much of the decline in support, however, was unexplained by the data.[68]

Follow-up research is not available to indicate whether this trend has strengthened or weakened among Oregonians. However, national survey research completed in 2015 found that support among Americans for the Endangered Species Act was consistently strong between 1996 and 2015. Over that time, support remained high among the public at 80 and 90 percent of the population. This support transcended political affiliation.[69]

If the patterns in these studies bear out in the future, to the extent that future population growth occurs primarily in urban areas, and local economic conditions remain favorable, current levels of demand for fish protection and recovery—and thus maintaining instream flows—may continue. As population grows, the overall number of households increases, which may offset declining per-household willingness to pay, should that be a prevailing trend.

Climate change may also affect demand, in several ways: to the extent that climate change increases air temperatures and water temperatures, maintaining instream flows may become even more critical for fish recovery, especially in basins that reach into the higher elevations, such as the NSW. If the public understands these vulnerabilities and their implications for species recovery, demand may remain steady or increase.

In summary, multiple trends may affect demand for and economic value of maintaining instream flows for salmon recovery. Some of these factors may increase demand and value, while others may decrease demand and value. The cumulative effect on the direction and magnitude of demand and value remains somewhat uncertain.

3.3 Water-Related Recreation

Recreation opportunities abound on public and private land and at both managed and more dispersed sites in the North Santiam watershed. Many sites are concentrated near Detroit Lake, the North Santiam river and its tributaries. Boating, fishing, swimming, hiking, camping, picnicking, biking, and hunting are all popular activities.

3.3.1 Current Demand

In this section we report demand for recreational opportunities based on current levels of recreational use, relying on the most recent data available. In many cases, recreational use is not

[68] Montgomery, C. and T. Helvoigt. "Changes in attitudes about importance of and willingness to pay for salmon recovery in Oregon." *Journal of Environmental Management* 8 (4): 330-340.

[69] Bruskotter, J.T., et al. 2018. "Support for the U.S. Endangered Species Act over time and space: Controversial species do not weaken public support for protective legislation." *Conservation Letters* July 19. Retrieved October 2, 2018, from https://onlinelibrary.wiley.com/doi/full/10.1111/conl.12595

reported at the watershed level, so we adjust the available data to estimate the levels of use within the watershed.

Ultimately, we aim to identify the demand for recreational uses related to water in the North Santiam watershed. Such uses are not limited to swimming, boating, and fishing, however. In the North Santiam watershed, nearly all of the developed recreational sites are along water bodies, and even remote hiking trails are typically located along headwater streams. Therefore, we find that water is an integral part of the equation when it comes to demand for recreation in the North Santiam watershed, and we report all the available recreation data without attempting to exclude uses based on types of activities or distances from a water feature.

Researchers at Oregon State University conducted a statewide survey of Oregon residents for the Oregon Parks and Recreation Department to estimate outdoor recreation participation in Oregon as of 2011.[70] This survey calculated the number of user occasions (the number of times people engage in an activity) and participation rates for residents of Marion County for various freshwater recreation activities; Table 15 reports the results of the survey for activities directly related to water.

Table 15. Participation in freshwater activities by residents of Marion County and state averages

Activity	User Occasions in Marion County[1]	% of Statewide Occasions	% of Marion County Residents Participating	% of Oregon Population Participating
Swimming/playing in outdoor pools/spray parks[2]	922,822	6.0	22.7	20.7
Power boating (cruising/water skiing)	476,198	7.0	16.9	15.3
Fishing from a bank or shore (other than Fly Fishing)	458,273	5.0	12.0	17.3
Beach activities - lakes, reservoirs, rivers	425,451	3.0	30.2	32.5
Fishing from a boat (other than Fly Fishing)	157,595	2.0	16.7	15.3
Personal water craft - jet ski	112,016	7.0	6.7	4.2
Flat-water canoeing, rowing, paddling tubing/floating	67,937	2.0	7.2	11.7
White-water canoeing, kayaking, rafting	30,947	1.0	10.6	12.5
Fly Fishing	23,175	1.0	4.7	5.6

Source: Rosenberger and Lindberg 2012, Data for Marion County
Note: [1]User Occasions are defined as the number of times people engage in an activity. The same person can contribute multiple user occasions.
[2]The SCORP survey of recreation users does not define where swimming occurs. It categorizes swimming as a non-motorized water-based and beach activity. Survey respondents could report swimming activities in natural areas under this category. They also could have included swimming activities in natural areas under beach activities—lakes, reservoirs, rivers. Because of this ambiguity, we cannot rule out that the user occasions for swimming/playing in outdoor pools/spray parks did not include swimming in the waterways of the NSW.

Some of these activities include user occasions that occur somewhat or primarily in urban areas (e.g., playing in outdoor pools and spray parks), so may overstate the occurrence related to the NSW resources (although a swimming pool filled with water from Salem's municipal supply comes from the NSW). After swimming (the most frequently-engaged in activity), power boating, fishing, and beach recreation were the most frequently participated in activities in Marion County. The user occasions includes participation in Marion County by residents across Oregon, so includes Marion County residents as well as people who travel to Marion County to

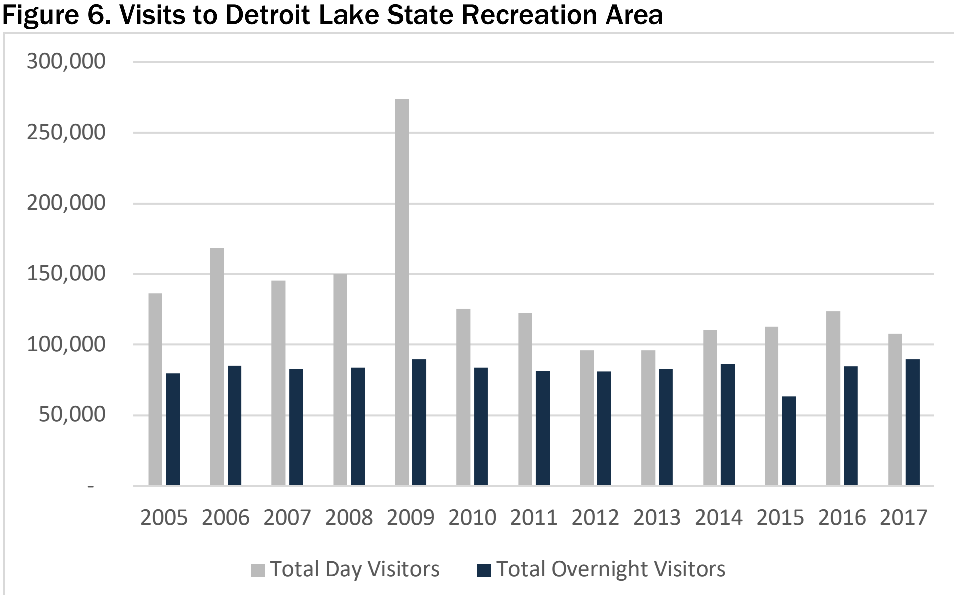
[70] Rosenberger, R., & Lindberg, K. 2012. *Oregon Resident Outdoor Recreation Demand Analysis*. 2013-2017 Oregon Statewide Comprehensive Outdoor Recreation Plan Supporting Documentation. Prepared for Oregon Parks and Recreation Department. Oregon State University. November 12. Retrieved from https://www.oregon.gov/oprd/PLANS/Pages/ORORDA.aspx

recreate. About 30 percent of Marion County and Oregon residents participate in beach activities at lakes, reservoirs, and rivers, and 3 percent of the visits in Oregon occur in Marion County. For power boating and personal water craft use, up to 7 percent of the user occasions occur in Marion County. These data demonstrate that people in Marion County engage in many forms of freshwater-related recreation, and people throughout Oregon come to Marion County to participate in these activities.

State Parks

There are three Oregon State Parks within the North Santiam watershed: Detroit Lake State Recreation Area, North Santiam State Recreational Area, and Mongold Day Use Area. Detroit Lake State Recreation Area has recorded average annual day-use visitation of 110,000 visitors and overnight visitation of approximately 82,000 over the 5-year period 2013-2017.[71] Figure 6 displays day-use visitation for the months June through September at Detroit Lake Recreation Park between 2005 and 2017. North Santiam State Recreational Area recorded average annual day-use visitation for 2015 to 2017 of 72,000 visitors and overnight visitation of approximately 2,400 (camping is available during May through September only).[72] Visitation data are not available for Mongold State Day Use Area, but day-use visitation is thought to be similar to levels at Detroit Lake Recreational Area.[73] As we understand, overnight visitors are likely at least partly counted in the day-use totals for these recreational areas. Based on this information, we estimate annual visitation to the two state parks with visitor counts at approximately 182,000 visitors per year.

Figure 6. Visits to Detroit Lake State Recreation Area



Source: Oregon Parks & Recreation Dept Visitor Counts for Detroit Lake State Recreation Area

[71] Based on Oregon Parks & Recreation Department data for 2005-2017.

[72] Based on Oregon Parks & Recreation Department data for 2015-2017.

[73] Personal communication with Oregon Parks & Recreation Department on August 9th, 2018.

County Parks

Marion County Parks and Recreation maintains several parks in the NSW. The parks offer picnic sites, water activities, trails, and other amenities. Most parks are day-use only, but one (Bear Creek) includes a campground.

Marion County collects fees at three of the parks: North Fork, Bear Creek and Salmon Falls. All three of these parks are on the Little North Santiam River. As a result of the fee collection system, the County tracks visitation at these parks, as shown in Table 16. There are no visitation data available for any of the other Marion County parks, but the County notes that Niagara Park attracts the most visitors of any other Marion County park in the area. Based on these data, we estimate annual July through September visitation of 14,350 at the three parks with visitor counts.

Table 16. Visitors at Three Marion County Parks, 2017

	July	August	September	Total
North Fork	3,451	3,409	1187	8,047
Bear Creek	1,124	998	210	2,331
Salmon Falls	1,796	1,551	627	3,973
Total	**6,370**	**5,957**	**2,023**	**14,350**

Source: Email from Marion County Parks on August 9th, 2018

Bureau of Land Management Lands

The Bureau of Land Management manages a number of recreation areas within the North Santiam watershed. These include Fishermen's Bend, Elkhorn Valley, Canyon Creek, and other dispersed areas along the Little North Santiam River. The BLM collects data on the number of recreational visits, the types of recreational activities visitors pursue, and the amount of time visitors spend on the land it manages. For 2017, the BLM reports approximately 140,000 visits to BLM lands and recreational sites in the North Santiam watershed. A "visit" is a trip of any length—an hour, a day, a week—by an individual to BLM land for recreational purposes.

The BLM also prepares annual estimates of the number of participants in a variety of recreational activities and reports participation levels in these activities in units of "visitor days"—defined as aggregated 12-hour periods of time. Table 17 shows a total of 170,484 visitor days spent in a variety of recreational activities, with camping and picnicking representing over 80 percent of the time spent on BLM lands.

Table 17. Visitation at BLM-Managed Sites in the North Santiam Region, 2017

Activity	Participants	Visitor Days
Camping and Picnicking	130,071	137,229
Fishing	67,846	12,188
Hiking/Walking/Running	63,319	5,758
Nature Study/Environmental Education	35,428	2,342
Biking – Road and Mountain	34,125	2,965
Viewing Wildlife, Flowers, Scenery	26,157	1,271
Swimming	24,108	3,736
Row/Float/Raft	18,296	1,560
Specialized Sport/Event (Non-motor)	10,893	908
Other	10,421	1,081
OHV	2,948	786
Hunting	1,531	660
Total	**425,143**	**170,484**

Source: ECONorthwest based on data from the BLM's Recreation Management Information System (RMIS)

U.S. Forest Service Lands

The majority of the land upstream of Detroit Lake is forested and managed by the U.S. Forest Service. The majority of this land lies within the Willamette National Forest, with some lying in the Mt. Hood National Forest. Developed USFS sites and trailheads are generally located along waterways.

Visitation data for national forests is collected by the USFS through visitor surveys.[74] Visitation data is generally reported at the scale of the entire national forest, and the USFS has been unable to provide data on the visits that occurred on the portion of national forest land within the North Santiam watershed. Therefore, we estimate visitation levels for the NSW based on broad data from the Willamette National Forest (WNF), which stretches 110 miles north to south along the western ridge of the Cascade Mountains (see Table 18).

Table 18. Visitation to Willamette National Forest

Category of Visitation	Number of Visits
Total Estimated Site Visits[1]	**1,387,000**
Day Use Developed Site Visits	522,000
Overnight Use Developed Site Visits	161,000
General Forest Area Visits	599,000
Designated Wilderness Visits	105,000
Total Estimated National Forest Visits[2]	**938,000**

Source: USDA Forest Service National Visitor Use Monitoring retrieved from https://apps.fs.usda.gov/nvum/results/A06018.aspx/FY2012
Note: [1]A Site Visit is the entry of one person onto a National Forest site or area to participate in recreation activities for an unspecified period of time. A National Forest Visit is defined as the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. [2] A National Forest Visit can be composed of multiple Site Visits.

We scaled annual visitation in the WNF to visits on USFS lands in the NSW based on the average number of visits per acre in the WNF. There were 938,000 visits across nearly 1.7

[74] U.S. Department of Agriculture. "USDA Forest Service National Visitor Use Monitoring" Accessed May 3, 2018 from: https://apps.fs.usda.gov/nvum/results/A06110.aspx/FY2012.

million acres in the WNF in 2012, for an average of .56 visits per acre. This equates to about 164,000 visits to the 292,627 acres of national forest within the NSW each year.

River Recreation—Privately Guided Fishing and Boating Trips

The North Santiam supports a multi-season river-based recreation industry. A variety of businesses, some based within the watershed and some based elsewhere, provide equipment rentals, transportation, and guided trips. Guided kayaking, rafting, and fishing (both fly fishing and bait-and-tackle) attract visitors from outside of the local area. Fishing trips, in particular, have attracted people from across the U.S., drawn to the North Santiam's fishing opportunities. No comprehensive data are available across this industry in the region. Information from representatives from this industry, however, suggests that there are over a dozen businesses that provide trips on the North Santiam (some based outside of the area), with five hundred to possibly a thousand individual participants and a number of large events each year. Because this industry uses public boat launches, the recreation usage should largely be included in visitation data reported by public agencies.

Breitenbush Hot Springs

Breitenbush Hot Springs is a private retreat and conference center located approximately 10 miles from Detroit on the Breitenbush River, which flows into Detroit Lake. The Center hosts overnight guests and day-use visitors throughout the year. Guests are drawn to the many natural amenities of the area—the hot springs, the river, the forest—as well as the lodging and other services provided by the facility. Information provided by Breitenbush personnel indicates that visitation is approximately 32,000 guest nights per year, with 130 overnight guests per day during the summer months and 90 overnight guests per day during the rest of the year and an average of 20 day-use only guests per day.[75]

Camp Taloali

Founded in 1973 as a camp for deaf and hard-of-hearing children, this camp located on the North Santiam River continues to provide summer camp opportunities to this community. It also hosts other camp programs, private events, and recreation events throughout the year for the larger population. During the summer, the facility averages 100 to 150 people a day, and larger international events attract up to 3,000 attendees.[76]

3.3.2 Economic Importance

Recreation in the NSW has many economic dimensions. For example, studies show that recreation generates local expenditures for items such as food, lodging, supplies, gas, equipment, and fees for guides and outfitters. These expenditures help support local economic activity. Recreation opportunities also attract new residents and firms, who bring income and

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[75] Interview with Peter Moore, Breitenbush Hot Springs, on August 15th, 2018, and Personal email from Breitenbush Hot Springs on August 14th, 2018.

[76] Personal communication with Janet Johanson, Chairperson, Camp Taloali Board of Directors. December 3, 2018.

economic opportunities with them. These types of effects are generally called the *economic impacts* of an activity.

To those engaged in recreational pursuits, the recreational opportunities increase overall well-being. We report these benefits as *economic value*, which is a measure used in benefit-cost analyses to weigh the tradeoffs associated with a policy or decision. Economic value is calculated as the willingness to pay minus the cost of participating in an activity. Table 19 summarizes results from research on the economic value of a variety of outdoor recreation activities in the Pacific Northwest. For example, the average economic value of nonmotorized boating is $116 (2018 dollars) per person per day. These values can be used to estimate the economic value associated with annual recreational visitation.

Table 19. Estimates of the average daily economic value of recreation benefits by primary activity in the Pacific Northwest, 2018 dollars

Primary Activity	Rounded Dollars
Backpacking	$35
Biking	$92
Cross-country skiing	$60
Developed camping	$38
Downhill skiing	$87
Fishing	$76
Hiking	$90
Hunting	$82
Motorized boating	$62
Nature related	$64
Nonmotorized boating	$116
OHV or snowmobiling	$54
Other recreation	$69
Picnicking	$52
Weighted Average	**$73**

Source: Rosenberger, R.S.; White, E.M.; Kline, J.D.; Cvitanovich, C. 2017. *Recreation economic values for estimating outdoor recreation economic benefits from the National Forest System*. Gen. Tech. Rep. PNW- GTR-957. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

The information agencies collect about recreational visitation on public lands in the NSW is not complete. For example, county and state parks do not even track visitation at some of the parks, and we have not attempted to estimate usage at the parks without data. Table 20 shows estimated visitation on public lands in the NSW of approximately 500,000 visitors per year. We emphasize that these are estimates—and likely underestimates—of use.[77] Using the data on the economic value of recreational activities, above, we estimate the overall value associated with recreational visits within the NSW, based on a weighted average value per day of $73. This yields a total value of about $36.5 million (in 2018 dollars).

[77] County Parks tracks usage at only 3 of the 6 parks in the NSW, and the park with the highest usage has no visitation tracking. State Parks does not track usage at one of the three parks. We have excluded overnight visitation estimates, as they may be partly included in the day-use estimates. USFS estimates are based on scaling down data from the Willamette National Forest.

Table 20. Estimated Annual Recreational Visitation on Public Lands in the North Santiam Watershed and Associated Economic Value (2018 Dollars)

	County Parks	State Parks	BLM Lands	USFS Lands	Total
Estimated Annual Visitation	14,350	182,000	140,000	164,000	500,350
Economic Value	$1,048,000	$13,286,000	$10,220,000	$11,972,000	$36,526,000

Source: ECONorthwest

Research conducted by economists at Oregon State University on the Willamette River Basin reservoirs used a travel cost method to estimate the value of recreation at these locations, and correlate recreation demand with levels in the reservoir. The study found that reservoir level positively correlated with demand: for every foot of drop in water level below full pool, visitor days declined by 2 percent.[78] The researchers found that the estimated value of each acre-foot of stored water at Detroit Lake for reservoir recreation use is $11 per month.

Economic Contribution of Recreation to the Economy

While this report does not focus on the jobs and incomes associated with water use in the NSW, during the course of our interviews with business owners engaged in providing recreation services including resort management and guided boating and fishing, we heard that recreation-related spending bolsters the economies of communities within the NSW. The leisure and hospitality sector accounts for 16 percent of employment in the North Santiam Canyon communities, employing over 200 people. Recreation drives economic activity in other sectors, including Government; and Trade, Transportation, and Utilities, through spending on retail goods, and via fee and tax payments to support ongoing management of recreation facilities. Breitenbush Hot Springs generates over $5 million in annual revenues. These revenues ripple through the local economy through purchases from local supplies and through wages paid to staff, who also spend money locally. Visitors to Breitenbush also make local expenditures in the communities in the North Santiam Canyon communities in conjunction with their visits. The same is true for visitors to Camp Taloali and other private facilities with identities closely linked to the water resources in the NSW.

3.3.3 Expected Future Trends in Demand and Value

Studies show that demand for outdoor recreation, in general, is expected to grow into the future. A variety of factors influence demand for recreation. Population growth is a primary driver of overall demand, and expected population growth in Oregon will result in higher levels of demand for recreational uses of land and water resources. We expect demand to grow in the NSW for this reason as well. Quality of recreation experience also drives demand. Factors that influence quality of recreation in the NSW include reservoir levels, water quality, fish abundance, and availability and upkeep of infrastructure.

[78] Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation*. Oregon State University.

A national assessment of recreation trends found that even with overall growth in recreation participation, some types of recreational activities are expected to grow more quickly than others.[79] Some activities are expected to become more popular on a per capita basis while others are expected to become less popular on a per capita basis. After accounting for population growth, however, the number of people participating in most outdoor recreation activities will continue to grow.

Table 21 summarizes forecasts of participation levels for several recreational categories. In each of these categories, recreational use is expected to increase, although at different rates depending on the type of use. These are national trends, but they are also relevant for understanding trends in the NSW.

Table 21. U.S. Participation Forecasts, Select Recreational Activities, 2008-2060

Activity	Forecast
Developed Camping & Picnicking	Participation rate will keep pace with population, with an overall increase in the number of participants of 42 to 77%.
Motorized Water Activities	Forecasts range from keeping pace with population to a 15% per capita increase in participation, for an overall increase of 41 to 81%.
Fishing	Participation rate will decline, but the overall amount of participation will increase by 28 to 56% due to population growth.
Swimming	The number of adult participants will increase slightly faster than the rate of population growth, for an overall increase of 47 to 85%.
Canoeing, Kayaking, Rafting	Projections range from an increase slightly less than to more than the rate of population, with overall participation increasing 30 to 62%.

Source: ECONorthwest, based on Cordell (2012)

The Oregon Statewide Comprehensive Outdoor Recreation Plan (SCORP, 2013-2017) found that recreation trends in Oregon followed similar patterns as the nation, with developed camping more popular in Oregon and swimming and fishing less popular.[80] The most recent survey of Oregonians, conducted in 2017, found that when asked about their priorities for future state investment both within and outside their communities, Oregon residents identified access to waterways and nature and wildlife viewing areas among their top demands.[81]

A 2013 study of recreation use in NSW at Detroit Lake provides a limited snapshot of trends within the region. The study identified crowding as a concern for visitors, with indications that day-use areas were experiencing "high normal" levels of crowding, and overnight areas at

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[79] Cordell, H.K. 2012. *Outdoor recreation trends and futures: a technical document supporting the Forest Service 2010 RPA Assessment*. Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

[80] Oregon Parks and Recreation Department. 2012. *2013-2017 Statewide Comprehensive Outdoor Recreation Plan.* Retrieved October 3, 2018, from https://www.oregon.gov/oprd/PLANS/docs/scorp/2013-2018_SCORP/2013-2017_Oregon_SCORP.pdf

[81] Bergson, T. 2018. *2017 Oregon Resident Outdoor Recreation Survey.* 2018-2022 Oregon Statewide Comprehensive Outdoor Recreation Plan Supporting Documentation. Oregon Parks and Recreation Department. February 22. Retrieved October 3, 2018, from https://www.oregon.gov/oprd/PLANS/docs/scorp/2017_Oregon_Resident_Outdoor_Recreation_Survey.pdf

"more than capacity." In addition, approximately 75 percent of visitors surveyed expressed support for more opportunities to escape crowds.[82] Other factors that influence the quality of recreation in the NSW include reservoir levels and quality of water at Detroit Lake and downstream in the North Santiam. An analysis of visitation found that across all the Willamette Valley projects a one-foot decrease in water levels was associated with a 0.3 percent decrease in visitation.[83] During algae blooms that produce toxins, the Oregon Department of Health recommends reducing contact with the water. To the extent that reservoir levels are lower for longer periods during the summer recreation season, and toxic algae blooms increase in frequency or duration, the value of recreation in the NSW likely will decrease and users will look elsewhere for opportunities.

The economic value associated with recreational opportunities is influenced by a number of factors, including the overall quality of the recreation site and the relative abundance or scarcity of such opportunities. Rising incomes and increasing population growth in the Willamette Valley and Portland metro region are likely to lead to increased values for high-quality recreational opportunities. The conclusions of a report written by researchers in 1951 at Oregon State College (before it was designated Oregon State University) about the utilization of resources in the Little North Santiam River Basin still hold today:

> *"As the urban centers of the Willamette Valley grow, this accessible basin with its forest, streams and wildlife will be increasingly used by the people from these more crowded areas."*[84]

3.4 Aesthetics

Water in the NSW provides value by enhancing resident's and visitors' experience of their surroundings. This category of value is often referred to as aesthetic value. OWRD has identified aesthetic use as a beneficial use for water rights, defining it as the use of water for scenic, beautification, and enhancing the appeal of an area. However, a water right is not required to generate aesthetic use value: instream flows in the North Santiam and its tributaries also support this use and value. Aesthetic values can sometimes be difficult to disentangle from demand for other amenities provided by waterways, such as passive recreation and fish and wildlife habitat, discussed in more detail in Sections 4.2 and 4.3.

3.4.1 Current Demand

Demand for aesthetic resources tied to water is typically most strongly expressed through the market for property nearby waterways. While demand for these properties is often also driven

[82] Bergerson, T. and W. Mouw. 2013. Visitor Survey of Day-use and Overnight Visitors at Detroit Lake State Recreation Area. Oregon Parks and Recreation Department. p. 45.

[83] Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation*. Oregon State University.

[84] Jenson, J.G., and R.M. Highsmith. 1951. *The Little North Santiam River Basin: Its Resources and Their Utilization.* Oregon State College, School of Science.

by easier access to recreation opportunities, especially in popular recreation areas, part of the appeal comes from the views and natural setting provided by the river and riparian ecosystem.

A detailed analysis of the quantity and characteristics of properties adjacent to the river is beyond the scope of this report. Marion and Linn County assessor records indicate that private property abuts the North Santiam River from Idanha to Jefferson. Many of these parcels are divided in ways to maximize the number of lots with river front access (i.e., they are long and skinny), and some include homes that serve as primary or secondary residences. Some of these riverfront lots, especially in the communities in the North Santiam Canyon, appear from assessor records to be undeveloped. This may indicate that demand for developing river front property in the NSW is weak, or, more likely, that other attributes which would affect demand for residences in the NSW, such as access to services and infrastructure, are underdeveloped. Further study would be required to determine all of the multiple factors driving demand for residential development of riverfront property in the NSW, and how aesthetic characteristics factor into this demand.

Though Detroit Lake is a popular recreation amenity in the NSW, there are few private residential properties with lake frontage, because of the topography and land ownership patterns surrounding the reservoir. These are concentrated in the community of Detroit. Development on these parcels tends to be modest, with real market value estimated in the range of less than $100,000 to (a few) around $600,000.[85] As with riverfront property throughout the watershed, some of the parcels are not developed.

Markets for river-front property in the NSW do not appear to be robust. However, some evidence indicates that people are choosing to live in communities close to the North Santiam River, even though they work in Salem and elsewhere, and incur extra costs of commuting. Census data describing commuting patterns reveal that in Lyons, where median household incomes are among the highest in the NSW, 20 percent of workers commute to Salem, and almost 50 percent of workers commute more than 10 miles to work.[86] The relationship between environmental amenities, including of water-related resources (especially lakes), on household location decisions, quality of life, and economic growth has been well-documented in the literature,[87] and it seems likely that at least some of the people who work in Salem and live in places like Lyons and Mehama are choosing to do so in part because of the aesthetic values provided by the waterways and water-related ecosystems.

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[85] Marion County Assessor's Office. 2018. *Property Records Database* (Access via interactive map). Retrieved October 3, 2018, from http://www.co.marion.or.us/AO/

[86] U.S. Census Bureau. 2015. "Job Counts Where Workers Live." *On the Map*. Retrieved October 3, 2018, from https://onthemap.ces.census.gov/

[87] *See*, e.g., Hill, E., J. Bergstrom, K. Cordell, and J.M. Bowker. 2009. *Natural Resource Amenity Service Values and Impacts in the U.S*. A Demographic Research Report in the IRIS Series. U.S. Department of Agriculture, Forest Service. April. Retrieved October 3, 2018, from https://www.srs.fs.usda.gov/trends/pdf-iris/IRISDemo2rptfs.pdf

The NSW also supports aesthetic uses in Mill Creek, which is a tributary to the Willamette River. Water is diverted from the North Santiam River into Salem Ditch, and enters Mill Creek upstream of Aumsville. During the dry summer season, water from the NSW substantially augments flows in Mill Creek. Demand for aesthetics along Mill Creek are particularly strong, as it flows through Oregon's capitol grounds and, via the Mill Race, through the campus of Willamette University. These waterways are enjoyed by employees, residents, and visitors to Salem, especially during the summer months when people spend more time outside. The timing of relatively higher demand coincides with the period when flows from the NSW make up a greater share of Mill Creek's flow.

3.4.2 Economic Importance

A detailed review of the effect of rivers, streams, and canals on property values indicates that there is generally a positive relationship between proximity to a linear waterway and property values. These relationships are generally stronger in urban settings than in rural settings.[88] For example, research in Portland (OR) found that location within a quarter-mile of a creek was strongly associated with property prices. The effect diminished for properties more distant, and was insignificant when the distance reached a mile.[89] Across the studies reviewed, the premium associated with river views for property in urban settings was typically in the range of 10 to 30 percent. These values are likely most appropriate to indicate the potential value of aesthetic benefits to properties enhanced by Mill Creek in Salem.

In rural settings, the effect of river view/access was less definitive. The authors conclude that the supply of aesthetic amenities in rural areas tends to be higher, so there is relatively less scarcity for these kinds of amenities. Property adjacent to reservoirs also benefits from the aesthetic qualities of views and natural surroundings. Fluctuations in reservoir levels, and thus the aesthetic quality of the surroundings, tend to temper the effect.[90]

3.4.3 Expected Future Trends in Demand and Value

Increasingly, people are able to live further from their place of work, because access to communication networks, technology, and workplace culture (i.e., working fewer days per week and working remotely) reduces the cost of commuting. For this reason, the proportion of households able to relocate to places they enjoy being, because of their aesthetic and amenity value, may increase over time. This would increase the demand for, and value of the aesthetic resources provided by the NSW. Future actions that affect the pattern, timing, and magnitude of

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[88] Nicholls, S. and J.L. Crompton. 2017. "The Effects of Rivers, Streams, and Canals on Property Values." *River Reservoir Applications.* 2017(33): 1377-1386. Retrieved from https://rpts.tamu.edu/wp-content/uploads/sites/21/2015/05/The-Effect-of-Rivers-Streams-and-Canals-on-Property-Values.pdf

[89] Netusil, N.R., M. Kincaid, and H. Chang. 2014. "Valuing water quality in urban watersheds: A comparative analysis of Johnson Creek, Oregon and Burnt Ridge Creek, Washington." *Water Resources Research* 50(5): 4254-4268.

[90] Loomis, J. and M. Feldman. 2003. "Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method." *Water Resources Research* 39(9):1259.

reservoir levels in Detroit Reservoir may adversely impact property values adjacent to the lake, to the extent they increase periods of drawdown.

3.5 Electricity Generation

Development of Detroit and Big Cliff Dams in the 1950s added the capacity to use the water in the NSW for electricity generation. In this section, we describe the demand for electricity from the Columbia River system, generation capacity, and value of power generated from these hydropower facilities.[91]

3.5.1 Current Demand

Detroit Dam and Big Cliff Dam are operated by the U.S. Army Corps of Engineers and are considered part of the Federal Columbia River Power System. Power generated by these facilities is transported and marketed by Bonneville Power Administration. Detroit Dam has two generators, which at full production can produce 100 MW. Big Cliff Dam has one generator which at full production can produce 18 MW. Together, generators at Detroit and Big Cliff generated 405 GWh of electricity in 2017. The amount of electricity generated in any given year fluctuates based on flow conditions and reservoir operations. Demand for the power generated from these facilities comes from residential, commercial, and industrial customers in Oregon, Washington, and California.

In addition to these two large federal dams, Breitenbush Hot Springs operates a hydroelectric facility on the Breitenbush River which is used to provide power to the resort. Demand for this power comes directly from Breitenbush customers and owners and all power is consumed on site. The Santiam Water Control District operates a small hydropower project as well (less than 5 MW), and is in the process of licensing additional generation capacity.

3.5.2 Economic Importance

According to the USACE, the value of the power generated in 2017 was $7.8 million. Generating electricity via hydropower does not emit significant carbon dioxide emissions, thus another value of generating hydropower is in avoiding CO_2 emissions associated with climate change.[92] Applying the social cost of carbon of $48 per metric ton of CO2 (adjusted to 2018 dollars), used by the Northwest Power and Conservation Council in its *Seventh Northwest Conservation and Electric Power Plan*, the annual value of avoided CO_2 emissions at these power generation rates is $19.8 million.

[91] This section focuses on the values associated with hydropower production, and does not address the potential opportunity costs and direct costs associated with the dams. For example, it does not capture the value lost due to more limited opportunities for whitewater kayaking, or the cost of the dams in terms of diminished fish populations. Evaluating these opportunity costs is beyond the scope of this report, but could be explored in future research.

[92] Generating electricity with hydropower generates costs not reflected in these values, including the costs related to harm to fish: reduced value of commercial and recreational fisheries, nonuse values, and the costs required to manage and mitigate harm via ESA listing decisions.

Table 22. Amount and Value of Power Generated at Big Cliff and Detroit Dams

	GWh Generation	Value[1]	Avoided CO2 Emissions (k-ton)	Value of Avoided CO2 Emissions
Detroit Dam	315.4	$6,129,000	321	$15,408,000
Big Cliff Dam	90.1	$1,716,000	92	$4,416,000
Total	**405.5**	**$7,845,000**	**413**	**$19,824,000**

Source: Federal Columbia River Power System. FY 2017 Hydro Generation statistics.
Notes: [1] Represents the yearly value at daily net price.

3.5.3 Expected Future Trends in Demand and Value

According to the Northwest Power and Conservation Council's electricity demand analysis in its *Seventh Northwest Conservation and Electric Power Plan*, demand for electricity is increasing, but at lower rates than have occurred historically. The Council estimates that regional demand will grow by 1,800 megawatts between 2015 and 2035, with increases of between 90 and 220 megawatts per year. The Council expects to meet these increases with efficiency improvements, rather than new generation capacity. While demand for electricity overall may be increasing at a diminishing rate, the demand for low-carbon electricity is likely to increase as regional, national, and international carbon regulation policies restrict the use or increases the cost of high-carbon generation options. Thus, the overall value of the electricity produced in the NSW is likely to increase over time, especially as the real value of avoiding CO2 emissions increases each year as the social cost of carbon rises with concentrations of CO2 in the atmosphere.

3.6 Municipal and Industrial

The NSW supports municipal and industrial demands for water both within and outside the watershed. Water from municipal systems provides water for many purposes, including household demands (e.g., drinking, cooking, bathing) to commercial demands (e.g., food preparation, sanitation), to industrial demands (e.g., cooling, production, and sanitation). Water from municipal sources also serves an important public health and safety purpose when it is used for fire suppression and street sweeping. Finally, water from municipal systems is used to irrigate lawns and landscaping, which provides aesthetic benefits on public and private properties. The value of municipal and industrial water supply is a combination of the infrastructure investment and the water itself. The water would not have the same utility without treatment and distribution infrastructure. The treatment and distribution infrastructure would be useless without water at sufficient quantity and quality. The NSW contributes the water, but clearly investment in infrastructure is critical for households and businesses to generate economic value from water. We discuss demand for and importance of both in the following subsections.

3.6.1 Current Demand

There are eight communities which use water directly from the North Santiam or nearby groundwater as their primary municipal water source (Mill City is the only municipality which uses groundwater as its primary water source). In addition, three communities use water drawn from the Santiam that includes a mix of water from the North Santiam and South Santiam Rivers. Table 23 shows the characteristics of use for the communities that rely on water from the

NSW (excluding those that use a significant proportion of water from the South Santiam as well). Of these, Salem is by far the largest user of water from the NSW, and correspondingly has the largest water right.

Table 23. Characteristics of Municipal Systems that Rely on Water from the NSW

Community	Number of Connections	Average Annual Water Use (Gallons)	Percent of Total Use	Maximum Water Rights Available (Million Gallons)
Communities within the NSW (Listed West to East)				
Stayton	2,700	698,100,000	4.06%	1,825
Lyons-Mehama	855	56,000,000	0.33%	927
Mill City	830	131,400,000	0.76%	420
Gates	239	25,600,000	0.15%	401
Detroit	393	28,300,000	0.24%	217
Idanha	90	5,100,000	0.03%	91
Communities that Use Water From the NSW				
Salem	49,304	16,253,000,000	94.4%	56,210
Turner	798	With Salem	-	With Salem
Total	**55,209**	**17,197,500,000**	**100%**	-

Source: ECONorthwest, with data from personal correspondence and community websites.
Note: This table does not include Jefferson, Albany, and Millersburg. While these cities use water from the North Santiam, it is mixed with water from the South Santiam, and data were not available to describe the amount of water used exclusively from the North Santiam. Excluding these communities underestimates the use and importance of water from the NSW for municipal and industrial use.

The largest 100 municipal users of water for Salem are available in a 2016 report.[93] This listing of customers provides a snapshot of the types of demand for Salem's water. The largest customer is a wholesale customer (Suburban East Salem Water) that supplies water to households and businesses. Apart from that, all of the users in the top 10 are food processors and large institutions: Oregon Department of Corrections is the largest individual user of Salem's water, followed by Creekside Golf Operations, Rainsweet (a processor of local fruits and vegetables), Kettle Foods, Willamette University, and Oregon Cherry Growers. Many of these food processors are located in Salem because of their proximity to the crops they use as inputs to their products. For example, the Willamette Valley Fruit Company paid growers in the region $15 million in 2018 for fruit they processed.[94] Similarly, In Stayton, NORPAC Foods is the largest single user of water at 319,037,000 gallons per year, roughly half of the city's total use. The presence of these large industrial water users in Salem and Stayton reinforces the conclusions in the previous section that water used for agriculture is closely linked to other demands for water, including municipal and industrial sources.

3.6.2 Economic Importance

There are a variety of approaches to describe the economic importance of water supply from municipal and industrial sources. As discussed in the introduction to this section, demands from these customers are supplied through a combination of investment in infrastructure and investment in the water itself. To produce the highest utility from this water, it must be supplied reliably at a high quality. This requires ongoing investment in the treatment and distribution infrastructure, but also in planning for water scarcity and quality issues that arise at

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[93] Garlinghouse, K. 2016. Top 100 Water Customers for July, August, and September 2016. City of Salem, Oregon.

[94] Personal communication with Dave Dunn, Willamette Valley Fruit Company. October 18, 2018.

the source: within the NSW. Determining the optimal level of investment in each of these aspects of municipal and industrial water supply lies at the heart of many of the difficult decisions that managers must make, and for which we hope this report will provide useful information.

One way to describe the economic importance of the municipal and industrial water is to identify what its customers pay to receive it. In theory, this cost covers the annual cost to secure and maintain both the water supply at its source, and the infrastructure required to deliver it to customers. In fact, these costs may not always be aligned because financial planning for infrastructure investments is a long-run process, and water rates may not always be in step with current and expected future costs. More often, they reflect past costs of investment to cover financed capital costs, as well as annual operation and maintenance activities. Table 24 shows that customers pay an estimated amount of about $66.8 million per year to use water from their municipal providers. This cost is made up of a fixed base charge, which typically varies by type of user (though we use a flat residential rate assumption due to data limitations) and a variable charge for water (we also make simplifying assumptions for the rate we apply here: in reality, it typically decreases or increases by quantity of use). This total annual charge for water should be viewed as consistent with the scale of value, as estimated by the cost to provide water to customers, and is just one indication of the value of municipal and industrial water supply.

Table 24. Annual Water Rates and Estimated Charges to Municipal Customers (2018 Dollars)

Community	Annual Base Charge (Residential)	Number of Connections	Water Rate (Per 1,000 Gallons)	Annual Water Use (1,000 Gallons)	Total Annual Charge for Water
Communities within the NSW (Listed West to East)					
Stayton	$289.44	2,700	$1.18	698,100	$1,605,246
Lyons-Mehama	$387.00	855	$1.50	56,000	$414,885
Mill City	$192.00	830	$3.61	131,400	$633,632
Gates	$538.20	239	$3.00	25,600	$205,430
Detroit	$660.00	393	$1.50	28,380	$301,830
Idanha	$636.48	90	$2.85	5,100	$71,818
Communities that Use Water From the NSW					
Salem	$92.64	49,304	$3.50	16,253,000	$61,492,526
Turner	$270.00	798	-	With Salem	$215,460[1]
		(Total) 55,209	**(Average) $2.45**	**(Total) 17,197,500**	**(Total) $66,879,968**

Source: ECONorthwest, with data from personal correspondence and community websites.
Note: We have standardized data to rate per gallon. Actual rates are often in terms of cost per hundred cubic feet or ccf. This table does not include Jefferson, Albany, and Millersburg. While these cities use water from the North Santiam, it is mixed with water from the South Santiam, and data were not available to describe the amount of water used exclusively from the North Santiam. Excluding these communities underestimates the use and importance of water from the NSW for municipal and industrial use.
[1] Only includes base charge. Water use rate included with Salem due to data limitations.

Another way to look at the value of water for municipal and industrial sources is to ask people what they would be willing to pay to avoid going without water under different circumstances. Economists who value water supply reliability have done just that. In a study that evaluated water supply reliability among residential customers in five communities throughout the U.S., researchers asked people what they would be willing to pay to avoid two stages of water use restrictions:[95]

- Stage 1 restrictions included limitations on outdoor irrigation, filling swimming pools, and using ornamental water features.
- Stage 2 restrictions included mandatory prohibitions of outdoor uses of water, and some water rationing for other uses.

In all communities but one, people were not willing to pay to avoid Stage 1 restrictions. This suggests people have some willingness to accept temporary water use restrictions for some uses. However, when faced with mandatory restrictions, households were willing to pay between $23 and $42 (in 2018 dollars) per year, for each year of avoided Stage 2 restrictions. Using population data from Table 4 and 2.75 people per household, which was the average household size in Marion County in 2017, there are 85,421 households that depend on water from the NSW. This yields a value of between $2.0 and $3.6 million that residential households in the NSW would be willing to pay to avoid curtailment of some uses of water in a year. If these curtailments were more extreme and required mandatory water rationing of all uses of water, these values would be higher.

This finding only applies to residential customers. The value commercial and industrial customers would be willing to pay would depend on the expected loss of revenue or costs incurred resulting from water supply curtailments. These are specific to each business, and depend on how sensitive the business is to water supply disruptions. This sensitivity depends on the nature of the disruption (quality, quantity, or both), how long the disruptions last, how prepared the business is to manage disruptions (e.g., do they have a backup water supply), and what kind of risks accompany the disruption (water supply disruptions due to quality issues may come with additional risks and costs, especially for businesses involved in food processing or service).

Additional research would be required to determine the potential economic value of reduced water reliability for the commercial and industrial customers dependent on water from the NSW. During our interviews, one business offered their perspective on this issue, however. The NORPAC facility in Stayton relies on water from the NSW for their freezer defrost cycle. NORPAC estimates the replacement cost of alternative sources of cooling at $2 to $3 million. This represents just one portion of NORPAC's operations that relies on water from the NSW: the total cost they could incur related to water curtailments is likely much higher.

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[95] Raucher, R.S., J. Clements, C. Donovan, et. al. 2013. *The Value of Water Supply Reliability in the Residential Sector.* WateReuse Research Foundation, Bureau of Reclamation, and San Francisco Public Utilities. Retrieved October 5, 2018, from https://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/research/value_water_supply_reliability.pdf

Economic Contribution of Investments in Municipal Water Supply Infrastructure to the Economy

Many studies have explored the relationship between investments in public infrastructure, including water supply infrastructure, and economic growth. With few exceptions, they have found a positive relationship: public spending on infrastructure increases the productivity of private capital investment. One nationwide study found that investments in water and sewer systems provide greater returns than other public investments, such as highways.[96]

3.6.3 Expected Future Trends in Demand and Value

The Willamette Water 2100 project predicts that urban water demand will increase, driven both by overall population growth and expected increases in household income, which tends to positively correlate with increased water use.[97] While existing water supplies and water rights appear to be sufficient to support current and expected future population growth in communities dependent on water in the NSW, several issues may increase the risk of water supply shortages in the future:

- The frequency and magnitude of droughts may increase with climate change, as described elsewhere in this report, and in the NSW's *Drought Contingency Plan*.[98] This increases the risk of shortages and increased competition among water rights holders for available water. OWRD has never had to make a call on junior water rights holders in the NSW, but is increasing its attention to the issue given the potential future prolonged drawdown of Detroit Reservoir, which may result in a "regulatory drought" for some period of time while the USACE makes modifications to the Dam to comply with the 2008 Bi-Op.
- The City of Salem's water supply intake requires a certain minimum flow to operate efficiently. Although Salem's priority date on its water rights is old, meaning other water users likely wouldn't have priority over Salem in times of water scarcity, the intake requires higher flows for the City to exercise its rights. Releases of stored water behind Detroit Dam augment natural summer flows, ensuring the intake operates properly in some years and supplies water of sufficient quality for the treatment plant to operate optimally.[99] Reduced flows due to real or regulatory droughts may require

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[96] Krop, R.A., C. Hernick, C. Frantz. 2008. *Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Value to the National Economy.* August 14. Retrieved October 5, 2018, from https://www.cadmusgroup.com/wp-content/uploads/2012/11/Krop-et-al-2008-LocalGovt-InvtInMunicipalWaterandSewerInfrastructure.pdf

[97] Jaeger W.K, Plantinga A.J., Langpap C., Bigelow DP, Moore KM. 2017. *Water, Economics, and Climate Change in the Willamette Basin, Oregon*. OSU Extension Service Publication EM 9157.

[98] GSI Water Solutions, Inc and David Evans and Associates. 2017. *North Santiam Drought Contingency Plan.* North Santiam Watershed Drought Contingency Plan Task Force. July.

[99] Personal communication with Lacy Goeres-Priest, City of Salem Water Quality Supervisor, and Brent Stevenson, SWCD Manager.

Salem to make additional investments in its intake infrastructure to ensure it will be able to operate its water intake in the future.

- During the summer of 2018, algae blooms in Detroit Lake produced cyanotoxins that were concentrated enough downstream at the water intakes in the lower NSW that cities had to issue drinking water advisories for vulnerable populations. This meant that for some users, it was not safe to drink or use water from the tap. Some businesses opted to not serve water or food made with water until the advisory was lifted. Some food processors halted production until the risk of using contaminated water was better understood. Some businesses incurred costs related to additional testing of products to ensure safety before release to customers.[100] The City of Salem is beginning to study the factors that led to higher than average toxin levels, to better predict when they may cause problems to the water supply in the future. It is also studying potential investments to its treatment system to reduce toxin levels in finished water.

In addition to these factors that may increase the risk of water supply shortages, due to quantity or quality issues, many communities need to address aging infrastructure, to avoid future service disruptions from failing pipes, and increase the efficiency of their systems. For example, leaking pipes are a problem throughout the NSW that contribute to substantial loss of treated water. According to a report in 2014, 22.9 percent of Salem's water was lost within their system in FY 2011-2012 due to deteriorating infrastructure and compromised connections. Surveys are ongoing to repair any leaks detected through their monitoring program.[101] A large portion of Salem's unaccounted water is believed to be caused by the transmission line between Geren Island WTP and Turner Control.[102] The City of Detroit also has documented high water loss due to leaks. In 2018, they received a $3 million loan to begin repairs to fix the large water losses.[103] The City of Idanha also has documented leaks of 15.6 to 18.1 million gallons a year in 2007, which would be approximately 30 to 35 percent of the annual water use.[104]

Addressing these and other issues will require financial investments that water users may or may not be able to afford. Affordability challenges are especially acute in the North Santiam Canyon communities, where there are fewer customers among which to distribute new capital costs and debt burdens.

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[100] Poehler, B. and C. Radnovich. 2018. "Salem Water Crisis Puts Businesses Big and Small in a Bind." *Statesman Journal.* June 9. Retrieved from https://www.statesmanjournal.com/story/news/2018/06/09/salem-water-crisis-advisory-business-pinch/683704002/

[101] GSI Water Solutions, Inc. 2014. Water Management and Conservation Plan. Prepared for City of Salem, Oregon. November.

[102] Ibid.

[103] Personal conversation with Detroit Public Works on August 29th, 2018.

[104] Mid-Willamette Council of Governments. (2014). *North Santiam Canyon Economic Opportunity Study.*

3.7 Irrigated Agriculture

Both irrigated and non-irrigated agriculture occur in the NSW, and both require water to generate economic value. For irrigated crops, the water is diverted from surface or ground water and distributed to the crop. To a large extent, the water from the NSW is diverted outside the basin to irrigate crops to the north and south of the NSW. Non-irrigated crops rely on precipitation that falls within the NSW to grow. While non-irrigated crops require water and produce economic value associated with that water and we discuss these briefly, this section focuses on irrigated agriculture, because it is most vulnerable to changes in water supply, allocation, and competing demands for water. Comprehensive data about agricultural produce and land use are unavailable at the watershed scale, so we look to county data to describe broad trends in demand, use, and value in the NSW. We rely on private information provided by the two irrigation districts relying on NSW and one of the region's largest agricultural-industrial food processors to help fill in details on the value of agricultural production in the NSW specifically.

3.7.1 Current Demand

As described in Section 3, agriculture dominates land use in the western portion of the NSW. Two districts that provide water for irrigation have water rights to stored and live flows in the North Santiam River, and divert water for their customers. The Santiam Water Control District diverts water at Stayton to the north, within and outside of the NSW, and the Sidney Irrigation Cooperative diverts water to customers south of the river near Jefferson.

The most recent data available to describe agriculture at the county level in Oregon comes from the 2012 Agricultural Census, which the U.S. Department of Agriculture implements every five years. Data from the 2017 census are not yet available at the county level in Oregon.

Table 25. Selected characteristics of agriculture in Linn County and Marion County, Oregon

2012 Agricultural Census Characteristics	Linn County	Marion County	Linn & Marion	Oregon	% of Oregon
Farms	2,083	2,567	4,650	35,439	13.1%
Land in farms (acres)	331,316	286,194	617,510	16,301,578	3.8%
Average size of farm (acres)	159	111	135	460	-
Total cropland acres	227,547	213,788	441,335	4,690,420	9.4%
Irrigated acres	28,687	84,916	113,603	1,629,735	7.0%

Source: USDA Agricultural Census. "County Summary Highlights 2012: Oregon"

Table 25 presents selected data from the 2012 Agricultural Census for Marion and Linn Counties, and the state of Oregon. In 2012, about 13 percent of Oregon's farms were in Marion and Linn counties, but those farms included only about 4 percent of the total land in farms across Oregon. This is because the average size of a farm in Marion and Linn Counties tends to be smaller than the Oregon average (which makes sense, especially considering that farms and ranches in Eastern Oregon, where land is less productive, tend to be much larger). The average size of a farm in Linn and Marion counties is about 135 acres. Of the total land in farms in Linn and Marion counties (617,510 acres), 71 percent is cropland. About 25 percent of the cropland is irrigated, and about 18 percent of the total land in farms is irrigated. This is a smaller percent than the entire state, where about 35 percent of all cropland is irrigated. Again, this makes sense: in the western valleys more crops can be grown without irrigation because of the overall amount of precipitation the area receives during the wet October to April period. In the Willamette valley, the irrigation season typically lasts from April to October. The proportion of cropland that is irrigated is higher in Marion County (almost 40 percent) than in Linn County (12 percent). This is because crop production in Linn County is weighted toward sod and grass seed, which tends to be unirrigated.

According to data from the USDA, there are just over 26,000 acres of cropland within the boundary of the NSW. However, just like for municipal use, water is diverted outside the boundaries of the NSW for irrigation. Much of this land is located within two districts withdrawing water from the NSW for irrigation: the Santiam Water Control District (SWCD), which diverts water to the north of the NSW and the Sidney Irrigation Cooperative (SIC), which diverts water to the south. Table 26 provides data for farms within these districts. Between the two of them, there are 23,867 acres of irrigated land.

Because of the complexity of accounting for irrigated cropland both within and outside the NSW, and the risk of double-counting across the available data sets, we were unable to estimate exactly how many acres of cropland are irrigated with water from the North Santiam River and groundwater wells within the NSW. It is likely more than 24,000 acres—the approximate number of irrigated acres within the districts—and almost certainly less than 50,000, which is the approximate total of cropland within the NSW and irrigated cropland within the districts, and thus includes some overlap between the two geographies, as well as some non-irrigated cropland acres within the NSW.

Table 26. Demand from the Irrigation Districts that rely on water from the NSW

	SWCD	SIC
Customers Served	485	220
Irrigated Acres	16,880	6,987
Number of Water Rights	35	6
Quantity of Water in Rights (cfs)	875	266
Priority Date Range	1909-1996	1870-1991

Source: ECONorthwest, with data from OWRD (WRIS) and Crew, K.L., J. Lee, and D.Prull. 2010. *Irrigation Water Providers of Oregon: Hydropower Potential and Energy Savings Evaluation.* Black Rock Consulting and Energy Trust of Oregon. Retrieved October 4, 2018, from https://www.energytrust.org/wp-content/uploads/2010/09/HydropowerPotential_1.pdf

According to Brent Stevenson, who manages the SWCD, some of the farms in the district have water rights that supplement water purchased from the district, including rights to withdraw groundwater for irrigation purposes. SWCD works cooperatively with the City of Salem to manage the point of diversion at Lower Bennet Dam, after which water is diverted into approximately 90 miles of canals and ditches (including Salem Ditch) that distribute water to farms. A large percent of the farms produce crops for the NORPAC cannery in Stayton, including corn, beans, and squash.[105] NORPAC is one of the largest single customers for crops grown using water from the NSW. According to calculations by NORPAC, there are 33 farmers on 7,962 acres who have North Santiam water rights. Many, if not most of these farms are within the SWCD.[106]

In addition to these customers, individual irrigators divert water from the NSW. A 2002 assessment found that there are almost 1,000 points of diversion associated with irrigation water rights in the lower and middle reaches of the NSW.[107] Of the 63 primary and supplemental irrigation water rights for the North Santiam, 42.6 percent are held by SWCD, 29.5 percent are held by SIC, 15.4 percent are held by other private, non-corporate irrigators, and the remainder are held by other companies.

Figure 7 shows the top ten crops grown in the NSW in terms of percent of total acreage, and the same for Marion and Linn Counties (acres by crop as a percent of total acreage in each county). These include both irrigated and non-irrigated crops. Traditionally non-irrigated crops, such as grass seed and hazelnuts are increasingly transitioning to partially or fully-irrigated crops. Historically, filbert (hazelnut) crops tend not to be irrigated, especially after the first few years when they are being established, but this is changing.[108] Hazelnut growers inside and outside the NSW are investing in irrigation infrastructure to increase yield and quality and provide resilience against disease. According to one source, all new orchards are being installed with drip irrigation systems.[109] The crops with the highest acreage that are primarily irrigated include corn, beans,[110] mint, and blueberries. These are all crops identified by SWCD and NORPAC as important irrigated crops within the area irrigated by water from the NSW.

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[105] Personal conversation with Brent Stevenson, North Santiam Water Control District, on August 16th, 2018.

[106] Personal communication with Randy Bentz, Director of Operational Improvement, NORPAC Foods LLC. on September 11, 2018.

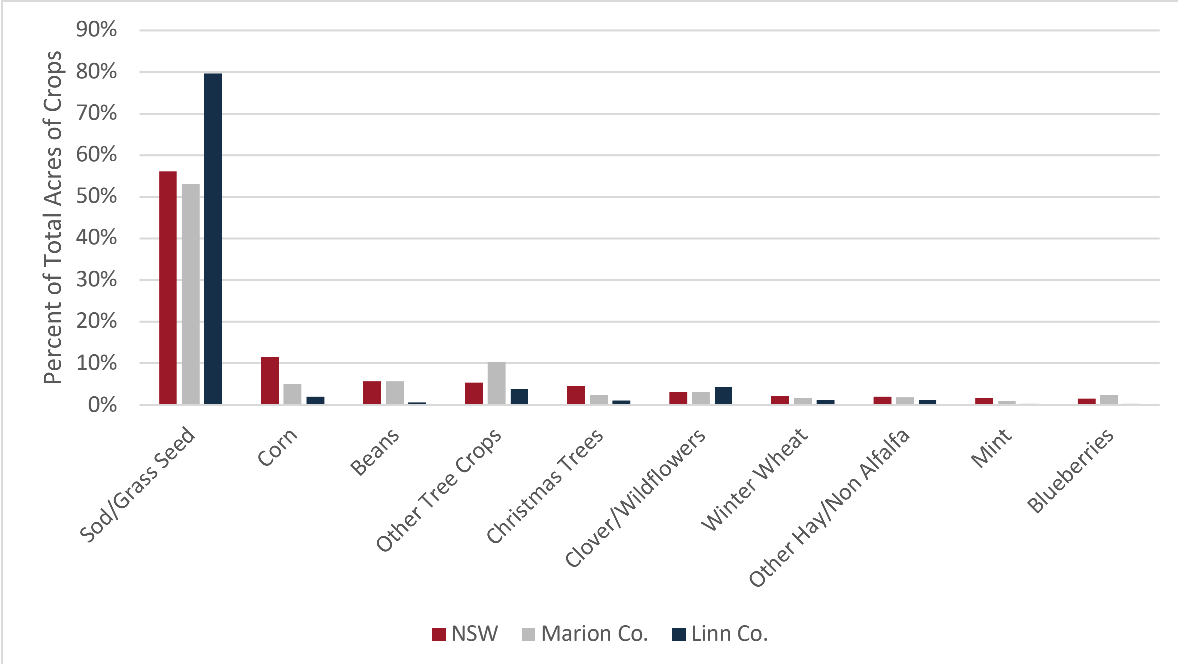
[107] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

[108] Oregon Hazelnut Commission. 2013. *Hazelnut Industry Good Agricultural Practices Manual.* Retrieved October 4, 2018, from http://oregonhazelnuts.org/wordpress/wp-content/uploads/2016/05/Haz-GAP-8-12-13.pdf

[109] Carter, B. 2017. "Successful Hazelnut Grower Champions Drip Irrigation." *Willamette Hazelnut Growers First.* Retrieved from https://www.willamettehazelnut.com/single-post/2017/04/06/Successful-Hazelnut-Grower-Champions-Drip-Irrigation

[110] This category is labeled "dry beans" in the USDA CropScape dataset. However, interviews with local producers and NORPAC staff suggest that the primary bean crop in the watershed is fresh green beans, and dried beans are not produced in this area (personal communication with Mark Steele, NORPAC).

Figure 7. Crops Grown in the NSW, Marion County, and Linn County, 2017



Source: ECONorthwest, with data from USDA CropScape 2017 (https://nassgeodata.gmu.edu/CropScape/)
Note: The category "Beans" is labeled "Dry Beans" in the CropScape data. However, interviews with local producers and NORPAC staff suggest that the primary bean crop in the watershed is fresh green beans, and dried beans are not produced in this area (personal communication with Mark Steele, NORPAC).

3.7.2 Economic Importance

The market value of agricultural products sold in Marion County was almost $593 million in 2012. Linn County's total was less than half of that, at $241 million. This includes the gross value of all products sold, before taxes and production expenses. Marion and Linn together accounted for about 17 percent of the value in all of Oregon. In Marion County, crops (including those produced from both irrigated and non-irrigated land) accounted for about 80 percent of the market value, and in Linn County, it accounted for about 77 percent. Gross income from farm related sources includes all income associated with farm operations that does not come directly from marketed agricultural products, such as agri-tourism and recreation, state and local agricultural program payments, cash rent, and sales of forest products. While these data provide information about the importance of agricultural production in these counties, some of which is certainly made possible by access to water for irrigation, they don't point directly to the value of irrigated agriculture tied directly to water in the NSW.

Table 27. Economic Characteristics of Agriculture in Marion and Linn Counties and Oregon, 2018 dollars

2012 Agricultural Census Characteristics	Linn County	Marion County	Linn & Marion	Oregon	% of Oregon
Market Value of Ag Products Sold ($)	267,385,982	657,121,590	924,507,573	5,413,064,262	17.1%
Crops, including nursery and greenhouse crops ($)	206,230,012	535,367,176	741,597,188	3,599,453,629	20.6%
Gross Income from Farm-Related Sources ($)	12,112,595	21,572,789	33,685,384	258,632,948	13.0%
Land in farms (acres)	331,316	286,194	617,510	16,301,578	3.8%
Total cropland (acres)	227,547	213,788	441,335	4,690,420	9.4%
Average value per acre of cropland ($)	$906	$2,504	$1,680	$767	-
Principal operator with primary occupation farming	48%	47%	48%	50%	-

Source: USDA Agricultural Census. "County Summary Highlights 2012: Oregon". Updated to 2018 dollars using the BLS CPI Inflation Calculator available at https://data.bls.gov/cgi-bin/cpicalc.pl
Note: The USDA Agricultural Census is taken every 5 years. As of the publication of this report, data for the 2017 Census are not yet publicly available.

To account for some of the value, we look to data supplied by NORPAC, which is the largest single buyer of agricultural products from farmers using water from the NSW. The 33 farms that NORPAC works with directly cover 7,962 acres, much of which is within the SWCD (SWCD does not keep systematic data on the crops grown within the district). For farmers who produce agricultural crops for NORPAC, the combined value of their crops (not including grain, seed, or nuts) is estimated at almost $7.5 million. This figure represents the raw product price that NORPAC pays the farmers, and is consistent with gross values reported in the Census of Agriculture. Table 28 shows the farm characteristics and market value of products sold to NORPAC, and equivalent data for Marion County as a whole, for comparison.

Table 28. Market Value of Crops Irrigated by Farms Contracted by NORPAC

Description	NORPAC Farms	Marion County	NORPAC's Percent of County
Number of Farms	33	2,567	1.29%
Total Number of Acres	7,962	286,194	2.78%
Market Value of Crop Production	$7,490,393	$657,121,590	1.14%
Average Market Value per Farm	$226,982	$255,988	88.67%
Average Size of Farm (Acres)	241	111	217.36%
Market Value Beans	$4,046,925	N/A	-
Market Value Cauliflower	$122,473	N/A	-
Market Value W Squash	$127,357	N/A	-
Market Value Blueberries	$106,918	N/A	-
Market Value Corn	$3,086,720	$3,297,154	93.62%
Total Number of Acres of Crops (Beans, Cauli, W Squash, Blueberries, and Corn)	7,962	17,835	44.64%

Source: USDA Agricultural Census (2012) and NORPAC Foods, LLC. Marion County results are from the 2012 USDA Agricultural Census, adjusted to 2018 dollars. Market value or economic value for NORPAC refers to the raw product price that is paid to the farmers in 2017 (adjusted to 2018 dollars) and for Marion County is the market value of agricultural products sold from the 2012 Agricultural Census (adjusted to 2018 dollars).
Note: N/A indicates that data are not available from the Census of Agriculture.

Based on the data in Table 28, the average value per acre for the NORPAC acres is $940.[111] This result—$940—is considerably less than the average value of crop production per acre of

[111] This is based on the $7,490,393 in market value of crop production as reported by NORPAC and the total number of acres of crops at 7,962.

cropland in Marion County. The data in Table 27 from the 2012 Agricultural Census indicate that average value of crop production (both irrigated and non-irrigated) per acre of cropland (both irrigated and non-irrigated) in Marion County is $2504, and $906 in Linn County. This suggests the average value of crop production per year based on NORPAC data may underestimate the total value of production from lands irrigated with water from the NSW, possibly by a significant margin. There may be several reasons for this: acres contracted for NORPAC production may accommodate other crops during the growing season, producing additional value from the same acre that is not reported in the NORPAC data; or the types of crops farmers grow for NORPAC are not representative in terms of market value of the crops grown in Marion County overall.

If the NORPAC data are representative of the value of crop production on lands irrigated with water from the NSW, the total value produced from irrigated lands within the two districts would be $22.4 million per year ($940 per acre * 23,867). This likely underestimates the total value of irrigation from the NSW for two reasons: first, almost certainly there are irrigated acres of cropland receiving water from the NSW that are located outside the two irrigation districts. Using the sum of district acres (23,867) and acres within the NSW (26,000), which more than likely double counts some acres, increases the total value of irrigated agriculture to $47 million. Second, the value of $940 per acre is less than the average value of crop production per acre of cropland in Marion County, but more than Linn County's average value. Using the average market value per acre harvested in Marion County for the 23,867 acres yields a total value for the acres within the districts of $59.8 million, and using the average of Marion and Linn Counties ($1,680 per acre) yields a total value of $40 million. Multiplying the Marion County per-acre value by the upper bound of acres (50,000) yields $125.2 million—almost certainly an overestimate. These values ($22.4 million to $125.2 million) more than likely bound the range of the value of crop production irrigating with water from the NSW. For the purpose of this analysis, we use the $59.8 million value per year, which incorporates Marion County's per-acre crop value (likely an overestimate for all acres in the NSW) and the district-only acreage (likely an underestimate of all acres irrigated by water from the NSW).

Research shows that irrigated farmland is higher value than non-irrigated farmland, and this reflects the additional value of production that access to irrigation allows. In an analysis of property values in the Willamette Valley, a study by an Oregon State University student found that value of a water right depends on soil class (which also impacts productivity and crop value) and derived a value for irrigation water that ranges from about $10 to $23 per acre foot. Using economic and statistical methods, the researcher also found that the value of precipitation in the Willamette valley is $16.44 per acre foot.[112]

In addition to the value of irrigated crop production, water from the NSW supports agricultural processing and the production of value-added agricultural products, such as frozen vegetables.

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[112] Kalinin, A. 2013. *Right as Rain? The Value of Water in Willamette Valley Agriculture*. Master's thesis. Oregon State University.

NORPAC operates facilities in Stayton and Salem that depend on process water from the NSW, sourced primarily through municipal supplies. The value of this production is incorporated into the value of municipal supply, discussed in previous sections. NORPAC has stated that they rely on water from the NSW for their freezer defrost cycle. NORPAC estimates the replacement cost of alternative sources of cooling at $2 to $3 million.[113]

Economic Contribution of Agriculture to the Economy

Agricultural production contributes to local economies in a variety of ways. Farm operations create direct jobs, but also demand goods and services from and direct spending to other sectors of the economy, such as wholesale trade, transportation and warehousing. The goods produced from Oregon farms are sold nationally and internationally, bringing dollars into Oregon that are spent and re-spent, generating jobs and additional income along the way.

The data from the 2012 Agricultural Census also show that almost 50 percent of the farms in Linn and Marion counties are operated by people who make their living primarily through their farm (i.e., their primary occupation is farming). Those represent jobs (often sole proprietors and small businesses) in Oregon's economy. This also implies that 50 percent of farms are not the primary source of income or employment for the operator. This is typical of Oregon farms. It strongly suggests that agricultural production, even when it is not the sole source of income for a household, allows some Oregon families to maintain their rural property and lifestyle, and supports Oregonian's quality of life by maintaining the pastoral landscape so many residents enjoy.

3.7.3 Expected Future Trends in Demand and Value

Climate change may impact demand for irrigation: as average temperatures rise, evapotranspiration and crop water demand during the drier summer months may increase.[114] Research from the Willamette Water 2100 project found that some farmers may respond to climate change by irrigating earlier, which may change the timing of demand for water in the future. As water supplies for irrigation become more scarce in other basins or stressed groundwater basins surrounding the NSW, demand for water from the NSW may increase among farmers in surrounding areas. Irrigation demand may also increase as farmers continue to develop irrigation infrastructure for crops that have historically been unirrigated or minimally irrigated, such as hazelnuts and grass seed. For both crops, yields decrease during times of drought, so if drought becomes more frequent or severe, farmers may mitigate the increase risk of crop loss by investing in irrigation.

Population growth and urban development in the future may also change demand for irrigation, by shifting land use from crop production to housing production. This trend would

[113] Ibid.

[114] Jaeger, W. K., Amos, A., Bigelow, D. P., Chang, H., Conklin, D. R., Haggerty, R., Langpap, C., Moore, K., Mote, P., Nolin, A., Plantinga, A. J., Schwartz, C. L., Tullos, D., & Turner, D. P. (2017). Finding water scarcity amid abundance using human–natural system models. Proceedings of the National Academy of Sciences, 201706847.

have the opposite effect, potentially reducing demand for irrigation. Findings from the Willamette Water 2100 project suggest that over the rest of this century, land use change may result in an 8 percent decline in farmland acres, leading to a 5 percent reduction in irrigated acres.[115] If this trend occurs at the same time that demand for irrigation expands the number of irrigated acres supported by water from the NSW, the increase in demand may be offset somewhat.

3.8 Cultural and Tribal Use

Cultural values for natural resources held by members of Tribal nations are distinct from recreational use, aesthetic use, and non-use values. Tribal cultural well-being is the product of intensive and complex uses of resources, knowledge and relationships with the natural environment. Interaction with water resources in the NSW provides goods and services and additional cultural services including a sense of place and the sharing of cultural experiences between generations.

As documented in Section 3, native tribal people traditionally used and continue to use areas within the NSW. Until wide-spread European settlement and tribal removal to reservations, native people occupied large, semi-permanent winter villages in the lower reaches of the NSW, along the valley bottom of the North Santiam and Santiam Rivers. Throughout the spring, summer, and fall, people migrated into higher elevations to gather food and materials, to fish, and to hunt. People followed tributaries, and evidence of past habitation is found along streams.

Water provided—and continues to provide—important cultural value by sustaining fish and ecosystems they depend on; riparian vegetation used as food, medicine, and fiber for clothing, baskets, and tools; and other organic and non-organic materials used for subsistence and cultural purposes. The cyclical availability of these resources traditionally supported people throughout the year. Settlements concentrated around water in part also because water modulated the environment during both the hot summer and cold winter.

The cultural importance of water goes deeper than subsistence and physical environment, however. From water, native people derive cultural services that connect them to the earth and to each other. Water and water-related ecosystems contribute to individual and group identity, sense of place, spirituality, and serve to link past and future generations.

Traditional monetary measures of economic importance are inappropriate to describe the value of cultural and tribal use of water from the NSW. Monetization implies substitutability (i.e., that monetary compensation at some level can make whole the loss of the service, because equivalent services may be purchased). Given that many, if not all, cultural services are defined by place, tradition, and continuity of use and practice, no alternative resource could provide a

[115] Oregon State University. *Agricultural Land & Water Use*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1301

sufficient substitute for the resources in question. Because of the uncertainty, complexity, and inadequacy involved with identifying a monetary measure for cultural values, they are considered in this report of significant importance, and included qualitatively.

3.9 Public Health and Well Being

The water from the NSW supports ecosystems, as described in previous sections. Ecosystems regulate elements of the environment and provide goods and services that are connected to public health and well-being in several ways:

- Trees and vegetation within the NSW help regulate air quality, removing pollutants that have adverse impacts on public health. Economic benefits are greatest in areas with high concentrations of pollution sources, and where people—especially sensitive populations, such as elderly and children—spend time.[116,117] Thus trees within the NSW are likely most valuable from an air-quality perspective in communities and along major roadways, such as Highway 22.
- Natural spaces that are accessible to and used by people have numerous positive effects on mental and physical health, including ADHD, school performance, and cardiovascular disease.[118] One study found a relationship between tree die-offs in the Midwest and an increase in cardiovascular and respiratory tract illness.[119]
- Low-cost, accessible opportunities for recreation may increase people's activity levels, producing positive effects on indicators of physical health.[120] Some of the economic value associated with health improvements may be captured in the *consumer surplus* value described in the recreation section above (e.g., people enjoy recreation because it makes them feel good or helps them achieve health and wellness goals). However, consumer surplus value does not typically reflect avoided health care costs that may arise from improved health outcomes associated with outdoor recreation.
- Connection to place, mediated by access to natural spaces that enhance individual and community identity, may increase social capital (the interconnections between people

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[116] Nowak, D.J., S. Hirabayashi, A. Bodine, and E. Greenfield. 2014. "Tree and Forest Effects on Air Quality and Human Health in the United States." *Environmental Pollution* 193 (2014): 119-129.

[117] Baldauf, R. et al. 2013. "Integrating Vegetation and Green Infrastructure into Sustainable Transportation Planning." *TR News* September-October.

[118] Wolf, K.L., M.K. Measells, S.C. Grado, and A.S.T. Robbins. 2015. "Economic values of metro nature health benefits: a life course approach." *Urban Forestry & Urban Greening* 14(2015): 694-701.

[119] Donovan, G.H., et al. 2013. "The relationship between trees and human health: Evidence from the spread of the Emerald Ash Borer." *American Journal of Preventive Medicine* 44(2): 139-145.

[120] Godbey, G. and A. Mowen. 2010. *The Benefits of Physical Activity Provided by Park and Recreation Services: The Scientific Evidence.* National Recreation and Park Association. Research Series.

and institutions), which has been shown to positively impact individual well-being through myriad direct and indirect effects.[121]

Water is an essential ingredient in producing all of these effects. Economists have attempted to measure some of them in monetary terms. Air quality effects on public health are probably the most well-developed area of research. Considerable attention is currently being applied to measuring the economic effects of ecosystems and "green" and "blue" spaces on mental and physical health, but the relationships are complex and interrelated with many other factors that influence health outcomes. Attributing specific health and well-being outcomes (either in physical or economic terms) to a particular area or resource, such as water within the NSW is beyond the current state of the science. However, the relationships outlined above strongly suggest that human interactions with water in the NSW—both directly and indirectly—result in positive economic outcomes in terms of public health and well-being that are not otherwise accounted for in this report.

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[121] Capaldi, C. A., Passmore, H.-A., Nisbet, E. K., Zelenski, J. M., & Dopko, R. L. 2015. "Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention." *International Journal of Wellbeing* 5(4), 1-16.

4 Illustrative Case Studies

In the following sketches, we illustrate how the economic information presented in the previous section can be used to identify the tradeoffs and investment decisions facing communities and managers in the North Santiam Watershed.

4.1 Wastewater Infrastructure in the North Santiam Canyon Communities

Communities in the canyon are experiencing degrading wastewater treatment infrastructure, in the form of aging septic systems. No centralized wastewater treatment exists in Idanha, Detroit, Gates, Mehama, and Lyons, and Mill City's wastewater system needs upgrades. Other studies have found that the lack of community wastewater systems are a limiting factor in economic and community development in the canyon.[122]

Although fecal bacteria has not been identified at levels requiring regulation in the upper reaches of the watershed, it could become a problem if enough systems fail. It is unclear the extent to which failing septic systems may be contributing to toxic algae blooms in Detroit Lake. Failure of these systems has several effects that could result in negative economic consequences:

- If failure of the existing septic systems increases water pollution in the form of nutrients and fecal bacteria to waterbodies within the watershed, the value of water for recreation and municipal uses could decline. Water-contact recreation may become riskier, and costs for municipal water treatment could increase. It may also impose additional treatment costs for industrial or agricultural users.
- If levels increase to the point where additional regulation is required, it could increase costs to current NDPES dischargers and other non-point source dischargers.
- Undertaking development and redevelopment requires that property owners provide sufficient capacity to treat waste generated by the use of the development. Without access to adequate and affordable wastewater treatment systems, either in the form of new septic systems or centralized treatment, development is unlikely to occur in the canyon communities. As existing infrastructure ages and demand for services increases with populations—particularly outside the NSW that contribute recreation visitors within the NSW—the communities will be unable to serve these populations. It is possible that recreation visitation will stagnate or increase at slower rates than if services were available. More certainly, businesses in the canyon communities will capture less of the spending by recreation visitors—they will spend their money elsewhere. For

[122] Keller Associates. 2017. *North Santiam Canyon Regional Wastewater Analysis.* January. Marion County, Oregon. Retrieved October 5, 2018, from https://www.co.marion.or.us/CS/EconomicDevelopment/Documents/Keller%20Associates-NSC%20-%20Regional%20Wastewater%20Analysis%201-12-17.pdf

example, a recreation visitor heading to camp at Detroit Lake for the weekend may purchase firewood in Salem instead of in Detroit, knowing that retail services are not available in Detroit.

Regulatory constraints, fiscal constraints, and land constraints make addressing this problem through conventional means (e.g., building a centralized wastewater treatment system) difficult. Current estimates indicate that the investment to upgrade wastewater treatment for the canyon communities could range from $8.4 million for investments in Detroit[123] to $100 million for investments in all of the canyon communities[124] (adjusted to 2018 dollars).

To the extent that people outside of the canyon communities benefit from the goods and services available within the NSW, there may be justification for outside funding or subsidies to support investment in wastewater infrastructure. There are several ways non-local users benefit:

- Municipal and industrial water providers using water from the NSW may be able to avoid expensive upgrades to water treatment facilities or reduce costs associated with water treatment processes, if the water quality remains high and does not degrade from upstream infrastructure failures.
- Recreation visitors from within and outside the NSW may be willing to pay more for their trip if additional services are available closer to their recreation destination, saving time and resources to travel west to resupply or have dinner out.
- Currently permitted wastewater dischargers downstream of failing infrastructure may be willing to pay to avoid stricter controls on discharge.

This study demonstrates that demand for diverse recreation opportunities and services in the canyon is strong, and likely increasing as population in Oregon increases. Growing demand for clean water also exists from municipalities downstream. As long as the quality of the resource remains consistent with current levels, this economic value will continue to materialize at steady or growing levels. If it degrades, fewer people may come to the NSW to recreate and costs of using the water will increase, reducing its value to municipal and industrial customers.

Key questions to answer to inform the design and implementation of investment strategies include:

- To what extent will failing septic systems in the canyon compromise surface water quality for other users in the future?

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[123] HBH Consulting Engineers. 2014. *City of Detroit Wastewater Feasibility Study.* September.

[124] Keller Associates. 2017. *North Santiam Canyon Regional Wastewater Analysis.* January. Marion County, Oregon. Retrieved October 5, 2018, from https://www.co.marion.or.us/CS/EconomicDevelopment/Documents/Keller%20Associates-NSC%20-%20Regional%20Wastewater%20Analysis%201-12-17.pdf

- What other factors may impact water quality, and how do they compare to potential future impacts from failing septic systems?
- To what extent is economic development in the canyon communities hampered by the lack of access to wastewater infrastructure?
- Are there other factors acting to constrain economic development in the communities that should be addressed to maximize benefits from potential future sewer investments?

Addressing these questions in more detail will help clarify the problem, and may illuminate additional issues that should be addressed in tandem with wastewater infrastructure deficiencies. It may also suggest opportunities to leverage additional resources and achieve greater benefits from future investments.

4.2 Municipal and Irrigation Systems: Relationships Between Water Availability and Efficiency

Quality concerns aside, water from the North Santiam is generally available to meet current demands for agriculture, municipal purposes, domestic use, manufacturing, etc., at current levels of supply. Parties throughout the watershed, however, are cautious about what the future may hold. Given the many factors affecting the availability of adequate quantities of high quality water, many water users are interested in taking measures to secure supplies and reduce the possibility that they might be left without enough water under a variety of potential future scenarios. Stakeholders throughout the watershed recently convened and prepared a Drought Contingency Plan that addressed the risks and potential mitigation actions.[125]

The information presented throughout the previous sections of this report can help water users develop strategies by helping parties throughout the watershed develop a common understanding of both a) the trends affecting the *supply* of water, such as anticipated changes in the timing and quantity of flows due to climate change, and b) the trends affecting the various sources of *demand*, such as population growth. Together with this information, water users must operate within the system of water rights adjudication, to envision how the supply and demand scenarios might affect individual users of NSW water. For example, users with junior water rights may have concerns not only about overall water availability within the NSW but also about users with more senior water rights exercising more of their right than they do today.

To senior water rights holders, the difference between the full water right and their current (lower) level of usage provides some security and flexibility in planning for future water supply and demand scenarios. To junior water rights holders, however, the potential for increased water usage by more senior water rights holders, particularly during periods of water scarcity, creates uncertainty and poses the potential for the future loss of investments.

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[125] GSI Water Solutions, Inc and David Evans and Associates. 2017. *North Santiam Drought Contingency Plan.* North Santiam Watershed Drought Contingency Plan Task Force. July.

With an eye toward maximizing the economic value of water in the NSW, as described throughout this report, water users can begin to see the interconnected nature of water throughout the NSW. For example, as residential demand grows in response to population growth in Salem, those residents are also likely to value access to recreational opportunities in the NSW. Some of those residents will work in sectors of the water economy that have water rights that are junior to the City of Salem's rights. The effects of expenditures related to recreation and other water-dependent sectors of the economy, such as agriculture, likely ripple through Salem's economy. Water available for irrigation provides security for farmers, and also increases the opportunities for generating value from their land: irrigated land can produce a wider variety of higher-valued crops than land without access to reliable water supplies.

The reverse is also true: without a reliable water supply, an urban area such as the City of Salem can be constrained economically. The people and businesses in Salem are important inputs—for example, as labor, consumers, and suppliers—to the economic activity related to other water users in the NSW. Without a reliable water supply, farmers may not be able to grow higher-valued crops, a situation that may be exacerbated in the future under expected climate-change conditions. An understanding of all these relationships can provide an incentive for all parties to find economically efficient solutions to water management throughout the NSW.

Some potential questions to explore:

- Are there inefficiencies within the current system that could be addressed, in preparation for future periods of scarcity—leaking pipes, water usage during peak periods, etc.?
- Are there opportunities to make adjustments in water use that reflect the relative values of use? For example, could any irrigated acreage be converted to non-irrigated acreage, with compensation for the difference in value paid by other users that would benefit from the access to additional supplies?
- Are there opportunities to increase the certainty of supplies for both senior and junior water rights holders by negotiating payments for options to sell, transfer, or limit use under certain water supply scenarios?

4.3 Management of Detroit Reservoir: Economic Importance of Distributional Effects

While the Willamette Project Dams have not always been a part of the NSW, since the 1950s, they have had a tremendous influence on the way people use water throughout the watershed, by changing the availability and distribution of water-related goods and services. Through these changes, they have generated both benefits and costs, at a scale and scope that has influenced the decisions of most, if not all water users dependent on water from the NSW.

The dams generate flood control benefits estimated in the millions of dollars each year, largely to beneficiaries downstream of the NSW, in the Willamette Basin. The dams created one of the most popular summer reservoir recreation destinations in Oregon.[126] They generate hydropower to satisfy peak demands of the region's population. And by storing water and changing the timing of flows in the North Santiam River, the dams increased water availability when farmers' and communities' demands are highest: during the dry summer season. The dams also generated costs, by blocking access to historically productive salmon and steelhead habitat in the Willamette Basin and changing the characteristics of flow and habitat downstream. The cumulative effect of these dams, along with the other dams in the Willamette Basin and changes in land use over the 20th century, caused the populations of steelhead and Chinook to fall to levels that NOAA Fisheries deemed required protection under the ESA. This has led to increased costs for water users and land managers in the form of mitigation requirements for all actions that have the potential to harm the species.

To maintain the benefits while addressing the costs of the dams, the USACE and other federal agencies involved in their operation have developed options that would mitigate harm and speed recovery of the fish populations. Implementing these various changes (including changing the timing and quantity of reservoir releases, infrastructure improvements, and habitat investments) influence water users: changing reservoir levels (especially those that exceed the magnitude and timing of historical fluctuations) alternately increase and decrease the value recreational users derive from water-related recreation; minimum instream flow releases augment flows downstream of the dam from what they may otherwise be, especially during the summer, benefiting water users and property owners in the lower watershed.

The requirement structurally modify the dam to provide better control over downstream water temperatures, however, has led the USACE to propose draining Detroit Reservoir for some period of time during construction. This action would produce greater potential variability and uncertainty about water availability downstream of the dams than management actions to date, and has generated considerable concern about the potential costs. This report does not evaluate the USACE proposed action or recommend any specific outcome. It does, however, provide information that may be used to deepen understanding about the potential economic effects of changes in water supply arising from the proposed action.

One important dimension of economic importance that the USACE proposal illuminates, and is at play whenever there are multiple users attempting to access scarce resources, is that distribution of costs and benefits is not always equal or equitable. Distribution of costs and benefits varies spatially and temporally. A large portion of the value provided by the water-management infrastructure in the NSW accrues to beneficiaries outside of the NSW:

- Flood control value is concentrated in the communities along the Willamette River, downstream of the NSW (communities in the lower reaches within the NSW also

[126] Based on the recreation figures reported in Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation*. Oregon State University.

experience flood reduction benefits, but communities above the dams don't benefit at all).

- Over 90 percent of the water used for municipal and industrial purposes is used outside of the NSW (communities within the NSW use water too).
- Clean water from the North Santiam flowing in the Willamette has a diluting effect downstream of the confluence, improving water quality parameters in the Willamette River.
- Visitors to recreation sites within the NSW, including Detroit Lake are predominately from communities outside the NSW (people within the NSW also recreate here, perhaps at greater per-user frequencies because of their proximity to opportunities).
- The hydropower produced from Detroit and Big Cliff generators is transmitted outside the NSW (although electric utility customers within the NSW share in value of the region's hydropower generating capacity).
- Water stored in Detroit Lake is currently under review for reallocation to new water uses. Users downstream of the NSW may potentially be able to claim this water, but regulatory barriers may preclude users within the NSW from obtaining new rights.

The costs of management actions intended to maintain the quality and quantity of water from the NSW in the long run accrue disproportionately to communities and populations within the NSW:

- Reductions in recreation opportunity arising from water quality concerns or reservoir dewatering impact recreation users, who won't be able to recreate in their desired location. However, many will go elsewhere and substitute other experiences that will offset the loss in value somewhat. Communities dependent on the economic activity generated through recreation visitation cannot as easily substitute other economic activity to make up for the loss, especially in the short term.
- The Three Basin Rule and 2008 Bi-Op impose restrictions on discharges into and diversions from the NSW to protect water quality and salmon habitat. These restrictions have the potential to increase costs of development in the communities within the NSW, where populations are smaller and have lower median household incomes compared to larger communities downstream. While these actions serve to protect the quality of the resources that these communities depend on, the value of high-quality water and species recovery improvements accrue to a much broader population downstream of the NSW.
- All Oregon households (and likely households throughout the Pacific Northwest and the United States) will benefit from recovery of the Upper Willamette River Chinook (and steelhead as well), as evidenced by the research and values detailed in Section 3.2. However, most of the recovery actions must occur within the NSW and other watersheds in the Upper Willamette basin where the fish reproduce, imposing disproportionate costs on the land owners and water users within the NSW.

That these distributional inequities occur does not mean that actions taken to protect values that are enjoyed by wider populations should be abandoned. It does mean, however, that policy makers and managers may consider looking for opportunities to spread costs more widely as well. Mechanisms to do this include tapping outside funding to subsidize activities within the NSW (ideally from sources related to beneficiaries), and establishing user fees to capture revenue to pay for the services people enjoy. Carefully documenting these relationships through an equity frame may provide credibility toward and help justify future investment decisions. Actions and policies that have the potential to impose additional costs within the NSW may provide opportunities for addressing equity and distributional issues.

Appendix A. Key-Informants

Name	Position	Affiliation	When Contacted	Who Contacted	Type of Contact
Randy Bentz	Director of Operational Improvement	NORPAC	7/10/18 (email), 7/25/18 (email), 8/7/18 (phone and email), 9/11/18 (email), 9/25/8 (email)	Laura Marshall	Data Request
Daniel Holbrook	Industrial Lands Specialist	Business Oregon	7/10/18 (email), 7/17/18 (email), 7/18/18 (email)	Laura Marshall	Data Request
Robert Gentry	Natural Resources Staff	USFS - Detroit RD	7/11/18 (email) and follow-ups	Kristin Lee	Data Request
Suzanne Cable	Santiam River Zone Recreation, Lands, and Minerals Staff	USFS - Detroit RD	8/6/18 (email) and follow-ups	Kristin Lee	Data Request
Mike McCord	NW Region Manager	OWRD	7/10/18 (email), 7/19/18 (in person in Salem), 8/2/18 (email), 8/6/18 (email)	Laura Marshall	Informational Interview
Dave Carpenter	Owner	Oregon Outdoor Excursions	7/10/18 (phone)	Kristin Lee	Informational Interview
Russ Foltz	Public Works Supervisor	Mill City Public Works	8/8/18 (phone)	Laura Marshall	Informational Interview
Deborah Hastings	City Clerk	City of Detroit	8/27/18 (phone), and 8/29/18 (phone)	Laura Marshall	Data Request
Will Summers	Workforce Analyst	Oregon Employment Department	8/22/18 (email)	Laura Marshall	Data Request
Caleb Dickson	Marketing Research Analyst	Oregon Parks and Recreation Department	8/9/18 (email)	Laura Marshall	Data Request
Russell Dilley	Parks Program Coordinator	Marion County Parks & Recreation	8/9/18 (email)	Laura Marshall	Data Request
Brett Stevenson	District Manager	Santiam Water Control District	8/16/18 (phone), follow-up emails	Kristin Lee & Laura Marshall	Informational Interview
Louis Landry	Project Manager	US Army Corps of Engineers	8/15/18 (in person), 8/27/18 (email)	Sarah Reich & Laura Marshall	Informational Interview
Peter Moore	Business Director	Breitenbush Hot Springs	8/15/18 (phone)	Kristin Lee	Informational Interview
Lacey Goeres-Priest	Water Quality Supervisor	City of Salem	9/6/18 (phone)	Kristin Lee	Informational Interview
Kurt Carpenter	Hydrologist	USGS	6/1/18 (email)	Sarah Reich (via Danielle Gonzalez)	Information
Brinton Foy Reed	Director of Marketing, Events and Hospitality	Breitenbush Hot Springs	8/14/18 (email)	Laura Marshall	Data Request
Sam Drevo	Director	eNRG Kayaking	8/12/18 (email) and follow-ups	Kristin Lee	Informational Interview

Bill Jaeger	Researcher	Oregon State University	4/17/18 (in person) and follow-ups	Sarah Reich, Kristin Lee, and Laura Marshall	Informational Interview
David Conklin	Researcher	Oregon Freshwater Simulations	4/19/18 (email), 4/24,18 (phone), 4/30/18 (in person)	Sarah Reich and Laura Marshall	Informational Interview
Danielle Gonzalez	Economic Development	Marion County	6/1/2018 (in person)	Sarah Reich	Informational Interview

Pacific Coast Federation of Fishermen's Associations (PCFFA
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Oregon Dept. of Environmental Quality
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31 October 2022
Via email PDF

RE: Comments on the Draft Fiscal Impacts Statement (DFIS) Version 2,
Yaquina River Watershed TMDLs rulemaking proposal

Dear Mr. Waltz:

These are the joint written comments of Pacific Coast Federation of Fishermen's Associations (PCFFA) and its sister organization, Institute for Fisheries Resources (IFR), on Version 2 of the Draft Fiscal Impact Statement (DFIS) for the Upper Yaquina River Watershed TMDL rule-making process as presented to the Rule Advisory Committee meeting on October 19, 2022. As you know, I am a member of the Rule Advisory Committee for this DEQ rulemaking process.

With these specific comments we are also filing a separate but parallel document titled *PCFFA Statement on the Value of Salmon to the State of Oregon*, (the "*Salmon Values Report*") to accompany these written, more rule-specific narrative comments. The *Salmon Values Report* contains what we hope is additional useful economic information for consideration in your next iteration of the DFIS. Please include it in the Administrative Record for this rulemaking process.

General Comment on DFIS Accounting for Values of Salmon: As noted in the *Salmon Values Report* filed separately, particularly referring to Attachment A of that document, nearly every regional Natural Resource Economist finds fault with most salmon-restoration project costs vs. benefits analyses in two major ways: (a) rarely do such analyses describe the benefits of regulations intended to foster salmon habitat restoration, which include broad-based benefits to society in general and to local and regional economies in particular, but instead nearly always over-emphasize only the costs of regulation, and; (b) rarely do such analyses talk about "the cost of doing nothing," i.e., the costs to society as a whole and to local and regional economies of *continuing water pollution, salmon habitat destruction and river industrialization practices that deplete valuable salmon runs and reduce salmon abundance.*

Unfortunately, this DFIS report comes dangerously close to making that same basic analytical mistake, and in the process severely biasing its findings in only one direction – i.e., over-emphasizing the "costs" to landowners and small businesses of cleaning up existing water pollution caused by their prior management actions, which have in fact jeopardized the state's watersheds and clean-water natural resources, which are held by the State in public trust for the benefit of all.

However, on page one of the DFIS, to DEQ's credit, you do provide at least some mention of this analytical problem, noting:

> "This fiscal impact statement does not quantify the costs of on-going water quality impairment to beneficial uses of waters of the state…. The negative economic and health impacts of water pollution potentially affect all those who live, work and recreate within the watershed, as well as those downstream, including commercial, recreational and subsistence fishing communities. The externalized costs of water pollution may disproportionately negatively affect poor, rural indigenous and minority communities in Oregon."

We also very much appreciate and support including the information on the economic benefits of restoring impaired waters in the Yaquina Basin in the section titled "Public." This is at least the beginning of an objective, inclusive costs vs. benefits analysis that includes the benefits (not just the costs) of landowner and small business compliance with standards that protect both beneficial uses and high water quality as an important public resource:

> "As a result of the proposed rule, DEQ expects that currently impaired beneficial uses of water in the Upper Yaquina River Watershed will be restored. These improvements would provide an overall positive direct economic impact to the public who live, work and recreate in the watershed.

> "The proposed rule supports the Oregon Plan mission: *Restoring our native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, culture, and economic benefits."* (emphasis in original)

And later in that same section, we are also gratified to see fisheries values that would be restored through improved water quality as a result of these proposed rules specifically mentioned as follows:

> "Commercial and recreational fishing is a major driver in the Oregon economy, especially in smaller rural communities. Water quality is a limiting factor that imperils the Yaquina population of Oregon coastal coho, which is significant in the culture and employment of the Oregon central coast that is severely depleted. The proposed rules support state and federal conservation or recovery plans to restore or maintain healthy fisheries and will also help improve water contact recreation and livestock watering opportunities. Small Oregon coastal communities downstream of the watershed, which once relied heavily on commercial salmon fishing for their income, may experience a positive economic impact due to the proposed rules, if salmonid populations increase."

And indeed, as shown in our accompanying *Salmon Values Report*, Oregon's salmonid populations are extremely valuable to its economy as well as to its ecosystems and cultures. The Yaquina Basin's losses of economic, ecological and cultural values that have been caused by decades of prior losses of the region's once-productive salmonid habitat, and resulting losses of its once-abundant salmonid runs may be at least an order of magnitude larger, once all the lost salmon values are accounted for, than the relatively minor "costs" to individual watershed landowners and small businesses of not polluting this watershed, not cutting down all of its trees right down to the waterlines, and of not keeping toxins out of the basin's public rivers and water supplies.

Timber Extraction is Often at the Cost of Watershed and Salmon Values: A common theme expressed by opponents of TMDLs, including in this process, that might reduce industrial timber production is that any reduction in timber production will have a profound negative impact on jobs. A number of economic facts, however, undercut these assertions. These facts show that, for decades, the Oregon timber industry has destabilized and depressed local rural economies by eliminating jobs through downsizing, out-sourcing once local production to other areas or countries, depletion of local forests and through automation, and that these industries are often contributing to unhealthy social as well as deteriorating water quality conditions in local communities. Research in Oregon provides some detail to these negative effects on local economies, by showing a strong statistical correlation between logging and negative economic indicators. Specifically, Oregon counties with more logging have lower median wages, and a higher percentage of the population lives in poverty.[1]

In modern industrialized timber extraction operations, which are largely unsustainable, the economic profits generated from logging do not generally stay within the local community – they go instead to corporate headquarters and to company shareholders. The negative economic, ecological and social externalities from industrial logging, however – water pollution, severe erosion problems, reduced biodiversity, increased fire hazards, damaged and degraded salmon habitat, boom/bust economies – all tend to stay in these local rural communities, where they adversely affect local economies and quality of life, potentially for decades, long after the timber industry has moved on to other forested areas.

In short, when industrial logging operations degrade biologically important watershed "buffer zones" that support clean water and provide habitat protection for salmonid spawning and rearing areas, as was frequently the case in the past, the net impact of these operations is likely to be negative, both economically and ecologically, to local communities, as noted in the accompanying *Salmon Values Report*.

Agricultural Practices Can Also Degrade Water Quality: The same can also be true of poorly managed agricultural operations that produce sediments and nutrient fertilizers or pesticides washing into local salmon-bearing streams. In short, poorly managed agricultural operations can greatly reduce the value of local streams to society as a whole, creating massive "externalities" that adversely affect downstream industries like the commercial fishing industry, and also create water pollution and sedimentation problems for downriver landowners, including municipal water purveyors who must absorb the additional costs of water pollution mitigation – and pass those additional costs on to their customers.

The Economic and Ecological Benefits of Appropriate Stream Buffers: Many of Oregon's laws require at least some measure of protection for fish-bearing watersheds to protect their valuable biological resources, through various no-cut or no-spray "buffer zones" and various types of best management practices. There is no absolute "right" for landowners to log down to waterlines in fish-bearing streams, and there is no "right" for agricultural operations to dump sediments or toxic fertilizers or pesticides in Oregon's rivers. All private property land-use practices in Oregon must be balanced against the "public property" Public Trust-driven values of protecting Oregon's watersheds for all the citizens of the State, and particularly those downstream of potential impacts.

New Oregon Logging and Agricultural Rules Better Protect Riparian Buffer Zones – Costs Which Cannot Be Attributed to TMDL Protections: It should continue to be noted in

[1] County harvest data courtesy of Oregon Department of Forestry. Poverty and median wage data are taken from the U.S. Census. See Talberth, J., 2017. Modernizing State Forest Practices Laws to Halt and Reverse Deforestation. West Linn, OR: Center for Sustainable Economy.

the DFIS that the proposed riparian "buffer zones" for compliance with these TMDLs are more or less the same requirements as the new "no cut" buffer zones which were recently adopted by the Oregon Board of Forestry as part of the Private Forest Accord (PFA). These new riparian protection standards for stream buffer zones were adopted by the Legislature in March, 2022, through Senate Bills 1501 and 1502, and House Bill 4055. Senate Bill 1501 specifically incorporated by reference the Private Forest Accord Report dated Feb. 2, 2022.[2] This consolidated rule-making package was formally adopted by the Board of Forestry on October 26, 2022. DEQ Staff mention this new rule package on DFIS pages 6 & 7 as (at the time of writing) a possibility, but its adoption by the Board of Forestry makes it now a certainty.

The DFIS also notes that the Oregon Dept. of Agriculture has its own set of riparian protection rules that require additional protections for water quality, under separate legal authority, and these additional riparian area water quality compliance costs (if any) also will not be TMDL-dependent.

In short, Upper Yaquina Basin local landowners are already required by other Rules or by statute to provide for comparable buffer zones as will eventually be required under the still proposed Yaquina TMDLs. Thus any additional costs associated with compliance with these proposed TMDL buffer zones are already going to be required under new Forest Practices Act and other entirely separate riparian protection regulations. Logically then, NONE of these water quality improvement costs could then be attributed to the TMDLs themselves. This would imply that the costs of TMDL compliance under these rules would most likely not be a significant additional cost to landowners.

*****

Thanks for the opportunity to comment on these proposals and their likely fiscal impacts. We look forward to moving these important TMDL rules forward.

Sincerely,

Glen H. Spain
Acting Executive Director
PCFFA/IFR

[2] See: https://www.oregon.gov/odf/aboutodf/documents/2022-odf-private-forest-accord-report.pdf

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Lorne Edwards
Secretary
Lori French
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PCFFA STATEMENT ON THE VALUE OF SALMON TO THE STATE OF OREGON

28 October 2022

There are many rule-making processes now underway in Oregon as part of major public programs to recover and restore the valuable salmonid habitat resources of this state that, unfortunately, have suffered in recent decades from steep declines. As more and more salmonid habitat has been blocked, dewatered, over-logged, over-grazed or industrialized, this historic loss of a major Oregon natural resource has had tragic consequences for many salmon-dependent economies, communities and jobs.

Many of those salmonid species (such as salmon and steelhead) are also the basis of economically and culturally important commercial, recreational, and Tribal fisheries which have *enormous* value to Oregon and the Pacific Northwest economically, ecologically and culturally. They are also a valuable food resource for America's tables.

Yet all too often these "salmon values," including the enormous socio-economic benefits to the people of Oregon from salmonid habitat restoration and watershed protections, are often ignored in the typical costs vs. benefits analyses for watershed protection measures. These "salmon values" (both monetizable and non-monetizable) should instead all be factored into the analysis as benefits of any proposed watershed restoration rules, and as losses when those rules are weakened, as noted below and in Appendix A.

1.0. Identifying and Accounting for Non-monetized Values

In the following discussion of the value of intact river ecosystems, we use the Pacific Northwest's salmon and steelhead runs (both classed as "salmonids" as closely related species[1]) and their related commercial, recreational and Tribal fisheries as but one obvious example of the

[1] For purposes of this discussion, unless a specific species is referred to, all salmonids are included in the commonly used term "salmon," including coho, Chinook, sockeye, chum, pink salmon, steelhead and cutthroat. All are anadromous, all are in the genus *Oncorhynchus*, and all require similar watershed characteristics.

many economic and other societal values that will be improved by having more protective Oregon water quality standards than currently exist.[2] Salmon harvests are also monetarily quantifiable in terms of "fiscal and economic effects." But additionally, there are numerous other salmon-related values and benefits that will flow from improved water quality standards in Oregon, including both cultural and ecosystem benefits, which are termed "non-monetized values," but which – although difficult to translate directly into dollars – are nonetheless of ***great value*** to the Pacific Northwest as well as to society as a whole, including multiple other stakeholder groups, communities and economies.

These non-monetized cultural and ecosystem values cannot just be ignored! When asking the bigger question not just of monetary values, but rather, "What are all the values of an intact and functioning riverine ecosystem?" these so-called "non-monetized values" may include multiple cultural, lifestyle, food production, clean water and other social benefits that, if they could be monetized, would likely *greatly exceed* in monetary value whatever purely localized monetary value could be obtained by industrializing (or polluting) those same river systems.

Indeed, Oregon's still relatively healthy river systems and watersheds are a major component of what makes life livable in our state, providing multiple benefits which in turn create multiple economic opportunities, including providing the vast majority of Oregonian's potable drinking water for its growing population. Those healthy (and especially important, unpolluted) river systems also support nearly all of our state's irrigated agriculture, which in turn provides jobs as well as healthy food for Oregon's citizens. They also support a multitude of other industries and communities.

Even well-water sources depend, ultimately, on inflows that are unpolluted and naturally filtered through soils into aquifers that also must remain unpolluted. Other states (notably California) are suffering from growing pollution problems in their remaining aquifers, problems which in turn are closing down drinking water wells in a number of towns and cities, and forcing the closures of some farms and related businesses. That could be Oregon's fate also – but for our strong water quality standards, which will also be improved by the proposed Rules.

2.0. Economists' Guidance Principles for Salmon Restoration Project Costs vs. Benefits Analysis

When considering whether or not to go forward with any particular salmon habitat restoration proposal (water quality improvements being one type of this restoration), one needs to look objectively at both the social costs as well as the social benefits of such an action, and on both sides of the equation. This is usually done at the agency decision-maker level through some type

[2] Since salmon are a highly migratory set of species, and circulate widely throughout the North Pacific Ocean, Oregon-origin salmon runs are a major component of the entire Pacific Northwest's salmon fisheries, especially since Oregon-origin salmon mostly migrate north into cooler waters where they can be harvested in Washington, British Columbia and Alaska fisheries. Oregon also shares the worlds' most important salmon producing river – the Columbia River – as its northern border with Washington. Oregon's water quality protections thus contribute to the health of all Pacific Northwest salmon fisheries, because Oregon-origin and Columbia basin-origin salmon runs are all protected by those standards.

of “costs-benefits” analysis. DEQ Staff are required to do something similar in assessing the impacts of the proposed Rules.

However, as a number of professional natural resource Economists have noted, while purely economic costs of compliance are important in many analyses of impacts, both the economic and non-monetized social benefits of salmon habitat restoration proposals are often given short-shrift or ignored in most current, standard, agency “costs-benefits” analyses. *This initial analytical bias greatly distorts the economic balance sheet and thus unfairly pre-biases public policy decision-making toward one end of the spectrum*.

Professional Economists tell us that in any legitimate “costs vs. benefits” analysis, we must account for the fact that salmon recovery (and by extension, water pollution mitigation efforts) will generate economic benefits as well as costs. To understand the net benefit (a net cost if negative) to the economy as a whole, one must consider the effects on the production of all goods and services. The effects on goods and services that are traded in markets, such as commercial salmon, timber production, and agricultural production, should receive the same consideration as those, such as recreational fishing, clean streams, and biodiversity (i.e., non-market values) that are not. Economists also tell us that a full accounting must be provided of the true value of each affected good or service, taking into account the market price, where appropriate, as well as all factors, such as subsidies, taxes, and environmental externalities, that may distort the level of supply or demand.

In addition, a true “costs vs. benefits” analysis should take into account “the costs of doing nothing.” In a highly degraded system (which all too many Oregon watersheds are now suffering from) and in streams with already poor water quality resulting from human-caused pollution, there is an often very large social cost of maintaining the degraded *status quo*. That social cost is a net drag on the economy that could include economic costs that are monetizable as well, including: (a) greatly depleted (even ESA-listed) salmon runs, which then foreclose harvest opportunities and cost coastal fishing-dependent communities jobs and incomes; (b) additional water treatment costs to local municipal water providers who are required to filter out pollutants and treat water for additional pathogens; (c) lost recreational activities because of health-code restrictions on recreational use of polluted water bodies (including closures caused by toxic algae blooms that are becoming much more common), thus reducing the recreation-based income of local affected communities ; (d) loss of local property values triggered by poor water quality as well as the above impacts. These externalized costs of water pollution to society, especially to many water quality-dependent businesses, as well as from pollution-caused threats to public health, are often ignored in typical costs vs. benefits analysis – *but this “cost of doing nothing” can be very high.*

That said, attached for reference are two well-respected Guidance Letters from numerous western-based professional resource Economists that contain principles of costs-benefits analysis they believe should apply to all salmon habitat and water quality protection efforts such as those proposed by DEQ’s Rules, as well as to all other western U.S. natural resource decisions. (See APPENDIX A)

3.0. The Value of Pacific NW Salmon

There are a multitude of good policy as well as economic, ecological and cultural reasons for the protection and restoration of the Pacific Northwest's dwindling salmon runs. Furthermore, since Oregon's and the Pacific Northwest's salmon runs are all highly migratory, the value they bring to society is distributed over a wide geographical region, from at least central California to southeast Alaska, where these salmon, when harvested, provide food, jobs and economic value to many people and businesses, and support multiple food chains and ecosystems.

3.1. Salmon Ecosystem Benefits

The once-great salmon runs of Oregon and the Pacific Northwest never existed in an ecological vacuum, but are instead an integral part of an entire food-web that still supports many other species. Salmon are a major or important food source not just for humans, but for at least 138 species of birds, mammals, amphibians and reptiles native to the Pacific Northwest that have been identified by scientists as predators or scavengers of salmon at one or more stages of the salmon lifecycle. Of this group of 138 species, 9 species have a *strong-consistent* relationship with salmon, and another 58 have a *recurrent* relationship with salmon. Yet another 25 species have *indirect* relationships that depend upon healthy salmon runs to support their direct prey base.

As a recent survey of these salmon-driven ecological relationships notes:

> "Salmon act as an ecological process vector, important in the transport of energy and nutrients between the ocean, estuaries, and freshwater environments...... As a seasonal resource, salmon directly affect the ecology of many aquatic and terrestrial consumers, and indirectly affect the entire food web." [3]

Indeed, the return of salmon back to their natal watersheds as adults is the one known mechanism for returning irreplaceable land-based nutrients, otherwise lost by erosion, back to the land. But as the region's salmon runs have collapsed, so has this important nutrient recycling mechanism. Recent calculations by Gresh, *et al.* indicate that only about 3 percent of the marine-derived biomass once delivered annually by anadromous salmon to the rivers of the Puget Sound, the Washington coast, Columbia River, and the Oregon coast is currently still reaching those streams.[4] *In other words, lack of returning salmon in recent decades is starving whole inland ecosystems, with unknown ultimate consequences.*

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[3] Species numbers and quote from introductory Abstract in Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. *Pacific Salmon and Wildlife – Ecological Contexts, Relationship, and Implications for Management. Special Edition Technical Report*, Prepared for D. H. Johnson and T. A. O'Neil (Managing directors), Wildlife-Habitat Relationships in Oregon and Washington. WA Dept. of Fish & Wildlife, Olympia, WA. (Hereinafter "Pacific Salmon and Wildlife.) Available at: https://wdfw.wa.gov/publications/00063 (last viewed 10/27/22).

[4] Gresh, T. J., Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. *Fisheries* 25(1):15-21. Available from American Fisheries Society at: https://fisheries.org/books-journals/fisheries-2/ (last viewed 10/27/22).

Table 2.2.1-1: The nine wildlife species identified as having (or historically had) a strong, consistent relationship with salmon in Oregon and Washington. An "X" identifies the life stage(s) of salmon applicable to the species (from Appendix 1, *Pacific Salmon and Wildlife, supra*).

	Incubation	Freshwater Rearing	Saltwater	Spawning	Carcass	Comments
Common Merganser	X	X	X			
Harlequin Duck	X		X			Strong relationship w/drift eggs and alevin; indirect relationship with carcass-derived insects.
Osprey		X	X	X		
Bald Eagle			X	X	X	Strong relationship w/salmon; also indirect relationship – feeds on gulls, terns, and waterfowl that eat salmon; occasionally have been seen catching and consuming smolts.
Caspian Turn		X	X			
Black Bear				X	X	
Grizzly Bear				X	X	
Northern River Otter		X		X	X	
Killer Whale			X			

The Plight of Southern Resident Killer Whales as an Example of this Biological Interdependence: As just one current popular example of the intimate food-web dependency of many species on healthy Northwest salmon runs, consider the plight of endangered Southern Resident killer whales (*Orcinus orca*). In 2005, due to their small population size and significant threats to their survival, NOAA Fisheries issued a final rule designating Southern Resident killer whales as "endangered" under the U.S. Endangered Species Act.[5] Scientific studies have shown that this whale population is food-limited, with declines in survival,[6] fecundity,[7] and social cohesion[8] during years with low Chinook salmon availability.

As it turns out, these orcas depend almost exclusively on salmon, with salmonids comprising over 98 percent of their diet.[9] Of that, roughly 80 percent of their diet is Chinook salmon. As many key salmon runs have declined, lack of prey, principally of their favored Chinook, is among the greatest threats to Southern Resident killer whale recovery and survival. The science shows that these orcas are feeding on salmon off the outer coast of Washington, Oregon, and California

[5] 70 *Fed. Reg.* 69,903 (November 18, 2005).
[6] Ford JKB, Ellis GM, Olesiuk PF, Balcomb KC III (2009). Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. *Biol Lett* 6:139–142.
[7] Ward EJ, Holmes EE, Balcomb KC (2009). Quantifying the effects of prey abundance on killer whale reproduction. *J Appl Ecol* 46:632–640.
[8] Parsons KM, Balcomb KC III, Ford JKB, Durban JW (2009). The social dynamics of the southern resident killer whales and implications for the conservation of this endangered population. *Anim Behav* 77:963–971.
[9] Ford MJ, Hempelmann J, Hanson MB, Ayres KL, Baird RW, Emmons CK, et al. (2016). Estimation of a Killer Whale (*Orcinus orca*) Population's Diet Using Sequencing Analysis of DNA from Feces. *PLoS ONE* 11(1): e0144956.doi:10.1371/journal.pone.0144956.

between January and June, and that these orcas concentrate near the mouth of the Columbia River at times that coincide with the return of spring Chinook.[10]

The 2008 NOAA Fisheries Southern Resident killer whale recovery plan states: "Perhaps the single greatest change in food availability for resident killer whales since the late 1800s has been the decline of salmon in the Columbia River basin."[11] Salmon restoration efforts at a region-wide basis are necessary to help achieve Southern Resident killer whale recovery goals. Oregon DEQ's improvements to existing salmon habitat protection Rules under consideration are an important element of Oregon's statewide salmon restoration efforts.

Salmon and Healthy Forests: Ecologically, trees need salmon as much as salmon need trees. Throughout the Pacific Northwest and northern California, where forest soils are often nutrient-poor, the salmon lifecycle is an important driver of the overall forest nutrient cycling system that supports forest health. Salmon are "anadromous" – this means they start their lives in freshwater lakes, streams and rivers, then migrate to saltwater where they spend, according to species, from two to seven years at sea before returning to freshwater to spawn and then die.

But when they return to spawn then die, salmon become a conveyor belt for key forest nutrients to come back from the ocean to land. For example, an adult chum salmon returning to spawn contains an average of 130 grams of nitrogen, 20 grams of phosphorus and more than 20,000 kilojoules of energy in the form of protein and fat; a 250-meter reach of salmon stream in southeast Alaska, for instance, receives more than 80 kilograms of nitrogen and 11 kilograms of phosphorous in the form of chum salmon tissue in just over one month.[12]

As the bodies of spawning salmon break down, nitrogen, phosphorus and other nutrients become available to streamside vegetation. According to Robert Naiman of the University of Washington, streamside vegetation in the Pacific Northwest gets just under 25 percent of its nitrogen from salmon. Other researchers report up to 70 percent of the nitrogen found in riparian zone foliage comes from salmon. One study concludes that trees on the banks of salmon-stocked rivers grow more than three times faster than their counterparts along salmon-free rivers and, growing side by side with salmon, Sitka spruce take 86 years, rather the usual 300 years, to reach 50 cm thick.[13]

In short, if the Pacific Northwest loses its salmon runs, this places many of its native forests at long-term ecological risk as well.

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[10] Haneson MB, Emmons CK, Ward EJ (2013) Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. J. Acoustic Soc. Am. 134(5) 3486-3495.
[11] National Marine Fisheries Service (2008) Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington. At: II-82.
[12] For an overview of the many studies of this phenomenon, see Robert J. Naiman, et al. Pacific Salmon, Nutrients, and the Dynamics of Freshwater and Riparian Ecosystems, Ecosystems, Vol. 5, No. 4 (June 2002), pp. 399-417, available on the Internet at: https://www.jstor.org/stable/3658977
[13] Helfield, James M., "Effects of Salmon-Derived Nitrogen on Riparian Forest Growth and Implications for Stream Productivity"(2001). *Environmental Sciences Faculty Publications. 19.* https://cedar.wwu.edu/esci_facpubs/19; Reimchen, T., *et al.* 2003. Isotopic evidence for enrichment of salmon-derived nutrients in vegetation, soil and insects in riparian zones in coastal British Columbia. *American Fisheries Society Symposium* 34:59–69.

Salmon and Healthy Estuaries: Salmon occupy the estuaries of the Pacific Northwest in two life-stages: (1) as very small out-going juvenile smolts that are adapting to ocean life in brackish salt-water marshes and estuaries as a transition stage to ocean migrations, and; (2) as returning, in-migrating adults. In the first stage they are important prey species for many other types of fish, but in the adult stage they are both predator as well as important prey to marine mammals such as sea-lions and orcas, and to much larger fish. In both roles they are an important contributor to the ecological health of the region's estuaries, as well as linked to the overall health of these estuaries as critical habitat for many other species.

All river estuaries are ecologically important. As an example, the Columbia River estuary ecosystem contains more life per square inch than the richest farmland and provides for multiple species of wildlife. The greater number of distinct habitats there are within an ecosystem, the more species it supports, the more ecological processes and functions it provides, and the better it withstands disturbances. Unfortunately, its historically wide range of complex, diverse habitats is now greatly diminished in the lower Columbia estuary. In the last 100 years more than 114,000 acres of lower Columbia River estuary floodplain have been converted to agricultural, urban, or other uses – a habitat loss in excess of 50%. Loss of critical estuary habitat has also been a factor driving regional salmon declines. Similar losses have occurred in many of Oregon coastal estuaries as well. Therefore, restoration of critical estuarine habitat for salmon should also be a part of any comprehensive salmon restoration strategy.

Salmon as Highly Migratory Ocean Species: Most salmon species are highly migratory, and once they reach the ocean they can travel literally thousands of miles both north and south as they search for food and grow to maturity, with established coastal-shelf migration routes down the west coast to as far south as San Diego, and far north well into the waters of southeast Alaska. See Chart 1.

Oregon coastal salmon thus constitute a significant portion of ocean harvests in all these other areas. More important, these widely migrating salmon become a major component of the entire west coast ocean ecosystem, in the roles of both predator and prey, during the years of their whole juvenile and adult life stages in the oceans. Their value in supporting and contributing to abundant ocean ecosystems and food webs is of incalculable (but clearly large) value to those rich ocean biological systems.

3.2. Specific Salmon Economic/Monetary Benefits

Commercial, recreational and Tribal subsistence fisheries support many communities and economies in the Pacific Northwest, including (as examples) the following:

Ocean Commercial Salmon Fisheries: Commercial salmon fishing generates thousands of jobs in smaller coastal Pacific Northwest communities that lack the diversity of economic opportunity present in major urban areas.[14] Oregon's valuable commercial and recreational salmon fisheries are no exception.

[14] Community Attributes Inc., *Washington State Maritime Sector Economic Impact Study* at 37-40 (2017) at: https://www.maritimefederation.com/wmf-2017-impact-study.html. *See also* Wash. Dept. of Fish and Wildlife, *Final Report: Economic Analysis of the Non-Treaty Commercial and Recreational Fisheries in Washington State* at

Chart 1: Ocean migration routes of the major west coast salmon runs.

According to the Oregon Department of Fish & Wildlife, even greatly reduced in size as they have been in recent years, Oregon's ocean coastal commercial salmon fisheries still generated an average over the years 2010-2017 of 396,728 landed pounds of salmon in its multiple coastal ports, representing an *ex-vessel* (i.e., essentially at the wholesale price at the boat-processor delivery point) of an average of $2,073,481 – which would have created, because of typical economic

https://wdfw.wa.gov/publications/00464. [hereinafter *Final Report*]; Gordon Gislason & Gunnar Knapp, *Economic Impacts of Pacific Salmon Fisheries*, Pacific Salmon Comm'n, at 27 (2017), available for download at: www.psc.org/download/333/special-reports/9337/economic-impacts- of-pacific-salmon-fisheries.pdf.

multipliers, more than $5,000,000 in net economic impacts to mostly poor Oregon coastal communities through the chain of commerce.[15]

Oregon coastal salmon landings during 2019, however, were improved over seriously depressed immediately prior year averages: 985,000 landed pounds, valued at (*ex-vessel* prices) $4.1 million – an increase of 34,000 pounds (4%) but a decrease of $1.5 million (27%) ex-vessel value compared with landings for 2018. In that same year, Washington's salmon landings (to which Oregon-origin salmon contribute) were 7.2 million pounds valued at $13.1 million ex-vessel prices.[16] But both of these harvests were still far below what was landed in earlier decades, reflecting overall declines of salmon runs coastwide.

Because Oregon-origin coastal Chinook salmon are also highly migratory, most of them seeking colder and food-richer upwelling waters by swimming (once they have hit the ocean) northward up the coast to enter Washington State's ocean salmon fisheries. While it is true historically (and even today) that many more salmon came from Oregon's rivers and tributaries emptying into the mighty Columbia River than came from purely coastal rivers, Oregon-origin salmon (particularly Chinook) from both Columbia Basin and coastal river contribute signficantly to ocean commercial salmon fisheries landings offshore the coast of Washington, British Columbia and even Southeast Alaska.[17]

Alaska's fishing families also depend heavily on the Columbia River's salmon runs (a large portion of which originate in Oregon) because so many of the salmon caught off the coast of Southeast Alaska are from the Columbia River Basin.[18] In 2019, commercial salmon landings in Alaska were 827.1 million pounds, valued at $673.4 million (again the *ex vessel* price).[19]

The Columbia River Basin was historically the largest salmonid producing river in the world, with annually returning salmon runs estimated at between 5.0 and 16.3 million returning adults, including spring, summer and fall runs of Chinook, as well as coho, chum, sockeye and both winter and summer runs of steelhead.[20] Even though most of the juvenile salmon emerging from the Columbia estuary would normally migrate northward where they would contribute heavily to Washington, British Columbia and southeast Alaska ocean fisheries, Columbia River-origin salmon runs are still so large that they also contribute significantly to ocean salmon fisheries

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[15] See ODFW publication (Sept. 2019): https://www.dfw.state.or.us/MRP/docs/Backgrounder_Comm_Fishing.pdf.

[16] National Marine Fisheries Service (NMFS), *Fisheries of the United States (FUS 2019)* at xxii and xxiii (2019), *available for download at* https://www.fisheries.noaa.gov/resource/document/fisheries-united-states-2019.

[17] Typically about 50% of the salmon harvested in the abundant Southeast Alaska ocean fisheries originated from the Columbia Basin, with perhaps half of those coming from Oregon natal streams and rivers. In short, perhaps about 25% of the salmon landed in southeast Alaska fisheries could have originated from Oregon's Columbia Basin rivers, with additional fish from Oregon coastal streams from outside the Columbia Basin also significantly contributing.

[18] *See Penelope Crane*, W. D. Templin, D. M. Eggers & L.W. Seeb. *Genetic Stock Idenficiation of Southeast Alaska Chinook Salmon Fishery Catches* (January 2000), Alaska Dep't of Fish and Game, available through https://www.adfg.alaska.gov.

[19] *Fisheries of the United States (FUS 2019)* at xxii, *supra.*

[20] See *A Vision for Salmon and Steelhead, Phase 2 Report* of the Columbia Basin Partnership Task Force, pg. 44 for a comparison of several different estimates of historic run sizes: https://www.fisheries.noaa.gov/vision-salmon-and-steelhead-goals-restore-thriving-salmon-and-steelhead-columbia-river-basin#:~:text=MAFAC%20convened%20the%20Columbia%20Basin,and%20its%20salmon%20and%20steelhead

throughout the Oregon and northern California coastlines. This is in addition to the also significant contribution of Oregon coastal-only salmon runs, also highly migratory.

A "snapshot" economic study of the impacts of salmon fisheries on the entire Pacific Northwest for the year 1988 showed that commercial salmon fishing in northern California contributed more than $95 million in personal income impacts to the regional economy, supporting 4,000 family-wage jobs, and the recreational salmon fishery in that state contributed $372 million and supported 19,000 family wage jobs; Oregon's commercial salmon fisheries in 1988 generated $89 million, supporting 4,450 family-wage jobs, while its recreational salmon fishery generated $186 million, supporting 9,500 family-wage jobs. Idaho has no commercial salmon fishery, but recreational salmon and steelhead fishing that same year in Idaho generated nearly $93 million in income, supporting 4,750 family-wage jobs.[21] These numbers show the great potential that salmon watershed restoration efforts have to return great economic value to once salmon-dependent communities, if we can only clean up their habitat and give them a way to get there.

From boat builders to seafood processers, even greatly reduced in recent years, commercial salmon fishing still generates many thousands of additional jobs throughout northern California, the Pacific Northwest and Alaska. Like direct the commercial fishing jobs, many of these additional jobs generated by the salmon fishing industry are located in smaller coastal communities whose economies are heavily dependent on the fishery.[22]

Oregon's Inland Recreational Fisheries: In-river recreational fishing (particularly for much prized steelhead) is also a major economic driver in the Oregon economy, especially in smaller rural communities.

According to a recent economic impacts study by the American Sportfishing Association (ASA), *Economic Contributions of Recreational Fishing in Oregon* (published Jan. 21, 2021) in 2018 year alone (as a typical sample year) ASA estimated that 569,600 Oregon recreational anglers spent $871.8 million.[23]

Tribal Subsistence and Some Tribal Commercial Fisheries: There are also multiple Tribal Nations throughout the Pacific Northwest, including in Oregon, to whom the U.S. owes Treaty obligations to provide for the protection of their native river systems and the salmon runs that use those systems. The value of the Tribal fisheries to their people and their Tribal economy, both subsistence fisheries and small commercial fisheries, cannot be easily quantified but is clearly enormous in terms of support for Tribal cultures and providing these sovereign First Nations and their communities a secure economic future, as noted below.

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[21] The Economic Imperative of Protecting Riverine Habitat in the Pacific Northwest, Pacific Rivers Council (January, 1992) Publication No. 5 (1992). These numbers are much greater in 2022 dollars than cited in 1988 dollars in the original report.

[22] *See Final Report*, *supra* n.6, at 12 (These jobs are "important at the community level along the Washington Coast, the Strait of Juan de Fuca, and the Puget Sound areas.").

[23] For the ASA Oregon Report see: https://asafishing.org/state-reports/economic-impacts-of-recreational-fishing-oregon/. For a wider Northwest economic impacts summary report see: https://www.psc.org/download/333/special-reports/9337/economic-impacts-of-pacific-salmon-fisheries.pdf.

3.3. Salmon Cultural Values

Writer Tim Egan once defined the Pacific Northwest as "Wherever salmon can get to." In fact, salmon are a major cultural icon for the entire region, and are woven into the lives and cultures of many communities throughout northern California, Oregon and Washington. Coastal fishing-dependent communities celebrate the return of the salmon every year, and hundreds of inland communities and businesses depend upon recreational salmon fishing as a regular part of their incomes and annual family recreational.

But nowhere is the connection between salmon and culture more direct than within the various Native American communities throughout the region. Restoring the salmon runs these Tribes depend upon for both their subsistence and fish marketing economies, their cultures and their futures as Tribal people is a legal as well as high moral obligation.

In the words of these sovereign Tribal governments whose lands span the Columbia basin, from the recent Columbia Basin Partnership's 100-year salmon and steelhead restoration plan, *A Vision for Salmon and Steelhead*, the Columbia River Treaty Tribes particularly remind us:

> "The Columbia River Treaty Tribes are still here and are still committed to the same ancient covenant with salmon. We will continue to speak for those that cannot. Columbia River Treaty Tribes have been fighting for the rights and perpetuation of Columbia River salmon since 1855 and will always hold the government, and those that settled here, accountable to the intent of the treaties that were signed…. The treaty tribal baseline for tribal salmon restoration and harvest remains 1855. This entitlement is a fair share of the salmon harvest from all streams in their ceded areas – measured at the fully functioning product levels observed in the mid-1800s. This was the tribal entitlement at the time of treaty signing. It is still so today, and into the future."

And as to looking at the "costs" of salmon protections, the Columbia River Treaty Tribes also have this to remind us of:

> "Over the last 200 years, tribal resource losses, including reduced availability of salmon and steelhead, are a direct consequence of the resource gains of others in the Columbia Basin. It is a false equivalency to propose that all parties on this Task Force should be willing to give up equally, because historical gain/loss balances weight heavily against tribes….."

> "Rather than debating how many salmon we need to meet everyone's needs, we should also ask how many apples the river reasonably needs to produce. How many potatoes do we need? How many cows do we need? And to what cost are we willing, as a society, to pay in the currency of salmon for the various economies the region now supports? To date, most can only demonstrate their anxiety by the money they will lose and how it will hurt them, you, or me right now. Few have talked about their own ability for adaptation and change."[24]

[24] Quotes from Tribal Statement in *A Vision for Salmon and Steelhead, Phase 2 Report of the Columbia Basin Partnership Task Force*, supra., pages 110 & 114-115.

4.0. Declining Salmon Runs Threaten Entire Communities

One of the most dramatic natural resource tragedies of our times, and one that has directly affected our coastal commercial salmon fishing industry by destroying thousands of fishing jobs coastwide, has been the thoughtless and sometimes deliberate destruction of the west coast's once abundant salmon-bearing rivers. Everywhere on the west coast (both U.S. and Canada) these once abundant wild salmon runs are in steep decline, with many of them already extinct.

The steady decline of west coast salmon runs was an unacknowledged disaster until the prestigious American Fisheries Society (AFS) published a peer-reviewed, comprehensive scientific survey of the problem in "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington," (Nehlsen, *et al.*, *Fisheries*, Vol 16, No. 2, pp. 4-21 (March-April, 1991)).[25] That first-ever rigorous survey of all west coast salmonid stocks found that of the 214 separate stocks still existing, 101 were at high risk of extinction, 58 at moderate risk of extinction, 54 of special concern, and one (California Central Valley winter-run Chinook) already by that time classed as threatened with extinction under the federal Endangered Species Act (ESA) and as endangered under California's separate ESA statute. *It also found from historical records that at least 106 to more than 200 other distinct stocks of salmonids had already by that time been extirpated from their native habitat.*

Human actions driving salmon declines are many: thoughtlessly over-engineered rivers with too many dams that block migratory salmon and destroy downstream water quality; massive dewatering of key salmon-producing rivers, some of which – like the once great San Joaquin River in California – were totally dewatered for decades; poorly thought out logging and agricultural practices that drive sediment loads up to fatal levels for fish, and fill our rivers with toxic, fish-killing pesticides; widespread land-use, urbanization and water diversion policies that ignore natural river processes and fish needs, and which destroy key salmon spawning and rearing habitat from estuaries to far inland. Widespread and accelerating climate change (also driven by human-generated greenhouse gases) just exacerbates all these problems.

Even though greatly diminished from historic baselines, and both coastal Oregon and Columbia-origin salmon runs still contribute greatly to the Pacific Northwest's economy, for decades salmon have also been disappearing from the Pacific Northwest at alarming rates. Once too numerous to count, these fish today persist at only a small fraction of their historic abundance.

The collapse of what were once the world's largest runs of salmon has led the National Marine Fisheries Service (NMFS, also known as "NOAA Fisheries") to protect 28 different salmonid populations as either threatened or endangered under the federal Endangered Species Act.[26] For many other populations it is too late – *they are already extinct.* The industrialization and pollution of Oregon's watersheds in ways, including diminished water quality, that have caused the elimination and degradation of available salmon spawning and rearing habitat has been a major factor in these declines.

[25] Available from AFS archives at: https://fisheries.org/books-journals/fisheries-2/
[26] See NOAA Fisheries ESA listed salmon & steelhead list at: https://www.fisheries.noaa.gov/species/pacific-salmon-and-steelhead.

Despite some recent efforts to recover damaged salmon runs, Oregon's once-abundant salmon are still very much in trouble, and so are the Oregon commercial fishing families and coastal communities who depend upon them for their livelihoods. Salmon landings in our Oregon commercial ocean fisheries have dropped off dramatically in recent years, with long-term trends downward, in spite of annual fluctuations (see Chart 2).[27] To separate out the long-term trends from annual fluctuations, we simply take landing averages derived from several-year periods, and then compare those to similar ranges of other years, such as these ranges:

1950-1960 average annual landings = 10,910,050 pounds
2010-2020 average annual landings = 2,651,122 pounds

LOSSES between these two periods = 76% lost productivity

What those losses mean in practice is that, as compared to the average landings in the years 1950-1960, some 8,258,928 landed pounds of salmon are now effectively missing annually, on average, from Oregon's commercial ocean salmon fisheries. At an *ex vessel* price of $3.33/pound landed (which was what was received in 2020, using the figures in Chart 2), this means that *more than $27.5 million dollars in economic value has been taken from Oregon's coastal salmon-dependent communities, on average, each recent year because of pervasive salmon declines.* This has meant lost jobs, collapsing fisheries infrastructure, and lost economic opportunities for these communities' futures.

Oregon salmon runs also contribute considerable numbers of salmon to viable ocean salmon fisheries in Washington State, where north-migrating Oregon-origin salmon are intermingling with stocks from other states, and thus Oregon-origin salmon greatly contribute to Washington State ocean salmon harvests.

When fewer Oregon-origin salmon migrate into and though Washington's waters, however, this translates directly into lower salmon catch limits, shorter seasons, and a reduced ability for commercial fishing families to earn a living. Chinook (king) salmon and Coho salmon are also the most commercially valuable of western Washington's salmon species,[28] and these are the species that have seen some of the steepest declines in Oregon as well as in Washington.[29] From 1950 to 1955 in Washington, commercial landings of Chinook salmon averaged 10,248,683 pounds and coho averaged 11,779,067 pounds, but from 2011 to 2016, chinook landings averaged only 5,866,870 pounds, a reduction of about 43%, and coho landings averaged only 3,102,894 pounds,

[27] Nat'l Marine Fisheries Serv., Annual Commercial Landing Statistics (searchable by state, species, and year), https://www.fisheries.noaa.gov/national/sustainable-fisheries/commercial-fisheries-landings. Sorted from 1950 to 2020 for Chinook and Coho salmon (pink, chum and Sockeye salmon are not usually caught in Oregon ocean commercial fisheries so landings for those species are not significant in Oregon ocean commercial fisheries).
[28] *See* Gislason & Knapp, *supra* n.6, at 12 Exh. 2 (compare weight landed with *ex-vessel* value).
[29] *See* Wash. State Recreation and Conservation Office, Governor's Salmon Recovery Office, *State of Salmon in Watershed 2016* at 2 (showing declining trend in non-Tribal Chinook and Coho harvests from the 1970s through 2015), https://stateofsalmon.wa.gov/

a reduction of about 74%.[30] This is the same pattern of declines as in Oregon's salmon populations, and for many of the same reasons – *pervasive loss of in-stream spawning and rearing habitat.*

And these numbers represent only the declines in ocean salmon harvests. Similar declines have occurred in inland recreational salmon fisheries, particularly in the Columbia Basin, as well as declines of harvestable salmon for the various Treaty Tribes who have a right to catch fish that all too often these days are simply not there!

The good news is that much of what has been lost over the past decades in salmon economic contributions could be recaptured through appropriate salmon habitat restoration investments. The restoration work needed to return Oregon's salmon runs back to health are thus not purely "costs"-- they are investments that over time, and with the return of these salmon, will generate more jobs and prosperity for our rural coast economies indefinitely and on a sustainable basis. It also means investing in improved water quality in our coastal and inland salmon-bearing rivers, which is the whole point of currently proposed TMDL water quality standards improvements.

Salmon watershed restoration also includes investing not only in the protection and restoration of Oregon's coastal salmon-producing watersheds, but also for salmon produced in Columbia River watersheds, as for instance in the Columbia Basin Partnership's currently active 100-year salmon restoration plan.[31] One estimate of how much purely monetary value such a Columbia Basin salmon restoration program could return to our Pacific Northwest economy is that restored salmon fisheries in the Columbia Basin could generate up to $500 million/year in regional personal income and support up to 25,000 additional family wage jobs.[32]

Learning to make those watershed restoration and water quality investments wisely and efficiently is one of the underlying themes of Oregon's ongoing efforts to restore its damaged salmon runs – and is ultimately also the purpose of this Rulemaking.

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Salmon Values Report (OR) (10-28-22)

[30] National Marine Fisheries Service (NMFS), *Annual Commercial Landing Statistics*, supra, for Washington numbers.
[31] See citation in footnote 19.
[32] *The Cost of Doing Nothing: The Economic Burden of Salmon Declines in the Columbia River Basin*, Institute for Fisheries Resources (Oct. 1996), available at: http://pcffa.org/wp-content/uploads/2016/10/CDNReport-Columbia.pdf. These numbers are also in 1996 dollars, so would be higher today given changes in the value of money over time.

CHART 2: OCEAN COMMERCIAL SALMON LANDINGS IN THE STATE OF OREGON
(Chinook and Coho salmon only)

YEAR	Pounds	Metric Tons	*Ex Vessel* Value
1950	11,194,000	5,078	2,509,761
1951	13,173,500	5,975	3,282,294
1952	12,266,800	5,564	2,573,092
1953	9,685,400	4,393	1,989,508
1954	8,153,000	3,698	1,824,483
1955	12,230,100	5,548	3,098,872
1956	13,952,300	6,329	4,014,994
1957	10,927,000	4,956	2,820,523
1958	7,479,700	3,393	2,410,984
1959	4,753,600	2,156	1,489,460
1960	5,285,100	2,397	2,074,687
1961	6,912,800	3,136	2,531,718
1962	7,130,000	3,234	2,550,455
1963	8,198,700	3,719	2,591,074
1964	9,802,100	4,446	3,036,117
1965	11,570,400	5,248	3,442,846
1966	12,355,000	5,604	3,971,916
1967	16,011,400	7,263	5,722,746
1968	9,562,100	4,337	3,553,894

1969	10,176,300	4,616	4,126,915
1970	19,396,000	8,798	8,974,127
1971	16,795,500	7,618	5,595,758
1972	11,571,800	5,249	6,471,882
1973	16,904,700	7,668	11,765,135
1974	15,188,100	6,889	12,796,698
1975	12,375,900	5,614	9,422,249
1976	15,246,700	6,916	18,895,482
1977	10,257,176	4,653	16,354,814
1978	8,691,429	3,942	12,024,512
1979	10,965,282	4,974	21,849,449
1980	7,209,972	3,270	10,936,910
1981	6,595,933	2,992	10,734,465
1982	8,563,376	3,884	12,354,579
1983	2,586,279	1,173	2,980,345
1984	2,940,843	1,334	4,433,389
1985	5,674,745	2,574	8,526,602
1986	13,415,519	6,085	14,970,122
1987	14,542,534	6,596	26,380,110
1988	17,441,956	7,912	38,499,238
1989	11,447,111	5,192	14,076,519
1990	5,244,099	2,379	9,437,230
1991	5,216,452	2,366	5,750,836
1992	2,123,329	963	3,530,246

1993	1,697,997	770	2,348,154
1994	1,209,282	549	1,422,401
1995	2,792,859	1,267	3,551,677
1996	2,828,275	1,283	3,283,966
1997	2,234,306	1,013	2,768,342
1998	1,971,040	894	2,587,673
1999	1,549,070	703	2,040,279
2000	3,123,204	1,417	4,026,514
2001	5,254,772	2,384	5,841,059
2002	6,115,468	2,774	6,932,424
2003	6,719,581	3,048	8,868,128
2004	5,929,546	2,690	12,988,978
2005	4,681,290	2,123	10,434,476
2006	1,777,806	806	4,931,865
2007	1,341,732	609	4,622,494
2008	1,789,490	812	4,117,299
2009	2,281,782	1,035	3,529,415
2010	2,746,295	1,246	7,676,296
2011	2,387,824	1,083	6,719,210
2012	1,918,901	870	6,935,089
2013	3,502,259	1,589	12,415,609
2014	6,374,659	2,892	20,066,563
2015	3,134,308	1,422	11,826,615
2016	1,818,812	825	8,259,155

2017	1,184,322	537	5,529,111
2018	950,632	431	5,653,121
2019	992,740	450	4,148,577
2020	1,500,464	681	4,997,309

1950-1960 average annual landings = 10,910,050 pounds
2010-2020 average annual landings = 2,651,122 pounds

LOSSES as between these two periods = 76% lost productivity

Data from National Marine Fisheries Service (NMFS), *Annual Commercial Landing Statistics* (searchable by state, species, and year), https://www.fisheries.noaa.gov/national/sustainable-fisheries/commercial-fisheries-landings. Sorted from 1950 to 2020 for Chinook and Coho salmon only (Pink, Chum and Sockeye salmon are not usually caught in Oregon ocean commercial fisheries so landings for those species are not significant in Oregon ocean commercial fisheries). Values are estimated *ex vessel* (i.e., wholesale at the dock by processors) prices, and are not adjusted for inflation in annual citations. These are also raw pounds, not dressed pounds.

APPENDIX A

Economists' Guidance Principles for Salmon Restoration Costs vs. Benefits Analysis

<u>References</u>:

A Letter from Economists to Governors of Oregon (Kitzhaber), California (Wilson), Washington (Loche) and Alaska (Knowles) and Premier of British Columbia (Clark). (Sept. 9, 1998) [77 signatures]

A Letter from Economists to President Bush and the Governors of Eleven Western States Regarding the Economic Importance of the West's Natural Environment. (December 3, 2003) [95 signatures]

09 September 1998

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Dear Governors Kitzhaber, Knowles, Locke, and Wilson, and Premier Clark:

Decisions regarding the management of Pacific salmon, many of which are experiencing deep declines in numbers, can affect a vast landscape along the western edge of North America and markedly influence the region's future economy. With this letter, we hope to help lay the foundation for the public debate over the economic aspects of these decisions.

Most of the discourse on the economic issues of salmon recovery has focused too narrowly, concentrating almost exclusively on the costs of recovery. Costs are indeed important, but they tell only part of the economic story. We encourage you and the members of your Administrations to adopt a broader perspective and consider the full range of economic consequences of salmon-management decisions. Toward this end, we recommend that you examine and weigh all these factors:

* Costs, Benefits, and Net Benefits.

Salmon recovery will generate economic benefits as well as costs. To understand the net benefit (a net cost if negative) to the economy as a whole, one must consider the effects on the production of all goods and services. The effects on goods and services that are traded in markets, such as commercial salmon, timber production, and agricultural production, should receive the same consideration as those, such as recreational fishing, clean streams, and biodiversity, that are not. A full accounting must be provided of the true value of each affected good or service, taking into account the market price, where appropriate, as well as all factors, such as subsidies, taxes, and environmental externalities, that distort the level of supply or demand. Some of the benefits and costs will manifest themselves in the immediate vicinity of the resources affected by salmon recovery, while others will manifest themselves at greater distances.

* Jobs, Incomes, and Transitions.

Salmon recovery will have diverse impacts on labor markets, increasing some demands for labor and decreasing others. It also may affect the spatial distribution of the supply of labor by influencing the location decisions of some households. To understand the resulting impacts on jobs and incomes, one must consider the salmon-related changes in demand and supply against the backdrop of the markets' ability to adjust. One should examine both the overall change in jobs and incomes as well as the transitions for affected workers, their families, and their communities.

* Distribution of Economic Consequences.

The positive and negative effects of salmon recovery will not be distributed equally. Identifying the winners and losers can create opportunities to explore options for breaking political gridlock–by clarifying mechanisms, for example, for the winners to provide some compensation to the losers.

* Rights and Responsibilities.

Owners of natural resources affected by salmon-recovery measures have both rights regarding their use of these resources and responsibilities not to exercise these rights in ways that unreasonably restrict the rights of others. This is true of both private- and public-property owners. To understand the costs and benefits associated with salmon recovery, one first must have a clear understanding of the relevant rights and responsibilities, because society might assign very different values to two recovery actions that are otherwise identical but one restricts a property owner's rights and the other forces it to comply with its responsibilities.

* Uncertainty and Sustainability.

Nobody can eliminate the uncertainty regarding how salmon-recovery decisions will affect salmon populations and the economy, and it is inevitable that some decisions will not yield the desired outcomes. Reversing undesired outcomes is always costly, however, some outcomes are less costly to reverse than others. Some, of course, are irreversible. To understand the full economic consequences of salmon-recovery decisions, one should consider the potential reversal costs if the decision should yield undesired outcomes.

* Looking Beyond Salmon.

To understand the full consequences of salmon recovery, one must look beyond those tied to the salmon, themselves, and examine those linked to the productivity and use of the surrounding ecosystem. Changes in ecosystem productivity may occur through the restoration of the ecological functions of salmon-bearing streams and the surrounding watersheds that will accompany salmon recovery. Changes in the use of the resources of the larger ecosystem may have both positive and negative effects on the economy.

We hope you will consider the factors outlined here, and use this outline to improve the public's understanding of the full economic consequences of salmon recovery.

Sincerely,

W. Ed Whitelaw
University of Oregon/ECONorthwest

Ernest Niemi
ECONorthwest

And the following co-signing economists:

Russ Beaton, Willamette University
Peter Berck, University of California Berkeley
Bruce Blonigen, University of Oregon
Peter Bohmer, Evergreen College
Richard Brinkman, Portland State University
Gardner Brown, University of Washington
Walt Butcher, Washington State University
Kevin Calandri, California State University Sacramento
Arthur Caplan, Weber State University
Ken Casavant, Washington State University
Laura Connolly, Oregon State University
Jeffrey Connor, Oregon State University
Robert Curry, California State University Sacramento
Elizabeth E. Davis, Oregon State University
Robert Deacon, University of California Santa Barbara
David Donaldson, University of British Columbia
Bryan Ellickson, University of California Los Angeles
Mark Evans, California State University Bakersfield
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David E. Gallo, California State University Chico
Alan Gin, University of San Diego
Eban Goodstein, Lewis & Clark College
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Robert Halvorsen, University of Washington
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Martin Hart-Landsberg, Lewis & Clark College
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John F. Henry, California State University Sacramento
Steve Henson, Western Washington University

Richard B. Howarth, Dartmouth
Lovell S. Jarvis, University of California Davis
Desmond Jolly, University of California Davis
Mary King, Portland State University
Van Kolpin, University of Oregon
B. Y. Lee, University of Oregon
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Arthur O'Sullivan, Oregon State University
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Norm Whittlesey, Washington State University
Yung Yang, California State University
Ross Youmans, Oregon State University
Zenon X. Zygmont, Western Oregon University

Note: Affiliations are for informational purposes and do not imply consent by organizations.

cc: David Anderson, Minister, Fisheries and Oceans, Canada
Will Stelle, National Marine Fisheries Service

December 3, 2003

A Letter from Economists to President Bush and the Governors of Eleven Western States Regarding the Economic Importance of the West's Natural Environment.

To:

President George W. Bush
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

The Honorable Dave Freudenthal, Governor of Wyoming
State Capitol Building
Cheyenne, WY 82002-0010

The Honorable Kenny Guinn, Governor of Nevada
State Capitol
101 North Carson Street
Carson City, NV 89701

The Honorable Dirk Kempthorne, Governor of Idaho
700 West Jefferson, 2nd Floor
P.O. Box 83720
Boise, Idaho 83720-0034

The Honorable Ted Kulongoski, Governor of Oregon
160 State Capitol
900 Court Street
Salem, Oregon 97301-4047

The Honorable Gary Locke, Governor of Washington
PO Box 40002
Olympia, WA 98504-0002

The Honorable Judy Martz, Governor of Montana
P.O. Box 0801
204 State Capitol
Helena, MT 59620-0801

The Honorable Janet Napolitano, Governor of Arizona
1700 West Washington
Phoenix, AZ 85007

The Honorable Bill Owens, Governor of Colorado
136 State Capitol
Denver, CO 80203-1792

The Honorable Bill Richardson, Governor of New Mexico
Office of the Governor
Room 400, State Capitol Building
Santa Fe, NM 87501

The Honorable Arnold Schwarzenegger, Governor of California
State Capitol Building
Sacramento, CA 95814

The Honorable Olene Walker, Governor of Utah
210 State Capitol
Salt Lake City, UT 84114

Dear Mr. President;
Dear Governor Freudenthal;
Dear Governor Guinn;
Dear Governor Kempthorne;
Dear Governor Kulongoski;
Dear Governor Locke;
Dear Governor Martz;
Dear Governor Napolitano;
Dear Governor Owens;
Dear Governor Richardson;
Dear Governor Schwarzenegger;
Dear Governor Walker:

We are economists, and we are writing to express our concern about federal and state actions that harm the West's natural environment and, as a result, the economic outlook for this region's workers, families, firms, and communities.

The West's natural environment is, arguably, its greatest, long-run economic strength. The natural landscapes of the western states, with wide open spaces, outdoor recreational opportunities, and productive natural-resource systems underlie a quality of life that contributes to robust economic growth by attracting productive families, firms, and investments. The West's natural environment, however, faces serious challenges that threaten to undermine its contribution to the economy. These include air and water pollution, urban sprawl, the extension of roads and other development into roadless public lands, and fragmentation of habitat for native fish and wildlife.

The economic importance of the West's natural environment is widely recognized. Last year, for example, the Western Governors' Association, recognizing that "There is a lot at stake," reaffirmed its adoption of the Enlibra Principles for guiding policy and decision-making regarding natural resources and the environment.[1]

The seventh of these principles is, "Recognition of Benefits and Costs – Make Sure All Decisions Affecting Infrastructure, Development and Environment are Fully Informed."[2] We endorse this principle, and we commend each of you for your commitments to apply it to the actions of your administration. Despite your commitments, however, many state and federal actions are causing additional environmental degradation, increasing the risks of future degradation, or slowing efforts to reverse past degradation. These actions harm the economy—across the West and in each of the states. They diminish the economic well-being of many residents, divert natural resources from their highest and best use, reduce the

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[1] Western Governors' Association, "Principles for Environmental Management in the West." http://www.westgov.org./wga/policy/02/enlibra_07.pdf. p. 2.

[2] Ibid. p. 6.

environmental amenities that are essential ingredients of the West's quality of life, and pass to future generations the costs of cleaning up this generation's environmental messes.

We ask each of you to renew and strengthen your efforts to secure for the West both a healthy environment and a prosperous economy. Toward this end, we ask you to initiate a review of your administration's actions affecting the environment and the economy. This review should:

- Identify actions having a significant impact on the environment and fully describe the benefits and costs of each.
- Reinforce those actions that strengthen the economy by protecting or restoring environmental quality.
- Arrest those actions that damage the economy by degrading the environment.

In the remainder of this letter we describe the linkage between environmental quality and economic prosperity, identify some of the environmental policies and activities harmful to western economies, and express eight principles for capitalizing on the environment-economy linkage.

Environmental Quality Is a Major Source of the West's Long-Run, Economic Strength

In the distant past, the West's natural resources were widely abundant and important to the economy primarily when they were converted into something else. We converted forests, mineral deposits, and streams into lumber, metals, and hydroelectricity; valleys, wetlands, and hillsides into agricultural and urban landscapes; and land, water and air into waste repositories.

Today, conditions have changed.

Some important elements of the environment are scarcer. The population and distribution of many native species have diminished markedly. Similarly, the supplies of roadless lands, free-flowing rivers, and unexploited marine areas have diminished and, although there have been some notable improvements recently, much of the West's air and water remains degraded.

The structure of the western economy has changed. Though still important, extractive industries (logging, mining, and commercial fishing) and agriculture now play a smaller economic role because their ability to generate new jobs and higher incomes has declined. Across most of the West, a community's ability to retain and attract workers and firms now drives its prosperity. But if a community's natural environment is degraded, it has greater difficulty retaining and attracting workers and firms.

The economic costs of environmental degradation are rising. As the West's population increases, so too do the damages (current and future) from exposure to hazardous pollution and the degradation of environmental amenities. As their habitats shrink, many native species face an increased risk of extinction. Reversing this trend becomes more expensive over time. As ecosystems are degraded, they provide fewer economically valuable services, such as cleansing the water in streams, and communities therefore must provide replacement services with water-treatment plants and other costly investments.

The economic benefits of protecting and restoring environmental quality are large and increasing. As the West's population increases, the West enjoys greater economic benefits by avoiding exposure to hazardous pollution, maintaining scenic natural vistas, extending the availability of recreational opportunities in clean environments and on public lands, and sustaining the existence of undeveloped lands and healthy ecosystems.

Misleading price signals slow economic growth. Inefficient pricing of many natural resources encourages waste and diminishes economic productivity by allocating resources to low-value uses, while higher-value uses languish. Subsidies to irrigation, logging, public-land ranching, and mining prop up activities that would not take place under efficient, market conditions. Underpricing of urban roads, municipal-industrial water, and pollution emissions sends false signals regarding the true cost of urban sprawl, and the true value of free-flowing streams, and clean air and water.

Climate change poses significant economic risks. Global warming threatens to alter winter snow fall in the West's mountains, increasing the risk that runoff in important rivers will fall short of summer demands for water; raise sea levels, increase the risk of coastal flooding, change the distribution of habitats, and increase the risk of extinction for some threatened and endangered species.

As these and related changes evolve, the economic health of western communities increasingly will depend on the health of the environment. Long-run prosperity will derive from efficient, effective efforts to conserve increasingly scarce environmental resources, protect high-quality natural environments, reverse past environmental degradation, and manage congestion in both urban areas and on public lands with high recreational use. Resource-management policies and economic-development activities that significantly compromise the environment will likely do more economic harm than good.

Many Current Policies and Activities Degrade or Threaten the West's Environment and Jeopardize the West's Prosperity

Numerous governmental policies and activities affecting the West's natural resources, which purportedly help the West's economies, are doing just the opposite. Here are a few examples:

Inadequate investment in parks. The federal government has failed to maintain the infrastructure and environmental quality of national parks. State and local governments have done the same with their own parks. These failures have weakened the West's economies by reducing the attractiveness of nearby communities to workers and firms and by eroding the foundation for the outdoor recreation and tourism industries.

Reduced protection for roadless public lands. By opening roadless lands to vehicular traffic, mining, logging, grazing, and other development, usually at a net cost to the US taxpayer, the federal government has expanded the supply of that which is already plentiful and common at the expense of that which is increasingly scarce and unique. Such actions fail to account for the benefits non-motorized visitors receive from these lands and for the loss of the considerable economic benefits—recreation, high-quality water, wildlife habitat, spiritual values, and more—that public lands provide when they are undeveloped. The loss of these benefits undermines one of the cornerstones of economic strength for communities throughout the West.

Slow action to conserve threatened and endangered species. Congress has failed to provide adequate funding, and federal agencies have dragged their feet when called upon to conserve threatened and endangered species. These actions jeopardize the economic outlook for western communities by increasing the risks to species with high economic value, protecting inefficient and often subsidized activities harmful to both the species and the economy, and raising the ultimate costs of conserving the species.

Slow clean-up of polluted sites. Federal agencies have not requested and Congress has not provided adequate funding to clean-up Superfund sites promptly. Some state and local governments have slowed the clean-up process. Delayed clean-up of these sites harms the economy by extending westerners' exposure to hazardous materials, diminishing the value of nearby properties, impeding economic-development activities near polluted sites, and giving polluters additional incentives to pollute in the future.

Ineffective response to risks of global warming. Current research results are sufficiently robust to conclude that global warming poses significant economic risks to the West, including increases in coastal flooding, more frequent severe storms, and reductions in snowpack resulting in lower summer flows of important rivers and streams. These risks are perpetuated and strengthened by the failure of Congress and the White House to take decisive action to curb emissions of carbon dioxide and other global greenhouse gases.

Inefficient management of public forests. Federal and state forest managers emphasize the production of logs, forage, minerals, and other commodities without fully accounting for adverse impacts on services, such as recreation, provision of clean water in streams, sequestration of carbon, and the existence of roadless lands. These actions reduce the overall value of goods and services derived from public forests.

Lack of appropriate incentives for resource conservation. With subsidies and inefficient pricing, federal, state, and local policies encourage waste and discourage conservation by hiding from consumers the full costs of resource-intensive activities, such as exploration for oil and gas, irrigation, public-land grazing, and congestion on urban roadways and at public-land recreation sites.

Unreasonable exemptions from environmental review. Federal resource managers have granted exemptions for military operations, logging, exploration for oil and gas, operation of motor vehicles on roadless public lands, the use of some pesticides, the emission of air pollution, and other activities. Also, de facto exemptions occur when federal and state agencies fail to enforce environmental laws. The economy is harmed when activities are allowed to proceed even though their economic costs outweigh their benefits.

Unnecessarily divisive approaches to economic/environmental issues. The costs—to individual workers, families, firms, communities, and the economy as a whole—of the changing relationship between the economy and the environment are worsened by federal, state, and local actions that promote misunderstanding and divisiveness rather than cooperative problem-solving. Especially divisive and costly are proposals and decisions that presume the economic benefits of an increase in an extractive, agricultural, or development activity necessarily exceed the costs, even when the evidence indicates otherwise. Recent examples include proposals or decisions to:

- Encourage road development, vehicular traffic, and other development on lands with roadless or wilderness qualities, including national parks, national forests, and lands administered by the Bureau of Land Management.
- Promote energy consumption rather than conservation.
- Relax restrictions on emissions of water and air pollution.
- Forgo U.S. leadership of efforts to shape a prompt, efficient and global response to climate-change risks.
- Relax restrictions on the use of or exposure to potentially harmful substances.

We Encourage You to Adopt Initiatives that Promote Both a Healthy Environment and a Healthy Economy

We ask each of you to initiate a review of the economic effects of actions taken by your administration that have a significant impact on the environment. The primary objective of this review should be to identify and correct those actions that are harming the economy by degrading the environment. It also should highlight the merits of those actions beneficial to both the environment and the economy. We urge you to act promptly.

We also urge you to implement appropriate policies and procedures to increase the likelihood that future governmental actions will capitalize on and reinforce the evolving relationship between the West's environment and its economy. These initiatives should incorporate these eight principles:

Principle #1: Environmental protection has economic benefits as well as economic costs. It has positive as well as negative impacts on jobs and incomes.

Principle #2: Some economic interests in natural resources are mostly local but, increasingly, the interests are broader in geographic scope: regional, national, and even global.

Principle #3: To discourage waste, prices for the use of environmental resources should reflect the full costs and benefits to the economy, exclusive of subsidies.

Principle #4: Given their stewardship responsibilities regarding the environment, it is appropriate for governments to encourage or undertake activities that protect the environment and to discourage or prohibit those that do not. It is also appropriate for government to own and use land and water resources to protect the environment and to support others who desire to own and use resources for the same purpose.

Principle #5: Governments should continually seek to improve the efficiency of their environmental- and resource-management programs without compromising their responsibilities. These programs may include a mixture of regulations, incentives, and public ownership of resources. They should aim to bring about as high a level of environmental quality as possible for a given expenditure.

Principle #6: To understand the full, potential economic consequences of a pending resource-management decision, one should consider the potential reversal costs if the decision should yield undesirable outcomes.

Principle #7: The benefits and costs of environmental protection and degradation fall unevenly on different groups. Anticipating and mitigating these effects can reduce the controversies over the West's environment and economy. Having the winners compensate the losers, for example, could serve this principle.

Principle #8: Owners of natural resources have both rights and responsibilities. Both private- and public-property owners have rights to use their properties in ways that do not unreasonably harm others or restrict their rights. Clarifying and respecting the rights of all parties—including future generations—affected by the uses of environmental resources remains a necessary condition for effective environmental management.

Conclusion

We are not saying that resource-intensive industries (agriculture, timber, commercial fishing, and mining) do not play an important role in the West's economies. They are important today, and we expect they will remain important in the future.

We are not saying that the shift away from industries and activities harmful to the environment will not hurt some workers, families, and communities. It has in the past and it will in the future.

We are not saying that protecting and improving the environment can be accomplished without costs, nor are we saying that governmental entities should disregard such costs. To the contrary, we are calling for consideration of the full range of costs and benefits of policies, decisions, and activities that affect the western environment and, hence, its economy.

We are not saying that no progress is being made in capitalizing on the link between environmental health and economic prosperity. Many private-sector firms and public agencies have taken actions to reduce their negative impact on the environment and found that they saved money.

Rather, we are saying that nearly all communities in the West will find they cannot have a healthy economy without a healthy environment. Moreover, there exist many opportunities in the West to improve both the environment and the economy, for example, the elimination of inefficient subsidies would make more money available for other public services or to reduce debt. The longer these opportunities languish, the fewer will be the West's jobs, the lower its incomes, and the poorer its communities. Conversely, the sooner we seize these opportunities, the sooner the West will enjoy more jobs, higher incomes, and greater prosperity.

We are saying that the economic pressures to arrest and reverse environmental degradation will increase. Those who promise that workers, firms, and communities tied to environmentally harmful activities can avoid these pressures if only the environmental laws, such as the Endangered Species Act, were set aside raise false hopes. The pressures are independent of specific laws. Even if such laws are repealed, the costs of environmentally harmful activities will continue to rise and jeopardize the economic outlook for affected communities. Public officials can best promote long-run economic prosperity in the West by encouraging efficient transitions away from harmful activities toward those beneficial to both the environment and the economy.

We are requesting that you recognize the important role the environment plays in western economies and take the steps we've identified to strengthen these economies by protecting and enhancing the quality of the region's natural environment.

Sincerely and respectfully,

The following individuals have endorsed the contents of this letter. Institutional references are provided for identification only.

State	***Name, institutional affiliation***
Arizona	Bonnie G. Colby, The University of Arizona
	Dennis Cory, University of Arizona
	Ron Trosper, Northern Arizona University
California	Dennis J. Aigner, University of California, Santa Barbara
	Kenneth J. Arrow, Stanford University
	Ted Bergstrom, University of California, Santa Barbara
	Christopher Costello, University of California, Santa Barbara
	Robert Deacon, University of California, Santa Barbara
	Stephen J. DeCanio, University of California, Santa Barbara
	Anthony Fisher, University of California, Berkeley
	Lawrence Goulder, Stanford University
	Steve Hackett, Humboldt State University
	Michael Hanemann, University of California, Berkeley

Amy Horne, Sierra Business Council
Daniel Ihara, Center for Environmental Economic Development
Charles Kolstad, University of California, Santa Barbara
Stephan Kroll, California State University, Sacramento
Peter Kuhn, University of California, Santa Barbara
Carol McAusland, University of California, Santa Barbara
John M. Marshall, University of California, Santa Barbara
Wade E. Martin, California State University, Long Beach
Roger Noll, Stanford University
Richard B. Norgaard, University of California, Berkeley
Kenneth Small, University of California at Irvine
David Starrett, Stanford University

Colorado	Lee J. Alston, University of Colorado
	Janis M. Carey, Colorado School of Mines
	Katherine Carson, Affiliation: United States Air Force Academy
	Brad Crowder, U.S. Environmental Protection Agency
	Graham A. Davis, Colorado School of Mines
	Nicholas Flores, University of Colorado
	Philip E. Graves, University of Colorado
	Marie Leigh Livingston, University of Northern Colorado
	John Loomis, Colorado State University
	Pete Morton, The Wilderness Society
	Jennie Spelman Rice, Consulting Economist
	Linda Stanley, Colorado State University
Idaho	Joel Hamilton, University of Idaho
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	Robert Tokle, Idaho State University
Montana	Richard Barrett, University of Montana
	Douglas Dalenberg, University of Montana
	Tom Power, University of Montana
	Ray Rasker, Sonoran Institute and Montana State University

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	Eban Goodstein, Lewis & Clark University
	Joe Kerkvliet, Oregon State University
	K. John McConnell, Oregon Health & Science University
	Don Negri, Willamette University
	Noelwah Netusil, Reed College
	Ernie Niemi, ECONorthwest
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	Andrew J. Plantinga, Oregon State University
	Carl M. Stevens, Reed College
	Ed Whitelaw, University of Oregon
Utah	Arthur Caplan, Utah State University
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	Robert J. Lilieholm, Utah State University
Washington	Gardner Brown, University of Washington
	Ken Casavant, Washington State University
	Dan Hagen, Western Washington University
	Steve Henson, Western Washington University
	Hart Hodges, Western Washington University
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	Norm Whittlesey, Washington State University
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	Dallas Burtraw, Resources for the Future
	Ujjayant Chakravorty, Emory University
	Paul N. Courant, University of Michigan
	Ronald Cummings, Georgia State University (Univ. New Mexico, emeritus)
	Robert Haveman, University of Wisconsin-Madison
	Thomas S. Jayne, Michigan State University
	Matthew Martin, Economy.com
	Kenneth E. (Ted) McConnell, University of Maryland
	Michael R. Moore, University of Michigan
	Rodney B.W. Smith, University of Minnesota
	Robert Solow, Massachusetts Institute of Technology
	John Sorrentino, Temple University Ambler
	Ivar Strand, University of Maryland
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Please cite this paper to Ed Whitelaw, editor.

WALTZ David * DEQ

From: Russ and Linda Glascock
Sent: Friday, September 2, 2022 8:33 AM
To: LIVERMAN Alex * DEQ
Subject: Upper Yaquina meeting minutes

Alex,

I reviewed the minutes of the Upper Yaquina rule making committee meeting, and I have a few comments.

On page 5, there is this paragraph:

Russ suggested the Farm Service Agency as a resource for information on 176 acres of small farmlands in
current CREP contracts ($16,000 worth). He suggested obtaining information from the Mid Coast Watershed
Council and Lincoln County Soil Water Conservation District on conservation projects. Alex requested
submittal of specific contacts and studies to request. Joe planted 90 acres in 2000 that are 50 to 60 feet tall
starting to shade the river.

-Farm Service Agency is headed by Heather Tritt in Tangent. Her contact # is 541-967-5925. The current CREP contracts mentioned are for all of Lincoln county.

-Heather added that the CREP contracts reflect approx 50% cost share. Some landowners have done practices above and beyond. Some have also received OWEB grants to assist in implementation and maintenance.

-I have served on the Farm Service Agency committee two different times about 30 years apart.

-I am aware of riparian projects of myself and upriver landowners aided by 1)Farm Service Agency

2)Mid Coast Watershed Council

3)Lincoln County Soil and Water (I was a past director)

4)OWEB

5)NCRS

-"Joe planted..." is not correct. It should read Russ planted... I also note that we also planted 10 acres along the Yaquina river in 1977. These trees are approximately 150 feet tall and are definitely shading the river. I would hope that DEQ would understand that landowner contributions to riparian plantings take decades to become effective.

I would also note that Oregon Department of Agriculture has mailed out notice of an open house concerning the Upper Yaquina river strategic implementation area to me and my neighbors to be held at the Eddyville school at 6pm on Sept 12th.

Russ

WALTZ David * DEQ

From: WALTZ David * DEQ
Sent: Thursday, October 27, 2022 5:49 PM
To: LIVERMAN Alex * DEQ; Upper Yaquina TMDL * DEQ
Subject: FW: Upper Yaquina Watershed TMDL second RAC Meeting materials

For the record.

From: Russ and Linda Glascock
Sent: Thursday, October 27, 2022 5:31 PM
To: WALTZ David * DEQ <David.WALTZ@deq.oregon.gov>
Subject: Re: Upper Yaquina Watershed TMDL second RAC Meeting materials

David,

The BOF has approved the Oregon forest accord. This is conjoined with the Upper Yaquina Watershed TMDL for small landowners. The financial burden is compounded. For me personally, 25 acres out of 100 acres is out of the ability to thin forever within 110 feet of the river. Measure 49 was passed in 2007 to deal with these issues: https://www.oregon.gov/lcd/Measure49/SupportingDocuments/M49_ClaimInstructionPacket_Fee_20220509.pdf.pdf.

Russ

WALTZ David * DEQ

From: Russ and Linda Glascock
Sent: Wednesday, November 2, 2022 1:08 PM
To: LIVERMAN Alex * DEQ
Subject: Fwd: Final DEQ TMDL comments

-------- Forwarded Message --------
Subject: Final DEQ TMDL comments
Date: Wed, 2 Nov 2022 13:05:42 -0700
From: Russ and Linda Glascock <rgranch@pioneer.net>
To:WALTZ David * DEQ <David.WALTZ@deq.oregon.gov>

-Page 3 - "Russ Glascock summarized riparian planting projects completed on his property that are now providing shade on the river in the last 20 years."

Actually said 10 acres along the river were planted 47 years ago and are shading the river. 90 acres along the river were planting in 2000, and are partially shading the river. The point was that it takes 3 or 4 decades of planning and effort to create shade. David responded that type of information supports the need for site-specific assessment before investing significant resources.

-Page 3 - Russ asked whether DEQ has mapped logs placed in tributaries for shade (and clarified this question applies to large wood directly providing shade or to improve channel condition).

-Google earth will not show logs placed in tribs. Logs also provide shelter for juvenile fish from predators. Many of these were placed in the 90's and enhance biology of the streams. Effort in placing logs in tribs by private timber companies need to be mapped for this DEQ committee, just as important as noting the riparian plantings done by small land owners, and in kind contributions (OWEB, etc).

-Page 5 - Russ asked whether a distinction will be made between the livestock sources and elk.

Bacteria from livestock sources and wildlife sources are intermingled in your data.

David responded that one goal of the water monitoring that will be conducted under both the ODA's Strategic Implementation Area
process and the TMDL implementation is to attempt to distinguish among sources including wildlife and livestock, but that it can be difficult to accomplish.

Russ indicated that issue is a small business impact and Alex asked him to please elaborate in written comments.

Your study was sampled in 2016, while I had 15 head of cattle. Two years ago I reduced my herd to 3 animals. More elk and deer are using my property than my animals, so the bacteria load from all wildlife (birds , beaver elk, etc) will always be present. My neighbor Edwards two years ago sold off his cattle herd and produces hay only. DEQ data should be done over. Drought conditions continue, and there is no telling if my stretch of river ever will meet DEQ TMDL standards if there were no livestock. 303d list on property decreases land value, although my new property tax statement had a 2% increase.

-Page 7 - Russ asked whether the Forest Practices Act amendments are a piggyback on the TMDL. Alex reiterated the revisions DEQ made to the fiscal impacts statement in response to ODF and ODA comments that their existing rules are already required and should not be "double-counted" as costs of the TMDL rule.

When DEQ lays out stream temperature and dissolved oxygen goals, the Oregon forest accord is mentioned. Current forest practice act allows thinning inside of 100 feet of fish stream buffers. Next year is when the Oregon forest accord rules take effect. Next year no thinning will be allowed within 110 feet of fish stream buffer. For the 100 acres of timber that I have planted along the river up to the first bench, 25 acres will not be able to be thinned. This reduces my retirement by 25% and devalues my property. A 303d list also further reduces my property value.

"Measure 49 provides that if a public entity enacts one or more land use regulations that restrict the residential use of private real property, or a farming or forest practice, and that reduce the fair market value of the property, then the owner of the property shall be entitled to just compensation from the public entity that enacted the land use regulation or regulations."

https://www.oregon.gov/lcd/Measure49/SupportingDocuments/M49_ClaimInstructionPacket_Fee_20220509.pdf.pdf

David,

It is not lost on me that ODA found 4 Upper Yaquina entities possibly out of compliance with 1010 rules. At the Eddyville meeting, the ODA noted 90 percent compliance in the Upper Yaquina. For the entire Upper Yaquina basin to be put onto 303d list seems overkill. I have stressed that small land owners as myself and many neighbors have for decades voluntarily made riparian plantings with the help of CREP, OWEB and several other in kind contributions. Patience and perseverance is needed for shade to improve. Private timber owners have placed logs since the 1990's to improve tributary habitat.

When a sewer line broke in July at Newport's bayfront, bacteria entered the bay and tides took it up to tide water. The chinook salmon juveniles that spawned at my place had traversed to the tide water. Did you place a 303d list on Newport? Every flood event at cities along the Willamette river causes sewage treatment plants to overflow bacteria into the water. Does DEQ place each city under 303d list?

Please understand that placing regulations on rural property owners who have for years improved riparian habitat, in the area that small producers live and work do nothing to improve Oregon's city/rural divide.

Russ Glascock

WALTZ David * DEQ

From: Paul Engelmeyer
Sent: Friday, November 4, 2022 8:03 AM
To: WALTZ David * DEQ; LIVERMAN Alex * DEQ; ernie.niemi@nreconomics.com
Subject: Fwd: Comments on Draft Fiscal Impacts Statement for the Upper Yaquina River Watershed
Attachments: ODEQ Critique2022-1101.pdf

Hello David and Alex,

Just making sure you know I have been working with Ernie Niemi on the comments below to reflect my concerns about ensuring a comprehensive costs, benefits and broader economic picture is incorporated into the Draft Fiscal Impacts Statement version 2 for the Upper Yaquina River Watershed.

I am also working with the NRCS on information about incentive strategies for landowners willing to improve riparian habitat conditions and water quality. We should have that handout available shortly.

Any questions do not hesitate to give me a call.

Paul Engelmeyer
541-547-4097

Oregon Dept. of Environmental Quality 2 November 2022

Attn: David Waltz Via email

Email: david.waltz@deq.oregon.gov

700 NE Multnomah Street, Suite 600, Portland, OR 97232

RE: Comments on the Draft Fiscal Impacts Statement (DFIS) Version 2, Yaquina River Watershed TMDLs rulemaking proposal

Dear Mr. Waltz:

Attached please find the pdf file, *Deficiencies in ODEQ's Draft Fiscal Impact Statement for the Upper Yaquina River Watershed.* I am submitting this document for your consideration in the Upper Yaquina River Watershed TMDL rule-making process.

If you have any problem downloading and opening the document, or any questions about its contents, please let me know

Sincerely,

Ernie Niemi, President
Natural Resource Economics

Deficiencies in ODEQ's Draft Fiscal Impact Statement for the Upper Yaquina River Watershed

November 2022

Ernie Niemi, President of the consultancy, Natural Resource Economics, prepared this document. The report draws from his review of the Updated Draft Fiscal Impact Statement (DFIS) prepared by the Oregon Department of Environmental Quality (ODEQ) and from more than 40 years of his efforts to describe the economic impacts of resource exploitation, conservation, and restoration. He prepared this document without material influence from any other party, and reserves the right to change the document in response to new information that might become available in the future. Natural Resource Economics is solely responsible for the contents of this document.

For more information, please contact:
Ernie Niemi, President
Natural Resource Economics
ernie.niemi@nreconomics.com

Natural Resource Economics

1430 Willamette St., # 553
Eugene, Oregon USA 97401
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Introduction and Summary

As it completes the Upper Yaquina Watershed Project, ODEQ is preparing a new Water Quality Management Plan (WQMP) and new total maximum daily loads (TMDLs) for bacteria and dissolved oxygen. ODEQ has determined that these two "impairments" result primarily from three pollutants—E.coli, total phosphorus, and excess solar radiation— and "affect two primary beneficial uses – aquatic life and recreation that involves contacting water, such as fishing and swimming." Adopting appropriate TMDLs and taking other steps to reduce the pollutants and relax impairment of the watershed's water quality is necessary to satisfy obligations for Oregon and the US Environmental Protection Agency (USEPA) under the Clean Water Act. The watershed occupies about 54,000 acres and the land ownership and management activities that affect water quality are "predominately industrial and public forest with a smaller percentage of agriculture and rural residential."

As part of the process for preparing and adopting the TMDLs, ODEQ must prepare and submit for public review a Fiscal Impact Statement. ODEQ has issued a Draft Fiscal Impact Statement (DFIS), with this introduction:

> *"Consistent with Oregon Revised Statute 468B.110 and OAR chapter 340 division 42, DEQ prepared Total Maximum Daily Loads and a Water Quality Management Plan to address bacteria and dissolved oxygen impairments in the Upper Yaquina River Watershed. The TMDLs and WQMP will be proposed for adoption by Oregon's Environmental Quality Commission [EQC], by reference, into OAR 340-042-0090. The TMDLs and WQMP are supported by DEQ's Upper Yaquina River Watershed TMDL Technical Support Document. These draft documents will be available for public review during the comment period and hearing that will precede proposing the rule for adoption by the EQC. "*

The Oregon Department of Justice has provided a guidance checklist regarding what must be included in a "Statement of Fiscal Impact." This guidance instructs ODEQ, when preparing a Fiscal Impact Statement, to answer a set of questions that includes these:

☐ *Are any state agencies likely to be economically affected by the rule change? If yes, which ones?*

☐ *Are any units of local government likely to be economically affected by this rule change? If yes, which ones?*

☐ *Are any members of the public likely to be economically affected by the rule change? If yes, which ones?*

☐ *Can the agency provide an estimate of the economic impact on state agencies, units of local government and members of the public? If yes, what is the estimate for each?*

☐ *Has the agency included a cost of compliance on small businesses affected, including:*

...

☐ *A description of how small businesses were involved in developing the rule.*

☐ *If the agency cannot provide an estimate of the economic impact on state agencies, units of local government or members of the public, does the statement of fiscal impact explain why an estimate is not possible?*

☐ *Is the fiscal impact statement sufficient to notify those who might be economically affected to evaluate their position?*

ODEQ's DFIS for the Upper Yaquina Watershed provides only partial answers to these questions, using only a small segment of the readily available, relevant information. Moreover, it presents its answers in a biased manner that favors doing less, rather than more, to improve water quality in the watershed. This bias arises from asymmetries between ODEQ's description of the potential negative impacts and positive impacts of actions that would improve water quality. ODEQ describes with considerable detail potential negative economic impacts to industrial timber and livestock producers from the adoption of TMDLs and other actions that would improve water quality in the watershed by requiring them to reduce the amounts of E.coli, total phosphorus, and excess solar radiation they introduce into the watershed. In contrast, ODEQ provides only vastly incomplete, general information about the potential positive economic impacts. The disparity in the descriptions of specific costs versus general benefits likely will increase the likelihood that some decision-makers and members of the public will conclude the agency believes the costs from doing more to improve water quality are more important than the benefits. In reality, though, this gap in the presentation disregards large amounts of research and data that show the potential positive impacts likely will far exceed the negative impacts.

This document provides information to fill the gap. The presentation has three sections. The first outlines widely applied professional standards for presenting a comprehensive, credible, and unbiased assessment of the potential economic impacts of actions that improve water quality. The second summarizes some of the research and data, omitted from the DFIS, regarding the potential positive economic impacts of doing more, rather than less, to improve water quality in the Upper Yaquina Watershed. The third presents the opposite by summarizing some of the economic costs likely to result if ODEQ does not correct the deficiencies in the DFIS and proposes to do less, rather than more, to improve water quality in the watershed.

Presenting a comprehensive, credible, and unbiased Final Fiscal Impact Statement has implications not just for understanding the economic importance of high-quality water in the watershed. It also would help insulate US EPA from the legal challenges it likely would face if it were to accept from ODEQ proposed TMDLs supported by an incomplete and biased assessment of economic impacts.

I. Applicable Professional Standards

Detailing the economic impacts of resource-management actions, such as defining and implementing new TMDLs, has always been a daunting task. The task has become ever more complex amid accelerating changes in economic, environmental, and social systems, especially those associated with the climate crisis and the biodiversity/ecosystem service crisis. Two sets of guidelines, however, point the way. One is embedded in the National Environmental Policy

Act (NEPA).[1] The other is represented in the Principles, Requirements, and Guidelines for Federal Investments in Water Resources (PR&Gs).[2]

NEPA sets the overall requirements that USEPA and, hence, ODEQ must satisfy when assessing the economic impacts of actions affecting water quality in the watershed. NEPA states that Federal agencies "to the fullest extent possible" must provide a detailed impact statement. In applying this standard, courts have held that, at a minimum, NEPA imposes on an agency a duty to take a "hard look at environmental consequences" and a "requirement of a substantial, good faith effort at studying, analyzing, and expressing the environmental issues in the EIS and the decisionmaking process".[3] A sufficient impact statement must provide good faith analysis and sufficient information to allow a firm basis for weighing the risks and benefits of a proposed action.[4]

To satisfy NEPA, USEPA and ODEQ must fully identify, describe, and assess the full scope of environmental and social impacts, risks, and other concerns associated with any proposed TMDLs and water-management plan, so that the public and decision-makers can take them into account when evaluating the proposal. The origins for these requirements reach back to the 1970s, when communities in the U.S. and across the globe became increasingly aware that, although private-sector projects often generated net internal benefits for their sponsors, they also imposed large net costs on others through their adverse impacts on the environment, local communities, and global society. These external costs materialized whenever a project caused people and entities to lose something important to them. Concern was heating up, both because these "external" costs (Figure 1) to society as a whole were large and rapidly becoming larger, and because project developers often ignored them. Communities, hence, often had no advance warning of the adverse impacts a project would impose on them, and no information about how to avoid the costs or receive compensation. Decision-makers often had little or no information about the external costs when they approved projects, but then, after the costs materialized, conceded that they would not have approved the project had they had full, advance knowledge. Increasingly, the consequences and inequities—from local to global—were severe, with acute degradation of the quality of life or deaths and injuries to humans, livestock, and wildlife. Increasing awareness of the climate crisis and the biodiversity/ecosystem services crisis shows that actions benefitting today's generation will impose potentially catastrophic external costs on future generations and, in response, economists have realized that the moral and ethical issues require giving greater weight to these costs than would occur if the costs were borne by the current generation enjoying the benefits. In many instances, analyses have shown that the net external costs to society have exceeded the net internal benefits to the direct beneficiaries. Given the potential for such an outcome, NEPA, and

Figure 1. Projects Harm Society Whenever They Impose External Costs on Others

Internal Cost = Borne By Project Proponents

External Cost = Borne By Everybody Else
= Harm To Society

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[1] 42 U.S.C. 4332.

[2] Council on Environmental Quality. 2013. Updated Principles and Requirements for Federal Investments in Water Resources; and 2014. Interagency Guidelines.

[3] Natural Resources Defense Council v. Morton, 458 F.2d 827, 838 (D.C. Cir., 1972)

[4] County of Suffolk v. Secretary of the Interior, 562 F.2d 1368 (2nd Cir. 1977), cert. denied, 434 U.S. 1064 (1978)

the best professional standards require Federal agencies to do their best to analyze external costs fully without bias and communicate the process of their analysis and its results in a transparent manner. By extension, these requirements apply to ODEQ.

The PR&Gs define the high professional analytical standards ODEQ and USEPA must follow for describing the environmental, social, and socioeconomic impacts of actions affecting the nation's water resources.

> *"The PR&Gs provide a common framework for evaluating federal water resource investments. This framework includes an ecosystem service and watershed-based approach; using the best available science; taking advantage of opportunities for collaboration with other federal agencies as well as with tribal and other non-federal entities; identifying and quantifying, where possible, areas of risks and uncertainties; and addressing healthy and resilient ecosystems; sustainable economic development; floodplains; public safety; and environmental justice. In particular:*
>
> - *The PR&Gs are designed to change the focus for federal water resource investments from essentially an economic-based analysis to encompass a much broader perspective. … The PR&Gs require that economic development, environmental, and social effects all be considered and evaluated in determining which alternative to recommend for implementation. The P&Rs state that agencies 'should strive to maximize public benefits, with appropriate consideration of costs.' Public benefits are defined as encompassing environmental, economic, and social goals, including 'monetary and non-monetary effects and allow for the consideration of both quantified and unquantified measures.'"*[5]

ODEQ's efforts, as reflected in the DFIS, do not comport with the professional standards expressed in the PR&Gs. To correct these deficiencies, as it produces its final proposal for TMDLs and the water management plan, ODEQ must strive to:

1. Protect and restore the functions of ecosystems and mitigate any unavoidable damage to these natural systems.
2. Improve economic well-being for present and future generations through the sustainable use and management of resources.
3. Avoid unreasonable adverse effects on public health and safety.
4. Avoid, reduce, and mitigate risks to the extent practicable, and manage and clearly communicate residual risks.
5. Seek actions that would eliminate or avoid disproportionately high and adverse public safety, human health, or environmental burdens on minority, Tribal, and low-income populations.

Moreover, in preparing its final fiscal impact statement, ODEQ must:

- Provide a comprehensive, credible assessment of all the external costs likely to be avoided by implementing the proposed actions. Use all of the best available science to provide decision-makers and the public with the best possible understanding of these benefits: monetized as well as non-monetized, quantifiable as well as described only in qualitative terms, certain as well as uncertain.
- Provide a credible estimate of the net public benefits of the proposed actions and alternatives.

[5] U.S. Department of the Interior. 2015. Frequently Asked Questions Water Resources Principles, Requirements and Guidelines (Revisions to the Principles and Guidelines).

- Describe the net impact on jobs, incomes, etc.
- Assess and clearly communicate the potential sustainability of the proposed actions, accounting for both market and non-market components of the economy.
- Explicitly and fully account for the economic importance of ecosystem services.
- Explicitly and fully account for all subsidies, externalities, and other factors that distort the distribution of goods and services.
- Explicitly and fully account for cultural values.
- Describe each alternative's impacts on the climate crisis and the biodiversity/ecosystem services crisis, and the potential impacts of these crises—individually and in combination—on the alternative's benefits and costs.

II. Potential Positive Economic Impacts of Doing More to Improve Water Quality

The DFIS does not exhibit a comprehensive effort to identify, describe, and assess the potential positive economic impacts of tighter TMDLs and other actions that would improve water quality in the watershed. Not even close. Particularly important, it does not provide a credible assessment of these potential positive impacts:

A. Reductions in carbon dioxide emissions and climate-related economic damage.

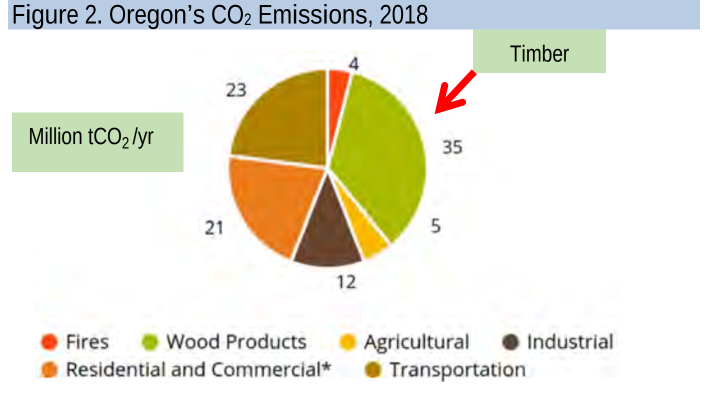
B. Reductions in contributions to the crisis in biodiversity and ecosystem services.

C. Strengthen the outlook for robust, sustainable job creation.

A. Reductions in CO_2 Emissions and Climate-Related Economic Damage

Industrial timber production can contribute to impairment of water quality in the Upper Yaquina Watershed by exposing water and soils to excess solar radiation and by allowing the runoff of phosphorus following the application of fertilizers. Restrictive TMDLs and other actions can reduce the impairment and the direct costs that accompany negative impacts on aquatic life and water-related recreation. In addition, these restrictions can reduce timber-related emissions of carbon dioxide and, hence, reduce climate-related economic damage. Industrial timber production in Oregon substantially increases atmospheric carbon dioxide; data indicate that timber production in Oregon is the state's largest, single source of carbon dioxide emissions (Figure 2). These increases will impose economic costs on society for the foreseeable future (Figure 3). These external costs are complex and

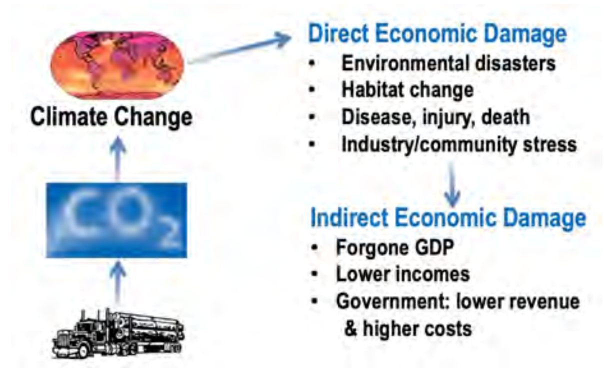
Figure 2. Oregon's CO_2 Emissions, 2018



difficult to measure, but the data currently available indicate that they far exceed the value of the logging revenues. Recent research findings strongly indicate that the climate-related external costs from future increases in atmospheric carbon dioxide will grow rapidly, perhaps catastrophically, in the coming years.

Timber production in the watershed will increase atmospheric CO_2 through several pathways. Trees killed by logging will no longer grow bigger and sequester more carbon, logging residue will be burned as slash, mills will burn sawdust, and many wood and paper products will decompose within a few years.[6] The extent of the CO_2 emissions was recently determined by researchers in Oregon, who found that timber production increases atmospheric CO_2 by about 8,500 metric tons per million board feet (mmbf) of timber.[7]

Figure 3. Industrial Timber Production Emits CO_2 and Intensifies Climate-Relate Economic Damage



This additional CO_2 in the atmosphere will impose economic harm on all people by exacerbating the many components of the climate crisis. It will make heatwaves, droughts, and wildfires more frequent and intense, for example. Many economists have developed estimates of the economic damage per metric ton of carbon dioxide, commonly called the "social cost of carbon dioxide" (sometimes abbreviated as the "social cost of carbon"). In 2016, federal agencies estimated that each metric ton of CO_2 added to the atmosphere will cause economic damage of about $50.[8] The agencies acknowledged that the true social cost is considerably higher, insofar as these numbers rest on some powerful simplifying assumptions and fail to incorporate the full range of potential damage likely to result from increases in atmospheric CO_2. Nonetheless, in 2016 the Bureau of Land Management used this estimate to determine that the external, climate-related costs resulting from logging on the forests it manages in Oregon are more than four times the value of the logs produced.[9]

The Trump Administration downplayed the concept that CO_2 emissions cause economic damage. President Biden, however, has ordered the agencies to reinstate $50 per metric ton on an interim basis.

Since 2016, researchers not subject to President Trump's restrictions have continued to develop new estimates of the social cost of carbon dioxide, using updated assumptions and data. One prominent study, published in 2018, found that each metric ton of CO_2 added to the atmosphere

[6] Additional detail on the potential for Washington's forests to slow the climate crisis if trees are not logged but, instead, allowed to grow bigger, is available in: Declaration of Paula Swedeen. 2020. Superior Court of Washington for Thurston County. Conservation Northwest, et al. v. Commissioner of State Lands Hilary Franz, et al. and Wahkiakum County, et al. No. 20-2-01051-34.
[7] Law, B.E., et al. 2018. Land use strategies to mitigate climate change in carbon dense temperate forests; Center for Sustainable Economy (CSE). 2017. Oregon forest carbon policy: scientific and technical brief to guide legislative interventions.
[8] EPA Fact Sheet: Social Cost of Carbon.
[9] U.S. Bureau of Land Management. 2016. Proposed Resource Management Plan, Final Environmental Impact Statement: Western Oregon, Vol. 2.

will impose economic damage of $417, and perhaps as high as $800.[10] Another, submitted for publication in 2021, concluded that the social cost of carbon dioxide is at least $562 and perhaps $3,319 per metric ton.[11] In 2022, researchers published research findings that show currently quantifiable the social costs of carbon dioxide are at least $185 per tonne. Combined, these estimates of the social cost of carbon dioxide—$50 at the lower end, up to $3,319 at the upper end—provide the basis for developing provisional estimates of the climate-related economic benefits from actions, such as tight TMDLs, that would reduce timber production on lands in the watershed.

Unless ODEQ has better information, it should use these numbers to describe the potential positive economic impacts of actions that would reduce timber production in the watershed as it reduces the industry's negative impacts on water quality.

B. Reductions in Contributions to the Crisis in Biodiversity and Ecosystem Services

Industrial timber production in the watershed imposes costs on society as a whole not just by intensifying the climate crisis but also by contributing to the crisis in biodiversity and ecosystems. This latter crisis has received much less attention than climate, but it is also severe and existential to human life as we know it.[12] This reality is being made more apparent by research conducted and compiled by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which stands parallel to the comparable institution, the Intergovernmental Panel on Climate Change (IPCC).[13]

The biodiversity/ecosystem crisis is occurring within the Upper Yaquina Watershed and across the globe. Concern about biodiversity and ecosystems arises from research that shows nature makes countless contributions to human well-being, but its capacity to continue providing these so-called ecosystem services is diminishing at an unprecedented rate. This decline is more than worrisome because more than one-half of the economic activity measured by conventional indicators, such as the world's gross domestic product (GDP) is dependent on ecosystem services from nature.[14] Globally, about one-third of the world's forest area has been destroyed, more than 85 percent of wetlands have been lost, one-third of the topsoil has been degraded, freshwater species and vertebrate species have experienced population declines of 83 percent and 60 percent, respectfully, since 1970. These losses and trends create societal and economic risks through their impacts on global health, global peace, intra- and international trade, gender equity, cultural and social connections between ecosystems and indigenous communities, and economic development. A major driver of these losses and trends has been the industrial exploitation of ecosystems to produce wood products and other materials. Industrial timber

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[10] Ricke, K., Drouet, L., Caldeira, K., and Tavoni, M. (2018). Country-Level Social Cost of Carbon.

[11] Kikstra, J., P. Waidelich, J. Rising, and others. 2021. The Social Cost of Carbon Dioxide Under Climate-Economy Feedbacks and Temperature Variability.

[12] A just-published peer-reviewed report from a panel of 50 of the world's leading biodiversity and climate experts states: "Biodiversity loss and climate change are both driven by human economic activities and mutually reinforce each other. **Neither will be successfully resolved unless both are tackled together.**" [Bold emphasis added.]

[13] For more information about the IPBES, please see the home page.

[14] Support for the facts in this paragraph come from World Economic Forum. 2020. Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy.

production, which is more dependent upon ecosystems than many other industries, is among the greatest contributors to the biodiversity/ecosystem crisis.

Industrial timber production in the watershed imposes negative impacts on biodiversity and ecosystems. Many of the negative impacts follow from practices that include mechanized logging that removes the majority of forest on a parcel and replaces them with single-aged stands of conifers (referred to as "regeneration harvest" or "variable retention harvest," but commonly known as clearcut logging), a core feature of industrial timber production in this region. For example, this practice has negative impacts on nature by reducing the flow of streams in late summer and raising the water temperature.[15] These effects can increase the likelihood that streams will experience algae blooms that create health risks for wildlife and for recreationists and their pets who come in contact with the water, and increase the cost of providing safe drinking water to communities downstream.[16]

These negative impacts on streamflows also can play a role in reducing populations of salmon and other species that depend on cold water and increase the cost of restoring these populations to higher levels.[17] Timber production can have negative impacts on salmon and other cold-water species directly, through the impacts of timber-management on stream flows and temperatures, and indirectly, by increasing atmospheric CO_2 and intensifying the impacts of the climate crisis on stream temperatures. Research from EPA confirms that, if left unchecked, changes in climate will raise stream temperatures enough to eliminate, throughout most of the state, the cold-water habitat salmon require (Figure 4). Industrial timber production in the watershed, thus, contributes to the warming effects of changes in climate and exacerbates the impacts by diminishing streamflows and exposing them to warm sunlight.

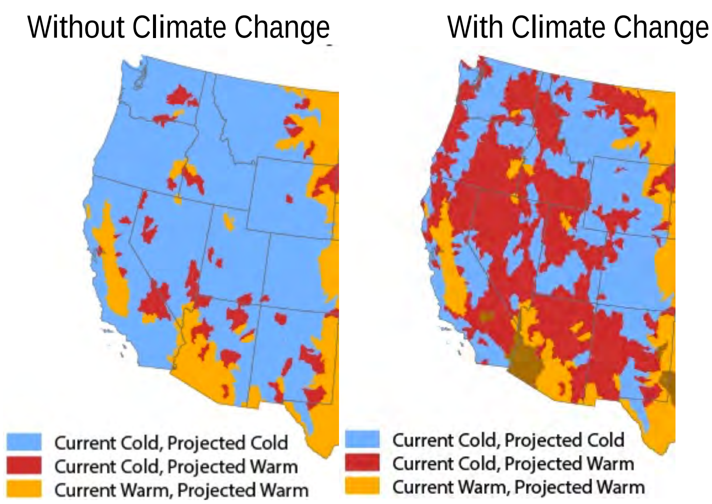

Figure 4. Climate Change Is Raising Stream Temperatures and Threatens to Eliminate Habitat Required by Salmon and Other Cold-Water Fish by the End of this Century

[15] Perry, T.P., and J.A. Jones. 2017. Summer Streamflow Deficits from Regenerating Douglas-fir Forest in the Pacific Northwest, USA; and Oregon State University. 2011. Study Outlines Stream Temperature Changes Following Timber Harvests: Groom, J.D. 2013. Stream Temperature Responses to Timber Harvest and Best Management Practices

[16] USEPA research shows that more than 57% of surface drinking water in Lincoln County comes from intermittent, ephemeral, and headwater streams that might be adversely affected by industrial timber production.

[17] National Marine Fisheries Service, West Coast Region. 2016. Final ESA Recovery Plan for Oregon Coast Coho Salmon (Oncorhynchus kisutch).

ODEQ has not published an estimate of the value of the external costs resulting from its impacts on salmon. There can be no doubt, however, that the external costs exist: a 2009 analysis by a team of regional economists estimated that anticipated declines in Washington's salmon populations resulting from climate change would impose costs of $175 – $640 per household per year.[18] Research conducted elsewhere confirms the overall economic importance of changes in salmon populations, with households believing that decreases in populations would cause them considerable economic harm, and increases would significantly boost their overall economic well-being. Research conducted in 2000, for example, found that Oregonians living near the Yaquina estuary place substantial value on actions that promise expansion of salmon populations.[19] More recent research found that passive-use values associated with changes in Oregon Coastal Coho Salmon populations can exceed $5,000 per returning adult.[20]

Unless ODEQ has better information, it should use these numbers to describe the potential positive economic impacts of any potential increases in salmon populations that might result from actions to improve and protect water quality in the watershed.

ODEQ also should identify, describe, and assess other potential positive economic impacts from reductions in industrial timber production in the watershed. These include reductions in negative impacts on biodiversity and ecosystems. Reductions in smoke from burning post-logging slash, for example, can have positive impacts on the health of humans, livestock, and wildlife. Reductions in clearcuts and forest roads established to support timber production can reduce the risks of future landslides. Reductions in the use of herbicides to discourage the growth of brush and other vegetation that might compete with seedlings can improve biological diversity and reduce health risks from polluted drinking water supplies. Each of these reductions, and others that would reduce the negative impacts of industrial timber production on biodiversity and ecosystems' ability to provide services, will generate positive economic impacts via processes that affect health, trade, gender equity, cultural and social connections between ecosystems and indigenous communities, and economic development.

Efforts to quantify the external costs from negative impacts on biodiversity and ecosystem services have only just begun (they lag behind analogous efforts to quantify the social cost of carbon dioxide, described above). The preliminary evidence suggests that they are huge. For example, the loss of biodiversity and degradation of ecosystems can contribute to the emergence of devastating diseases, the degradation of forest wetlands can diminish their ability to retard, even arrest wildfires, and industrial modification of ecosystems can diminish soils and degrade their productivity.[21]

Research to date suggests it would be prudent to expect that the external costs from the negative impacts on biodiversity and ecosystem services of timber production is equal to or greater than the value of the logs produced. A recent review of global research, for example, reached these conclusions:

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[18] Niemi, E. K. Baird, W. Barnes, and others. 2009. An Overview of Potential Economic Costs to Washington of a Business-As-Usual Approach to Climate Change.

[19] Bell, K.P., D. Huppert, and R.L. Johnson. 2003. Willingness to Pay for Local Coho Salmon Enhancement in Coastal Communities.

[20] Lewis, D.J., Dundas, S.J. D.M., Kling, and others. 2019. The Non-Market Benefits of Early and Partial Gains in Managing Threatened Salmon.

[21] UN Environment Programme. 2021. Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity and Pollution Emergencies, Executive Summary.

> *"Our analysis shows that both conservation and ecological restoration bring considerable net benefits in terms of public goods and common pool resources, regardless of the habitat or type of ecosystem state change being considered. … [O]ur findings do suggest that, within the broad habitat and geographic range present in our data,* ***we have typically passed the point where the benefits of further change from nature towards human-modified uses exceed the costs to society****."*[22] *[bold emphasis added]*

Research conducted in in the Pacific Northwest confirms that this conclusion applies to industrial timber production in this region. For example, after comparing two alternatives—one that would allow logging to proceed, and another that would restrict logging to protect potential nesting sites for northern spotted owls—researchers concluded that the benefits of protecting the habitat are 2–5 times the benefits from logging.[23] In other words, global and local research findings indicate that the positive economic impacts from reducing the negative biodiversity/ecosystem-related impacts from timber production in the watershed will be at least as large as the benefits from these actions, i.e., the value of the logs produced.

Extensive evidence supports and expands these conclusions. Curtailing industrial timber production in the watershed to reduce its negative contributions to water quality, might decrease the risk of wildfire, reduce the application of fertilizers, improve the quantity and quality of streams, and improve habitat for salmon and other species. Managing forestlands in the watershed to produce better habitats and water quality, rather than timber, likely will yield markedly higher returns on investment and, hence, positive overall economic impacts.

A recent assessment, prepared for Washington's Department of Natural Resources, found that the financial rate of return from its timber-production program is less than 6 percent.[24] This means that the net annual revenues from the timber-production program are less than 6 percent of the underlying value of the forestland assets. This rate of return belies any belief that timber-production on the trust lands is somehow especially valuable, for it resembles the rates of return exhibited by timber production in countries around the world.[25] There are no apparent, credible reasons to anticipate, post-pandemic, that forestlands in the watershed have significantly higher rates of return.

More important, this rate of return coincides with the findings of a landmark assessment, commissioned by the UK government, that examined the performance of timber and other industries that extract materials from ecosystems around the globe and concluded that, regardless of focus or location, they typically exhibit a financial rate of return of about 5 percent.[26] Perhaps more important, this assessment expects the rate of return for timber and other extractive industries will stagnate or decline. It reaches this conclusion after reviewing catalogs of scientific and economic research regarding the economic consequences of the biodiversity/ecosystem crisis (described above) that arises because human actions "have

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[22] Bradbury, R.B., S.H.M. Butchart, B. Fisher, and others. 2021. The Economic Consequences of Conserving or Restoring Sites for Nature.

[23] Krug, D., 2007. Preliminary Economic Analysis: Forest Practices Rulemaking Affecting Northern Spotted Owl Conservation. Olympia, WA: Department of Natural Resources.

[24] Deloitte. 2020. Trust Land Performance Assessment.

[25] Cubbage, F., B. Kanieski, R. Rubilar, and others. 2020. Global timber investments, 2005 to 2017.

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degraded the biosphere to the point where the demands we make of its [ecosystem] goods and services far exceed its ability to meet them on a sustainable basis."

In other words, humans have so degraded nature that it no longer can sustain past and current levels of production of timber and other materials. This degradation comes from more than just the emission of greenhouse gases and the obliteration of biodiversity. It also includes soil degradation, the emission of toxic pollutants, modifications to stream flows, elimination of wetlands, and more. Moreover, the degradation has become a worldwide reality, so there is no opportunity for an industry to exhaust the extraction of materials in one location, then move to another that has been untouched, and enjoy transitory higher levels of productivity. This reality, thus, is a major component of the biodiversity/ecosystem crisis: as nature becomes more degraded, ecosystems provide fewer services, suppressing the productivity of timber and other extractive industries. Insofar as these global relationships apply to forestlands in the watershed, it is reasonable to anticipate that the rate of return from timber production on them will remain stagnant or, more likely, decline.

In sum, with continued timber production, the productivity and value of these resources will decline. It is reasonable, therefore, to ask if a greater emphasis on conservation and restoration would better outcomes. There are strong reasons to conclude that they generally will outperform the less-than 6 percent rate of return from continued production of timber. Most notably, the study commissioned by the UK government, described above, shows that investments in conservation and restoration typically yield a rate of return greater than 19 percent, almost four times greater than the rate of return on timber production and other forms of resource exploitation. This estimate of the superior performance of conservation and restoration is consistent with the research, described above, that found "both conservation and ecological restoration bring considerable net benefit."[27]

Unless ODEQ has better information, it should use these numbers and this information to identify the potential positive economic impacts of any potential increase in conservation/restoration of forestlands in the watershed that would accompany actions to restrict the negative impacts of industrial timber production on water quality, and to provide decision-makers and the public with a full description and assessment of these positive impacts.

C. Strengthen the Outlook for Robust, Sustainable Job Creation

A common theme expressed by opponents of actions that might reduce industrial timber production is that any reduction in timber production will have a profound negative impact on jobs. The economic facts, however, undercut these assertions. These facts show that, for decades, the timber industry has destabilized and depressed local economies by eliminating jobs and contributing to unhealthy social conditions in local communities.

These negative impacts come as no surprise. The timber industry aggressively strives to cut costs, most notably by eliminating jobs. Strong downward pressure on jobs also accompanied the transition in log supply and technology that has occurred over the past few decades. The large logs that were common when logging occurred in old-growth forests required far more

[27] Bradbury, R.B., S.H.M. Butchart, B. Fisher, and others. 2021. The Economic Consequences of Conserving or Restoring Sites for Nature.

workers to move and process than the much smaller and more uniform logs of today, which can be logged, moved, and processed largely by automated machines. No reversal of these trends can be seen on the horizon. Thus, rather than being a pillar of continued job opportunities for rural workers the timber industry is a major source of job decline (Figure 5).[28] Moreover, as the number of jobs declines, less of the income generated by logging and the conversion of logs into paper and wood products flows to workers and, through them, to local communities. Instead, this income leaves the local area and flows to the investors and managers of the industry's corporations.

The negative economic impacts of timber production extend beyond timber-industry workers to the communities where the industry and its workers reside. Extensive research has documented the industry's negative impacts on local communities. Much of this research occurred in response to the decline in logging on federal lands in the Pacific Northwest during the 1990s. A summary of this research, compiled by the National Research Council, concluded that a higher concentration of timber-related activity "seemed to hurt rather than help communities" (Figure 6).[29] Much of this "hurt" comes directly from the industry's impacts on workers. Eliminating jobs in the timber industry, for example, can have ripple effects that increase unemployment and the incidence of families in poverty throughout the local community. These outcomes can diminish activity within the local economy, diminish tax revenues for local communities, and stimulate communities to divert resources from other programs to provide public services to the affected families. Note that, although the research underlying Figure 6 comes from the 1990s, when logging on federal lands declined, most of the jobs eliminated since then and to the present reflect industry's protracted determination to reduce labor costs.

"In most cases, timber dependency seemed to hurt rather than help communities"

Higher unemployment	– Lower income
More poverty	– Less education
Lower birth rates	– Higher death rates
Higher infant mortality	– Poorer health care
Fewer churches	– More arrests

Figure 6. Summary of Research Findings Regarding the Timber Industry's Influence on Community Well-Being

The negative relationship between timber and the social health of communities, shown in Figure 6, was reaffirmed recently by the Bureau of Land Management (BLM), which examined the relationship between log production and local economies. It found that the timber industry is among the world's most volatile and this volatility has negative spillover impacts on local

[28] Beleiciks, N. 2014. Jobs per Board Feet of Timber Harvests in Oregon.
[29] National Research Council. 2000. Environmental Issues in Pacific Northwest Forest Management. Washington, DC: The National Academies Press. https://doi.org/10.17226/4983.

communities. As a result, the BLM concluded that proposed increases in log production likely would destabilize, rather than stabilize, the economy of nearby rural communities.[30]

Research in Oregon provides some detail to the negative effects on local economies, by showing a strong statistical correlation between logging and negative economic indicators. Specifically, counties with more logging have lower median wages, and a higher percentage of the population lives in poverty (Figure 7).[31] These relationships have not been specifically tested for Washington, but there is no apparent reason to anticipate that such tests would yield substantially different findings.

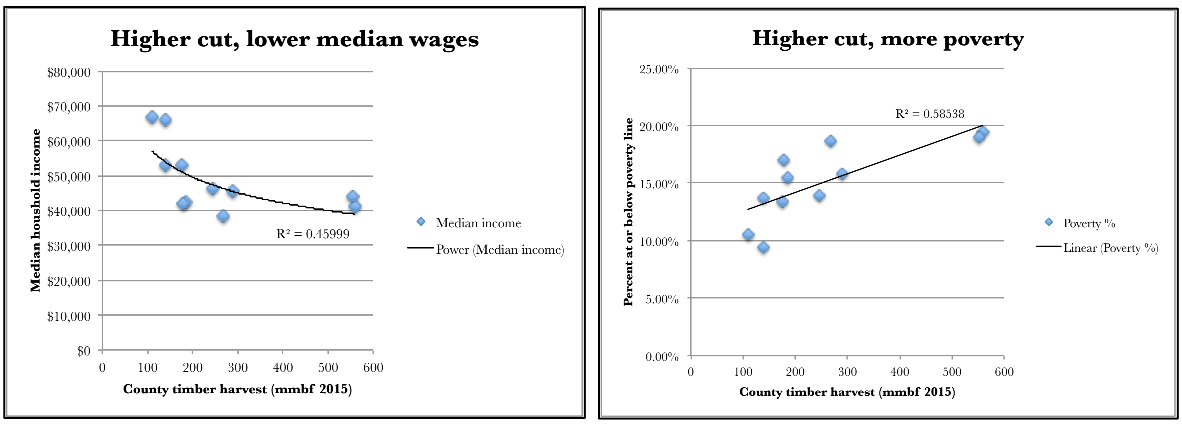

Figure 7. In Counties in Western Oregon with Significant Timber Harvest, More Logging Correlates with Lower Wages and More Poverty.

The discussion above supports the conclusion, that, if it takes relaxes protections for water quality in the watershed to favor future industrial timber production, ODEQ likely will not foster robust economic outcomes for workers, families, and communities. Instead, the production of timber will, instead, likely contribute to persistent economic and social decline.

Would increased emphasis on conservation and restoration of water quality in the watershed have the opposite effect on jobs? Substantial evidence says, "Yes." Research reaching back over several decades indicates that this change in emphasis likely would yield a much brighter future for jobs, incomes, and overall economic activity. Much of this evidence comes from research conducted in Oregon, which found that proximity to conserved forestlands typically correlates with faster growth in community wealth. Specifically, communities within 10 miles of land designated for species protection "experienced higher growth in community wealth than communities more than 10 miles from…protected land, even among those that were dependent upon logging."[32] More broadly, this research found that actions—known as the

[30] Bureau of Land Management, 2014. Final Environmental Impact Statement for the Proposed Resource Management Plan for Western Oregon, page 702. Portland, OR: USDI Bureau of Land Management, Oregon State Office.
[31] County harvest data courtesy of Oregon Department of Forestry. Poverty and median wage data are taken from the U.S. Census. See Talberth, J., 2017. Modernizing State Forest Practices Laws to Halt and Reverse Deforestation. West Linn, OR: Center for Sustainable Economy.
[32] Weber, Bruce, and Yong Chen. 2012. "Federal forest policy and community prosperity in the Pacific Northwest." *Choices.* 27(1). http://www.choicesmagazine.org/choices-magazine/theme-articles/rural-wealth-creation/federal-forest-policy-and-community-prosperity-in-the-pacific-northwest-.

Northwest Forest Plan (NWFP)—to manage federal lands for conservation rather than for timber production had wide-ranging, positive impacts on rural communities:

> *"The preservation of natural forest capital through the NWFP ultimately has induced a redistribution of the forest-related benefits of Federal forestland across communities. Historically, the major benefits came from the timber production which went mainly to the timber-dependent communities. The implementation of the NWFP, signaling that the federal government wanted to protect old-growth forestland, appears to have promoted community wealth in communities close to the protected land, and to have redistributed the economic benefits from the timber-dependent communities to a broader set of NWFP-adjacent communities*

Two major factors underlie the likelihood that that forest conservation would stimulate an increase in jobs and community prosperity. One is the outdoor recreation/tourism industry; the other is the movement of families and businesses to communities with attractive amenities. The outdoor recreation/tourism industry is huge—nationally it is larger than the motor vehicle manufacturing industry, the motion picture industry, and many other economic heavyweights—and it has been growing doggedly and rapidly—about 5 percent annually between 2005 and 2011, a period that includes a major recession and contraction for most industries.[33] ODEQ might stimulate activity in this industry by encouraging landowners to manage forests to provide more recreational opportunities rather than converting them into stumps and monoculture plantations. Some have disparaged this possibility, however, because, relative to timber, this industry pays lower average wages. But, for many workers and families, an industry that can deliver 5 percent growth in jobs, even with lower wages, is preferable to one that promises more layoffs, higher unemployment, and greater social distress.

Despite its huge size and robust growth, the ability of the outdoor recreation/tourism industry to stimulate growth in jobs, incomes, and economic activity often comes up short, relative to the forces and trends that drive the movement of workers, families, and businesses to communities with attractive amenities. New workers often have higher levels of skill and incomes, new families typically have higher incomes to spend in local shops, and new businesses generally have the ability to grow more rapidly than long-established businesses. All of these factors can contribute to a more robust and sustainable local economy. All of these factors can generate new economic opportunities for the current residents of communities near trust lands and provide resources to strengthen the support for schools, healthcare, and other services.

This is not a new phenomenon. In 1999, an economist with the USDA Economic Research Service, looked back and concluded:

> *"Climate, topography, and water area are highly related to rural county population change over the past 25 years. A natural amenities index, derived and discussed here, captures much of this relationship. Average 1970-96 population change in nonmetropolitan counties was 1 percent among counties low on the natural amenities index and 120 per- cent among counties high on the index. … Employment change is also highly related to natural amenities…. The importance of particular amenities varies by region…people are attracted to the West for its varied topography."*[34]

A more recent analysis concluded that, on average, counties with more public land protected from logging and other extractive activities enjoy increased economic performance. After

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[33] Outdoor Industry Association. 2021. The Outdoor Recreation Economy.
[34] McGranahan, D.A. 1999. Natural Amenities Drive Population Change.

statistically controlling for the influence of other factors, the researchers found that, on average, a western county with 10,000 additional acres of protected public land exhibited higher average per capita income (additional $436 in 2010), faster growth in per capita income (additional $237 for 1990-2010), and faster growth in non-labor per capita income (additional $174 for 1990-2010).[35]

An even more recently completed review of this phenomenon found that it has been transforming the economies of communities across the West:

> *"During the past three decades, rural communities in the American West have experienced significant economic restructuring, transitioning from extractive-based industries toward service-based economies. A major impetus for economic restructuring in the Western U.S. (hereafter, the West) has been amenity migration, a phenomenon in which people relocate to communities for physical and social amenities derived from an abundance of desired ecosystem services as opposed to simply following employment opportunities. These amenity migrants include footloose entrepreneurs, retirees, and people willing to trade income for a higher quality of life. … [P]ublic lands have consistently been shown to play a role in attracting amenity migrants."*[36] [Citations omitted]

The last sentence of this text indicates that, by requiring or providing incentives for landowners to manage forest lands to produce attractive amenities, ODEQ could encourage significant economic restructuring, transitioning away from extractive timber production and toward a service-based economy. In other words, producing less timber and more conservation and restoration, could facilitate the transition of local communities away from an industrial focus that evolved in the 1800s and encourage economic activities characteristic of the 21st Century.

The researchers who produced this last review also described the factors that have discouraged ODEQ and local communities from making this transition in the past. They observed that, in many counties and communities with historically strong ties to timber and other extractive industries, community leaders often fail to see the opportunities for conserving and restoring resources so they provide environmental amenities and then marketing these amenities to attract economic activity that can more than offset declines in the extractive industries.

> *"Our results…illustrate that protected areas have a substantial influence on migrant relocation decisions and have become a marketable commodity in their own right. The economic value associated with protected areas and their influence on amenity migration should become a regular component of the discourse that surrounds new proposals for protected areas and new proposals for resource extraction. Currently, these economic values are largely left out of conversations about rural development. County commissioners, conservationists, and regional policymakers would do well to become more fluent in understanding the wealth-attracting influence of protected areas."*

This statement captures the core messages supported by the evidence presented above. Those who advocate for more timber production from trust lands typically focus on the positive impacts for workers lucky enough to retain their jobs, but overlook the negative economic effects that the logging has on the overall welfare of all the people and on the economic and social well-being of local workers and communities. They would do well to investigate and understand the likelihood that conserving and restoring these lands would create opportunities for more jobs for a wider segment of the population, stimulate higher incomes and wealth, and

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[35] Rasker, R., Gude P.H., and Delorey, M., 2013. The Effect of Protected Federal Lands on Economic Prosperity in the Non-Metropolitan West.

[36] Hjerpe, E., A. Hussain, and T. Holmes. 2020. Amenity Migration and Public Lands: Rise of the Protected Areas.

thereby provide a stronger foundation for the local public services that currently receive timber revenues.

Stated differently, the evidence presented above shows that, if conservation and restoration activities can yield amenities attractive to potential in-migrants, recreationists, and tourists, the trust lands likely would become a powerful engine of economic development advantageous to local workers, families, and communities. This is not just tourism, far from it. Instead, it represents the economic realities of today's American rural West, where resource managers and communities that emphasize attracting talent and diverse investments have a far higher chance of enjoying prosperity and sustainable population than communities that emphasize the production of logs and stumps and monocultural plantations. By shifting its focus to conservation and restoration, ODEQ can help nearby communities and rural residents have access to these realities. If it continues to favor log production, however, it will continue laying the foundation for more economic decline and instability.

Unless ODEQ has better information, it should use these numbers and this information to identify the potential positive job impacts of any potential increase in conservation/restoration of forestlands in the watershed that would accompany actions to restrict the negative impacts of industrial timber production on water quality, and to provide decision-makers and the public with a full description and assessment of these positive impacts.

III. Potential Negative Economic Impacts of Not Doing More to Improve Water Quality

The preceding sections present credible information indicating that doing less to improve water quality in the watershed likely will have multiple negative economic impacts, including these:

1. Reduction in the quality of life for residents. This reduction will impose an economic cost on those affected. It also will diminish the area's attractiveness to workers, families, and investors, and curtail its ability to generate sustainable jobs for the foreseeable future.
2. Reduction in the quality of life for visitors. This reduction will impose an economic cost on those affected. It also will diminish the area's attractiveness to potential tourists and curtail its ability to generate and sustain tourism-related jobs for the foreseeable future.
3. Reduce the value of residential, recreational and business property, through the negative impacts on quality of life and sustainable jobs.
4. Intensify economic inequities by facilitating the ability of timberland and ranchland owners to realize higher incomes while imposing costs on those exposed to degraded water and diminishing the incomes of others.
5. Diminish the economic well-being of (impose economic costs on) individuals and groups who place a value on healthy habitats for and robust populations of salmon and other species by increasing the risk of habitat degradation and population decline.

6. Diminish the economic well-being of (impose economic costs on) individuals and groups who place a value on healthy ecosystems within the watershed by increasing the risk of degradation in their structure, function, processes, and ability to provide valuable ecosystem services.
7. Diminish the economic well-being of those who pay taxes and utilize public services by degrading the services derived from the watershed's ecosystems and increasing the public costs of restoring them.
8. Facilitate the timber industry's ability to emit greenhouse gases, and intensify the social costs of climate change, by allowing landowners to conduct industrial timber practices without bearing the full costs of their negative impacts on water quality.

Whenever it is weighing an alternative that would do less to protect water quality against one that would do more, ODEQ should describe and evaluate these potential economic costs that might result from implementing the former.

WALTZ David * DEQ

From: WALTZ David * DEQ
Sent: Wednesday, November 2, 2022 10:45 PM
To: LIVERMAN Alex * DEQ
Subject: FW: Estuary impaired estuaries in OR

For the FIS – RAC member input

From: Paul Engelmeyer
Sent: Wednesday, November 2, 2022 4:20 PM
To: WALTZ David * DEQ <David.WALTZ@deq.oregon.gov>; Glen Spain <fish1ifr@aol.com>; Ethan Brown <ethan@willamettepartnership.org>
Subject: Estuary impaired estuaries in OR

So, I thought we should include anything available ie water quality in the estuary - it looks like a significant portion of Oregon's estuaries are impaired.

Paul

Estuary, Bay, and Harbor Square Miles by State

	For Any Designated Use				Specific Designated Uses		
State	Total Square Miles	Square Miles Assessed for Any Use	% Assessed for Any Use	% Impaired for Any Use	Designated Use	Square Miles Assessed	% Impaired
Maine*	2,875	2,875	100%	15%	Water Contact Recreation	2,875	0%
					Aquatic Life	28	39%
					Fish Consumption	2,875	100%
Maryland	2,451	2,403	98%	100%	Water Contact Recreation	6	78%
					Aquatic Life	2,260	60%
					Fish Consumption	612	1%
Massachusetts	2,726	244	9%	87%	Water Contact Recreation	229	27%
					Aquatic Life	198	45%
					Fish Consumption	120	96%
New Hampshire*	18	18	100%	100%	Water Contact Recreation	17	69%
					Aquatic Life	17	100%
					Fish Consumption	18	100%
New Jersey	650	650	100%	97%	Water Contact Recreation	650	2%
					Aquatic Life	650	90%
					Fish Consumption	2,074	99%
New York	1,538	1,537	100%	27%	Water Contact Recreation	1,455	4%
					Aquatic Life	1,539	8%
					Fish Consumption	2,610	22%
North Carolina	3,332	3,210	96%	30%	Water Contact Recreation	1,492	1%
					Aquatic Life	1,063	79%
					Fish Consumption	89	12%
Oregon	128	126	99%	99%	Water Contact Recreation	96	66%
					Aquatic Life	121	87%

OCEANS

Mitigating Local Causes of Ocean Acidification with Existing Laws

Even as global and national efforts struggle to mitigate CO_2 emissions, local and state governments have policy tools to address "hot spots" of ocean acidification.

R. P. Kelly,[1*†] M. M. Foley,[1*] W. S. Fisher,[2] R. A. Feely,[3] B. S. Halpern,[4] G. G. Waldbusser,[5] M. R. Caldwell[1]

As the level of atmospheric carbon dioxide (CO_2) continues to rise, so too does the amount of CO_2 in the ocean (*1*, *2*), which increases the ocean's acidity. This affects marine ecosystems on a global scale in ways we are only beginning to understand: for example, impairing the ability of organisms to form shells or skeletons, altering food webs, and negatively affecting economies dependent on services ranging from coral reef tourism to shellfish harvests to salmon fisheries (*3*–*5*). Although increasing anthropogenic inputs drive acidification at global scales, local acidification disproportionately affects coastal ecosystems and the communities that rely on them. We describe policy options by which local and state governments—as opposed to federal and international bodies—can reduce these local and regional "hot spots" of ocean acidification.

Several studies document acidification hot spots, patches of ocean water with significantly depressed pH levels relative to historical baselines occurring at spatial scales of tens to hundreds of square kilometers [e.g., (*6*, *7*)]. These coastal hot spots may be due to nonuniform changes in circulation and biological processes (*6*), and precipitation runoff (*4*, *5*, *8*), in concert with globally increased atmospheric CO_2 (*8*) (see the figure). Local studies in the Kennebec River plume in the Gulf of Maine (*9*), the Chesapeake Bay (*10*), and the Manning River estuary in New South Wales, Australia (*11*), illustrate that freshwater inputs, pollutants, and soil erosion can acidify coastal waters at substantially higher rates than atmospheric CO_2 alone.

These nonatmospheric inputs can have particularly large consequences when they coincide with biotic phenomena [e.g., spawning events (*9*)] or abiotic processes, such as upwelling events that bring low-pH water to nearshore areas (*1*, *2*). Additional local phenomena—such as sulfur dioxide precipitation (*12*), hypoxia (*13*), eutrophication (*10*, *14*), and both emissions and runoff from acidic fertilizers (*15*)—can intensify these localized hot spots. These impacts are likely to be magnified when combined with other stressors in the coastal ocean, including overfishing, habitat destruction, temperature increases, and nonacidifying pollution (*16*).

Policy Recommendations

As global and national efforts to mitigate CO_2 emissions struggle to gain traction, smaller-scale actions become increasingly important. In the United States, for example, local and state governments have both the authority and motive to address many stressors that drive or exacerbate acidification conditions. This runs contrary to the widely held perception that acidification cannot be addressed at the scale of local (e.g., municipal and county) or regional (state, multistate, and territorial) jurisdictions [e.g., (*16*, *17*)]. Although we focus here on U.S. policies, similar legal tools exist elsewhere to guard against non-CO_2 acidification drivers.

U.S. federal environmental laws (e.g., Clean Air Act, Clean Water Act, and Coastal Zone Management Act), state laws, and local ordinances provide multiple layers of protection for coastal waters by controlling emissions, runoff, and land-use patterns through zoning and permitting (table S1). Implementing measures that reduce residential and agricultural runoff, for example, can minimize beach and river contamination and algal blooms, while reducing pollutants that acidify the local coastal ocean. Many states have already passed legislation to limit residential runoff, although these are not specifically aimed at mitigating acidification (*18*).

A recent lawsuit and the resulting U.S. Environmental Protection Agency (EPA) memoranda (*19*, *20*) illustrate states' responsibilities to apply federal environmental laws to combat acidification in state waters. In *Center for Biological Diversity* v. *EPA* (*21*), the Center for Biological Diversity (CBD) challenged Washington State's failure to designate coastal waters as "impaired" because of a decline in pH by 0.2 units from baseline levels, as required under the federal Clean Water Act (*22*). Despite the lack of substantive reform of the National Water Quality Standard for marine pH (*19*, *20*) owing to insufficient data, the EPA highlighted the seriousness of acidification's impacts on ocean life and encouraged states to list pH-impaired waters where data are available (*19*). A focus on data collection could lead to future regulatory revisions that allow state governments to better restrict pollutants in coastal waters (*23*). States may also use existing law to develop biological water quality standards for acidification to assess if a water body is impaired on the basis of biological indicators (e.g., negative impacts on coral species) (*24*). Water quality standards and impairment designations, however, are only ecologically meaningful in light of baseline conditions, vulnerability of ecosystems, and thresholds for ecosystem change, which are often undefined.

Four Approaches

Few jurisdictions have taken steps to mitigate acidification, likely because of the combination of low awareness and a sense that the causes are globally diffuse. Four approaches have particular potential for combating locally intensified acidification. First, the Clean Water Act directs state government agencies to ensure that precipitation runoff and associated pollutants (which can increase acidification) are monitored, limited, and consistent with the sustainable functioning of aquatic ecosystems. Stormwater surge prevention (e.g., holding tanks), coastal and riparian buffers (areas of vegetation near land-water intersections), intact wetlands, and improved onsite water treatment facilities are effective measures to address watershed runoff and associated pollutants. In many cases, federal funding is available to help local governments complete these kinds of projects, and local watershed groups provide a grassroots base for ensuring that states and EPA meet their responsibilities.

Second, controlling coastal erosion is a classic function of local and state governments and one that could markedly benefit

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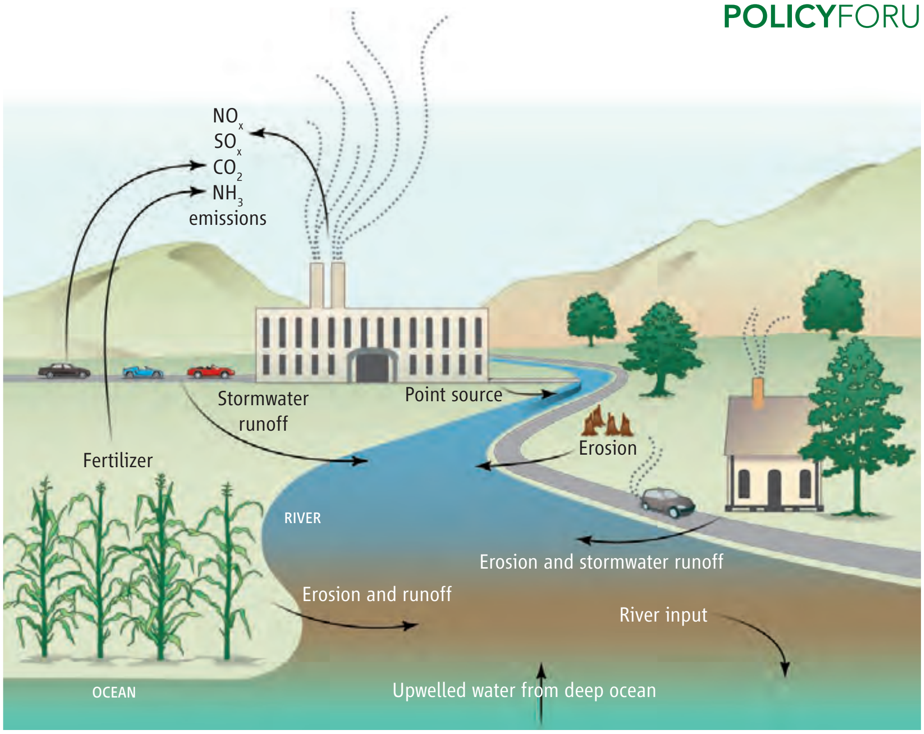
coastal ecosystems by reducing nutrient and sediment loading of water and protecting the physical integrity of the habitat itself. Such coastal inputs may be enriched with fertilizers and, if unchecked, can further increase acidification in estuaries and coastal waterways. Independent local actions, such as increasing vegetation cover, may be effective at small scales, but concerted action among multiple local jurisdictions—as would likely be necessary to address erosion within an entire watershed, for example—may require coordination among state or regional governments, adding a layer of regulatory complexity.

Third, land-use change facilitated through local and regional planning, zoning, and permitting policies can reduce direct and indirect (e.g., deforestation) CO_2 emissions, runoff, and other threats (*25*). Antisprawl land-use plans can help reduce vehicle-miles traveled and impermeable surface cover, limiting both emissions and runoff. At least two state laws [Massachusetts (Global Warming Solutions Act) and California (SB 375)] explicitly link land-use development, transportation, and climate change mitigation. These state-level rules are models for state action, but cities and counties can adopt policies and alter zoning provisions and general plans that could help safeguard their own waters—without waiting for state governments to act (*26*).

Finally, simply enforcing existing federal emissions limits for pollutants such as nitrogen oxide and sulfur oxide (for example, from coal-fired power plants) could help ameliorate local drivers of ocean acidification (*13*). Reductions could have immediate local effects, because these pollutants have short atmospheric residence times, falling out of the atmosphere and into the water and/or land near where they were produced (*12*). Reducing pollutants to benefit local environmental conditions increases the likelihood of responsible stewardship by matching political incentives and environmental remediation at the same spatial scale (*27*).

In addition to regulating inputs to the coastal zone, protecting important ecosystem components (such as shell material) provides another potential mechanism to combat locally intensified acidification. Returning crushed shell material to coastal habitats to approximate densities found in healthy clam populations can substantially increase pH and mitigate localized acidification impacts on clams (*10*, *28*).

Tenaciously enforcing existing limits for sediment runoff, erosion, and emissions may alone improve the health of coastal waters and safeguard coastal economies dependent on calcium carbonate–producing organisms, such as shellfish and corals. In the face of declining conditions, however, it is increasingly critical to establish historical and current pH levels to inform future federal or state regulations aimed at protecting against ocean acidification. The potential biological, ecological, and socioeconomic effects of acidification are likely to affect nearshore environments most severely, affecting the delivery of ecosystem services that over half of the world's population depend on and costing billions of dollars in lost product and income (*5*). Minimizing additional stressors on coastal ecosystems can also help to ameliorate threats to coastal resources, thereby maintaining ecosystem resilience and sustainable economic benefits from the ocean.



Contributors to ocean acidification. In addition to global atmospheric CO_2, this figure depicts the major local (within 100 km) sources contributing to coastal ocean acidification.

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The value of estuarine and coastal ecosystem services

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Abstract. The global decline in estuarine and coastal ecosystems (ECEs) is affecting a number of critical benefits, or ecosystem services. We review the main ecological services across a variety of ECEs, including marshes, mangroves, nearshore coral reefs, seagrass beds, and sand beaches and dunes. Where possible, we indicate estimates of the key economic values arising from these services, and discuss how the natural variability of ECEs impacts their benefits, the synergistic relationships of ECEs across seascapes, and management implications. Although reliable valuation estimates are beginning to emerge for the key services of some ECEs, such as coral reefs, salt marshes, and mangroves, many of the important benefits of seagrass beds and sand dunes and beaches have not been assessed properly. Even for coral reefs, marshes, and mangroves, important ecological services have yet to be valued reliably, such as cross-ecosystem nutrient transfer (coral reefs), erosion control (marshes), and pollution control (mangroves). An important issue for valuing certain ECE services, such as coastal protection and habitat–fishery linkages, is that the ecological functions underlying these services vary spatially and temporally. Allowing for the connectivity between ECE habitats also may have important implications for assessing the ecological functions underlying key ecosystems services, such coastal protection, control of erosion, and habitat–fishery linkages. Finally, we conclude by suggesting an action plan for protecting and/or enhancing the immediate and longer-term values of ECE services. Because the connectivity of ECEs across land–sea gradients also influences the provision of certain ecosystem services, management of the entire seascape will be necessary to preserve such synergistic effects. Other key elements of an action plan include further ecological and economic collaborative research on valuing ECE services, improving institutional and legal frameworks for management, controlling and regulating destructive economic activities, and developing ecological restoration options.

Key words: coral reef; economic value; ecosystem service; estuarine and coastal ecosystem; mangrove; salt marsh; sand beach and dune; seagrass; seascape.

Introduction

Estuarine and coastal ecosystems (ECEs) are some of the most heavily used and threatened natural systems globally (Lotze et al. 2006, Worm et al. 2006, Halpern et al. 2008). Their deterioration due to human activities is intense and increasing; 50% of salt marshes, 35% of mangroves, 30% of coral reefs, and 29% of seagrasses are either lost or degraded worldwide (Valiela et al. 2001, MEA 2005, Orth et al. 2006, UNEP 2006, FAO 2007, Waycott et al. 2009). This global decrease in ECEs is known to affect at least three critical ecosystem services (Worm et al. 2006): the number of viable (non-collapsed) fisheries (33% decline); the provision of nursery habitats such as oyster reefs, seagrass beds, and wetlands (69% decline); and filtering and detoxification services provided by suspension feeders, submerged vegetation, and wetlands (63% decline). The loss of biodiversity, ecosystem functions, and coastal vegetation in ECEs may have contributed to biological invasions, declining water quality, and decreased coastal protection from flooding and storm events (Braatz et al. 2007, Cochard et al. 2008, Koch et al. 2009).

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Such widespread and rapid transformation of ECEs and their services suggest that it is important to understand what is at stake in terms of critical benefits and values. The purpose of this paper is to provide an overview of the main ecological services across a variety of ECEs, including marshes, mangroves, nearshore coral reefs, seagrass beds, and sand beaches and dunes. Where available, we cite estimates of the key economic values arising from the services provided by these ECEs. In addition, we discuss how the natural variability in these systems in space and time results in nonlinear functions and services that greatly influence their economic value (Barbier et al. 2008, Koch et al. 2009) and some of the synergistic properties of ECEs. Because they exist at the interface between the coast, land, and watersheds, ECEs can produce cumulative benefits that are much more significant and unique than the services provided by any single ecosystem. Finally, we finish by highlighting the main management implications of this review of ECE services and their benefits, and provide an "action plan" to protect and/or enhance their immediate and longer term value to humankind.

Methods: Assessing ECE Services and Values

In identifying the ecosystem services provided by natural environments, a common practice is to adopt the broad definition of the Millennium Ecosystem Assessment (MEA 2005) that "ecosystem services are the benefits people obtain from ecosystems." Thus, the term "ecosystem services" is usually interpreted to imply the contribution of nature to a variety of "goods and services," which in economics would normally be classified under three different categories (Barbier 2007): (1) "goods" (e.g., products obtained from ecosystems, such as resource harvests, water, and genetic material), (2) "services" (e.g., recreational and tourism benefits or certain ecological regulatory and habitat functions, such as water purification, climate regulation, erosion control, and habitat provision), and (3) cultural benefits (e.g., spiritual and religious beliefs, heritage values).

However, for economists, the term "benefit" has a specific meaning. Mendelsohn and Olmstead (2009:326) summarize the standard definition as follows: "The economic benefit provided by an environmental good or service is the sum of what all members of society would be willing to pay for it." Thus, given this specific meaning, some economists argue that it is misleading to characterize all ecosystem services as "benefits." As explained by Boyd and Banzhaf (2007:619), "as end-products of nature, final ecosystem services are not benefits nor are they necessarily the final product consumed. For example, recreation is often called an ecosystem service. It is more appropriately considered a benefit produced using both ecological services and conventional goods and services." To illustrate this point, they consider recreational angling. It requires certain "ecosystem services," such as "surface waters and fish populations," but also "other goods and services including tackle, boats, time allocation, and access" (Boyd and Banzhaf 2007:619). But other economists still prefer a broader interpretation of ecosystem services, along the lines of the Millennium Ecosystem Assessment (MEA 2005), which equates ecosystem services with benefits. For example, Polasky and Segerson (2009:412) state: "We adopt a broad definition of the term ecosystem services that includes both intermediate and final services," which they justify by explaining that "supporting services, in economic terms, are akin to the infrastructure that provides the necessary conditions under which inputs can be usefully combined to provide intermediate and final goods and services of value to society." Thus, unlike Boyd and Banzhaf (2007), Polasky and Segerson (2009) consider recreation to be an ecosystem service.

Economists do agree that, in order to determine society's willingness to pay for the benefits provided by ecosystem goods and services, one needs to measure and account for their various impacts on human welfare. Or, as Freeman (2003:7) succinctly puts it: "The economic value of resource–environmental systems resides in the contributions that the ecosystem functions and services make to human well-being," and consequently, "the basis for deriving measures of the economic value of changes in resource–environmental systems is the effects of the changes on human welfare." Similarly, Bockstael et al. (2000:1385) state: "In economics, valuation concepts relate to human welfare. So the economic value of an ecosystem function or service relates only to the contribution it makes to human welfare, where human welfare is measured in terms of each individual's own assessment of his or her well-being." The key is determining how changes in ecosystem goods and services affect an individual's well-being, and then determining how much the individual is either willing to pay for changes that have a positive welfare impact, or conversely, how much the individual is willing to accept as compensation to avoid a negative effect.

In our approach to identifying the key services of estuarine and coastal ecosystem (ECEs) and their values, we adopt this consensus economic view. That is, as long as nature makes a contribution to human well-being, either entirely on its own or through joint use with other human inputs, then we can designate this contribution as an "ecosystem service." In other words, "ecosystem services are the direct or indirect contributions that ecosystems make to the well-being of human populations" (U.S. EPA 2009:12). In adopting this interpretation, (U.S. EPA 2009:12–13) "uses the term ecosystem service to refer broadly to both intermediate and final end services," and as a result, the report maintains that "in specific valuation contexts…it is important to identify whether the service being valued is an intermediate or a final service."

For example, following this approach, the tourism and recreation benefits that arise through interacting with an ECE can be considered the product of a "service" provided by that ecosystem. But it should be kept in mind, as pointed out by Boyd and Banzhaf (2007:619), that the role of the ECE is really to provide an "intermediate service" (along with "conventional goods and services") in the production of the final benefit of recreation and tourism. In selecting estimates of the "value" of this "intermediate" ecosystem service in producing recreational benefits, it is therefore important to consider only those valuation estimates that assess the effects of changes in the ECE habitat on the tourism and recreation benefits, but not the additional influence of any human inputs. The same approach should be taken for those "final" ecosystem services, such as coastal protection, erosion control, nutrient cycling, water purification, and carbon sequestration, which may benefit human well-being without any additional human-provided goods and services. But if "final" services do involve any human inputs, the appropriate valuation estimates should show how changes in these services affect human welfare, after controlling for the influence of these additional human-provided goods and services. Although this approach to selecting among valuation estimates of various ECE services seems straightforward, in practice there are a number of challenges to overcome. These difficulties are key to understanding an important finding of our review: Whereas considerable progress has been made in valuing a handful of ECE services, there are still a large number of these services that have either no or very unreliable valuation estimates.

The most significant problem faced in valuing ecosystem services, including those of ECEs, is that very few are marketed. Some of the products arising from ECEs, such as raw materials, food, and fish harvests, are bought and sold in markets. Given that the price and quantities of these marketed products are easy to observe, there are many value estimates of the contribution of the environmental input to this production. However, this valuation is more complicated than it appears. Market conditions and regulatory policies for the marketed output will influence the values imputed to the environment input (Freeman 2003:259–296, McConnell and Bockstael 2005, Barbier 2007). For example, one important service of many ECEs is the maintenance of fisheries through providing coastal breeding and nursery habitat. Although many fisheries are exploited for commercial harvests sold in domestic and international markets, studies have shown that the inability to control fishing access and the presence of production subsidies and other market distortions can impact harvests, the price of fish sold, and ultimately, the estimated value of ECE habitats in supporting commercial fisheries (Freeman 1991, Barbier 2007, Smith 2007).

However, the majority of other key ECE services do not lead to marketed outputs. These include many services arising from ecosystem processes and functions that benefit human beings largely without any additional input from them, such as coastal protection, nutrient cycling, erosion control, water purification, and carbon sequestration. In recent years, substantial progress has been made by economists working with ecologists and other natural scientists in applying environmental valuation methodologies to assess the welfare contribution of these services. The various nonmarket valuation methods employed for ecosystem services are essentially the standard techniques that are available to economists. For example, Freeman (2003), Pagiola et al. (2004), NRC (2005), Barbier (2007), U.S. EPA (2009), Mendelsohn and Olmstead (2009), and Hanley and Barbier (2009) discuss how these standard valuation methods are best applied to ecosystem services, emphasizing in particular both the advantages and the shortcomings of the different methods and their application. However, what makes applying these methods especially difficult is that they require three important, and interrelated, steps (Barbier 1994, 2007, Freeman 2003, NRC 2005, Polasky and Segerson 2009).

The first step involves determining how best to characterize the change in ecosystem structure, functions, and processes that gives rise to the change in the ecosystem service. For instance, the change could be in the spatial area or quality of a particular type of ECE habitat, such as a mangrove forest, marsh vegetation, or sand dune extent. It could also be a change in a key population, such as fish or main predator. Alternatively, the change could be due to variation in the flow of water, energy or nutrients through the system, such as the variability in tidal surges due to coastal storm events or the influx of organic waste from pollution upstream from ECEs.

The second step requires tracing how the changes in ecosystem structure, functions, and processes influence the quantities and qualities of ecosystem service flows to people. Underlying each ecosystem service is a range of important energy flow, biogeochemical and biotic processes and functions. For example, water purification by seagrass beds is linked to the ecological processes of nutrient uptake and suspended particle deposition (Rybicki 1997, Koch et al. 2006). However, the key ecological process and functions that generate an ecosystem service are, in turn, controlled by certain abiotic and biotic components that are unique to each ecosystem's structure. The various controlling components that may affect nutrient uptake and particle deposition by seagrasses include seagrass species and density, nutrient load, water residence time, hydrodynamic conditions, and light availability. Only when these first two steps are completed is it possible to conduct the final step, which involves using existing economic valuation method to assess the changes in human well-being that result from the change in ecosystem services.

As summarized by NRC (2005:2) this three-step approach implies that "the fundamental challenge of valuing ecosystem services lies in providing an explicit description and adequate assessment of the links between the structure and functions of natural systems, the benefits (i.e., goods and services) derived by humanity, and their subsequent values." This approach is summarized in Fig. 1. Human drivers of ecosystem change affect important ecosystem processes and functions and their controlling components. Assessing this change is fundamental yet difficult. However, "making the translation from ecosystem structure and function to ecosystem goods and services (i.e., the ecological production) is even more difficult" and "probably the greatest challenge for successful valuation of ecosystem services is to integrate studies of the ecological production function with studies of the economic valuation function" (NRC 2005:2–3). Similarly, Polasky and Segerson (2009:422) maintain that "among the more practical difficulties that arise in either predicting changes in service flows or estimating the associated value of ecosystem services" include the "lack of multiproduct, ecological production functions to quantitatively map ecosystem structure and function to a flow of services that can then be valued."

We find that, for many key ECE services, the integration of the "ecological production function" with the "economic valuation function" is incomplete. In many instances, how to go about making this linkage is poorly understood. However, for a handful of services, considerable progress has been made in estimating how the structure and functions of ECEs generate economic benefits. Thus, the main purpose of our review is to illustrate the current state of identifying, assessing, and valuing the key ecosystem services of ECEs, which is motivated by an important question: What is the current state of progress in integrating knowledge about the "ecological production function" underlying each important ECE service with economic methods to value changes in this service in terms of impacts on human welfare? To answer this important question, we adopt the following approach.

First, for each of five critical ECEs, coral reefs, seagrass beds, salt marshes, mangroves, and sand beaches and dunes, we identified the main ecosystem services associated with each habitat. Second, we provided an overview of the "ecological production function" underlying each service by assessing current knowledge of the important ecosystem processes, functions, and controlling components that are vital to this service. Third, where possible, we cited estimates of economic values arising from each service, and identified those services where there is no reliable estimate of an economic value. Fourth, we discussed briefly the main human drivers of ecosystem change that are affecting each ECE habitat. Finally, the results of our review are summarized in a table for each ECE. This facilitates comparison across all five habitats and also illustrates the important "gaps" in the current state of valuing some key ECE services. To keep the summary table short, we selected only one valuation estimate as a representative example. In some cases, it may be the only valuation estimate of a particular ecosystem service; in others, we have tried to choose one of the best examples from recent studies.

Note that our purpose in reviewing valuation estimates of ECE services is, first, to determine which services have at least one or more reliable estimate and which do not, and, second, to identify future areas of ecological and economic research to further progress in valuing ECE services. We do not attempt to quantify the total number of valuation studies for each ECE service, nor do we analyze in detail the various valuation methods used in assessing an ecosystem service. Instead, we selected those examples of valuation studies that conform to the standard and appropriate techniques that are recommended for application to various ecosystem services, as discussed in Freeman (2003), Pagiola et al. (2004), NRC (2005), Barbier (2007), Hanley and Barbier (2009), U.S. EPA (2009), and Mendelsohn and Olmstead (2009). The interested reader should consult these references for a comprehensive discussion of economic nonmarket valuation methods and their suitable application to ecosystem services.

Because our aim is to assess the extent to which reliable valuation estimates exist for each identified ECE service, we have reported each estimate as it appears in the original valuation study. This is for two principal reasons. First, many of the studies are for specific ECE habitats in distinct locations at different time periods, such as the recreation value of several coral reef marine parks in the Seychelles (Mathieu et al. 2003), the value of increased offshore fishery production from mangrove habitat in Thailand (Barbier 2007), or the benefits of beach restoration in the U.S. states of Maine and New Hampshire (Huang et al. 2007). Each study also uses specific measures and units of value appropriate for the relevant study. For example, in the Seychelles study, the value estimate was expressed in terms of the average consumer surplus per tourist for a single year, the Maine and New Hampshire study estimated each household's willingness to pay for an erosion control program to preserve five miles of beach, and the Thailand study calculated the capitalized value per hectare of mangrove in terms of offshore fishery production. Although it is possible to make assumptions to transform the valuation estimate of each study into the same physical units (e.g., per hectare), temporal period (e.g., capitalized or annual value), or currency (e.g., US$), we do not think such a transformation is warranted for the purposes of this study.

Second, we do not alter the original valuation estimates into a common unit of measure (such as US$$\cdot$ha$^{-1}\cdot$yr^{-1} in 2010 prices) because of the concern that such standardizing of values will be misused or misinterpreted. For example, one might be tempted to "add up" all the ecosystem service values and come up with a "total value" of a particular ECE habitat, such as a salt marsh. Or, one might take the estimate for a specific location, such as the recreation value of several

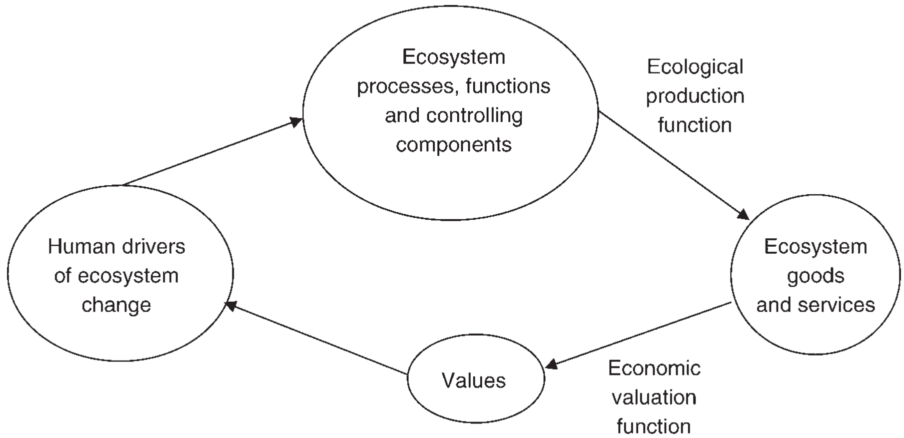

FIG. 1. Key interrelated steps in the valuation of ecosystem goods and services. This figure is adapted from NRC (2005: Fig. 1-3).

coral reef marine parks in the Seychelles (Mathieu et al. 2003), and "scale it up" by all the total hectares of coral reefs in the Indian Ocean or even the world to come up with a regional or global value of the recreational value of coral reefs. As argued by Bockstael et al. (2000:1396), when "the original studies valued small changes in specific and localized components of individual ecosystems . . . it is incorrect to extrapolate the value estimates obtained in any of these studies to a much larger scale, let alone to suppose that the extrapolated estimates could then be added together."

Finally, because our efforts here focus on identifying individual ECE services and any reliable estimates that value changes in these specific services, we do not emphasize valuation studies that estimate the value of entire ecosystems to human beings or assessing broader values, such as many nonuse existence and bequest values, that relate to the protection of ecosystems. However, we do recognize that such values are an important motivation for the willingness to pay by many members of society to protect ecosystems, including ECEs.

For example, Fig. 2 is a more detailed version of Fig. 1, emphasizing the economic valuation component of the latter diagram. As indicated in Fig. 2, there are a number of different ways in which humans benefit from, or value, ecosystem goods and services. The first distinction is between the "use values" as opposed to "nonuse values" arising from these goods and services. Typically, use values involve some human "interaction" with the environment, whereas nonuse values do not, as they represent an individual valuing the pure "existence" of a natural habitat or ecosystem or wanting to "bequest" it to future generations. Direct-use values refer to both consumptive and nonconsumptive uses that involve some form of direct physical interaction with environmental goods and services, such as recreational activities, resource harvesting, drinking clean water, breathing unpolluted air, and so forth. Indirect-use values refer to those ecosystem services whose values can only be measured indirectly, since they are derived from supporting and protecting activities that have directly measurable values.

As is apparent from Tables 1–5, the individual ECE services that we identified and discuss contribute to consumptive direct-use values (e.g., raw materials and food), nonconsumptive direct-use values (e.g., tourism, recreation, education, and research), and indirect-use values (e.g., coastal protection, erosion control, water catchment and purification, maintenance of beneficial species, and carbon sequestration). When it comes to valuing whether or not to create national parks from ECEs, or to protect entire ecosystems, assessing non-users' willingness to pay is also important. For example, Bateman and Langford (1997) assess the nonuse values of households across Great Britain for preserving the Norfolk and Suffolk Broads coastal wetlands in the United Kingdom from salt water intrusion. Even poor coastal communities in Malaysia, Micronesia, and Sri Lanka show considerable existence and other nonuse values for mangroves that can justify the creation of national parks and other protection measures (Naylor and Drew 1998, Othman et al. 2004, Wattage and Mardle 2008). As our review highlights how ECEs globally are endangered by a wide range of human drivers of change, it will be important that future studies assess all the use and nonuse values that arise from ecosystem goods and services to determine whether it is worth preserving or restoring critical ECEs.

RESULTS: THE KEY SERVICES AND VALUES OF ECEs

In the following sections, we provide an overview of the results of our review of the main ecological services for five ECEs, arranged in order of most to least submerged: coral reefs, seagrass beds, salt marshes, mangroves, and sand beaches and dunes. To give an indication of the "ecological production function" underlying the ecological services generated by each

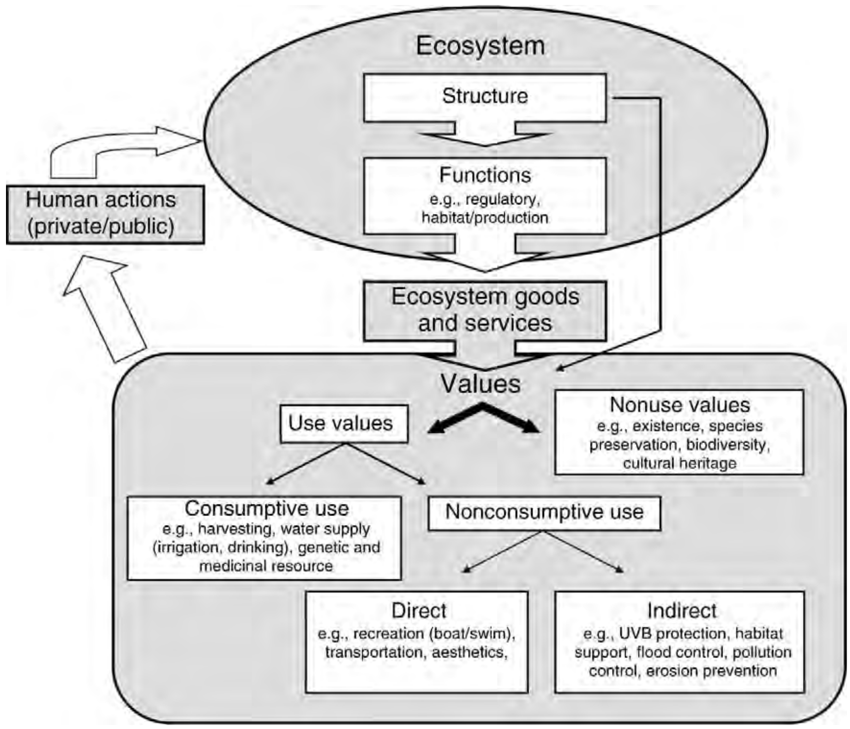

FIG. 2. Economic valuation of ecosystem goods and services. UVB is ultraviolet-B radiation from sunlight, which can cause skin cancer. This figure is adapted from NRC (2005: Fig. 4-1).

ECE (see Fig. 1), we outline briefly its key ecological structure, processes and functions, and identify the main controlling abiotic and biotic components. When available, we cite estimates of economic values from these services. The results give an indication as to the level of progress in valuing key ECE services and, equally important, where more integrated work on ecological and economic assessment of ecosystem services needs to be done.

Coral reefs

Coral reefs are structurally complex limestone habitats that form in shallow coastal waters of the tropics. Reefs can form nearshore and extend hundreds of kilometers in shallow offshore environments. Coral reefs are created by sedentary cnidarians (corals) that accrete calcium carbonate and feed on both zooplankton and maintain a mutualistic symbiosis with photosynthetic dinoflagellates. Thus, the majority of the reef structure is dead coral skeleton laid down over millennia, covered by a thin layer of live coral tissue that slowly accretes new limestone. In addition, coralline algae play an important role in stabilizing and cementing the coral reef structure. The community composition of reefs depends on global, regional, and local factors, which interact to produce the wide variety of coral reefs present on earth (Connell et al. 1997, Glynn 1997, Pandolfi 2002, Hughes et al. 2005).

As outlined in Table 1, coral reefs provide a number of ecosystem services to humans including raw materials, coastal protection, maintenance of fisheries, nutrient cycling, and tourism, recreation, education, and research. The table indicates representative examples of the values of some of these services, where they are available.

Historically, live reefs have served as a source of lime, which is an essential material in the manufacturing of mortar and cement and road building, and is used to control soil pH in agriculture (Dulvy et al. 1995). Presently, excavation of live reefs for lime is uncommon due to the obvious destructive nature of this resource extraction. As there are no examples of such coral mining being conducted sustainably, we have not included any value estimates in Table 1.

An important ecosystem service provided by coral reefs is coastal protection or the buffering of shorelines from severe weather, thus protecting coastal human populations, property, and economic activities. As indicated in Table 1, this service is directly related to the economic processes and functions of attenuating or dissipating waves and facilitating beach and shoreline retention. By altering the physical environment (i.e., reducing waves and currents), corals can engineer the physical environment for entire ecosystems, making it possible for other coastal ecosystems such as seagrass beds and mangroves to develop, which in turn serve their own suite of services to humans. Despite the importance of this coastal protection service, very few economic studies have estimated a value for it. Those

Table 1. Ecosystem services, processes and functions, important controlling components, examples of values, and human drivers of ecosystem change for nearshore coral reefs.

Ecosystem services	Ecosystem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials	generates biological productivity and diversity	reef size and depth, coral type, habitat quality	estimates unavailable	climate change, blast or cyanide fishing, lime mining, eutrophication, sedimentation, coastal development, dredging, pollution, biological invasion
Coastal protection	attenuates and/or dissipates waves, sediment retention	wave height and length, water depth above reef crest, reef length and distance from shore, coral species, wind climate	US\$174·ha^{-1}·yr^{-1} for Indian Ocean based on impacts from 1998 bleaching event on property values (Wilkinson et al. 1999)	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	coral species and density, habitat quality, food sources, hydrodynamic conditions	US\$15–45 000·km^{-2}·yr^{-1} in sustainable fishing for local consumption and \$5–10 000·km^{-2}·yr^{-1} for live-fish export, the Philippines (White et al. 2000)	
Nutrient cycling	provides biogeochemical activity, sedimentation, biological productivity	coral species and density, sediment deposition, subsidence, coastal geomorphology	estimates unavailable	
Tourism, recreation, education, and research	provides unique and aesthetic reefscapes, suitable habitat for diverse fauna and flora	lagoon size, beach area, wave height, habitat quality, coral species and density, diversity	US\$88 000 total consumer surplus for 40 000 tourists to marine parks, Seychelles (Mathieu et al. 2003) and meta-analysis of recreational values (Brander et al. 2007)	

studies that do exist tend to use benefit transfer and replacement cost methods of valuation in an ad hoc manner, which undermine the reliability of the value estimates (see Chong 2005 and Barbier 2007 for further discussion). However, the widespread reef destruction caused by catastrophic events and global change, such as hurricanes, typhoons, and coral bleaching, gives some indication of the value of the lost storm protection services. For example, as a result of the 1998 bleaching event in the Indian Ocean, the expected loss in property values from declining reef protection was estimated to be US\$174·ha^{-1}·yr^{-1} (hereafter all values in US\$, unless otherwise stated; Wilkinson et al. 1999).

Coral reefs also serve to maintain fisheries through the enhancement of ecologically and economically important species by providing shelter space and substrate for smaller organisms, and food sources for larger epibenthic and pelagic organisms. Increases in fishing technology and transport have transformed reef fisheries that initially functioned solely for subsistence into commercial operations that serve international markets. Coral reef fisheries consist of reef-associated pelagic fisheries (e.g., tuna, mackerel, mahi-mahi, and sharks), reef fishes (e.g., jacks, snappers, groupers, and parrot fishes), and large invertebrates (e.g., giant clams, conch, lobsters, and crabs). The commercial value of these fisheries can be significant for some economies. For example, fish harvested from Hawaiian coral reefs are estimated to contribute \$1.3 million yearly to the Hawaiian economy (Cesar and van Beukering 2004). From 1982 to 2002, small-scale, predominantly coral reef, fisheries contributed \$54.7 million to the economies of America Samoa and the Commonwealth of the Northern Mariana Islands (Zeller et al. 2007).

Additional fishery harvests consist of the live-animal aquarium trade, based on corals, small fishes, and invertebrates collected from reefs. The aquarium trade has substantially expanded in the past 20 years, listed in 1985 as making \$20–40 million/yr as a world market (Wood 1985) and expanding to an estimated \$90–300 million/yr in 2002 (Sadovy and Vincent 2002). The export and sale of shells and jewelry also makes up a substantial portion of fisheries on reefs; giant clams, conch shells, coral, and pearls are all among the many heavily harvested byproducts.

Reviews

Reliable values for the sustainable production of coral reef fish for local consumption and the aquarium trade are rare. White et al. (2000) provide some estimates for the Philippines. The potential annual revenue for sustainable fish production could be \$15–45 000/km^2 of healthy coral reef for local consumption and \$5–10 000/km^2 for live fish export. Zhang and Smith (*in press*) estimate the maximum sustainable yield to the Gulf of Mexico reef fishery (mainly grouper and snapper species, amberjack, and tilefish) to be ~1.30 million kg/month (~2.86 million pounds/month). Though the reefs in the Gulf of Mexico are generally exposed limestone or sandstone and not coral, the habitats are similar in their structural complexity, which is an important factor in protecting young fish and smaller species from predation.

Coral reef ecosystems also perform important services by cycling organic and inorganic nutrients. Despite housing a great deal of inorganic carbon in the limestone skeleton that makes up the structure of the reef, coral reefs may actually be a net source of atmospheric carbon dioxide (Kawahata et al. 1997). Reefs do, however, contribute significantly to the global calcium carbonate ($CaCO_3$) budget, estimated as 26% of coastal marine $CaCO_3$ and 11% of the total $CaCO_3$ precipitation (Hallock 1997, Gattuso et al. 1998). Reefs additionally transfer excess nitrogen production from cyanobacteria and benthic microbes on the reef to the pelagic (water column) environment (Moberg and Folke 1999). Though poorly quantified, the sequestering of $CaCO_3$ to form the foundation or habitat of the reef is the primary reason for such high abundance and diversity of organisms. Unfortunately, as indicated in Table 1, there are no reliable estimates of the economic value of the nutrient cycling and transfer services of coral reefs.

Coral reefs and associated placid lagoons are also economically valuable for the tourism and recreational activities they support. Resorts depend on the aesthetically turquoise lagoons, white sandy beaches, and underwater opportunities on the reef to attract tourists. The high biological diversity and clear waters of tropical reefs also support an abundance of recreational activities such as SCUBA diving, snorkeling, island tours, and sport fishing. These activities can be highly lucrative for individual economies; for example, in 2002, the earnings of ~100 diver operators in Hawaii were estimated at \$50–60 million/year (van Beukering and Cesar 2004). Revenues from coral reef tourism in the Pulau Payar Marine Park, Malaysia, are estimated at \$390 000/year (Yeo 2002), and coral reef diving earns gross revenue of \$10 500–45 540/year in the Bohol Marine Triangle, the Philippines (Samonte-Tan et al. 2007).

However, estimates of the recreational value of individual reefs should be interpreted with caution as a recent review of such studies found substantial bias in the estimates of individual recreation values (Brander et al. 2007). Reliable estimates can be made if such biases are controlled. For example, Mathieu et al. (2003) found that the average consumer surplus per tourist visiting the marine national parks in the Seychelles is \$2.20, giving a total consumer surplus estimate of \$88 000 for the 40 000 tourists to the coral reefs in 1997. Tapsuwan and Asafu-Adjaye (2008) were able to estimate the economic value of scuba diving in the Similan Island coral reefs in Thailand, controlling for diver's attitude toward the quality of the dive site, frequency of dive trips, and socioeconomic characteristics, including whether divers were Thai or foreign. The authors estimated a consumer surplus value of \$3233 per person per dive trip.

In addition to tourism and recreation, reefs also provide substantial services through research opportunities for scientists, work that is essential to basic and applied science (Greenstein and Pandolfi 2008). There are no reliable estimates of this value for coral reefs. As a rough indication of this value, expenditures for field work, primary data gathering, boat/vessel rental, supplies, and diving equipment amount to \$32–111$\cdot$ha$^{-1}\cdot$yr^{-1} in Bohol Marine Triangle, the Philippines (Samonte-Tan et al. 2007).

Despite the numerous economic benefits coral reefs provide, reef ecosystems are under threat of irrevocable decline worldwide from a suite of anthropogenic stressors. Localized stressors (i.e., within reefs or archipelagos) include overfishing, dynamite or cyanide fishing, pollution, mining, eutrophication, coastal development, dredging, sedimentation, and biological invasion (e.g., Hoegh-Guldberg 1999, Gardner et al. 2003, Bellwood et al. 2004, Hoegh-Guldberg et al. 2007). A variety of reef ecosystem services may be affected by coral degradation. For example, areas in Sumatra where dynamite fishing had occurred suffered 70% greater wave heights than undisturbed areas during the 2004 Indian Ocean Tsunami (Fernando et al. 2005). Blast fishing can also have negative effects on local economies by reducing the amount of available reef for tourisms; in Indonesia, blast fishing led to the loss of a reef that was valued at \$306 800/km^2 (Pet-Soede et al. 1999). Overfishing has important cascading consequences on both reef ecosystem function and sustainable production by inducing phase shifts (Mumby et al. 2006, 2007). Overharvesting by the aquarium industry has also been documented on local levels (Lubbock and Polunin 1975, Warren-Rhodes et al. 2004). Moreover, eutrophication-induced algal blooms led to millions of dollars of lost tourism revenue in Hawaii (van Beukering and Cesar 2004).

Global-scale climate change is also threatening reefs through coral bleaching, disease, and ocean acidification, leading to both reef destruction and structural degradation (Graham et al. 2007, Hoegh-Guldberg et al. 2007, Carpenter et al. 2008). Several important reef ecosystem services are likely to be affected. Though the economic impacts of climate change on fisheries remain somewhat unclear, the benthic composition of reefs is likely to shift, thus affecting overall fish productivity and

TABLE 2. Ecosystem services, processes and functions, important controlling components, examples of values, and human drivers of ecosystem change for seagrasses.

Ecosystem services	Ecosystem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials and food	generates biological productivity and diversity	vegetation type and density, habitat quality	estimates unavailable	eutrophication, overharvesting, coastal development, vegetation disturbance, dredging, aquaculture, climate change, sea level rise
Coastal protection	attenuates and/or dissipates waves	wave height and length, water depth above canopy, seagrass bed size and distance from shore, wind climate, beach slope, seagrass species and density, reproductive stage	estimates unavailable	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, subsidence, tidal stage, wave climate, coastal geomorphology, seagrass species and density	estimates unavailable	
Water purification	provides nutrient and pollution uptake, as well as retention, particle deposition	seagrass species and density, nutrient load, water residence time, hydrodynamic conditions, light availability	estimates unavailable	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	seagrass species and density, habitat quality, food sources, hydrodynamic conditions	loss of 12 700 ha of seagrasses in Australia; associated with lost fishery production of AU$235 000 (McArthur and Boland 2006)	
Carbon sequestration	generates biogeochemical activity, sedimentation, biological productivity	seagrass species and density, water depth, light availability, burial rates, biomass export	estimates unavailable	
Tourism, recreation, education, and research	provides unique and aesthetic submerged vegetated landscape, suitable habitat for diverse flora and fauna	biological productivity, storm events, habitat quality, seagrass species and density, diversity	estimates unavailable	

harvests, as well as the availability of the most valued fishes collected in the aquarium trade (Pratchett et al. 2008). Reductions in tourism due to recent climate change-driven coral bleaching events are estimated in the billions (Wilkinson et al. 1999, Pratchett et al. 2008). The overall estimated economic damages from lost fisheries production, tourism and recreation, coastal protection, and other ecosystem services from the 1998 Indian Ocean coral bleaching event have ranged from $706 million to $8.2 billion (Wilkinson et al. 1999).

Seagrass beds

Seagrasses are flowering plants that colonize shallow marine and estuarine habitats. With only one exception (the genus *Phyllospadix*), seagrasses colonize soft substrates (e.g., mud, sand, cobble) and grow to depths where ~11% of surface light reaches the bottom (Duarte 1991). Seagrasses prefer wave-sheltered conditions as sediments disturbed by currents and/or waves lead to patchy beds or their absence (Koch et al. 2006). Despite being among the most productive ecosystems on the planet, fulfilling a key role in the coastal zone (Duarte 2002) and being lost at an alarming rate (Orth et al. 2006, Waycott et al. 2009), seagrasses receive little attention when compared to other ECEs (Duarte et al. 2008).

As indicated in Table 2, seagrass beds provide a wide range of ecosystem services, including raw materials and food, coastal protection, erosion control, water purification, maintenance of fisheries, carbon sequestration, and tourism, recreation, education, and research, yet reliable estimates of the economic values of most of these services are lacking.

Although in the past seagrasses were highly valued as raw materials and food, modern direct uses of seagrasses are rather limited. For example, seagrasses are still harvested in Tanzania, Portugal, and Australia, where they are used as fertilizer (Hemminga and Duarte 2000, de la Torre-Castro and Rönnbäck 2004). In the Chesapeake Bay, USA, seagrass by-catch or beach-cast is used to keep crabs moist during transport. In East Africa, some species are served as salad, while others are used in potions and rituals (de la Torre-Castro and Rönnbäck 2004). In the Solomon Islands, roots of the seagrass *Enhalus acoroides* are sometimes used as food, while leaf fibers are used to make necklaces and to provide spiritual benefits such as a gift to a newborn child, for fishing luck, and to remove an aphrodisiac spell (Lauer and Aswani 2010). However, currently there are no reliable estimates of the values of these food and raw material uses of harvested seagrasses.

Coastal protection and erosion control are often listed as important ecosystem services provided by seagrasses (Hemminga and Duarte 2000, Spalding et al. 2003, Koch et al. 2009). Seagrasses can attenuate waves and, as a result, smaller waves reach the adjacent shoreline (Fonseca and Cahalan 1992, Koch 1996, Prager and Halley 1999). Coastal protection is highest when the plants occupy the entire water column, such as at low tide, or when plants produce long reproductive stems (Koch et al. 2006). When small seagrasses colonize deeper waters, their contribution to wave attenuation and coastal protection is more limited. Sediment stabilization by seagrass roots and rhizomes, as well as by their beach-casted debris is important for controlling coastal erosion (Hemminga and Nieuwenhuize 1990). The benefits seagrasses provide in terms of coastal protection and erosion control via sediment stabilization and wave attenuation are yet to be valued satisfactorily.

Water purification, or the increase in water clarity, by seagrasses occurs via two processes: nutrient uptake and suspended particle deposition. Seagrasses not only remove nutrients from the sediments and water column (Lee and Dunton 1999), but also their leaves are colonized by algae (epiphytes), which further remove nutrients from the water column (Cornelisen and Thomas 2006). The nutrients incorporated into the tissue of seagrasses and algae are slowly released back into the water column once the plants decompose or are removed from the nutrient cycle when buried in the sediment (Romero et al. 2006). In addition to reducing nutrients, seagrass beds also decrease the concentration of suspended particles (e.g., sediment and microalgae) from the water (Gacia et al. 1999). Leaves in the water column provide an obstruction to water flow and, as a result, currents and waves are reduced within seagrass canopies causing particles to be deposited (Koch et al. 2006). This water purification effect can be quite dramatic with clearer water in vegetated areas compared to those without vegetation (Rybicki 1997). No reliable economic estimates exist for the water purification service provided by seagrass beds.

Seagrasses also generate value as habitat for ecologically and economically important species such as scallops, shrimp, crabs, and juvenile fish. Seagrasses protect these species from predators and provide food in the form of leaves, detritus, and epiphytes. The market value of the potential shrimp yield in seagrass beds in Western Australia is estimated to be between \$684 and $\$2511 \cdot ha^{-1} \cdot yr^{-1}$ (Watson et al. 1993). In Bohol Marine Triangle, the Philippines, the annual net revenue from gleaning mollusks and echinoderms (e.g., starfish, sea urchins, sea cucumbers, etc.) from seagrass beds at low tide ranges from \$12–120/ha and from fishing \$8–84/ha (Samonte-Tan et al. 2007). The fish, shrimp, and crab yield in southern Australia is valued at $US\$1436 \cdot ha^{-1} \cdot yr^{-1}$ (McArthur and Boland 2006). Based on the latter estimate, a loss of 2700 ha of seagrass beds results in lost fishery production of AU\$235 000 (Table 2).

Seagrasses are involved in carbon sequestration by using carbon dissolved in the seawater (mostly in the form of CO_2, but also HCO_3^-) to grow. Once the plants complete their life cycle, a portion of these materials is then buried in the sediment in the form of refractory detritus. It has been estimated that detritus burial from vegetated coastal habitats contributes about half of the total carbon burial in the ocean (Duarte et al. 2005). Therefore, the decline in seagrasses could lead to an important loss in the global CO_2 sequestration capacity, although this effect has yet to be valued.

Anthropogenic influences such as eutrophication, overharvesting, sediment runoff, algal blooms, commercial fisheries and aquaculture practices, vegetation disturbance, global warming, and sea level rise are among the causes for the decline of seagrasses worldwide (Orth et al. 2006, Waycott et al. 2009). With the disappearance of seagrasses, valuable ecosystem services are also lost (McArthur and Boland 2006). Yet, as very few of these benefits have been estimated reliably (see Table 2), we have only historical and anecdotal evidence of the likely economic impacts. For example, the disappearance of most seagrasses in Long Island, USA, in the 1930s due to wasting disease led to the collapse of the scallop industry (Orth et al. 2006).

Salt marshes

Salt marshes are intertidal grasslands that form in low-energy, wave-protected shorelines along continental margins. Extensive salt marshes (>2 km in width) establish and grow both behind barrier-island systems and along the wave-protected shorelines of bays and estuaries. Salt marshes are characterized by sharp zonation of plants and low species diversity, but extremely high primary and secondary production. The structure and function of salt marsh plant communities (and thus their services) were long thought to be regulated by physical processes, such as elevation, salinity, flooding, and nutrient availability (Mitsch and Gosselink 2008). Over the past 25 years, however, experiments have shown that competition (Bertness 1991) and facilitation (Hacker and Bertness 1995) among marsh plants is also critically important in controlling community structure. More recently, research has revealed the presence of strong trophic cascades driven by habitat-destroying herbivorous grazers (Silliman and Bertness 2002, Silliman and Bortolus 2003, Silliman et al. 2005, Henry and Jefferies 2009).

Among coastal ecosystems, salt marshes provide a high number of valuable benefits to humans, including raw materials and food, coastal protection, erosion control, water purification, maintenance of fisheries, carbon sequestration, and tourism, recreation, education, and research. Some of these important values have been estimated (Table 3).

For over 8000 years, humans have relied on salt marshes for direct provisioning of raw materials and food (Davy et al. 2009). Although harvesting of marsh grasses and use of salt marshes as pasture lands has decreased today, these services are still important locally in both developed and developing areas of the world (Bromberg-Gedan et al. 2009). For example, in the Ribble estuary on England's west coast, annual net income from grazing in a salt marsh nature reserve is: £15.27·ha^{-1}·yr^{-1} (King and Lester 1995).

For thousands of years, salt marshes have provided coastal protection from waves and storm surge, as well as from coastal erosion, for humans (Davy et al. 2009). By stabilizing sediment, increasing the intertidal height, and providing baffling vertical structures (grass), salt marshes reduce impacts of incoming waves by reducing their velocity, height, and duration (Morgan et al. 2009; Bromberg-Gedan et al., *in press*). Marshes are also likely to reduce storm surge duration and height by providing extra water uptake and holding capacity in comparison to the sediments of unvegetated mudflats. This storm protection value can be substantial, as a study of the protection against hurricanes by coastal wetlands along the U.S. Atlantic and Gulf coasts reveals (Table 3; Costanza et al. 2008). However, there are no reliable estimates of the economic value of salt marshes in controlling coastal erosion.

Salt marshes act as natural filters that purify water entering the estuary (Mitsch and Gosselink 2008). As water (e.g., from rivers, terrestrial runoff, groundwater, or rain) passes through marshes, it slows due to the baffling and friction effect of upright grasses (Morgan et al. 2009). Suspended sediments are then deposited on the marsh surface, facilitating nutrient uptake by salt marsh grasses. This water filtration service benefits human health, but also adjacent ecosystems, such as seagrasses, which may be degraded by nutrients and pollutants. In southern Louisiana, USA, treatment of wastewater by predominantly marsh swamps achieved capitalized cost savings of \$785 to \$15 000/acre (1 acre = 0.4 ha) compared to conventional municipal treatment (Breaux et al. 1995).

Salt marsh ecosystems also serve to maintain fisheries by boosting the production of economically and ecologically important fishery species, such as shrimp, oysters, clams, and fishes (Boesch and Turner 1984, MacKenzie and Dionne 2008). For example, salt marshes may account for 66% of the shrimp and 25% of the blue crab production in the Gulf of Mexico (Zimmerman et al. 2000). Because of their complex and tightly packed plant structure, marshes provide habitat that is mostly inaccessible to large fishes, thus providing protection and shelter for the increased growth and survival of young fishes, shrimp, and shellfish (Boesch and Turner 1984). For example, the capitalized value of an acre of salt marsh in terms of recreational fishing is estimated to be \$6471 and \$981 for the east and west coasts of Florida, USA, respectively (Bell 1997). The contribution of an additional acre of salt marsh to the value of the Gulf Coast blue crab fishery ranges from \$0.19 to \$1.89/acre (Freeman 1991).

As one of the most productive ecosystems in the world (up to 3900 g C·m^{-2}·yr^{-1}), salt marshes sequester millions of tons of carbon annually (Mitsch and Gosselink 2008). Because of the anoxic nature of the marsh soils (as in most wetlands), carbon sequestered by salt marsh plants during photosynthesis is often shifted from the short-term carbon cycle (10–100 years) to the long-term carbon cycle (1000 years) as buried, slowly decaying biomass in the form of peat (Mitsch and Gosselink 2008, Mayor and Hicks 2009). This cycle-shifting capability is unique among many of the world's ecosystems, where carbon is mostly turned over quickly and does not often move into the long-term carbon cycle. However, to our knowledge, there is no valuation estimation of this carbon sequestration service. Based on an estimate of permanent carbon sequestration by global salt marshes of 2.1 Mg C/ha by Chmura et al. (2003), and employing the 23 September 2009 Carbon Emission Reduction (CER) price of the European Emission Trading System (ETS) of €12.38/Mg converted to \$2000, we calculated a value of \$30.50·ha^{-1}·yr^{-1} as an approximate indicator of this benefit, but this is likely to vary greatly depending on latitude, as warmer marshes do not accumulate peat like their colder counterparts.

Salt marshes provide important habitat for many other beneficial species, which are important for tourism, recreation, education, and research. For example, estimates from land sales and leases for marshes in England suggest prices in the range of £150–493/acre for bird shooting and wildfowling (King and Lester 1995). Respondents were willing to pay £31.60/person to create otter habitat and £1.20 to

TABLE 3. Ecosystem services, processes and functions, important controlling components, examples of values, and human drivers of ecosystem change for salt marshes.

Ecosystem services	Ecosystem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials and food	generates biological productivity and diversity	vegetation type and density, habitat quality, inundation depth, habitat quality, healthy predator populations	£15.27· $ha^{-1}·yr^{-1}$ net income from livestock grazing, UK (King and Lester 1995)	marsh reclamation, vegetation disturbance, climate change, sea level rise, pollution, altered hydrological regimes, biological invasion
Coastal protection	attenuates and/or dissipates waves	tidal height, wave height and length, water depth in or above canopy, marsh area and width, wind climate, marsh species and density, local geomorphology	US$8236·$ha^{-1}·yr^{-1}$ in reduced hurricane damages, USA (Costanza et al. 2008)	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, tidal stage, coastal geomorphology, subsidence, fluvial sediment deposition and load, marsh grass species and density, distance from sea edge	estimates unavailable	
Water purification	provides nutrient and pollution uptake, as well as retention, particle deposition	marsh grass species and density, marsh quality and area, nutrient and sediment load, water supply and quality, healthy predator populations	US$785–15 000/acre capitalized cost savings over traditional waste treatment, USA (Breaux et al. 1995)†	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	marsh grass species and density, marsh quality and area, primary productivity, healthy predator populations	US$6471/acre and $981/acre capitalized value for recreational fishing for the east and west coasts, respectively, of Florida, USA (Bell 1997) and $0.19–1.89/acre marginal value product in Gulf Coast blue crab fishery, USA (Freeman 1991)†	
Carbon sequestration	generates biogeochemical activity, sedimentation, biological productivity	marsh grass species and density, sediment type, primary productivity, healthy predator populations	US$30.50·$ha^{-1}·yr^{-1}$‡	
Tourism, recreation, education, and research	provides unique and aesthetic landscape, suitable habitat for diverse fauna and flora	marsh grass species and density, habitat quality and area, prey species availability, healthy predator populations	£31.60/person for otter habitat creation and £1.20/person for protecting birds, UK (Birl and Cox 2007)	

† One acre = 0.4 ha.
‡ Based on Chumra et al. (2003) estimate of permanent carbon sequestration by global salt marshes of 2.1 Mg C·$ha^{-1}·yr^{-1}$ and 23 September 2009 Carbon Emission Reduction (CER) price of the European Emission Trading System (ETS) of €12.38/Mg, which was converted to US$2000.

protect birds in the Severn Estuary Wetlands bordering England and Wales (Birol and Cox 2007).

Current human threats to salt marshes include biological invasions, eutrophication, climate change and sea level rise, increasing air and sea surface temperatures, increasing CO_2 concentrations, altered hydrologic regimes, marsh reclamation, vegetation disturbance, and pollution (Silliman et al. 2009). As indicated in Table 3, a growing number of valuable marsh services are lost with the destruction of this habitat. Approximately 50% of the original salt marsh ecosystems have been degraded or lost globally, and in some areas, such as the West Coast of the USA, the loss is >90% (Bromberg and Silliman 2009, Bromberg-Gedan et al. 2009). This is likely to be exacerbated by the recent Gulf of Mexico oil spill in 2010.

TABLE 4. Ecosystem services, processes and functions, important controlling components, examples of values, and human drivers of ecosystem change for mangroves.

Ecosystem services	Ecosystem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials and food	generates biological productivity and diversity	vegetation type and density, habitat quality	US$484–585·ha^{-1}·yr^{-1} capitalized value of collected products, Thailand (Barbier 2007)	mangrove disturbance, degradation, conversion; coastline disturbance; pollution; upstream soil loss; overharvesting of resources
Coastal protection	attenuates and/or dissipates waves and wind energy	tidal height, wave height and length, wind velocity, beach slope, tide height, vegetation type and density, distance from sea edge	US$8966–10 821/ha capitalized value for storm protection, Thailand (Barbier 2007)	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, tidal stage, fluvial sediment deposition, subsidence, coastal geomorphology, vegetation type and density, distance from sea edge	US$3679·ha^{-1}·yr^{-1} annualized replacement cost, Thailand (Sathirathai and Barbier 2001)	
Water purification	provides nutrient and pollution uptake, as well as particle retention and deposition	mangrove root length and density, mangrove quality and area	estimates unavailable	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	mangrove species and density, habitat quality and area, primary productivity	US$708-$987/ha capitalized value of increased offshore fishery production, Thailand (Barbier 2007)	
Carbon sequestration	generates biological productivity, biogeochemical activity, sedimentation	vegetation type and density, fluvial sediment deposition, subsidence, coastal geomorphology	US$30.50·ha^{-1}·yr^{-1}†	
Tourism, recreation, education, and research	provides unique and aesthetic landscape, suitable habitat for diverse fauna and flora	mangrove species and density, habitat quality and area, prey species availability, healthy predator populations	estimates unavailable	

† Based on Chumra et al. (2003) estimate of permanent carbon sequestration by global salt marshes of 2.1 Mg C·ha^{-1}·yr^{-1}and 23 September 2009 Carbon Emission Reduction (CER) price of the European Emission Trading System (ETS) of €12.38/Mg, which was converted to US$2000.

Mangroves

Mangroves are coastal forests that inhabit saline tidal areas along sheltered bays, estuaries, and inlets in the tropics and subtropics throughout the world. Around 50–75 woody species are designated as "mangrove," which is a term that describes both the ecosystem and the plant families (Ellison and Farnsworth 2001). In the 1970s, mangroves may have covered as much as 200 000 km^2, or 75% of the world's coastlines (Spalding et al. 1997). But since then, at least 35% of global mangrove area has been lost, and mangroves are currently disappearing at the rate of 1–2% annually (Valiela et al. 2001, Alongi 2002, FAO 2007).

The worldwide destruction of mangroves is of concern because they provide a number of highly valued ecosystems services, including raw materials and food, coastal protection, erosion control, water purification, maintenance of fisheries, carbon sequestration, and tourism, recreation, education, and research (Table 4). For many coastal communities, their traditional use of mangrove resources is often closely connected with the health and functioning of the system, and thus this use is often intimately tied to local culture, heritage, and traditional knowledge (Walters et al. 2008).

Of the ecosystem services listed, three have received most attention in terms of determining their value to coastal populations. These include (1) their use by local coastal communities for a variety of products, such as fuel wood, timber, raw materials, honey and resins, and crabs and shellfish; (2) their role as nursery and breeding

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habitats for offshore fisheries; and (3) their propensity to serve as natural "coastal storm barriers" to periodic wind and wave or storm surge events, such as tropical storms, coastal floods, typhoons, and tsunamis. Assigning a value to these three mangrove ecosystem services has been conducted for Thailand by Barbier (2007), who compared the net economic returns per hectare to shrimp farming, the costs of mangrove rehabilitation, and the value of mangrove services. All land uses were assumed to be instigated over a nine-year period (1996 to 2004), and the net present value (NPV) of each land use or ecosystem service was estimated in 1996 US$ per hectare. The NPV arising from the net income to local communities from collected forest and other products and shellfish was $484 to $584/ha. In addition, the NPV of mangroves as breeding and nursery habitat in support of offshore artisanal fisheries ranged from $708 to $987/ha, and the storm protection service was $8966 to $10 821/ha.

Such benefits are considerable when compared to the average incomes of coastal households; a survey conducted in July 2000 of four mangrove-dependent communities in two different coastal provinces of Thailand indicates that the average household income per village ranged from $2606 to $6623/yr, and the overall incidence of poverty (corresponding to an annual income of $180 or lower) in all but three villages exceeded the average incidence rate of 8% found across all rural areas of Thailand (Sarntisart and Sathirathai 2004). The authors also found that excluding the income from collecting mangrove forest products would have raised the incidence of poverty to 55.3% and 48.1% in two of the villages, and to 20.7% and 13.64% in the other two communities.

The Thailand example is not unusual; coastal households across the world typically benefit from the mangrove services, indicated in Table 4 (Ruitenbeek 1994, Bandaranayake 1998, Barbier and Strand 1998, Naylor and Drew 1998, Janssen and Padilla 1999, Rönnbäck 1999, Badola and Hussain 2005, Chong 2005, Brander et al. 2006, Walton et al. 2006, Rönnbäck et al. 2007, Aburto-Oropeza et al. 2008, Walters et al. 2008, Lange and Jiddawi 2009, Nfotabong Atheull et al. 2009). Mangroves also provide important cultural benefits to coastal inhabitants. A study in Micronesia finds that the communities "place some value on the existence and ecosystem functions of mangroves over and above the value of mangroves' marketable products" (Naylor and Drew 1998:488).

Since the 2004 Indian Ocean Tsunami, there has been considerable global interest in one particular service of mangroves: their role as natural barriers that protect the lives and properties of coastal communities from periodic storm events and flooding. Eco-hydrological evidence indicates that this protection service is based on the ability of mangroves to attenuate waves and thus reduce storm surges (Mazda et al. 1997, 2006, Massel et al. 1999, Wolanski 2007, Barbier et al. 2008, Koch et al. 2009). Comprehensive reviews of all the field assessments in the aftermath of the Indian Ocean Tsunami suggest that some areas were more protected by the presence of healthy mangroves, provided that the tidal wave was not too extreme in magnitude (Montgomery 2006, Braatz et al. 2007, Forbes and Broadhead 2007, Alongi 2008, Cochard et al. 2008). For other major storm events, there is more economic evidence of the protective role of mangroves. For example, during the 1999 cyclone that struck Orissa, India, mangroves significantly reduced the number of deaths as well as damages to property, livestock, agriculture, fisheries, and other assets (Badola and Hussain 2005, Das and Vincent 2009). Das and Vincent estimated that there could have been 1.72 additional deaths per village within 10 km of the coast if the mangrove width along shorelines had been reduced to zero. Losses incurred per household were greatest ($154) in a village that was protected by an embankment but had no mangroves compared to losses per household ($33) in a village protected only by mangrove forests (Badola and Hussain 2005).

The ability of mangroves to stabilize sediment and retain soil in their root structure reduces shoreline erosion and deterioration (Daehler and Strong 1996, Sathirathai and Barbier 2001, Thampanya et al. 2006, Wolanski 2007). But despite the importance of this erosion control service, very few economic studies have been conducted to value it. Existing studies tend to use the replacement cost methods of valuation, due to lack of data, which can undermine the reliability of the value estimates (Chong 2005, Barbier 2007). In Thailand, the annualized replacement cost of using artificial barriers instead of mangroves is estimated to be $3679·ha^{-1}·yr^{-1} (Sathirathai and Barbier 2001).

Mangroves also serve as barriers in the other direction; their water purification functions protect coral reefs, seagrass beds, and important navigation waters against siltation and pollution (Wolanski 2007). In southern China, field experiments have been conducted to determine the feasibility of using mangrove wetlands for wastewater treatment (Chen et al. 2009). Mangrove roots may also serve as a sensitive bio-indicator for metal pollution in estuarine systems (MacFarlane et al. 2003). The economic value of the pollution control service of mangroves has not been reliably estimated, however.

Because mangroves are among the most productive and biogeochemically active ecosystems, they are important sources of global carbon sequestration. To date, the value of mangroves as a carbon sink has not been estimated. Based on an estimate of permanent carbon sequestration by all mangroves globally (Chumra et al. 2003), following the same approach described above for salt marshes (see *Salt marshes*), we calculate a value of $30.50·ha^{-1}·yr^{-1} as an approximate indicator of this benefit for mangroves.

Although many factors contribute to global mangrove deforestation, a major cause is aquaculture expansion in coastal areas, especially the establishment of shrimp farms (Barbier and Cox 2003). Aquaculture accounts for 52% of mangrove loss globally, with shrimp farming alone accounting for 38%. Forest use, mainly from industrial lumber and woodchip operations, causes 26% of mangrove loss globally. Freshwater diversion accounts for 11% of deforestation, and reclamation of land for other uses causes 5% of decline. The remaining sources of mangrove deforestation consist of herbicide impacts, agriculture, salt ponds, and other coastal developments (Valiela et al. 2001). The extensive and rapid loss of mangroves globally reinforces the importance of measuring the value of such ecological services, and employing these values appropriately in coastal management and planning.

Sand beaches and dunes

Coastal sand beaches and dunes are important but understudied arbiters of coastal ecosystem services. They form at low-lying coastal margins where sand transported by oceanic waves and wind combine with vegetation to produce dynamic geomorphic structures. Thus, sandy-shore ecosystems include both marine and terrestrial components and vary, depending on sand supply, in the extent to which the beach vs. the dune dominates (Short and Hesp 1982). Sandy beaches and dunes occur at all latitudes on earth and cover roughly 34% of the world's ice-free coastlines (Hardisty 1994).

For centuries, due to their unique position between ocean and land, coastal beaches and dunes have provided humans with important services such as raw materials, coastal protection, erosion control, water catchment and purification, maintenance of wildlife, carbon sequestration, and tourism, recreation, education, and research (Table 5; Carter 1990, Pye and Tsoar 1990). However, very few of these services have been valued, with the exception of erosion control and recreation and tourism (Table 5).

Beaches and dunes provide raw materials in the form of sand that has been mined for centuries for multiple uses, including extraction of minerals such silica and feldspar for glass and ceramic production, infill for development, amendments for agriculture, and base material for construction products. Although sand is a valuable resource, its extraction through mining can have obvious negative effects, especially on coastal protection and aquifers.

Coastal protection is arguably one of the most valuable services provided by sand shore ecosystems especially in the face of extreme storms, tsunamis, and sea level rise. As waves reach the shoreline they are attenuated by the beach slope and, at high tide, also by the foredune, a structure immediately behind the beach where sand accumulates in hills or ridges parallel to the shoreline. Beaches vary in their ability to attenuate waves depending on a continuum in their morphology (Carter 1991, Hesp and Short 1999, Short 1999). Foredunes can vary in height and width, and thus their ability to attenuate waves, depending on the presence of vegetation and sand supply from the beach (Hesp 1989; Hacker et al., *in press*). Measuring the coastal protective properties of sand shoreline systems involves understanding the relationship between beach and foredune shape and wave attenuation, especially in the aftermath of storms, hurricanes, or tsunamis (Leatherman 1979, Lui et al. 2005, Sallenger et al. 2006, Morton et al. 2007, Stockdon et al. 2007, Ruggiero et al. 2010). The economic value, although not calculated previously, is likely to be substantial. For example, Liu et al. (2005) report that, after the 2004 Indian Ocean Tsunami, there was total devastation and loss of 150 lives in a resort located directly behind where a foredune was removed to improve the scenic view of the beach and ocean.

Beaches and sand dunes provide sediment stabilization and soil retention in vegetation root structure, thus controlling coastal erosion and protecting recreational beaches, tourist-related business, ocean front properties, land for aquaculture and agriculture, and wildlife habitat. Although this service has not been valued directly, there have been a growing number of studies that value the benefits gained from erosion control programs that either preserve or "nourish" existing beaches and dunes (Landry et al. 2003, Kriesel and Landry 2004, Huang et al. 2007, Whitehead et al. 2008, Morgan and Hamilton 2010). Such programs often substitute for property owners building their own erosion protection structures, such as seawalls and groins, which can inadvertently accelerate the degradation of the coastal environment (Landry et al. 2003, Kriesel and Landry 2004). However, erosion control programs can also have negative effects on the surrounding environment, including affecting recreational beach use and views, displacing coastal erosion elsewhere, and disturbing wildlife habitat. For example, in the U.S. states of New Hampshire and Maine, a coastal erosion program that preserves five miles of beach is estimated to have net benefits, adjusted for the costs associated with the risk of injury to swimmers from the control measures, disturbance to wildlife habitat, and deterioration of water quality, of $4.45/household (Huang et al. 2007). Landry et al. (2003) find that a one-meter increase in beach width, or equivalently, the prevention of one meter of beach erosion, increased oceanfront and inlet-front property values by $233 on Tybee Island in the U.S. state of Georgia.

Another important service of coastal sand ecosystems is water catchment. Sand dunes are able to store significant amounts of water that can serve as aquifers for coastal populations (Carter 1990). For example, in the Meijendel dunes in The Netherlands, dune aquifers have been used as a source of drinking water for centuries (van der Meulen et al. 2004). The aquifer still supplies enough water for 1.5 million people in

TABLE 5. Ecosystem services, processes and functions, important controlling components, examples of values, and human drivers of ecosystem change for sand beaches and dunes.

Ecosystem services	Ecosystem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials	provides sand of particular grain size, proportion of minerals	dune and beach area, sand supply, grain size, proportion of desired minerals (e.g., silica, feldspar)	estimates unavailable for sustainable extraction	loss of sand through mining, development and coastal structures (e.g., jetties), vegetation disturbance, overuse of water, pollution, biological invasion
Coastal protection	attenuates and/or dissipates waves and reduces flooding and spray from sea	wave height and length, beach slope, tidal height, dune height, vegetation type and density, sand supply	estimates unavailable	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, subsidence, tidal stage, wave climate, coastal geomorphology, beach grass species and density	US$4.45/household for an erosion control program to preserve 8 km of beach, for Maine and New Hampshire beaches, USA (Huang et al. 2007)	
Water catchment and purification	stores and filters water through sand; raises water table	dune area, dune height, sand and water supply	estimates unavailable	
Maintenance of wildlife	biological productivity and diversity, habitat for wild and cultivated animal and plant species	dune and beach area, water and nutrient supply, vegetation and prey biomass and density	estimates unavailable	
Carbon sequestration	generates biological productivity, biogeochemical activity	vegetative type and density, fluvial sediment deposition, subsidence, coastal geomorphology	estimates unavailable	
Tourism, recreation, education, and research	provides unique and aesthetic landscapes, suitable habitat for diverse fauna and flora	dune and beach area, sand supply, wave height, grain size, habitat quality, wildlife species, density and diversity, desirable shells and rocks	US$166/trip or $1574 per visiting household per year for North Carolina beaches, USA (Landry and Liu 2009)	

surrounding cities. Because of the importance of this water source, the Meijendel dune is managed as a nature reserve that serves both drinking water and recreation needs. In 1999, the cost of management was $3.8 million/year, while the yearly income of the reserve was $99.2 million/year.

Coastal dunes can provide maintenance of wildlife in the form of habitat for fish, shellfish, birds, rodents, and ungulates, which have been captured or cultivated for food since humans first colonized the coast (Carter 1990, Pye and Tsoar 1990). In Europe, protection and restoration of dune wildlife and habitat has become a priority (Baeyens and Martínez 2004). In other regions of the world, dunes have been used for agricultural purposes (Pye and Tsoar 1990). However, there are no reliable estimates on the value of beaches and dunes as a source of habitat for wildlife.

Dunes that encourage vegetation growth and productivity will also assist in carbon sequestration, although this process is likely to vary with the type of vegetation, sediment deposition and subsidence, and coastal geomorphology. There are currently no estimates of the value of this service provided by dunes, however.

Beaches and dunes also supply important recreational benefits. Boating, fishing, swimming, scuba diving, walking, beachcombing, and sunbathing are among the numerous recreational and scenic opportunities that are provided by beach and dune access. In the USA alone, 70% of the population visits the beach on vacation, and 85% of total tourism dollars come from beach visits (Houston 2008). An analysis of North Carolina beaches shows that implementation of a beach replenishment policy to improve beach width by an average of 100 feet would increase the average number of trips by visitors in the subsequent year from 11 to 14, with beach-goers willing to pay \$166/trip or \$1574 per visiting household per year (Landry and Liu 2009). Another study of North Carolina beaches found that widening beach width increases the consumer surplus of visitors by \$7/trip (Whitehead et al. 2008). However, overuse of dune habitat due to beach recreation can also cause significant damages. The impacts to beach and dune function have been mostly in the form of changes in sand stabilization and distribution. Trampling of native vegetation by pedestrians or vehicles can destabilize sand and result in the loss of foredunes and thus coastal protection. Therefore, as with all coastal systems, reducing the damages caused by overuse of certain services such as the recreation and tourism benefits provided by beaches and dunes, requires thoughtful management and planning (e.g., Heslenfeld et al. 2004, Moreno-Casasola 2004).

Many of the services provided by sand beaches and dunes are threatened by human use, species invasions, and climate change (Brown and McLachlan 2002, Zarnetske et al. 2010; Hacker et al., *in press*). In particular, the removal or disruption of sand and vegetation coupled with increased storm intensity and sea level rise threaten critical services provided by this ecosystem, specifically those of coastal protection (Ruggiero et al. 2010) and coastal freshwater catchment. The fact that no reliable estimates of these services are currently available is worrisome.

Discussion: Issues for Future Research

Our review of economic values of key ecosystem services for five estuarine and coastal ecosystems (coral reefs, seagrass beds, salt marshes, mangroves, and sand beaches and dunes) reveals that progress has been made in estimating these benefits for some systems and services, but much work remains. For example, reliable valuation estimates are beginning to emerge for the key services of some ECEs, such as coral reefs, salt marshes, and mangroves, but many of the important benefits of seagrass beds and sand dunes and beaches have not been assessed properly. Even for coral reefs, marshes, and mangroves, important ecological services have yet to be valued reliably, such as cross-ecosystem nutrient transfer (coral reefs), erosion control (marshes), and pollution control (mangroves). Although more studies valuing ECE services have been conducted recently, our review shows that the number of reliable estimates is still relatively small.

Measurement issues, data availability, and other limitations continue to prevent the application of standard valuation methods to many ecosystem services. In circumstances where an ecological service is unique to a specific ecosystem and is difficult to value, often the cost of replacing the service or treating the damages arising from the loss of the service is used as a valuation approach. Such methods have been employed frequently to measure coastal protection, erosion control, and water purification services by ECEs (Ellis and Fisher 1987, Chong 2005, Barbier 2007). However, economists recommend that the replacement cost approach should be used with caution because, first, one is essentially estimating a benefit (e.g., storm protection) by a cost (e.g., the costs of constructing seawalls, groins, and other structures), and second, the human-built alternative is rarely the most cost-effective means of providing the service (Ellis and Fisher 1987, Barbier 1994, 2007, Freeman 2003, NRC 2005).

As summarized in our tables, ECE habitats tend to generate multiple ecosystem services. These typically range from tourism and recreation benefits to coastal protection, erosion control, nutrient cycling, water purification, and carbon sequestration to food and raw-material products. Where studies are aware of such multiple benefits, the current approach is still to value each service as if it is independent, as was done for coastal protection, habitat–fishery linkages, and raw materials for mangroves in Thailand (Barbier 2007). However, as our tables indicate, similar ecological processes and functions, as well as controlling components, may influence more than one ecosystem service. Such ecological interactions are bound to affect the value of multiple services arising from a single habitat, which is an important direction for future research in valuing ECE services.

For a growing number of services, there is evidence that ecological functions vary spatially or temporally, and thus influence the economic benefits that they provide (Peterson and Turner 1994, Petersen et al. 2003, Rountree and Able 2007, Aburto-Oropeza et al. 2008, Aguilar-Perera and Appeldoorn 2008, Barbier et al. 2008, Meynecke et al. 2008, Koch et al. 2009). For example, wave attenuation by coral reefs, seagrass beds, salt marshes, mangroves, and sand dunes provides protection against wind and wave damage caused by coastal storm and surge events, but the magnitude of protection will vary spatially across the extent of these habitats (Barbier et al. 2008, Koch et al. 2009). In particular, ecological and hydrological field studies suggest that mangroves are unlikely to stop storm waves that are greater than 6 m in height (Forbes and Broadhead 2007, Wolanski 2007, Alongi 2008, Cochard et al. 2008). On the other hand, where mangroves are effective as "natural barriers" against storms that generate waves less than 6 m in height, the wave height of a storm decreases quadratically for each 100 m that a mangrove forest extends out to sea (Mazda et al. 1997, Barbier et al. 2008). In other words, wave attenuation is greatest for the first 100 m of mangroves, but declines as more mangroves are added to the seaward edge.

Valuation of coastal habitat support for offshore fisheries increasingly indicates that the value of this service varies spatially because the quality of the habitat is greater at the seaward edge or "fringe" of the coastal ecosystem than further inland (Peterson and Turner 1994, Manson et al. 2005, Aburto-Oropeza et al. 2008,

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Aguilar-Perera and Appeldoorn 2008). In the case of mangroves and salt marshes, the evidence suggests that both storm protection and habitat–fishery linkage benefits tend to decline with the distance inshore from the seaward edge of most coastal wetland habitats, such as mangroves and salt marshes. For example, Peterson and Turner (1994) found that densities of most fish and crustaceans were highest in salt marshes in Louisiana within 3 m of the water's edge compared to the interior marshes. In the Gulf of California, Mexico, the mangrove fringe with a width of 5–10 m has the most influence on the productivity of nearshore fisheries, with a median value of $37 500/ha. Fishery landings also increased positively with the length of the mangrove fringe in a given location (Aburto-Oropeza et al. 2008). The tendency for these services to vary unidirectionally across such coastal landscapes has implications for modeling the provision of these services and valuing their benefits (Barbier 2008).

Coastal protection can also vary if damaging storm events occur when plant biomass and/or density are low (Koch et al. 2009). This is particularly important in temperate regions, where seasonal fluctuations of biomass may differ from the seasonal occurrence of storms. For example, along the U.S. Atlantic coast, the biomass of seagrass peaks in the summer (April–June), yet decreases in the fall (July–September) when storm events usually strike. In tropical areas, vegetation in coastal systems, such as mangroves but also seagrasses, has relatively constant biomass throughout the year, so the coastal protection service is relatively unaffected by seasonal or temporal variability.

The value of some ECE services can also vary spatially (i.e., distance from the shoreline) and temporally (i.e., seasonality). This is of particular importance for recreational and property-related benefits (Coombes et al. 2010, Morgan and Hamilton 2010). A study of home values near Pensacola Beach, Florida, found that Gulf-front property owners were willing to pay an annual tax of $5807 for a five-year beach nourishment project that would improve access and shoreline views; however, the tax payment declines to $2770 for a property in the next block, $2540 for a property two blocks away, and $1684 for a property three blocks away (Morgan and Hamilton 2010). Models of beach visitors in East Anglia, UK, reveal that seasonal differences are important. For example, school holidays and temperatures have the greatest influence on visitor numbers, and the visitors' propensity to visit the coast increases rapidly at temperatures exceeding 15°C (Coombes et al. 2010). Spatial characteristics that were also associated with more visitors included wide and sandy beaches, beach cleanliness, the presence of a nature reserve, pier, or an urban area behind the beach, and close proximity of an entrance point, car park, and toilet facilities.

Another unique feature of ECEs is that they occur at the interface between the coast, land, and watersheds, which also make them especially valuable. The location of ECEs in the land–sea interface suggests a high degree of "interconnectedness" or "connectivity" across these systems, leading to the linked provision of one or multiple services by more than one ECE.

As Moberg and Rönnbäck (2003) describe for tropical regions, numerous physical and biogeochemical interactions have been identified among mangroves, seagrass beds, and coral reefs that effectively create interconnected systems, or a single "seascape." By dissipating the force of currents and waves, coral reefs are instrumental for the evolution of lagoons and sheltered bays that are suitable environments for seagrass beds and mangroves. In turn, the control of sedimentation, nutrients, and pollutants by mangroves and seagrasses create the coastal water conditions that favor the growth of coral reefs. This synergistic relationship between coral reefs, seagrasses, mangroves, and even sand dunes, suggests that the presence of these interlinked habitats in a seascape may considerably enhance the ecosystem service provided by one single habitat.

For example, Alongi (2008) suggests that the extent to which mangroves offer protection against catastrophic storm events, such as tsunamis, may depend not only on the relevant features and conditions within the mangrove ecosystem, such as width of forest, slope of forest floor, forest density, tree diameter and height, proportion of aboveground biomass in the roots, soil texture, and forest location (open coast vs. lagoon), but also on the presence of foreshore habitats, such as coral reefs, seagrass beds, and dunes. Similar cumulative effects of wave attenuation are noted for seascapes containing coral reefs, seagrasses, and marshes (Koch et al. 2009). As can be seen from Tables 1–5, each ECE habitat has considerable ability to attenuate waves, and thus the presence of foreshore habitats, such as coral reefs and seagrasses, can reduce significantly the wave energy reaching the seaward edge of mangroves, salt marshes, and sand beaches and dunes. For instance, evidence from the Seychelles documents how rising coral reef mortality and deterioration have increased significantly the wave energy reaching shores that are normally protected from erosion and storm surges by these reefs (Sheppard et al. 2005). In the Caribbean, mangroves appear not only to protect shorelines from coastal storms, but may also enhance the recovery of coral reef fish populations from disturbances due to hurricanes and other violent storms (Mumby and Hastings 2008).

ECE habitats are also linked biologically. Many fish and shellfish species utilize mangroves and seagrass beds as nursery grounds, and eventually migrate to coral reefs as adults, only to return to the mangroves and seagrasses to spawn (Layman and Silliman 2002, Nagelkerken et al. 2002, Mumby et al. 2004, Rountree and Able 2007, Meynecke et al. 2008). In addition, the high biological productivity of mangroves, marshes, and seagrasses also produce significant amounts of organic matter that is used directly or indirectly by marine fishes, shrimps,

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crabs, and other species (Chong 2007). The consequence is that interconnected seascapes contribute significantly to supporting fisheries via a number of ecosystem functions including nursery and breeding habitat, trophic interactions, and predator-free habitat.

For example, studies in the Caribbean show that the presence of mangroves and seagrasses enhance considerably the biomass of coral reef fish communities (Nagelkerken et al. 2002, Mumby et al. 2004, Mumby 2006). In Malaysia, it is estimated that mangrove forests sustain more than half of the annual offshore fish landings, much of which are from reef fisheries (Chong 2007). In Puerto Rico, maps show fish distributions to be controlled by the spatial arrangement of mangroves, seagrasses, and coral reefs and the relative value of these habitats as nurseries (Aguilar-Perera and Appeldoorn 2008). Stratification of environmental conditions along a marsh habitat gradient, stretching from intertidal vegetated salt marshes, to subtidal marsh creeks, to marsh–bay fringe, and then to open water channels, indicates large spatial and temporal variability in fish migration, nursery habitats, and food webs (Rountree and Able 2007). Finally, indices representing the connectivity of mangroves, salt marshes, and channels explained 30% to 70% of the catch-per-unit effort harvesting yields for commercially caught species in Queensland, Australia (Meynecke et al. 2008).

There are two ways in which current economic studies of ECE services are incorporating such synergies. One approach is to assess the multiple benefits arising from entire interconnected habitats, such as estuaries. A second method is to allow for the biological connectivity of habitats, food webs, and migration and life-cycle patterns across specific seascapes, such as mangrove–seagrass–reef systems and large marine systems.

For example, Johnston et al. (2002) estimate the benefits arising from a wide range of ecosystem services provided by the Peconic Estuary in Long Island, New York, USA. The tidal mudflats, salt marshes, and seagrass (eelgrass) beds of the estuary support the shellfish and demersal fisheries. In addition, bird-watching and waterfowl hunting are popular activities. Incorporating production function methods, the authors simulate the biological and food web interactions of the ecosystems to assess the marginal value per acre in terms of gains in commercial value for fish and shellfish, bird-watching, and waterfowl hunting. The aggregate annual benefits are estimated to be $67 per acre for intertidal mud flats, $338 for salt marsh, and $1065 for seagrass across the estuary system. Using these estimates, the authors calculate that the asset value per acre of protecting existing habits to be $12 412 per acre for seagrass, $4291 for salt marsh, and $786 for mudflats; in comparison, the asset value of restored habitats is $9996 per acre for seagrass, $3454 for marsh, and $626 for mudflats.

Sanchirico and Mumby (2009) developed an integrated seascape model to illustrate how the presence of mangroves and seagrasses enhance considerably the biomass of coral reef fish communities. A key finding is that mangroves become more important as nursery habitat when excessive fishing effort levels are applied to the reef, because the mangroves can directly offset the negative impacts of fishing effort. Such results support the development of "ecosystem-based" fishery management and the design of integrated coastal-marine reserves that emphasize the importance of conserving and restoring coastal mangroves as nursery sites for reef fisheries (Mumby 2006).

In sum, allowing for the connectivity of ECE habitats may have important implications for assessing the ecological functions underling key ecosystems services, such as coastal protection, control of erosion, and habitat–fishery linkages. Only recently have studies of ECEs begun to assess the cumulative implications for these services, or to model this connectivity. This is one important area for future direction of research into ECE services that requires close collaboration between economists, ecologists and other environmental scientists.

Conclusion: Toward a Management Action Plan

Given the rate and scale at which ECEs are disappearing worldwide, assessing and valuing the ecological services of these systems are critically important for improving their management and for designing better policies. Certainly, the various economic values of ECEs should be incorporated into policy decisions that are currently determining the major human drivers of ecological change, such as ecosystem conversion and degradation, resource overexploitation, pollution, and water diversion. As indicated in Figs. 1 and 2, valuation of ECE services is a key step in demonstrating how these human drivers of change alter ecosystem structure and functions, and thus the ecological production of important ecosystem goods and services that benefit human beings.

Yet, as this review has shown, many ECE values are non-marketed. If the aggregate willingness to pay for these benefits is not revealed through market outcomes, then efficient management of such ecosystem services requires explicit methods to measure this social value. Thus, it should not be surprising that the failure to consider the values provided by key ECE services in current policy and management decisions is a major reason for the widespread disappearance of many of these ecosystems and habitats across the globe. Improving the assessment and valuation of ECE services should therefore be a top policy priority for any global management plan for these ecosystems (Granek et al. 2010).

Such a priority is urgent. Our review of five ECEs (i.e., nearshore coral reefs, seagrass beds, salt marshes, mangroves, and sand beaches and dunes) reveals that many of the important benefits of these habitats have not been estimated reliably, and even for those services that have been valued, only a few dependable studies have been conducted. Without more efforts to value the key services of ECEs, and to employ these values appropriately in coastal management and planning, slowing the worldwide degradation of coastal and estuarine landscapes will be difficult. Assessing the values of ECE services is critical, as all coastal interface habitats are facing increasing pressure for conversion to other economic activities, while at the same time, in many coastal areas where ECEs have been degraded or lost, there is often keen interest in restoring these habitats.

Our review also points to other important policy challenges for improving global management of ECEs. For example, there is now sufficient evidence to suggest that some services, such as coastal protection and habitat–fishery linkages, are not uniform across a coastal seascape. Maintaining ECEs for their multiple and synergistic ecosystem services will also invariably involve managing coastal landscapes across different spatial and temporal scales. Incorporating nonlinear and synergistic characteristics of ECEs into management scenarios is likely to result in the most ecologically and economically sustainable management plan possible (Granek et al. 2010). How an ecological function, and thus the ecosystem service it supports, varies nonlinearly across a coastal landscape can have important implications for management at the landscape scale for all ECEs (Koch et al. 2009).

Because the connectivity of ECEs across land–sea gradients also influences the provision of certain ecosystem services, management of the entire seascape will be necessary to preserve such synergistic effects. For example, Mumby (2006) argues that the management of ECE habitats in the Caribbean should take into account the life cycle migration of fish between mangroves, seagrass beds, and coral reefs. He recommends that management planning should focus on connected corridors of these habitats and emphasize four key priorities: (1) the relative importance of mangrove nursery sites, (2) the connectivity of individual reefs to mangrove nurseries, (3) areas of nursery habitat that have an unusually large importance to specific reefs, and (4) priority sites for mangrove restoration projects. Similarly, Meynecke et al. (2008) emphasize that to improve marine protected areas, it is important to understand the role of connectivity in the life history of fishes that likely utilize different ECEs.

Given the perilous state of many ECEs globally and their critically important benefits, there is clearly a need for a global action plan for protecting and/or enhancing the immediate and longer term values of important ECE services. Such a plan should contain the following features.

First, more interdisciplinary studies involving economists, ecologists, and environmental scientists are required to assess the values of the various ECE services identified in this review for coral reefs, seagrasses, salt marshes, mangroves, and sand beaches and dunes (Tables 1–5). A key priority is to value those services identified in this review for which estimates are currently unavailable or unreliable. Although we know less about the economic benefits of seagrasses and sand beaches and dunes compared to the other ECEs, the number of reliable estimates of almost all services remains woefully inadequate.

Second, destruction of these five critical ECEs for coastal economic development can no longer be viewed as "costless" by those responsible for managing and approving such developments. In particular, the widespread global practice of giving away mangroves, salt marshes, and other ECEs as "free land" for coastal aquaculture, agricultural, and residential development needs to be halted. Especially destructive economic activities, such as dynamite fishing of coral reefs, clear-cutting mangroves for wood chips or shrimp farming, mining of sand dunes, extracting seagrasses for shellfish beds, and using salt marshes for landfills, should be banned and the bans enforced. Coastal pollution from aquaculture, tourism activities and infrastructure, agriculture, urban areas and industry need to be monitored, regulated, and where appropriate, taxed.

Third, in many developing countries, the current legal framework and formal institutional structures of ECEs and resource management do not allow local coastal communities any legal rights to establish and enforce control over the ECE goods and services on which the livelihoods of these communities depend. Establishing an improved institutional framework does not necessarily require transferring full ownership of ECE resources to local communities, but could involve co-management by governments and local communities that would allow, for example, the participation of the communities in decisions concerning the long-term management, development and utilization of these resources.

Finally, where appropriate, ecological restoration of key ECEs should be encouraged. However, ecological restoration of these systems is difficult and costly, and requires the right incentives. For example, in Thailand, the full costs of replanting and restoring mangroves in abandoned shrimp ponds is estimated to be around \$9318/ha, which nearly accounts for the entire capitalized value of the restored services of \$12 392/ha (Barbier 2007). This suggests that investors in shrimp farms and other coastal developments that cause widespread mangrove destruction should have the legal requirement to replant mangroves and finance the costs, rather than leaving mangrove restoration solely to governments and local communities. It should be recognized, however, that ex post ecological restoration is no panacea for failed conservation. Such investments are not only costly but risky, and in many cases fall short of recovering the full suite of ecosystem services (Palmer and Filoso 2009). For example, as discussed in the previous section, the Johnston et al. (2002) study of the Peconic Estuary of Long Island found that the asset value of restored salt marsh and seagrass and tidal mudflats in terms of nursery habitat and recreational services were much lower than for conserving the original habitats.

In sum, the more we learn about ECEs and their services, it is apparent that ignoring these benefits is detrimental to coastal management and planning. In addition, more attention needs to be paid to how these services vary across seascapes, as these considerations clearly matter to managing estuarine, coastal, and inshore marine environments (Granek et al. 2010). Coasts and small islands may comprise just 4% of the Earth's total land area, but as this review has shown, the ECEs that dominate these geographic areas provide some of the most important global benefits for humankind.

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Weyerhaeuser

SUSTAINABLE FORESTRY INITIATIVE SFI-00008

September 23, 2022

R. David Waltz
TMDL Basin Coordinator
Oregon Dept. of Environmental Quality
165 East 7th Ave. Suite 100
Eugene, OR 97401

Dear Mr. Waltz,

Subject: Upper Yaquina River Watershed Total Maximum Daily Loads
Rule Advisory Committee Comments

We offer the following high-level comments on the draft Upper Yaquina River Watershed Total Maximum Daily Loads (TMDLs), particularly as related to the potential fiscal and economic impacts of the TMDLs on Weyerhaeuser Company, as a stakeholder within the private timber industry. Because this is currently the only comment period afforded during the Rule Advisory Committee (RAC) process, this letter addresses several technical issues that have the potential for fiscal and economic impacts on the timber industry. We also renew our request for an additional opportunity to provide further comment as part of the RAC process, in advance of the public comment period, ideally after the draft TMDL documents are available for review.

Effective Shade Model.

DEQ has identified a need for a 76% reduction of "solar radiation loading capacity" based on what DEQ describes as "insufficient height and density of riparian vegetation" associated with nonpoint sources. Based on the information provided by DEQ to date, this target reduction likely overstates the need due to an inaccurate assessment of baseline.

Based on our preliminary understanding of DEQ's approach, the model that the agency intends to use for "effective shade" does not take into account topographic shade. The impact of topography on shading has been known and studied for several decades (Dubayah and Rich 1995). Not accounting for topographic shade results in an underestimate of current shade levels, particularly in the upper (steeper) portions of the watershed where private forestry operations are concentrated. In these upper reaches, steep banks can provide substantial shade--especially for small, non-fish streams.

We encourage DEQ to strengthen the TMDLs and reduce the possibility for arbitrary reductions being assigned to nonpoint sources by ensuring that any “effective shade” modeling include topographic shading. Perhaps a solar radiation model such as Penumbra (Halama et al. 2018) would be a better approach to be able to capture the shade provided by topography in the Upper Yaquina Watershed. In the absence of an appropriate model, the inflated reductions could result in unnecessary economic impacts.

Field Verification of Stream Permanence

DEQ's shade model is applied to all perennial streams in the watershed. Our understanding is that DEQ is using the high-resolution National Hydrography Dataset (NHD) to estimate the perennial stream network in the Upper Yaquina. We encourage DEQ to include field verification to calibrate the dataset to the perennial stream network in the Upper Yaquina watershed, since stream permanence classifications are known to be highly variable/inaccurate for headwater streams in the Pacific Northwest (Hafen et al. 2022). For example, Fritz et al. 2013 found that high-resolution NHD was only 40% in agreement with actual field conditions in headwater streams in western Oregon, with a tendency to over-estimate perenniality classifications.

Phosphorus Modeling: Bioavailability.

DEQ's phosphorus modeling only considers total phosphorus and treats all sources of phosphorus (sediment, manure, etc.) the same with regards to its forms, bioavailability, etc. of phosphorus. Studies going back several decades recognize the difference in bioavailability between different forms of phosphorus in freshwater (Boström 1988). By only considering total phosphorus, and therefore treating all forms of phosphorus the same with regards to bioavailability, the phosphorus modeling that DEQ has developed is potentially unreliable and overestimates the ecological impact of sediment-associated phosphorus.

Bioavailable forms of phosphorus are the most impactful on aquatic vegetation and algal growth. Phosphorus amounts/forms in manure can be affected by the animal's diet (Dou et al. 2003), but numerous studies have shown that the majority of total phosphorus found in manure is bioavailable. For example, Li et al. 2014 found that 87% of total P in dairy manure was in a bioavailable form, and Ajiboye et al. 2004 found that 70% of dairy manure was bioavailable (extractable in H_20 or $NaHCO_3$). Manure is often considered to have ~90% of the bioavailability of commercial phosphorus from a fertilization standpoint (Zhang 2017).

In contrast, particulate phosphorus (PP) associated with sediment has been shown to be mostly not bioavailable. For example, Ellison and Brett 2006 found that PP in runoff was only 20% bioavailable; Abell and Hamilton 2013 found that only 25% of stormwater PP was bioavailable under oxic conditions; and algal assays conducted by Prestigiacomo et al. 2015 showed that PP in various streams was only ~10-20% bioavailable.

Phosphorus Modeling: Sediment Parameters.

The sediment parameters that DEQ used in the phosphorus modeling are not derived from data within the Upper Yaquina but are instead from the Willamette Basin. The propriety of the Willamette Basin as a proxy for the Upper Yaquina in the context of sediment/runoff is unclear given the substantial differences in size, land use, and geology between the two watersheds. Phosphorus concentrations in sediment can vary substantially based on differences in geology and/or land use (Kreiling et al. 2019, Fiedler et al. 2021).

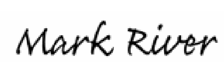
At a minimum, the TMDL should explain in detail why the Willamette Basin is a reliable proxy. Ideally, the phosphorus modeling would be based on data taken directly from the Upper Yaquina.

Private Forestry

We support the statement in the Draft Fiscal Impact Statement that "a mix of existing practices" and "voluntary measures," with the assistance of financial incentives, would be favored for water quality improvements associated with non-federal forestlands. This approach is particularly appropriate in light of the benefits expected from the historic, collaborative effort in the Private Forest Accord (PFA), which are not currently reflected in the draft TMDL. Focusing on existing practices, as modified by the PFA, will appropriately incorporate the recent significant changes in the private forestry sector, while voluntary measures and financial incentives will allow for innovation and creativity to further benefit the Upper Yaquina.

We look forward to working collaboratively during the development of the TMDL implementation plans addressing private forestry, and reserve comment on the potential economic and fiscal impacts that may be presented during this process.

Regards,



Mark River
Hydrology Scientist, Weyerhaeuser

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