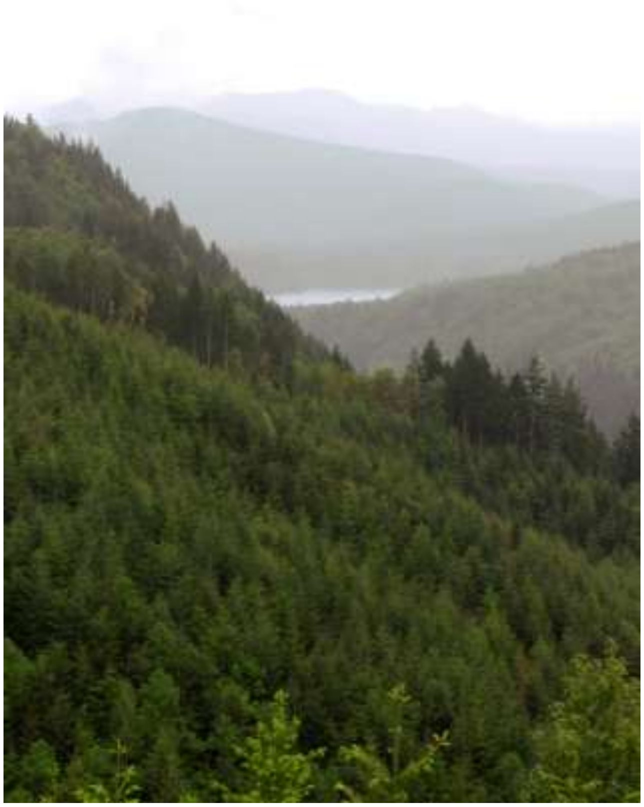
NATURAL RESOURCES

Watershed Services Transaction Demonstration Project: Final Project Report



2011 Watershed Protection and Restoration Grant

ECY G1200439/ DNR 12-284

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WASHINGTON STATE DEPARTMENT OF
Natural Resources
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Introduction

This report has been prepared in fulfillment of a condition of a financial grant to the Washington State Department of Natural Resources (DNR) from the Department of Ecology using federal National Estuary Program funds (ECY G1200439/ DNR 12-284). The grant constituted partial funding for DNR's Watershed Services Transaction Demonstration Project, conducted from 2011-2013. This report supplements a January 2013 project report to the Washington Legislature, called for by 2010 legislation. That Legislative Report is attached in Appendix A.

The purpose of DNR's demonstration project has been to further the goal of retention of forest cover and working forest lands in Washington by contributing to knowledge of, and experience with, innovative market-based policy tools supporting Payments for Ecosystem Services (PES). DNR's intent has been to create tangible evidence about real examples of market-like relationships among buyers and sellers of ecosystem services. Ecosystem services may include provision of clean water, healthy watershed functioning, biodiversity, and carbon storage, among other examples. A gap in the growing experience with PES transactions is the scarcity of examples of actual transactions involving private forest landowners as sellers of these services in the Pacific Northwest. Following advice from experts in this field, DNR designed its demonstration project specifically to test whether public water utilities, such as drinking water providers or stormwater management agencies, would be willing to expend utility funds as payment to upstream private forest landowners. Payments to induce discretionary actions by those landowners would serve to protect watershed characteristics and functions directly related to the water utilities' missions.

DNR undertook this demonstration project in concert with many partners. Specifically, the project was focused on two pilot watersheds, the Snohomish and Nisqually, and DNR worked with pilot teams in both watersheds. In the Snohomish watershed, DNR worked with staff of Snohomish County's Surface Water Management Agency (SWM). In the Nisqually watershed, DNR worked with a consortium of groups that included the Nisqually River Council, Nisqually Land Trust, Northwest Natural Resource Group, Swedeen Consultants, Earth Economics, and staff from City of Olympia Public Works. Other project partners included the University of Washington's Northwest Environmental Forum, U.S.D.A. Forest Service's Pacific Northwest Research Station, the Environmental Protection Agency, the Washington State Department of Health Office of Drinking Water, Washington State Department of Ecology Stormwater Program, Portland State University, the Willamette Partnership, World Resources Institute, Forterra, Washington Forest Protection Association, and Washington Environmental Council.

Thanks to the Ecology grant, DNR was able to play a leadership, staff coordination, and support role for the pilot projects, develop a website and project informational materials, pass through funds for, contract for, directly provide a variety of technical information to the pilots for their consideration in evaluating potential PES transactions, and provide overall project reporting. This specific, grant-funded work is described in Section 1 of this report, and in the January 2013 Legislative Report. Specific grant-funded project reports are included as appendices to this report. Project partners, using other funding sources, contributed a great deal of additional effort toward the pilots and the overall demonstration project, that is touched on but not comprehensively reported in this document.

Section 2 of the report builds on the January 2013 Legislative Report by describing a number of "lessons learned," based on grant-funded activities. These lessons are a core outcome of the demonstration project, along with the direct experience gained by all project participants.

Section 3 of the report, also expanding on the Legislative Report, provides some suggestions for moving forward with watershed services transactions and other PES activities aimed at retaining forest cover and working forest land ownership, based on the experience and lessons from this demonstration project and other experience in this field. The suggestions are organized in two future scenarios, one more cautious and one more ambitious. The Legislative Report also includes recommendations for legislative action.

Based on all activities conducted to date as part of this demonstration project, both Snohomish County and City of Olympia continue to evaluate prospects for undertaking watershed services transactions with one or more private forest landowners on a pilot basis. It is currently uncertain whether either entity will decide to proceed with a transaction. Meanwhile, the demonstration project has fulfilled its primary goal of providing substantial information and experiences to inform further development of PES activities, especially those involving water utilities as key drivers. For example, as the project developed, City of Olympia Public Works was updating its Land Acquisition Strategy, especially with regard to its new McAllister Wellfield, and welcomed the innovative opportunities presented by this project, especially its encouragement to consider less-than-fee acquisition of property interests in its wellhead protection area. In the Snohomish watershed, SWM has been developing a Snohomish Basin Protection Plan, in which the hydrologic modeling and other technical work funded through DNR's demonstration project will play a role. Other project partners interested in PES more generally have contributed to project activities, gained productive experience and insight, and have helped shape this project report.

Section 1 - Project Tasks

The following is a summary of all project work funded by the Ecology watershed grant. Most of this summary has been included in previous quarterly project progress reports. The summary is arranged according to the major tasks specified in the contract associated with grant funding.

Task 1: Project Administration - $80,400 (in concert with Project Leader)

Prior to initiating administrative roles with individual pilot teams, DNR's Project Leader carried out various foundational activities for project development. Such activities included assembling an internal DNR project steering committee, which met on a bi-weekly basis throughout the grant period; conducting weekly calls with an ecosystem services markets advisor, who assisted with project background research; reviewing literature that provides findings and lessons learned for relevant application; and developing a project resource library. Prior to project initiation, the Project Leader hired a Project Assistant, who received initial orientation and ongoing guidance. Over the course of the grant, the Project Leader, Project Assistant, and DNR support staff have remained on schedule with the completion and submission of all grant related paperwork, including four quarterly progress reports, as well as FEATs reports.

In concert with the Project Leader, the Project Assistant has been in charge of planning, communications and day-to-day operations. The Project Assistant supported pilot project managers and teams by providing general guidance, maintaining and integrating project plans, tracking and reporting overall timelines and progress, and planning and scheduling resources. These functions ensured that the projects were carried out in compliance with the EPA's federal grant guidelines.

DNR and Snohomish Surface Water Management co-drafted an interagency agreement to establish appropriate metrics for assessing the delivery of the target ecosystem service. Agreements were also executed for McAllister aquifer modeling by the U.S. Geological Survey. Project staff also drafted individual work plans for Snohomish and Nisqually buyer economic feasibility studies.

A group of active, self-identified and mutually acknowledged participants and observers functioned as an advisory group for the project, largely as an outgrowth of the University of Washington's Northwest Environmental Forum. DNR provided stakeholders and experts various opportunities to review and contribute to project progress. Over the course of the project, two Northwest Environmental Forums were held at the UW School of Environmental and Forest Sciences. Following the initial Forum, DNR coordinated with project teams to schedule regular watershed team meetings, which resulted in task lists. In addition to the bi-weekly Nisqually team meetings, which were co-organized by DNR staff and held at DNR's offices, the Nisqually team invited a group of stakeholders to participate in quarterly advisory committee meetings. DNR staff also participated in various meetings with Snohomish County partners and other organizations in King and Snohomish counties. DNR staff participated in a presentation introducing the project to the City of Olympia's Utility Advisory Committee. DNR also coordinated the development and production of fact sheets for both pilot projects.

DNR staff communicated with State and Federal agencies for policy-level support and regulatory and/or funding advice, such as reviewing and commenting on draft products and progress reports. This included consultation with the Watershed Characterization Technical Assistance Team at the Department of Ecology, as well as ongoing coordination with the Drinking Water Program at the State Department of Health, and the Stormwater Program at the Department of Ecology. Project staff and partners also engaged in interagency coordination and cross-hybridization with other agencies such as EPA and U.S. Forest Service.

The Northwest Environmental Forum at the University of Washington provided opportunities for the pilot teams to discuss scientific work and to determine the needed steps for transitioning to development of protocols, metrics, and market institutional structure. DNR co-planned, co-led and co-financed Forum proceedings. DNR also jointly oversaw the completion of an initial science report for the demonstration project that was conducted and presented by a Portland State University Ph.D. student. DNR staff provided guidance to both watershed pilots on Forum content development, assisted with creating Forum PowerPoint presentations, and presented findings to the Forum audience. The Project Assistant contributed to final documentation of proceedings for the Forum website and archives.

For purposes of the demonstration project, Nisqually project partners and staff developed a guidelines document ("market protocol"), which was initially intended to be shared with the Snohomish pilot team. Although a final document on easement guidelines was completed by a Nisqually associate, the Snohomish team determined that a similar document would not be necessary at this point in the process. Instead, the Snohomish pilot anticipates contracting with an outside organization, using separate funding, to accomplish this function.

Ecosystem service markets require at least one willing buyer in order to be effective. The Nisqually pilot team worked to identify potential buyers of ecosystem services. After several meetings with water utilities throughout the Nisqually watershed, the team approached City of Olympia's drinking water program. The team quickly gained the City's agreement to seriously consider acting as a buyer of watershed services in the form of protection and restoration of forest land in the vicinity of the new McAllister Wellfield. The partnership with the City of Olympia has advanced significantly over the course of the pilot project, and the City remains committed to participating.

The Snohomish pilot project differed from the Nisqually project in several ways, but most significantly contrasted by starting off with a designated buyer – Snohomish County's Surface Water Management Agency (SWM). It was therefore not as necessary to identify buyers. In the early stages of the project, the SWM pilot team did begin conversations with the Tulalip Tribes to engage in a potential watershed service transaction partnership.

A principal task for both watershed teams was to identify potential ecosystem service sellers willing to participate in the pilot. The Nisqually team made significant progress in this task. After researching priority parcels, a land conservation expert from the Nisqually Land Trust contacted associated landowners in both the upper and lower watershed. DNR staff assisted with zoning-related research to help prioritize parcels. Funding for an ecosystem service transaction by the City of Olympia related to its McAllister wellhead protection plan was more feasible than upper watershed funding, and led the Nisqually team to pursue focused efforts in this region. The Nisqually team has identified four parcels as feasible for a transaction, and has already engaged in appraisal discussions concerning the top two highest priority parcels.

DNR staff also participated in discussions with the Snohomish technical team regarding priority parcel identification. This group researched existing salmon recovery and watershed plans, and technical reports for the Snohomish watershed, to understand current identification of watershed service scenarios and priority landownership. While priority sub-basins have been identified, the Snohomish project has yet to conduct the landowner outreach component of the demonstration project. SWM will contract these functions to partner organizations.

DNR staff initiated steps to pursue separately funded feasibility studies to identify seller costs in both watersheds. The Project Leader and Assistant conducted informational discussions with forestland transaction experts and appraisers on coordinating the necessary process to complete a seller economic feasibility study (appraisal). In both cases, pilot teams determined that an appraisal would not be possible until land parcels and sellers had been identified. While both watershed pilots have delayed this project task, they are both preparing to conduct appraisals on one or two priority parcels in the future.

Project staff and partners initially discussed a variety of innovative market institutional structures through which to complete transactions. Under parallel funding, the Nisqually pilot team prepared guidance for elements of forest conservation easements.

The Project Assistant coordinated with communications staff at DNR on the development of diverse informational presentation materials, as well as a corresponding outreach plan to disseminate materials to interested parties. DNR staff assisted pilot teams with preparation and summaries of project efforts. Initial outreach materials in the form of fact sheets and project websites were developed and shared with partners and stakeholders. The Project Assistant presented project information at an American Rivers conference in Portland, Oregon. The Project Assistant also prepared a PowerPoint presentation for the Nisqually team to present to the Utility Advisory Committee at City of Olympia. Final project updates will be added to the DNR website.

The Project Leader and Project Assistant wrote and submitted a 41-page report to the Washington legislature summarizing the two payments for watershed services pilots, which included recommendations for legislative action. The report went through a thorough internal and external review process, and incorporated comments and revisions from a total of 17 individuals. The report drew interest from several legislators, which resulted in a work session at the House Agriculture and Natural Resources Committee in mid-March 2013.

Task 2: Metric Development - $146,000

A portion of grant funds were used in both pilot watersheds to develop technical support for watershed service quantification for each of the two pilot watersheds, based on available science. For this project, DNR provided Nisqually partners with technical assistance in the form of contracted services, using grant funds.

DNR and Nisqually project partners worked together to issue a Request for Proposals for work to develop recommendations for technically sound and cost-effective metrics to allow participants to understand the forest watershed service of drinking water aquifer recharge area protection. DNR received no proposals in response to this request. Subsequently, DNR sought out qualified technical experts able to provide relevant technical support to the City of Olympia, using project funds provided by DNR.

DNR eventually developed a Joint Funding Agreement with US Geological Survey (USGS) to use an existing McAllister groundwater model to describe and quantify linkages between the forest cover and physical groundwater flow characteristics. USGS staff used a MODPATH-derived groundwater recharge and flow model to construct maps depicting changes in groundwater recharge, and wellfield capture zones, caused by possible future forest clearing, compared to retention of forest cover. The modeling shows minimal change in recharge rates resulting from forest clearing. The results developed by USGS for this pilot are considered the first in a series of necessary modeling phases in order to properly depict the complex groundwater contamination dynamics occurring in various forest management scenarios that may have a bearing on groundwater protection (See Appendix C). Meanwhile, Nisqually partners continue to consult with the City of Olympia to evaluate available scientific literature on site-specific relationships between forest clearing, soil characteristics, groundwater recharge, and, risk of contamination. The City of Olympia will use this information in making a decision on whether or not to pursue a watershed services demonstration transaction.

In the case of the Snohomish pilot, the task of metric development was conducted in-house by SWM engineering and GIS staff. Metric development was included in the terms of the Inter-local Agreement between DNR and Snohomish County, which was funded by the watershed grant. The technical team worked to help establish measurements of potential hydrologic benefits resulting from protecting forest cover. The Snohomish Pilot Project chose "flow attenuation" as the target ecosystem service, and evaluated three stream flow metrics for the pilot sub-basin, which included stream channel stability indicators, as well as habitat and biological integrity indicators. To inform the project team about the effects of forest cover on the three stream flow metrics, technical staff developed a Hydrologic Simulation Program FORTRAN (HSPF) model for seven forest cover retention scenarios within the "test" sub-basin, the Upper West Fork Woods Creek. Metric study results indicate that increased forestland conversion within the pilot sub-basin would cause an increase in stream flows, a decrease in channel stability, and a trend towards more degraded biological and habitat conditions. The results also imply that the addition of impervious surfaces to loss of forest cover would have a more dramatic impact on the three flow metrics than forest clearing by itself. The goal of establishing appropriate metrics for measuring hydrologic benefits of protecting forest cover was achieved (see Appendix B.) Modeling results will also be used in basin-wide efforts to assess hydrologic conditions and impacts to salmonid habitat.

Task 3: Buyer Economic Feasibility Analysis - $40,267

In order to assist in uncovering the strengths and weaknesses of the watershed services transaction demonstration project, DNR utilized grant funding to produce economic feasibility reports for both watersheds, intended to estimate the economic value to the "buyer" of the projected watershed service. The studies focus on relevant background research that informs the buyers and the communities they represent. They do so by evaluating the projects' potential measurable economic benefits in the form of costs avoided through securing ecosystem services, and comparing those benefits with the costs of transactions necessary to secure those services.

DNR originally expected to pass grant funds through to the "buyers," but SWM and City of Olympia requested that DNR staff conduct this analysis. DNR staff developed a study proposal and work plan that was reviewed and approved by both project teams. Project partners in each watershed assisted with background research, region-specific data collection, and general guidance. An ecological economist provided ongoing consultation and review of draft products.

The economic analysis conducted for City of Olympia's McAllister Wellfield protection program (See Appendix D) provided an understanding of the protection and filtration of the drinking water provided and, in turn, demonstrated risks to groundwater, costs of contamination and prevention, and the general relationship of forest cover to groundwater protection. In general, the study provided an analysis of the costs of improved protection via forestland conservation vs. the costs of incident response and damage remediation. The Nisqually economic study also included results from a nationwide survey distributed to members of the Association of State Drinking Water Administrators on costs of source water contamination, which was requested by a project partner at the Office of Drinking Water at the Washington State Department of Health. DNR project staff compiled survey responses into a cost summary matrix for use in the cost comparison. In general, the economic feasibility study showed that estimated costs for removing development rights from any one of the priority parcels being considered for a conservation transaction were roughly comparable to the estimated avoided costs of responding to one significant groundwater contamination occurrence, not considering either un-remediated damages from contamination or the value of the added co-benefits of forest conservation. Following precedent of other analyses, this study assumes the target contamination can originate from any one parcel.

For purposes of the Snohomish pilot, DNR staff assisted by providing an economic risk avoidance analysis that demonstrated flood risks to communities and streams, cost of flood response and protection, and the general relationship of forest cover to flood risks. The analysis included a thorough literature review on economic impacts caused by floods throughout the nation. The DNR staff completing this report contacted relevant SWM staff with expertise in flood mitigation to collect information on stormwater response and prevention costs. (See Appendix E) In general, this study showed that the estimated costs per development right removed from priority target parcels is roughly comparable to the cost of protecting one vulnerable floodplain structure from flood damage. As in the Olympia study, this comparison does not consider the value of either uncompensated flood damages or the co-benefits from forest conservation.

Although both of the reports show significant potential avoided costs through prevention in the form of watershed service transactions, the precise level of risk reduction remains unknown. Due to the lack of actuarial information regarding water quality and quantity protection, the analyses remained qualitative. Additional technical and quantitative information could be developed in the future. The two economic cost comparison studies have been submitted to the two “buyer” entities to assist in budget analyses related to possible watershed service transactions.

Section 2 – Lessons Learned

The January 2013 Legislative Report touches on eleven specific issues and associated lessons evident at the time of that writing. These issues related to the scientific and regulatory foundations for ecosystem services, the appropriate policy niche for a payment mechanism for securing ecosystem services, the need for broader mobilization and linkage of potential participants and financial resources, the development of needed transaction systems, and expanding to a larger scale (Appendix A, p. 24-37). Additional observations and lessons can be linked to the tasks funded by this grant.

Lessons from Task 1: Project Administration

Pilot Organizations Structure – Based on the different approaches taken by this project's two pilot efforts one tentative conclusion can be drawn about necessary participants for a successful Payment for Ecosystem Services (PES) demonstration, as well as a full-scale program: a broad range of organizational capacities and professional skills is needed to proceed toward a well-considered transaction in an expeditious way. For the Snohomish County pilot, the principal pilot entity was the Surface Water Management (SWM) Agency itself, primarily funded by the project's grant funding. SWM used in-house staff experts to carry out much of the project's analytical work described in Section 1. Although SWM engaged in numerous conversations about partnering with other organizations to conduct targeted landowner outreach and developed potential payment approaches, as of this writing, SWM has not executed contracts for conduct of this work.

For the Nisqually-Olympia pilot project, the pilot entity was a core team of non-profits and small governments, including the Nisqually River Council, Nisqually Land Trust, Northwest Natural Resources Group, Earth Economics, the Nisqually Tribe, and the City of Olympia. Except for City of Olympia and Earth Economics, these entities were funded by a grant of federal money separate from, but similar and parallel to, the grant received by DNR. DNR was a participant in both pilots, contributing project coordination, pass-through grant funding, and technical analysis, but more frequently interacted with the partners in the Nisqually-Olympia pilot.

The Nisqually-Olympia pilot project deferred to DNR for technical work, funded by this grant, to develop quantification of cause-effect relationships and associated watershed service "metrics." This work is described below under, "Lessons Learned from Task 2: Metrics Development." The Nisqually pilot core team has considerable local landowner outreach experience and prior geographic prioritization work available, and, as of this writing, has had significant interactions with target landowners, narrowing down to two landowners actively considering participation in a PES transaction. At this time, the City of

Olympia is cautiously considering a PES transaction in 2013 or 2014. For SWM, the nature and likelihood of a transaction is likely to develop only over the coming year or two. A conclusion may be that a broad range of organizational capacities and professional skills is needed to proceed toward a well-considered transaction in an expeditious way. A related conclusion is that a well-organized and funded multi-entity partnership may better supply the range of skills, motivations, and time commitments to pursue and conclude a PES transaction, rather than a single entity. However a primary "convener," with staff availability, capacity, and funding, may be a necessary component of a successful partnership. For this demonstration project, DNR played the role of "convener".

Public Outreach – Another tentative conclusion related to Task 1 is that outreach to the general public, which might generate information on public understanding of, and support for, PES, would most likely be premature in the absence of a specific proposed transaction or set of transactions. However, one factor that could contribute to buyer caution in undertaking a transaction is lack of information about public, or ratepayer, understanding and support. This paradox may be common to many innovative and conceptually challenging initiatives by public entities. The Nisqually core team conducted significant outreach to a variety of potential project participants, particularly potential buyers and sellers. Project presentations were given in specialized settings such as a topical legislative committee, a topical conference, and topical advisory committees. In the future, SWM, City of Olympia or other potential buyers of ecosystem services will likely choose to focus general public information and outreach on specific proposed ecosystem service transactions so as to provide an explicit example of an otherwise highly abstract concept. Public understanding of and support for PES will likely be essential to any large scale undertaking of this conservation tool. One of the primary purposes of demonstration projects is to help address the paradox noted above.

Target Types of Forest Landowners as Sellers – This demonstration project originated, in part, from an interest in perpetuating forest management on large commercial forest land ownerships – for example, those owned by Timber Investments Management Organizations. However, the project did not readily find a match in either pilot watershed between property interests that potential buyers were most interested in acquiring, and those that large forest landowners were interested in selling. This in part reflected the more "downstream" focus of the water utilities that emerged as active potential buyers. This also resulted from large landowners' concern for the future land market-liquidity of large forest parcels subject to obligations associated with an ecosystem service transaction, such as a rate-of-harvest restriction. In both pilot watersheds, owners of smaller forest land parcels located in sub-watersheds in more downstream portions of the total watershed were identified as the highest priority potential sellers of watershed services. This focus could tend to drive a potential future watershed services transaction program toward a pattern of more individual transactions with sellers less familiar with complex transactions. However, this type of seller may also be more vulnerable to market pressure to convert land to non-forest uses. (Also see Issue/Lesson #8 in January 2013 Legislative Report.)

Marketplace Structure – A final conclusion related to Task 1 relates to the choice of "marketplace" structure. Early project planning included expectations for development, albeit on a demonstration basis, of novel ways of bringing together potential buyers and sellers to explore and negotiate the possibilities and terms of a mutually advantageous transaction. A "reverse auction" is one example of what was envisioned. Ultimately, the Nisqually-Olympia pilot, where an early transaction is more likely, used outreach to individual landowners in hopes of one-on-one negotiation of a forestry conservation easement. A working forest conservation easement represents a novel extension of the traditional conservation easement, and is emerging in Washington State as a likely underpinning of ecosystem service transactions. In the Nisqually-Olympia pilot, where a broad pool of potential lands for protection was already identified, an active approach to individual landowners was most efficient. It remains to be seen whether more comprehensive and generic marketplace systems, such as a standardized credit bank, can be shown in practice to have advantages at a larger scale, compared to the separate development and execution of individual transactions. In the absence of a broad-scale regulatory driver, payments to individual landowner-sellers may remain the most feasible transaction mechanism. This is especially true where the pool of potential sellers is relatively small and geographically confined. Both "marketplace" development and aggregating individual landowner transactions most likely will entail major up-front effort, especially where long-term commitments are being made.

Lessons Learned from Task 2: Metric Development

In the January 2013 Legislative Report, a key lesson learned related to the challenge of developing locally-relevant technical understanding and acceptance of the relationship between discretionary forest landowner actions and the secure delivery of valued watershed services to downstream beneficiaries. One element of that general challenge is the development of "metrics" – specific quantitative measures of physical watershed characteristics directly reflecting the deliberate provision of intended services. The nature of metrics continues to be an important element of the project that needs ongoing consideration.

Development of metrics is subject to a number of confounding considerations. One is the departure of real-world ecological systems, including watersheds, from a single cause-single effect model of causality. Watersheds instead encompass complex networks of multiple, interactive causes, and multiple, interactive benefits. Another complicating consideration is the natural variability of ecological systems and the added superimposition of unpredictable effects from climate change. Finally, establishment of useful metrics is subject to the classic upstream-downstream conundrum that affects the establishment of monitoring programs, setting of regulatory standards, or developing programs of best management practices. In general, upstream features may be remote from desired downstream benefits, but are more easily targeted and measured. Meanwhile, downstream features may be of more interest, but are affected by multiple factors besides a single upstream cause, and may also be difficult to measure.

In the case of the Nisqually-Olympia pilot, initial DNR efforts to contract for metric development failed when no proposals were received in response to a very detailed Request For Proposal. Subsequently, the United States Geological Survey (USGS) has partnered with DNR to provide specific modeling of the aquifer beneath the McAllister Wellfield. Their analysis examines whether modeled inputs, including extent of forest cover, are related to model outputs such as aquifer flow dynamics, and therefore could possibly contribute to metric development. The results of this modeling suggest that physical flow characteristics of this large aquifer are fairly insensitive to changes in forest cover on lands overlying the aquifer. This modeling did not attempt to directly examine the interactions between land use, forest soils, and aquifer contamination potential. Future work to link additional modeling to the model of groundwater flow could be undertaken using available tools. This additional work was beyond the funding and time limits of this demonstration project. Pilot project team members have also done independent literature review related to forest-groundwater relationships that might reveal appropriate metrics. Water quality of drinking water pumped from the aquifer may be influenced by the size and dynamics of the entire aquifer, the extent of intact forest soils above permeable substrates, forest cover, land uses which result in chronic nitrate pollution of groundwater or increase the use of hazardous chemicals, the management and control of chemicals, and the actual incidence and location of and immediate response to chemical spills. Any or all of these factors could be the focus of metric development and of requirements negotiated with sellers of watershed services.

In the Snohomish County pilot, SWM technical staff used Hydrologic Simulation Program – FORTRAN modeling to explore the relationship of percent forest cover and percent impervious surfaces in a sub watershed to several model outputs that could be used as stormwater flow metrics – stream channel stability, relative stream power, and high pulse count. Because the model was not calibrated, possible regulatory requirements were not modeled, hydrologic parameters were generalized, and due to other input limitations, the results revealed important trends and relationships but not accurate results or reliable thresholds. Model results confirmed conclusions about relationships between forest cover, impervious surface coverage, and the selected output parameters. Further metric development for the Snohomish pilot could address the modeling limitations in this demonstration project.

Conclusion – Considerable useful work on metric development, as intended, has been completed for the pilots as part of this demonstration project. While further development of technically reliable metrics is clearly necessary for broader-scale adoption of PES programs, the exact nature of needed metrics will depend heavily on the legal and policy context. PES activities engaged in as part of or in lieu of highly regulated activities where precise downstream performance is of great significance will need a different approach to metrics than activities that are based on a clear but more general understanding of upstream – downstream relationships. The more general approach may also reflect a sense of urgency associated with public objectives for retention of working and conservation forest lands threatened by land use conversion pressures.

Lessons Learned from Task 3: Buyer Economic Feasibility Analysis

A limiting factor for using PES as a tool for forest retention in watersheds, recognized by those most experienced in PES, is active participation by potential buyers who might benefit from watershed services, such as water utilities. Consequently, gaining active participation by water utilities has been a major objective of this demonstration project. Therefore, as a fundamental early activity, the project partners approached local water utilities about their interest in participation, gauging the utilities' sensitivity to the potential benefits of PES transactions. These benefits can, in part, be understood in terms of potential metrics, as discussed in the previous section. Benefits also have an economic dimension that ought to be of interest to utilities as potential buyers. That is, what is the price in payments to forest landowners of securing a meaningful level of benefits, and how does that price compare to the economic value to that utility of the benefits so secured? To address this question, the grant for the project included funds for "economic feasibility analyses" focused on the potential buyers, Snohomish County and City of Olympia. This analysis was conceived of as a 'with/without' cost comparison, comparing costs of PES to projected avoided costs of responding to watershed challenges intended to be addressed by PES. These challenges could include drinking water contamination in the case of Olympia, and flood risk in the case of SWM.

DNR expected to pass grant funds through to the respective local governments for in-house or contracted analysis. Both SWM and City of Olympia, in the absence of skilled, in-house economic analytical expertise or staff capacity for contract administration, preferred to have DNR directly provide this analysis. In addition, City of Olympia had previously made preliminary policy level decisions to pursue acquisition of land as a drinking water source area protection strategy, and so already had achieved at least an intuitive understanding of a favorable relationship between costs and benefits. In this case, benefits were understood to be additional increments of risk reduction for an already "safe" water source, not direct prevention of imminent contamination. Meanwhile, SWM was already considering a significant evaluation of the level of utility rates, revenue generated, and the services provided or potentially available. This larger evaluation is more pressing for SWM than the specific cost comparison for a demonstration PES transaction. In consideration of these preferences and contextual factors, DNR used project staff, working with project partners, to produce cost comparisons tailored to the needs of City of Olympia and SWM. (See Appendices D and E.)

One issue faced in this economic cost comparison was scale. How could the scale of risk reduction in a watershed be matched to the level of benefit sought by the water utility acting as PES buyer? This is obviously of interest for a demonstration project. But even in a more programmatic approach, is there a threshold level of watershed protection that needs to be achieved before the desired benefits are delivered? On the one hand, such a threshold, perhaps a maximum level of impervious surfaces allowed, seems relevant for stormwater protection benefits. On the other hand, any reduction in risk of chemical spills potentially contaminating a drinking water aquifer would appear to have value, even the reduction of risk resulting from a single transaction. DNR's cost comparison treated these contexts separately. In the case of the McAllister Wellfield source area, each potential transaction was treated as relevant to the avoided cost of pollution or spill response.

To the extent that a full-scale watershed protection program is needed to secure a desired level of benefit to a water utility, a rational utility may seek to spread the costs of such a program beyond its own ratepayers, especially where forest protection provides multiple benefits. For example, this spread of costs could include acknowledging and supporting parallel forest retention programs like Snohomish County's recently adopted transfer of development rights program. This could also include attempting to mobilize other potential beneficiaries of environmental services –watershed services, carbon storage, biodiversity, or other services –to join in the payment effort so as to achieve the needed scale more efficiently. Both City of Olympia and SWM pilot utilities are considering such spread-the-cost strategies in order to move past a demonstration phase.

This project's economic analysis has helped both pilot entities think carefully about PES transactions and programs. This beneficial result has been more indirect than originally envisioned for the project, revealing that potential cost and potential avoided cost are two among many considerations in a decision to pursue PES as a buyer. Future work could seek to both sharpen economic analysis and deepen understanding of the role of such analysis in a PES program.

Section 3 – Moving Forward

As described in Section 1, the demonstration project has substantially completed the tasks called for in the Department of Ecology grant agreement. The fundamental purpose of the project has been to investigate the willingness of, and requirements for, water utilities to engage as buyers in payment-for-watershed-services transactions with forest landowners. Accordingly, the project has provided grant funding for technical analyses, specific in-house analytical products, project oversight, coordination, and support, a forum for discussion (in concert with the Northwest Environmental Forum), and preparation of reports, a website, other documentation and project materials. It's always been understood that the pilot projects' potential buyers, SWM and City of Olympia, would make the decisions about whether and how to engage in transactions. As of this writing, neither entity has done so. Continuing to support potential buyer decision-making is the most immediate future phase of the overall work, subsequent to the conclusion of DNR's grant-funded involvement.

DNR and project partners can encourage, support, and participate in further discussions with SWM and City of Olympia to assist those entities in formulating and concluding decision-making regarding pilot transactions. Determining additional technical, financial, or networking support that may be needed is a clear next step, along with discussions leading to providing that support. It may be that a relatively modest additional investment in technical or financial information, or additional coordination with regulatory agencies or others, would lead to final decisions on transactions.

For both SWM and City of Olympia, partnering with other potential buyers or funders appears highly desirable from the financial, accountability, and public outreach perspectives. It may be that water utilities will typically be reluctant to act as sole buyers seeking to secure forest watershed services that appear to have multiple benefits, especially where the costs are significant. A consortium of willing buyers pursuing multiple benefits, and able to satisfy technical, regulatory, and financial requirements, may be a more successful model to test in future demonstrations, and may better accomplish transactions at a larger scale.

Future Scenario #1: Continuing Demonstrations

Based on the outcome of this demonstration project to date, one future scenario contemplates a more cautious approach from water utilities not yet ready to engage in a watershed services transaction. This scenario would continue, on a demonstration basis, to seek potential watershed service circumstances most conducive to actual transactions in order to reveal the most appropriate niche for this type of action. Meanwhile, it would be wise to continue actively pursuing the full range of other methods of addressing the loss of forest land to development.

In this scenario, additional networking would be needed to reveal the most promising circumstance, perhaps still centered on water utilities (such as drinking water providers or stormwater management entities), but expanding to include or emphasize other clear beneficiaries who may have financial resources to participate. In the near term, likely buyers are probably those operating in a regulatory environment that provides them significant leeway for independent action. In such a case, scientific, financial, and legal requirements may be manageable – sufficient to provide conceptual rationale for a transaction, but not expected to demonstrate quantifiable certainty about benefits received. Even so, close partnerships with regulatory, science, and funding entities will be crucial at or above the level achieved in the current demonstration project. The extensive networking in this future scenario is consistent with the long history of local watershed planning in Washington, and may provide a more explicit context with state watershed statutes.

Landowners of smaller or larger forest parcels, either private or public, with discretionary authority over providing the target service or services could serve as potential watershed service sellers in this scenario. This project has demonstrated that any forest landowner will have a set of opportunities and constraints operating on their motivation to enter watershed service transactions. Particularly, as concluded in Section 2, large commercial forest landowners have land liquidity concerns constraining their willingness to encumber land title, short of a full property sale. However, individual cases may exist where a successful transaction can be structured with mutual benefits. Transactions could be with single or multiple sellers, and intermediaries between buyers and sellers, such as aggregators, may be a prerequisite.

As recommended in the January 2013 Legislative Report, it would be helpful encouragement to provide general legislative authorization for water utilities and other potential buyers to engage in payments for ecosystem services to achieve their mission.

Public and stakeholder outreach driven by potential buyers should be a more prominent activity in this scenario, both as a reality check for the substantive aspects of potential transactions, and to build understanding and support for future development of ecosystem service programs.

Meanwhile, those interested in containing urban sprawl and retaining working forests in the face of conversion pressure should continue to concentrate on other, perhaps more traditional policy approaches, as exemplified by the recent major development rights transaction between King County and Hancock Timber Resource Group. Public ownership of high priority lands should also continue to be pursued, for example through DNR's recent authority to establish Community Forest Trust lands, and through certain components of the Washington Wildlife and Recreation Program. Land trusts will continue to play a major role, too. Regulatory authority, such as is embodied in state stormwater permits and local growth management programs, will also be a crucial element. Ecosystem service transactions would be seen as one potential method among others in the pursuit of forest retention goals. Ecosystem service transactions have the added benefit of explicitly addressing the forest management practices needed to secure those services, beyond merely removing development rights.

Future Scenario #2: Ambitious Program-Building

A more confident and ambitious future approach might be pursued, either building on the successful completion of demonstration transactions resulting from this project, or based on strong conclusions that can be drawn from the absence of demonstration transactions.

In the former case, a central role for water utilities might be confirmed, acting either alone or with partners. This pathway would be similar to Scenario #1, but acting more quickly to find additional transaction opportunities that build on those of this demonstration. Leadership and coordination could either continue to be decentralized and entrepreneurial, or could be grounded in state water regulatory agencies, utility or local government associations, or an entity such as the Puget Sound Partnership. DNR's ongoing role would most likely be grounded in its technical service relationship to non-industrial private forest landowners. If granted necessary authority and funding (as described in the January 2013 Legislative Report), DNR could provide technical support to forest landowners who wish to sell ecosystem services, and could coordinate with other organizations supporting water utilities. This role would be consistent with DNR's 2010-2014 Strategic Plan goal to preserve forest cover and protect working forest lands from conversion. A key consideration in this pathway would be achieving economies of scale through more aggregated transaction mechanisms, rather than being so dependent on high cost single transactions. If efficiency gains seemed achievable, scientific, financial, and legal analysis and justification could also be pursued in a more aggregated manner, though still centered on water benefits to utilities.

In the latter case under Future Scenario #2, more definitive action would be triggered by the confident conclusion that a marketplace with water utilities acting as single watershed service buyers is not likely to be a successful approach to generating ecosystem service benefits or addressing conversion of working forests at a necessary scale, and therefore a different approach is clearly indicated. That different approach could originate at the policy level rather than by accumulating individual demonstration transactions. It would be based on a view of the relevant ecosystem service marketplace as one that encompasses the aggregate of multiple services, with the general public as the beneficiary. In this case, teasing out specific services to specific beneficiaries would not be the primary concern, so some of the scientific, financial, and legal burdens based on those distinctions would be relieved.

In this pathway, the critical activities would be program building, and the critical questions would be political, budgetary, and institutional. How would sufficient support be mobilized at the state legislative level to enable policy making to establish ecosystem service institutional mechanisms? How much and what kind of funding will be needed, where will revenue come from, and what kind of authority would need to be created to ensure that revenue? How would program delivery be organized, at what geographic and jurisdictional scale, and with what relationship to existing institutions? How will choices be made as to how available funding is used to secure ecosystem services, and what processes would landowners need to adhere to in order to participate?

One version of this programmatic approach is occurring now through the work of WRIA 9 (Green-Duwamish Watershed) in the central Puget Sound area to advance the idea of a Watershed Investment District as a new form of special purpose district. In theory, this mechanism could mobilize the value that the general public in the district receives from watershed and other ecosystem services. The resulting resources could be focused on a program of ecosystem service protection and enhancement measures, including retention of working forests. This idea has received initial legislative review through a draft bill and committee work sessions.

The Watershed Investment District may have its best application in urban or urbanizing areas that already enjoy the healthiest tax base. In more rural watersheds, other programmatic models may be more appropriate. Larger public conservation funding pools have been shown to be feasible and effective in both the salmon recovery effort and the Washington Wildlife and Recreation Program. A larger-scale approach could permit action at a necessary scale, and could lead to simpler and timelier transactions that overcome the “transaction fatigue” often associated with complex transactions and cases.

In a programmatic approach such as this, DNR’s role could range from central to peripheral. Most likely, DNR would participate through contributing technical expertise where needed, and acting as a manager of state-owned trust lands and other lands that might participate in an ecosystem services program. This role is also compatible with DNR’s Strategic Plan goals.

In this version of Future Scenario #2, the new programmatic approach could become the centerpiece of ecosystem conservation efforts. In that case, productive and wide-ranging discussions would be needed about the implications for other existing resource conservation programs at the local, state, and national levels.

Conclusion

The results to date from this forest watershed services demonstration project offer both encouraging and discouraging prospects for using ecosystem services payments as a conservation tool in Washington. Encouraging results have been the identification of promising jurisdictional and geographic contexts for transactions, gaining active participation by water utilities, production of substantial relevant reformation that will contribute to utility decision-making, and the possibility that a demonstration transaction will actually occur in a way that meets utility and landowner objectives while building momentum toward broader applications of this tool. Discouraging results include the disinclination, so far, by the two pilot utilities to execute a transaction through this project, with signs pointing toward a conclusion that, at the needed scale, with the likely costs and likely benefits, it may be prudent for water utilities to find partners, additional fund sources, greater regulatory encouragement, and additional transaction tools before proceeding.

For those primarily interested in PES on a systematic basis, this demonstration project offers a useful body of information, experience, lessons, and results that can contribute to further development of PES in the region. For example, constraints on individual commercial forest landowners' participation, and on individual buyer capabilities, may point toward PES systems that can aggregate both buyers and sellers.

For water utilities and their regulators and stakeholders, this demonstration project has indicated some of the circumstances in which watershed service transactions may be a valuable method of contributing to utility goals when used in combination with other traditional and innovative tools. For example, PES may be one way to proactively control, in advance, the extent of impervious surfaces in a watershed or the storage of hazardous chemicals on land above an aquifer, in addition to regulating development after it is proposed.

For forest landowners, this demonstration project indicates some of the challenges to realizing a financial benefit from PES programs. Within a market-like context in which funding appears to be the limiting factor, forest landowners face technical challenges and transaction costs, as well as the likely need to offer real land use or land management commitments in order to secure a transaction. Larger landowners offer advantages of scale and sophistication to potential buyers, while smaller landowners may offer desirable proximity to the locations in a watershed where the service is sought.

For DNR, the demonstration project has been a chance to pursue an important strategic goal of protecting working forests and forest cover. Close coordination with water utilities takes DNR somewhat outside its more typical jurisdictional areas. However, with a clear interest, broad stakeholder networks, grant funding and staff capacity, DNR has been able to play a useful convening, coordinating, and technical information-providing role. DNR currently lacks explicit authority or funding to play a major role as the establisher or administrator of PES systems on a programmatic basis. DNR can most likely be expected to act based on its existing roles providing services to private non-industrial forest landowners and managing state-owned forested trust lands and conservation lands, such as through the newly created Community Forest Trust. In either case, additional authority and funding may be necessary for DNR to play a major role in large scale PES systems. DNR will continue active consultation with current and new partners in charting a course forward that is consistent with DNR's mission and usefully contributes to shared conservation goals.

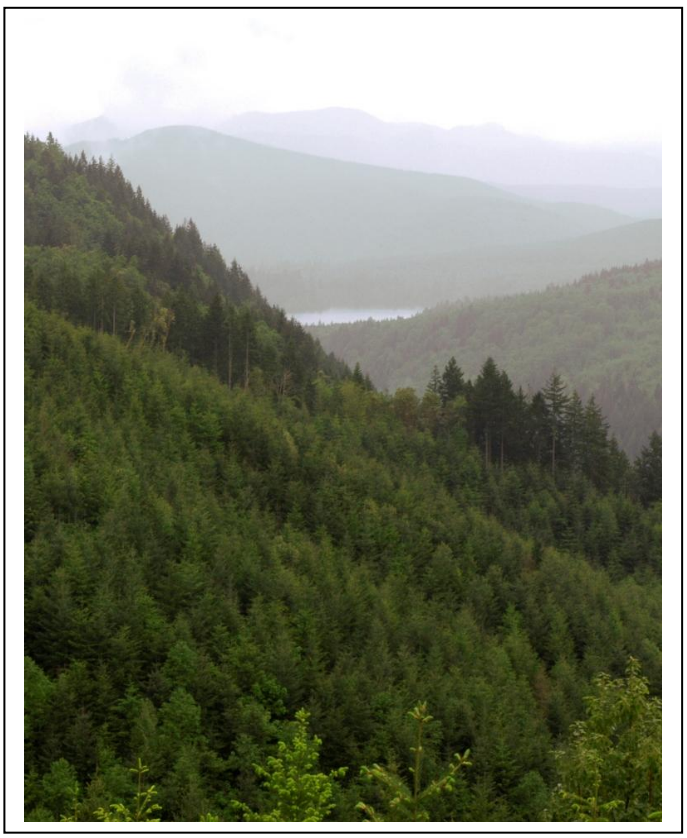
DNR greatly appreciates the opportunity provided by the project grant from Ecology, to make a contribution to this emerging conservation sector and to work with such dedicated, energetic, and public-spirited partners in the development of useful demonstration of forest watershed services transaction methods.

Appendices

Appendix A – Legislative Report

NATURAL RESOURCES

Watershed Services Transaction Project Report: ESHB 2541 (2010)



Eco-systems Services Transactions for Private Forestland Owners in Washington State: Lessons and Recommendations

January 2013

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

DNR has distributed this report to the following:

The Honorable Jay Inslee, Governor

The Honorable Brian Blake, Chair, Washington State House Agriculture and Natural Resources Committee

The Honorable Kirk Pearson, Chair, Washington State Senate Natural Resources and Parks Committee

The Honorable Dave Upthgrove, Chair, Washington State House Environment Committee

The Honorable Doug Erickssen, Chair, Washington State Senate Energy, Environment and Telecommunications Committee

Washington State Forest Practices Board

The following have received copies of the report

The Honorable Patty Murray, U.S. Senator

The Honorable Maria Cantwell, U.S. Senator

The Honorable Suzan DelBene, U.S. Representative

The Honorable Rick Larson, U.S. Representative

The Honorable Doc Hastings, U.S. Representative

The Honorable Jaime Herrera Beutler, U.S. Representative

The Honorable Cathy McMorris Rodgers, U.S. Representative

The Honorable Derek Kilmer, U.S. Representative

The Honorable Jim McDermott, U.S. Representative

The Honorable David Reichert, U.S. Representative

The Honorable Adam Smith, U.S. Representative

The Honorable Denny Heck, U.S. Representative

Eric Johnson, Executive Director, Washington Association of Counties

Kent Connaughton, Regional Forester, U.S. Forest Service

Ken Berg, Washington State Office Manager, U.S. Fish and Wildlife

William Stelle, Jr., Regional Director, National Oceanic and Atmospheric Administration

Roylene Rides at The Door, State Conservationist, Natural Resources Conservation Service

Senate Natural Resources and Parks Committee Members and Staff

House Agricultural and Natural Resources Committee Members and Staff

Senate Environment Committee Members and Staff

House Environment Committee Members and Staff

Watershed Services Transaction Project Report: ESHB 2541 (2010)

Eco-systems Services Transactions for Private Forestland Owners in Washington State: Lessons and Recommendations

January 2013

Washington State Department of Natural Resources

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Contents

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EXECUTIVE SUMMARY

This report responds to legislative direction in ESHB 2541 (2010) for DNR to provide information and recommendations regarding forest landowner conservation incentives. The legislature recognized that incentives that might result from payments for "ecosystem services" by forest landowners could support landowners maintaining their land in forestry. DNR worked with a wide range of partners from 2010 through 2012 to explore such payment systems, and launched a demonstration project in 2011 to bring about one or more "watershed services" transactions in pilot watersheds. Resulting information could contribute to development of larger-scale payment programs. Watershed services of working forest lands could include retention of stormwater, and protection and filtering of drinking water, which would exceed forest practices regulatory requirements and be relevant to the missions and capital spending plans of local water utilities. Preventing loss of working forest lands to non-forest development could be especially beneficial to these utilities.

DNR, with the help of a grant of federal funds administered by Washington Department of Ecology, worked with the Northwest Environmental Forum at the University of Washington, the U.S. Forest Service, Washington Department of Health, and other federal, state, and local agencies, tribes, and organizations, and representatives of key interests in the Snohomish and Nisqually watersheds to launch two pilot projects. During 2011 and 2012, partners worked to: (1) assemble applicable scientific information on forest-water relationships; (2) learn from nationwide experience with payment for ecosystem service projects; (3) identify the specific service scenarios important to interested water utilities in the Snohomish and Nisqually watersheds; (4) perform technical work to identify priority locations and specific forest management activities associated with the targeted services; (5) conduct outreach to forest landowners in priority locations to gauge interest in transactions; (6) conduct economic analysis to compare the value of watershed services to utilities with the landowner cost of associated forest management activities; and (7) develop draft protocols to govern pilot transactions. Through the demonstration project, the most likely potential "buyers" of watershed services from forest landowners are the Snohomish County Surface Water Management Division, interested primarily in stormwater management, and City of Olympia Public Works, interested in aquifer protection for drinking water from the City's new McAllister well field.

At the time of this report, technical studies are being completed and both utilities are actively pursuing possible transactions in 2013. In addition, discussions are continuing between the Nisqually watershed partners, industrial forest landowners in the Mashel River basin, and others, to structure an innovative conservation transaction in that basin.

A number of important lessons have emerged from project work completed thus far:

- **Scientific Information** A clear understanding of the connections between activities on forest lands and characteristics of water in watersheds and aquifers is crucial to establishing a rationale for payments for watershed services. While general information and modeling can be a suitable starting place, scientific validation will be needed for large-scale programs.
- **Relationship to Regulatory Requirements** Regulatory stability and clarity, both for utilities and forest landowners, is the best context for a functional watershed service payment system. Authorization for utilities supplementing current programs with watershed service incentive payments would advance development of these programs.
- **Conservation Niche for Payments for Watershed Services** Ecosystem service payments, even if fully developed, will not be a conservation panacea. Existing financial incentive programs for forest landowners will continue to be important, along with technical assistance and education, and public or land trust conservation land ownership. Watershed service payments may be most appropriate where there's a clear policy statement and sufficient existing scientific information, and in the middle geographic regions of watersheds, upstream from actively suburbanizing areas and downstream from publicly-owned upper watersheds.
- **Linkage of Transaction Participants and Funding** Without deliberate outreach between water utility-buyers and forest landowner-sellers, watershed service transactions are unlikely to occur. Some aggregation both of water utilities and of forest landowners may be necessary to achieve sufficient buying power and scale. Logically extending the purposes of some existing funding sources could help greatly, if the technical rationale for watershed service payments is well-established. Effective communication of this complex incentive concept to decision-makers and the public will require careful design, to simplify messages without distorting actual circumstances.
- **Transaction Models** At this early stage of development of payment for watershed services programs, transaction costs can be high, time requirements can be prolonged, and reconciling interests of buyers and sellers can be difficult. Flexibility and patience are important, and intermediaries attuned to local circumstances can play a key role. Familiar transaction vehicles such as conservation easements will probably be more useful than novel mechanisms, until case-by-case transactions can develop into larger-scale programs.
- **Expanding to a Larger Scale** The most prudent path toward larger-scale applications of payments for ecosystem services probably involves a combination of incremental accumulation of diverse individual cases and building of policy-level rules, funding, and implementation systems. Participants will need a clear "business case" that's generic enough for broad application yet can be tailored to specific situations. Also needed is better scientific understanding of the relationships between forest conditions generating watershed services and those generating carbon storage, habitat mitigation, or other multiple values.

Additionally, effort could be made to answer the policy questions raised by proposals to create a broad “ecosystem services district” as a public utility of its own, that could focus funding on landowner incentive payments at a broad scale.

Discussions among participants in this demonstration project have resulted in several preliminary suggestions for legislative action. These include:

1. Creating broad enabling authority for public water utilities to explore and engage in watershed services transactions as one means of achieving their mission, as well as broad authority and funding for natural resource agencies to participate in the development of ecosystem service transaction programs.
2. Providing funding or other support for further development of technical foundations for these transaction programs, including targeted scientific work, economic analysis, and guidance for their use in public ecosystem service transactions.

Completion of project activities necessary to enable City of Olympia and Snohomish County to consider approving specific pilot watershed service transactions with forest landowners is expected to be completed in the Spring of 2013, with approved transactions completed later in 2013. Further development of ecosystem service transaction mechanisms will depend on subsequent legislative, agency, and stakeholder discussion and decisions.

INTRODUCTION

The Washington State Department of Natural Resources (DNR) has undertaken a Forest Watershed Services Transaction Demonstration Project in order to create tangible evidence about real examples of market-like relationships among buyers and sellers of ecosystem services. These examples should generate valuable information and lessons that can be applied to a broader-scale application of the concept of monetizing ecosystem services. Many analysts, policy makers, and observers believe that ecosystems services can be the basis for large-scale market incentive systems that reward forest landowners for sustaining critical societal benefits from their lands. These landowner actions then may efficiently provide communities, public utilities, and business, industrial and development interests assurance of delivering specific ecosystem benefits or tangible credits representing such benefits. Ecosystem services may include provision of healthy watersheds, biodiversity, and forest carbon storage. Diligent efforts have been made to develop the institutional frameworks for such markets, and high-profile examples in the United States can be cited, especially involving agriculture lands. However, there have been few examples of actual transactions involving private forest landowners as sellers of services in the Pacific Northwest. The resulting scarcity of transaction evidence and real-world lessons slows progress in developing this sector. Commissioner of Public Lands Peter Goldmark launched DNR's demonstration project to help fill that gap in real-world experience, as a limited contribution to the development of "Payment for Ecosystem Services" (PES) systems. DNR is also responding to direction from the Washington legislature in Engrossed Substitute House Bill 2541 of 2010, which asked DNR to develop legislative recommendations for development of landowner conservation incentives such as ecosystem service market development that supports forest landowners maintaining their land in forestry.

This legislative report is provided in response to legislative direction in ESHB 2541 for DNR to present its research and any proposed incentives to the Legislature, Governor, Commissioner of Public Lands and Forest Practices Board. In December 2011, DNR presented a Legislative Progress Report describing the foundation laid to that point. The present report describes the substantial progress made in 2012 and the expected completion of one or more demonstration transactions in 2013. This report summarizes environmental and policy context; details the specific objectives of the demonstration project; describes relevant activities conducted in 2012, including project deliverables and documentation; identifies major issues, opportunities, and barriers, along with lessons learned; enumerates recommendations; and forecasts next steps.

DNR has undertaken this demonstration project in concert with many partners. DNR would like to thank Brian Boyle of the University of Washington College of the Environment whose several Northwest Environmental Forums devoted to this project generated valuable visibility and momentum at key milestones. The Washington Department of Ecology provided partial project funding from federal National Estuary Program funds. Much of the demonstration project work has been done by DNR's collaborators in the project's two pilot watersheds, Snohomish and Nisqually, including Terry Williams of the Tulalip Tribe, Debbie Terwilleger, Director of the Surface Water Management Division of Snohomish County Public Works and her excellent staff; Michelle Connor of Forterra; and the members of the Nisqually Watershed Pilot Core Team: Dan Stonington, Northwest Natural Resources Group; Justin Hall, Nisqually River Council; Joe Kane, Nisqually Land Trust; and Paula Swedeen, Swedeen Consulting, as well as Liz Hoenig and Donna Buxton, City of Olympia Public Works. A Scientific literature review was conducted by Jodi Schoenen, a Ph.D. student at Portland State University. A nationwide inventory of public drinking water system costs for response to spills and pollution was requested for this project by Kitty Weisman of the Washington State Department of Health, Office of Drinking Water. Thanks also go to Bobby Cochran of the Willamette Partnership, Tracy Stanton of Earth Economics, Todd Gartner of World Resources Institute and Jamie Barbour of the USDA Forest Service Pacific Northwest Research Station for their invaluable advice and comments throughout the project. This report was prepared by Craig Partridge and Nahal Ghoghaie of DNR, who take full responsibility for the content.

ENVIRONMENTAL CONTEXT

Ecosystem Services Concept and Examples

DNR's efforts to assist landowners in gaining access to additional sources of revenue for the benefits they generate from maintaining their lands in forestry are part of a widespread effort to increase understanding of ecosystem services. According to the Millennium Ecosystem Assessment (2005), ecosystem services are the flow of goods and services provided by functioning ecosystems upon which human well-being is based. Building this awareness will help governments, businesses, and the public recognize the extent of nature's value to society, which may result in improved investments in ecosystem protection.

The societal value of ecosystem service benefits, such as carbon sequestration or clean water provision, is difficult to account for in conventional economic assessments. Failure to adequately account for this "natural capital" carries with it the risk of ignoring its deterioration and loss, until a crisis occurs. The average economic planner does not consider ecosystem services as an economic investment because there has yet to be an accepted method to set a price for this form of capital, and estimated benefits may be experienced by future generations. Thus, ecosystem services are difficult to quantify. Yet, emerging research addressing these potential economic values suggests that the costs of investing in ecosystem protection may in some cases prove cheaper and more efficient than investing in new or improved engineered infrastructure. Additionally, intact forests provide services with relatively minimal maintenance costs, and may appreciate in value over time, whereas engineered infrastructure depreciates over time.

In theory, a market that accounts for ecosystem services would allow beneficiaries of healthy ecosystems' functions to pay those who voluntarily offer to manage and improve those ecosystem benefits. Payments would either be made through actual market mechanisms, or may resemble public or private direct payments to landowners. Currently, such payments are often made by means of transaction tools such as conservation easements or the lease, transfer, and purchase of development rights, or timber rights. The ecosystem services most commonly involved in PES programs include carbon storage in forests, biodiversity, and a range of watershed services important to water quality and/or quantity, including delivery of safe drinking water, and to fish habitat. When ecosystem services primarily involve water, payments may be referred to as "payments for watershed services" or PWS.

Working Forest Loss and Risk of Loss, and Accompanying Loss of Environmental Services

According to DNR's 2007 *Future of Washington Forests* report, the counties of Clark, King, Snohomish and Thurston will see the greatest loss of productive forestlands to conversion to non-forest uses.

In response to the rate of forest land conversion and the economic pressures felt by private forest landowners, the State of Washington has attempted to influence conversion patterns through legislative action. As part of this legislative trend, Engrossed Substitute House Bill 2541 establishes intent to incentivize forest landowners to maintain their lands in forestry.

It calls for evaluation of ecosystem service markets, tax incentives, easements, and technical assistance programs that may provide new sources of revenue to landowners, thereby helping forestall forestland conversion to development. The legislation defines ecosystem services markets as *"a system in which providers of ecosystem services can access financing or market capital to protect, restore, and maintain ecological values."*

Forests provide fundamental services to society, including carbon sequestration, water quality and quantity regulation, and habitat to various species. Forests in a watershed context are "living filters" that absorb excess nutrients and toxins, reduce erosion, and transform pollutants before they reach drinking water sources. Forests also soak up stormwater, which helps to protect downstream aquatic habitat and reduce downstream flooding. They also provide shade for streams that keeps water cool, which is critical to the health of salmon and other aquatic organisms. Forest conversion to non-forest land uses means the region's citizens, communities, and businesses lose vital forest watershed benefits, including water flow regulation, water purification and erosion control, as well as losses of biodiversity, recreation, non-timber forest products, and cultural values. Widespread conversion can also result in loss of timber supply and the jobs and tax revenues that accompany it.

Effect of Loss of Watershed Services on Water Utilities

As the ecological integrity of watershed ecosystems degrades, resource managers traditionally resort to engineered solutions, such as levees, water filtration plants, detention ponds, etc., to help protect water quality and quantity from negative impacts. But these structures are costly investments with high operation and maintenance costs. In 2007, New York City addressed this issue by deciding to invest in "green" versus "gray" infrastructure. In order to avoid building a water filtration plant costing between $6 billion and $8 billion, New York City opted to purchase and restore $1 billion to $1.5 billion worth of Delaware-Catskills watershed ecosystems responsible for water purification. Several US cities are following New York City's lead in successfully avoiding, delaying, or downsizing conventional filtration systems through forest watershed protection. In the recent Hurricane Sandy many public services like electricity, subways and internet were taken offline, and boil orders were put in place for many regional drinking water supplies that relied on groundwater, due to the risk of contamination. However, the New York City water supply was still working and safe to drink from the tap, due to the filtration services of the Catskills watershed.

Access to a clean water source such as a stream, river, lake or underground aquifer is essential to the health and prosperity of any community. Thus, it is not surprising that some of the most densely developed regions of the world are located adjacent to a water source. Many hazards associated with development, such as impervious surfaces, chemical spills, and microbial contamination are compromising the reliability of these water sources. Communities around the world are working to ensure their ability to supply sufficient freshwater protection and stormwater management for their inhabitants through forest protection. Municipal authorities and local governments are recognizing these important values of intact forest ecosystems.

In order to maintain the vital functions forested watersheds provide to communities, some water utilities in Washington State have begun working with watershed partners to restore and sustain watershed landscapes. Utilities providing drinking water, stormwater management, and power may be faced with the task of protecting, remediating, and mitigating vulnerable ecosystems. Washington tribes are also partners in watershed efforts, as protecting and restoring salmon resources is a top priority for tribes and Washington State. In order to meet health and safety commitments to their customers and members, such entities must research, identify, and pursue the most advanced protection measures. It is against this background that the Washington legislature has asked DNR to explore the "payment for ecosystem services" concept, and DNR has embarked on demonstration transactions as a means of testing some aspects of the concept.

POLICY CONTEXT

The policy rationale for using payments for ecosystems services, particularly watershed services, as a means of financially incentivizing retention of working forest land in forest uses generating those services, comes from two main directions, operating on sellers (forest landowners) and buyers (e.g. water utilities) respectively. These influences on policies for conservation incentives can exist alongside other policy options such as regulation, public enterprise, public ownership of lands or interest in lands, and volunteer-based stewardship.

Policy Context for Sellers

From the standpoint of forest landowners who might engage as sellers of watershed services, the primary policy context comes from the system of regulatory requirements for forestry activities, coming from the state Forest Practices Act and federal Clean Water Act and Endangered

Species Act. Additionally, land use changes involving forest lands are subject to the requirements of the system of local zoning regulations. These regulatory systems bring to bear governments' police power to protect public health welfare, and public resources from harm. Applicable regulatory requirements establish a baseline of watershed services associated with these protections. Furthermore, Washington State's forest practices regulations are designed in statute to be dynamic and evolutionary through a system of science-based adaptive management. This means that adjustments in the regulatory baseline are inherently expected to occur over time. The Forest Practices Act also calls for maintenance of a viable forest products industry. In the case of zoning regulations, considerations of fairness, vesting and grandfathering, and the need to accommodate the reality of population growth can reduce the long-term certainty of regulatory outcomes for maintaining watershed services.

The overall conclusion may be that adding an incentive component to regulatory approaches, including financial incentives, leading to contractual agreements may often be more efficient and certain over time, and lead to additional public benefits. Also, incentives call attention to the positive societal benefits provided by well-managed forest lands, in addition to the societal harms which regulations are designed to address. Inevitably, the interplay between incentives and regulations for potential watershed service sellers is complex and subject to interpretation. Policy debate results over what watershed services should be provided voluntarily in response to incentives and what should be required of forest landowners as a basic social obligation so as to avoid harms. Many participants in these debates regarding working forest land acknowledge that Washington State's current forest practices regulatory regimes related to such land are strict in relation to other states and that further guarantees of watershed services are likely to be best secured through offering incentives to forest landowners, such as payment for watershed services, for management activities that go beyond regulatory compliance.

Policy Context for Buyers

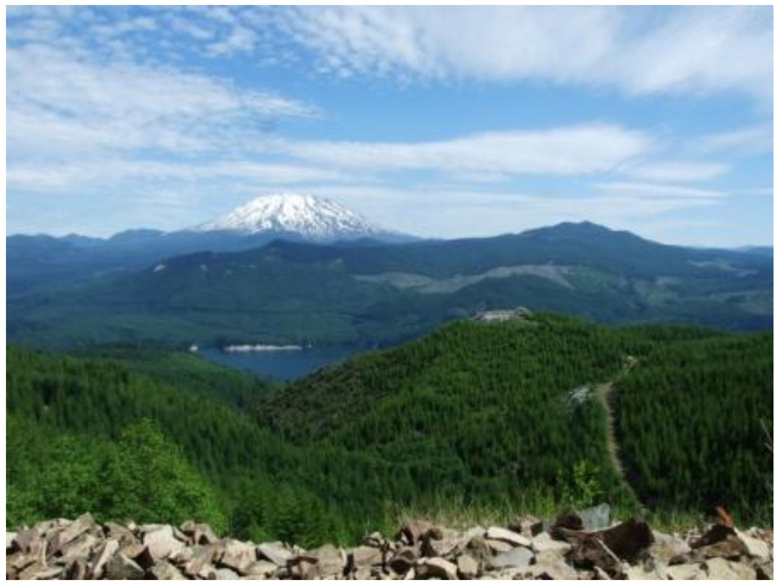
From the standpoint of the beneficiaries of watershed services who might engage as buyers of those services, there are several policy contexts. They include the core missions of public entities including agencies and utilities, such as providing stormwater management services or restoring salmon habitat. These missions, which may often be governed by state or federal regulatory requirements, could lead the entity to look for achievable benefits from watershed service transactions with forest landowners. In addition, public or private entities may have product quality objectives related to water for customers that can be enhanced through such transactions. Finally, watershed service buyers may be motivated directly by regulatory requirements to mitigate incidental harm to water resources from the buyer's actions, such as development projects, where engaging in transactions with third parties may be an attractive mitigation option. In any of these cases, buyers may also be motivated by the provision of additional "co-benefits" from potential transactions, such as biodiversity or open space. These additional benefits may or may not be relevant to the buying entity's rate-payers, decision makers, and stakeholders. Each of these policy contexts for potential buyers of watershed services have ramifications for adequate funding for watershed service transactions, and these financing considerations themselves form a crucial part of the context for proposed transactions. For example, in evaluating the credit-worthiness of public utilities issuing bonds to finance investments, bond rating organizations currently do not consider the risk of damage to ecosystems that may affect a utility's basic services, and thus the utility's capability for bond repayment.

Policy Context for Governments

Watershed service transactions as a form of forest landowner conservation incentive would co-exist with a wide range of other existing conservation incentives which may currently be more or less effective at meeting the same or similar conservation goals. These are mostly government payment programs such as the federal Conservation Reserve Program, state grants through salmon recovery programs, the Rivers and Habitat Open Space Program, or the Washington Wildlife and Recreation Program, local purchase of development rights or Conservation Futures expenditures, or provision of technical assistance through university extension programs or agencies. A number of non-profit land trusts are also already actively pursuing landowner conservation easements for a variety of purposes. Existing payment for ecosystem services incentive programs, not funded by government in many cases, take the form of wetland mitigation banks, habitat conservation banks, transfer of development rights, water quality credit trading in Oregon and elsewhere, and forest carbon storage credit sales in California. These existing programs offer many lessons for watershed services transactions, but also differ from such transactions in important ways. For example, these other programs may be significantly less rigorous or more rigorous in the degree of scientific certainty expected about the cause-effect relationship between incentives and market benefits.
A number of issues immediately arise when considering the policy context for watershed services transactions. These include issues of legal precedent, either in establishing landowner rights to withhold services, or in allowing potential buyers or stakeholders to instead pursue regulatory means of securing watershed services. There are also issues about the feasibility of a true marketplace: watershed services are geographically constrained, which makes it difficult to achieve the scale that commodity or credit-trading markets require for success. When this is the case, governments usually act as funders or facilitators for transactions. Additionally, transaction costs entailed by the need to satisfy standards of quality, measurability, predictability, and durability in these policy contexts can be daunting for prospective transaction participants. These will be treated more completely in a later section.

PURPOSE AND OBJECTIVES OF PROJECT

In ESHB 2541, the legislature intended to promote the ecosystem services provided by forest management through supporting landowners maintaining their land in forestry. The legislation recognizes that sustainably managed working forest lands are central to the quality of life of all Washingtonians, and that it is necessary to assist landowners in gaining access to additional sources of revenue to help diversify their incomes while improving the ecological functions of their lands. ESHB 2541 intends to develop tools to facilitate small and industrial forest landowners' access to market capital in order to finance the protection, restoration, and maintenance of ecological functions that protect public resources. Initial attempts to pursue legislative direction in ESHB 2541 involved a multi-stakeholder Forest Carbon Workgroup that was aimed at exploring carbon offset and other ecosystem service market opportunities for Washington forest landowners. The workgroup provided a 2010 report to the Commissioner of Public Lands Peter Goldmark and Department of Ecology Director Ted Sturdevant that recommended DNR's future investigations of ecosystem service market opportunities involve a pilot project to test the feasibility of various aspects of the PES system. The results of the pilot would then inform the design of future PES work. These recommendations for further work to implement the legislative direction provided by ESHB 2541 led DNR to pursue a demonstration project that addressed an apparent limiting factor – lack of regional PES transaction evidence related to private forest land. Another key finding resulting from stakeholder discussions in 2010 was that watershed services markets and biodiversity markets might have more current potential than forest carbon offset markets. Since that time, a forest carbon market driven by California's regulatory "cap and trade" program has come into operation, which allows forest carbon offset projects to be developed in any of the lower forty-eight states, thus providing a market opportunity for Washington forest landowners.



In response to these findings and stakeholder recommendations, Commissioner of Public Lands Peter Goldmark launched a Watershed Services Market Demonstration Project in March 2011.The project intends to create circumstances leading to one or more watershed service transactions between private forest landowners as "sellers" and "buyers" who benefit from the generation of watershed services. The objective of this project is to provide needed transaction evidence and other lessons to contribute to understanding ecosystem services provided by well-functioning forestlands. Anticipated outcomes of the initiative include:

- On-the-ground practices that are structured to produce tangible and measurable water and habitat benefits on-site and downstream;
- Contractual agreements among market participants;
- Public transaction evidence regarding services provided and prices paid;
- A monitoring program;
- A detailed analysis of lessons learned and suggestions for broader application; and
- Better understanding of the relationships of watershed services with other ecosystem services such as biodiversity and carbon storage, and the possibility of payments for these services.

In June 2011, the Northwest Environmental Forum, a service of the University of Washington School of Environmental and Forest Sciences (see below), co-convened with DNR a multi-stakeholder event related to working forest retention and watershed service transactions. The Forum was intended to assess the interest in watershed service transactions in Washington, and develop a project framework to develop and carry out feasible watershed service transactions on a demonstration basis. Two key geographic watersheds, Snohomish and Nisqually, emerged from breakout group discussions. These two watersheds represent a moderate level of urbanization, still have substantial commercial forest lands providing watershed services, have local Indian tribes exercising leadership for watershed protection, and have local government leaders, land trusts, and other non-profits who attended the Forum and expressed interest in the pilot opportunity. This Forum event served as a public launch of DNR's demonstration project.

Participants of the 2011 Northwest Environmental Forum identified the following desirable characteristics of a functioning program of watershed services transactions, many of which may be prerequisites:

- An urgent issue that includes the right geographic location, timing and vision;
- The right mix of stakeholders with clear leadership and engagement at the local watershed level;
- A combination of regulatory and voluntary mechanisms with clear environmental goals and flexible implementation options;
- The use, where feasible, of existing institutional mechanisms;
- A commitment to a cohesive policy with a clear regulatory driver and backstop;
- Linkage to climate change adaptation;
- Clearly identified willing buyers and sellers and an analysis of the potential beneficiaries;

- Clarity on the nature and ownership of the environmental service or services being transacted, including the specific management practices needed to sustain the services;
- A sustainable financing mechanism with diversified funding streams (i.e., government, municipalities, private foundations and corporations);
- Administrative structure to facilitate transactions between willing buyers and willing sellers while controlling transaction costs;
- A mechanism and institution for monitoring and enforcement;
- Transparent record keeping with clear reporting of activities and outcomes;
- The potential to bundle with other ecosystem services including carbon offsets, biodiversity, wildlife habitat, clean drinking water, flood protection, etc.;
- Payment levels which exceed the landowner’s opportunity costs associated with engaging in or forgoing target practices;
- A clear understanding of risk (economic, political, ecological) while addressing uncertainty;
- Metrics or units of trade clearly defined within the transaction framework; and
- A clear plan for program evaluation.

The DNR-led demonstration project has attempted to identify or create circumstances with these characteristics.

PROJECT ACTIVITIES

Since DNR launched this demonstration project in March 2011, it and its numerous partners have carried out a wide range of project activities. Activities described in this section include large and small project meetings, negotiated agreements, scientific and technical studies, development of information resources, outreach to the forest landowners, and interim reports. As discussed below, much of the project work has been performed through the Nisqually and Snohomish pilots.

Northwest Environmental Forum

A critical partnership throughout DNR's watershed services transaction demonstration project has been with the Northwest Environmental Forum. Since 2004, the Forum has conducted multi-stakeholder events on pressing public policy topics, and since 2008 the Forum has focused on ecosystem service payments and retention of working forests. Convened by Brian Boyle, the Forum has provided three focused sessions for key regional stakeholders to participate in neutral and knowledge-rich discussions to advance common understandings and create a sense of direction for watershed service transaction projects. These Forums have identified consensus on the belief that maintaining forests can provide a cost-effective means to manage and provide water for drinking, industrial use, energy production, flood stabilization, drought protection, aquifer protection, reduced erosion and sedimentation, moderation of the effects of human population, and biodiversity of aquatic life and fish resources.

From the outset of the June 2011 Forum, key Nisqually and Snohomish representatives have been active participants. The more than 70 other natural resource managers and policymakers who participated in this Forum represented large and small forest landowners, non-profits, land trusts, environmental organizations, ecosystem service market experts, academic researchers, foundations, water utilities, tribes and local, state and federal government interests.

Key outcomes were to:

- Highlight the critical role forests play in water quality and conservation;
- Identify key forested watersheds in Washington State for a demonstration watershed services marketplace, and attributes that would distinguish these areas;
- Identify actions needed to begin a collaboration to develop and implement a demonstration forest watershed services market project in 2011-12; and
- Secure government and stakeholder commitments to participate in initial project workgroups, including core members of project teams.

In April 2012, a second Northwest Environmental Forum served as a venue for watershed stakeholders to reconvene and expand upon their June 2011 work. More than 50 natural resource managers and policymakers participated in this Forum to review a Portland State University literature review: *Biophysical Aspects of Forestry Management* (Schoenen, 2012). This work was prepared specifically for this demonstration project through the efforts of the USDA Forest Service Northwest Research Station (PNW). The scientific report highlighted the current state of scientific understanding of the hydrological attributes of forest health. The April 2012 Forum also provided scientific responses and insights into how to develop the factual basis for proposed market transactions, starting with the Nisqually and Snohomish watershed pilot projects. Forum participants identified challenges and recommendations based on the report and their own areas of expertise, which include:

- Issues with scale of land use changes and overall impacts to hydrological processes;
- Linking temperature to riparian cover;
- Difficulties with assessing variations across landscapes;
- Understanding climate change's impacts to timing and quantity of storm flows; and
- Exploring the policy and regulatory framework that supports this work.

A final Northwest Environmental Forum devoted to DNR's watershed project was held in December 2012. Forum participants were briefed on the progress, challenges, and next steps of the demonstration projects, and were asked to assess, compare and critique them. They were also asked to advise DNR regarding the 2013 Legislative Report. Finally, Forum participants discussed the larger application of watershed services for working forest retention in the Pacific Northwest and elsewhere.

Ecology Grant

In the summer of 2011, the Departments of Ecology and Commerce issued a Request for Proposals for federal funds from the U.S. Environmental Protection Agency's National Estuary Program. In November 2011, DNR submitted a proposal to the Department of Ecology requesting $200,000 of these funds intended for Puget Sound Watershed Protection and Restoration of Freshwater Ecosystems. Ecology accepted DNR's proposal in December 2011, and the funds were awarded beginning in April 2012.

Grant funds are being used for:

- Project-specific staffing for implementation of transactions and development of project communication and technical reports;
- Development of supportive economic feasibility analysis;
- Developing metrics for specific watershed services and management practices;
- Identifying buyers and sellers; and
- Establishing institutional infrastructure for protocols for markets or market-like transactions in the two pilot watersheds, to eventually be utilized in other watersheds throughout Washington.

Outreach and Communication

DNR project staff, funded with the Ecology grant, coordinated development of informational materials for both the Snohomish and the Nisqually watershed pilots, and created a comprehensive project web page that includes information about the related legislation, ecosystem service concepts and associated reports, and the involvement of various partners. The website also included links to the Nisqually and Snohomish pilot project web pages that further describe watershed-specific efforts.

DNR staff assists in coordinating team meetings for the Nisqually watershed pilot project. Snohomish County Surface Water Management (SWM) also hired project staff to coordinate Snohomish pilot project activities. Both pilot groups have held regularly scheduled team meetings.

Partners

The two watershed teams are committed to building partnerships in their respective watersheds and regionally to encourage successful pilots. Partnerships with drinking water, stormwater, salmon recovery, and forestry interests are expected to advance a scientifically-informed and locally supported approach to developing the rationale for the pilot projects.

Since the earliest phases of project development, DNR has sought ongoing strategic advice from leading national experts in the field. Tracy Stanton, first representing The Freshwater Trust and currently with Earth Economics, Bobby Cochran of Oregon's Willamette Partnership, and Todd Gartner of World Resources Institute have provided valuable perspective, information, and guidance. Kitty Weisman from the Washington Department of Health Office of Drinking Water has provided enthusiastic support for the project as well as substantial technical information. Claire Schary, Water Quality Trading Coordinator for the EPA Region 10, also has offered her experienced perspective and critical wisdom.

The Nisqually Watershed Project Core Team is comprised of a consortium of partners representing the Nisqually River Council, the Nisqually Land Trust, Northwest Natural Resources Group, Swedeen Consulting, and Earth Economics. The core group invited representatives from state agencies, non-profits, academic institutions, tribes, representatives from the Snohomish pilot, and related entities to attend their quarterly Nisqually Watershed Services Advisory Committee meetings. These meetings were held in July and October of 2012, to discuss project progress, implementation, funding, and a list of other project-related details. The project team has also developed a significant partnership with the City of Olympia's Public Works Department, which includes the Drinking Water Utility, which intends to serve in the role of buyer of groundwater recharge area protection services in the lower Nisqually Watershed. The City has recently begun developing the McAllister Well Field, tapping a large groundwater aquifer which will become the primary drinking water source for the city's residents.

Snohomish County SWM managers and staff have taken the lead in developing and implementing the Snohomish pilot project. With the primary ecosystem service of interest being stream flow protection and stormwater management, the Snohomish team has coordinated with several forest, stormwater management, and salmon recovery interests including the Tulalip Tribes, Washington Department of Ecology, Forterra, WSU extension, Northwest Natural Resources Group, and World Resources Institute.

Key partners have met to discuss ideas about potential target sub-basins and associated landowner/seller outreach strategies to support the development of a forest ecosystem service transaction in the Snohomish Basin.

In November 2011, DNR hosted a video conference of principal project partners to assess progress and make commitments to following through with project completion. DNR developed a December 2011 Legislative Progress Report describing project activities to that time and forecasting anticipated project work in 2012.

Nisqually Watershed Pilot Project

The Nisqually Core Team is exploring a payment program for watershed-based ecosystem services that links private-forest landowner actions with improvements to water quality and quantity within the Nisqually Watershed. On behalf of the watershed pilot project partners, in May 2012, the Nisqually Tribe received a $170,000 grant from the State Department of Commerce under the same EPA program funding awarded to DNR. Under the grant, the pilot team is coordinating with Washington DNR and Earth Economics to:

- Develop a watershed-based payment for ecosystem services protocol that connects water utilities or others who have funds to purchase watershed services (buyers) and quantifiable actions that forest landowners (sellers) can take to improve water quality and quantity;
- Recruit potential buyers and sellers;
- Develop metrics;
- Secure a demonstration transaction between at least one buyer and one seller that brings additional environmental benefit;
- Quantify those benefits for beneficiaries; and
- Document lessons learned and provide a model that can be scaled up around Puget Sound.

BUYER OUTREACH

The Nisqually Project Core Team has identified and met with several potential upper- and lower-watershed ecosystem service buyers. Upper-watershed meetings were held with the Town of Eatonville, the Nisqually Tribe, and the City of Yelm, and lower-watershed meetings included the City of Olympia, the City of Lacey, and Pierce County. Circumstances in the lower watershed were well suited for prompt buyer involvement. The City of Olympia's drinking water program welcomed the Nisqually team's invitation to act as a buyer of watershed services in the form of protection/restoration of forest land above the aquifer supplying the new McAllister Well Field. The City is in the process of redrafting the land acquisition plan in its state-mandated Groundwater Protection Plan.

Group A public water systems, like City of Olympia, are required by state regulations to develop and implement a source water protection plan. The goal is to ensure safe and reliable drinking water over the long run. Source water protection focuses on maintaining, safeguarding, and improving the quality and quantity of drinking water by delineating the source water protection area, identifying potential contamination sources, and developing strategies for protection over time. Under the federal Safe Drinking Water Act, source water protection is considered the first step in protecting drinking water from contamination and loss of supply.

The Nisqually team's proposal for shaping land acquisition as payment for watershed services has been timely. The City has budgeted funds through 2018 to either purchase or acquire rights to parcels that are particularly vulnerable to contamination, and are in zones representing various travel times of groundwater to the wellhead. By owning land or easements, the City can control land uses and associated activities on land near its water sources and help prevent contamination of critical groundwater resources. The project team recommended that the City consider easements as more economically efficient, in terms of amount of land protected for a given budget and, potentially, more acceptable to landowners.

In the upper Nisqually Watershed, the Nisqually Tribe is already a leader in watershed protection, and has indicated interest in participating as a buyer of watershed services to aid salmon recovery. Tribal analysis has demonstrated sediment and temperature impairments to salmon habitat in several specific reaches of the Nisqually mainstem and its tributary, the Mashel River. The tribe has encouraged the project team to look into funding options that would help finance the Tribe's ability to make watershed service payments. The lack of funding for a recognized buyer has significantly delayed project progress in the upper watershed.

Also, the Town of Eatonville's stormwater management program and drinking water supply would greatly benefit from upper Mashel River Watershed protection work. Although Eatonville property owners are interested in participating in an Upper Mashel sub-basin transaction, the Town is not financially equipped to be involved as an ecosystem service buyer. Therefore, the project team is continuing to seek potential funding sources to provide Eatonville and/or the Nisqually Tribe with adequate funding to purchase ecosystem services from a willing landowner in the upper watershed.

QUANTIFYING BENEFITS

Quantification of benefits, or "metric" development, is a central component of a payment for watershed services transaction. In practice, "metrics" will be targets for forest watershed conditions needed to produce the desired "downstream" results, based on best available science and cost-effective methods of measuring those forest conditions over time. Nisqually pilot metric development is being undertaken by DNR and the Nisqually project team.

For the City of Olympia payment for watershed services transaction involving the new McAllister Well Field, the U.S. Geological Survey (USGS) is performing technical groundwater modeling work in a joint funding agreement with DNR. USGS will produce a report documenting model development, limitations, and the results from approximately four simulations representing a range of potential groundwater recharge conditions, which will be published by April 30, 2013. For the upper Nisqually Watershed, DNR has begun discussions with the U.S. Forest Service for contributions to metric development related to stream shade, sediment delivery, and overall sub-basin forest cover. This watershed analysis may occur in 2013.

ECONOMICS

Economic feasibility analyses, for both buyers and sellers, are included in the project to assist with utilities' decision-making and outreach efforts, and to help determine whether there's a good match between the utility's needs and the landowners' interests. In response to the City of Olympia's interest in a buyer economic feasibility analysis, DNR offered staff time to conduct a literature review and analysis of costs of improved land management protection vs. costs of incident response and damage cleanup. DNR project staff is collecting local and national drinking water contamination and protection data through a literature review and interviews. Data include results from an email survey of state members of the Association of State Drinking Water Administrators on studies of source water contamination costs. Data include contaminant types, cleanup/ response activities, associated costs, utility type, event year, and the state where the cleanup occurred. To date, survey analysis reveals a range of $4,000 to $2 million per cleanup for nitrate initial cleanup costs, and an average of $1.5 million for solvent-related contamination events. DNR's project assistant compiled the data into a cost summary matrix, along with data acquired through the literature, which will be summarized in a final economic feasibility report, expected to be completed by early 2013.

The study will also present a list of risks that face the McAllister Aquifer, and a qualitative cost comparison will describe the co-benefits of interest to the City of Olympia, for example:

- Contamination prevention
- Stormwater run-off prevention
- Carbon sequestration
- Property value enhancement
- Aquifer recharge
- Local climate moderation
- Wildlife habitat

The economic comparison is based on two hypothetical scenarios; full build-out of current zoning, and retained and restored forest and pasture cover with rural residential development. Results of the U.S.G.S. modeling work will help in evaluating differences of risk levels between the two scenarios. Ultimately, the economic analysis will analyze the economic benefits of ecosystem services that would be secured through the pilot, including maintaining risks at the very low levels desired by the City of Olympia.

Seller economic analysis involves informational discussions with forest landowner transaction experts and appraisers. After the project team conducts enough landowner outreach to focus on most likely sellers, they will consult metric development results, determine conservation easement guidelines, and finally consult an appraisal expert to measure the seller's cost for ecosystem service provision.

LANDOWNER OUTREACH

The project core team researched and identified priority parcels and associated landowners for City of Olympia's McAllister Wellhead protection plan, based on ranking criteria established by the City of Olympia. The City's parcel prioritization criteria emphasizes protecting land with the greatest risk for groundwater contamination and places greatest value on parcels with no confining glacial till layer above the aquifer, and with the shortest travel time of recharge through the aquifer to the wellhead. The City's criteria also emphasize current land use practices, amount of forest cover, and parcel size. The Nisqually Land Trust began contacting landowners of highest priority parcels to gauge their potential interest in receiving payments from watershed service buyers in exchange for quantifiable actions they could take to help protect the aquifer. In general, most landowners were very receptive to these initial contacts.

Landowner discussions involve sharing project details and gauging their needs. Additional required technical information, which is pending, will evaluate the specific management activities or constraints being requested of the landowner. Once USGS completes its modeling and evaluation of linkages between forest cover and groundwater protection, the project team will identify a few properties with the highest likelihood of success. The Nisqually Land Trust and project team will then work with those landowners and the City to develop easement terms.

In the upper Nisqually Watershed, the team has also researched and identified priority parcels with the highest potential for contributing to temperature and sediment impairments in the Mashel River, based on Nisqually Tribe analysis and Department of Ecology's Puget Sound Watershed Characterization analysis. Of the two major commercial timber landowners in the Mashel Watershed, Hancock Timber may be a candidate to enter into large-scale transactions resulting in improved watershed services. Hancock representatives have been actively engaged in communicating with the Nisqually team, and may be interested in further more detailed discussions.

PROTOCOL

Protocol development is a principal task included in both the Nisqually team's Commerce grant, and DNR's Ecology grant. A core team member has drafted a literature review and analysis for related protocol development. So far, this protocol study has led the Nisqually team to determine the most likely transaction mechanism will be a conservation easement. The City of Olympia has experience with conservation easements, which suggests that the demonstration project does not need to devote effort to developing new market infrastructure.

The protocol report outlines conditions of participation, landowner eligibility criteria, easement commitment length, required acceptable practices that will be incorporated into the terms of the easement, and monitoring and verification criteria for the City of Olympia Wellhead Protection Land/Easement Acquisition program. The protocol document will draw on model conservation easement language for source water protection programs occurring in New Hampshire, San Antonio, North Carolina, Michigan, and Virginia. It also draws from the scientific literature on groundwater/forest dynamics and original modeling done by the United States Geological Survey for the McAllister Wellhead protection area. The protocol provides approaches to easement terms, which should:

- Retain forest cover
- Limit the overall area of impervious surface increase
- Reduce the potential increase in overall number of septic systems
- Limit the potential for the use and storage of hazardous chemicals
- Provide sufficient restrictions and guidance for forest management

CURRENT STATUS

Although the City of Olympia has assigned funding for groundwater protection projects, several steps are involved to gain final approval by the City Council. In December 2012, the City staff and the project team presented plans for the McAllister Wellfield payment for watershed services transaction to the City’s Utility Advisory Committee (UAC). The UAC was positive about the project, and invited the team to return with the results of modeling and economic analysis. All technical work will be complete in spring 2013, after which landowner negotiations can take place and a final transaction decision can be made by the City of Olympia.

The Nisqually team is also actively searching for entities willing and able to invest in larger-scale forest land transactions in the upper watershed.

Snohomish Watershed Pilot Project

To support market development for forest ecosystem services in the Snohomish River Watershed, SWM has taken the lead in exploring a pilot transaction. SWM’s intent is to generate information which will allow SWM to explore the potential development of a market-based program to protect forest ecosystems that stabilize stream flows, and thereby help to reduce downstream flood risks, and protect salmon habitat.

The Snohomish Pilot Core Team is primarily comprised of SWM staff members who are responsible for administrative tasks, coordination with DNR, hydrologic modeling, and

GIS analyses. The Snohomish Core Team has recently partnered with Forterra to carry out certain analytical and outreach tasks associated with the pilot project.

INTERLOCAL AGREEMENT

In November 2012, DNR and SWM signed an Interlocal Agreement for $80,000 of grant funding to support project-specific staffing and development of supportive analysis for the Snohomish pilot. Under the Interlocal Agreement, SWM is providing project administration, metric development through modeling, sub-basin and parcel prioritization, support for economic feasibility analysis, and property appraisal as needed. DNR is providing lead staff work for the economic feasibility analysis and coordinating development of a transaction protocol.

PRIORITIZATION

To develop a methodology for prioritizing parcels for potential ecosystem services transactions, SWM staff first assessed the utility of the Conservation Priority Index (CPI) a tool developed by researchers at the University of Massachusetts in cooperation with the U.S. Forest Service, the Trust for Public Land, and the U.S. Environmental Protection Agency. In an initial test study, the CPI was used to score and rank privately owned parcels in the Upper West Fork Woods Creek sub-basin of the Snohomish River watershed in terms of their conservation value. This exercise produced a list of 20 high-priority forest parcels. Subsequently, SWM staff scored and ranked the same parcels in the sub-basin based not only on the CPI, but also on a hypothetical budget limitation and development pressure data provided by the Rural Technology Institute at the University of Washington. This exercise resulted in a different list of high-priority parcels.

At the conclusion of the test study, SWM staff utilized the CPI in combination with Department of Ecology Watershed Characterization results to prioritize and select three sub-basins within the Snohomish watershed for potential transactions, based on their relative importance to the protection of hydrologic processes. Parcels within these sub-basins will be scored and ranked using the CPI and development pressure. The selection of a parcel for a transaction will also hinge on cost and landowner willingness.

QUANTIFYING BENEFITS

In order to evaluate the effects of varying levels of forest cover protection on downstream flow characteristics, such as peak flows, flood flow duration, and flows that support fish habitat, SWM technical staff developed and applied a Hydrologic Simulation Program Fortran (HSPF) model of the Upper West Fork Woods Creek sub-basin.

Hydrologic modeling is being used to assess the effect of a range of forested land conversion scenarios on flood flows and duration of flood flows within this sub-basin, with results also applicable to other areas of the watershed. Modeling results will be used to test whether there is a break point in which the percent of forest lost has a marked effect on flood flow rate, duration, and habitat flow ratio in the stream. The technical team has also conducted a literature review of recent publications on the effects of forest conversion on stream flows and aquatic habitat. Results of this study will be used to inform forest management practices being requested of forest landowner project participants. A final document to report the modeling assumptions, methods, tested metrics, and results will be submitted to DNR by March 31, 2013.

ECONOMIC ANALYSIS

DNR is taking the lead on an economic feasibility analysis to compare the estimated costs and benefits to the County associated with various ecosystem services transactions to those of alternative projects that would offer similar stormwater management results. The economic feasibility analysis will compare conventional stormwater protection methods and alternative solutions that include forest ecosystem protection. The SWM technical staff is providing cost data for standard stormwater management procedures.

The final economic feasibility report, to be completed in February 2013, will include a list of types and likelihoods of risks and responses, as well as a comparison of the quantitative costs and qualitative benefits of various transactions that the buyer, Snohomish County, could potentially carry out in order to achieve similar levels of stream flow protection.

In addition, Forterra will be conducting an analysis of potential transaction mechanisms that Snohomish County could employ to carry out an ecosystem services transaction. Potential mechanisms to be evaluated include:

- Conservation easements (transfer or purchase of development rights, etc.)
- Short and long-term lease agreements
- Other types of recorded agreements.

Based on the results of Forterra’s analysis, SWM is also planning to contract the for professional services to produce an appraisal to help determine the amount of compensation a landowner would agree to receive for a secured commitment to adopt forest cover protection and restoration actions.

PROTOCOL

Market protocol development for the Snohomish Watershed pilot project is being coordinated with the work being conducted for the Nisqually watershed pilot. The Nisqually Core Team has agreed to share protocol-related findings and reporting with the Snohomish team, incorporating Snohomish Watershed-specific services and criteria.

CURRENT STATUS

Final work is being completed on all the analytical work, including parcel prioritization, modeling and metric development, and economic feasibility analysis. Landowner outreach will begin in late winter and spring of 2013, followed by a decision to pursue a transaction. Snohomish County will explore the possibility of coordinating this demonstration project with its recently approved Transfer of Development Rights program.

MAJOR ISSUES AND LESSONS LEARNED

The primary purposes of a demonstration project are to show that a particular course of action can be completed at least on a small scale, and to uncover issues that provide the basis for important experiential learning relevant to broader application of the action program. This is consistent with the legislature's purposes in ESHB 2541. The watershed services transaction demonstration project has been undertaken to, first, produce real transaction evidence regarding payments to forest landowners for forest land management outcomes relevant to watershed services sought by water utilities making the payments, and second, provide a basis for critical lessons necessary to understand how to apply this incentive method on a broader scale. This section describes a series of significant issues and attempts to draw initial lessons relevant to legislative recommendations and development of broader forest ecosystem services incentive programs.

1. Scientific Foundations

A good understanding of the ecological relationship between forest land management practices and watershed services is a necessary underpinning for a valid program of payments by watershed services beneficiaries to specific forest landowners to secure such services. Beneficiaries such as water utilities, including their decision-makers, customers, and stakeholders, seek reasonable assurance that proposed payments will actually result in tangible benefits. Landowners need to understand the specific practices and requirements proposed in order to evaluate opportunity costs and needed payments (also see #8). Regulators need to understand how the forest watershed services to be provided relate to existing requirements for the buyers and the landowners (also see #2).

On the other hand, participants will never have perfect information, especially for specific locations, considering the high level of variability in site-specific conditions and natural processes. Waiting for perfect information is not responsive to the urgency of forest loss in areas subject to growth pressures and to climate change effects. A great deal of general scientific information on forest-water relationships does exist, which has served as the basis for experimentation with ecosystem payment systems in the Pacific Northwest and nationally.

A typical component of a PES system is the “metric” or “metrics” – what can be measured over time to demonstrate that the watershed services being paid for are actually being delivered. Appropriate metrics can be found closer in the cause-effect chain to the beneficiary-buyer, such as water parameters (water quality, water flow, etc.), or closer to the forest landowner-seller, such a forest cover conditions (percent forest cover, streamside protection, etc.). The former relates more directly to the benefits sought, while the latter relates more directly to the practices paid for. Neither approach on its own guarantees to fully measure cause-effect relationships between the two.

A variety of models exist or can be developed to help fill in the gaps in site-specific knowledge by using what is generally known to predict processes and outcomes in specific cases. Modeling can help prioritize areas for protection, develop protection or restoration mechanisms, and evaluate the likelihood of forest activities leading to delivery of watershed services. Modeling can therefore support forest watershed services transactions, including development of suitable metrics.

The pilot projects have used a number of approaches to establishing sound scientific foundations for potential transactions. These approaches included the scientific literature review on forest-water relationships from Portland State University, which provided general information and indicated some broad forest management actions that could be incentivized to help provide watershed services, such as avoiding conversion to non-forest uses, limiting roads on sensitive soils, and protecting riparian areas. Both pilot teams also had access to previous watershed planning work in their watersheds, along with recent salmon recovery studies.

The Nisqually team made use of previous geographic prioritization work by the City of Olympia for the McAllister Wellfield source water protection area, in addition to the USGS aquifer modeling work, and Ecosystem Diagnosis and Treatment analysis by the Nisqually Tribe for the upper watershed.

The Snohomish SWM staff undertook parcel prioritization analysis using the CPI, and performed hydrologic modeling work in a test sub-basin to evaluate the effect of changing forest cover and impermeable surfaces, on various stormwater parameters.

Both pilot groups made use of Puget Sound Watershed Characterization mapping information developed by Washington Department of Ecology.

The scientific work left both pilot teams with a great deal of useful information, as well as important site-specific questions concerning the likely quantifiable outcomes of forest watershed service transactions for utilities.

Another scientific issue is the obvious inability of a single or small number of pilot watershed service transactions to succeed in generating significant benefits at a watershed scale.

Lessons

General scientific information, along with existing local understanding, can provide a good starting point for the development of forest watershed service payments. In addition existing information and modeling capabilities are helpful to prioritize target locations and landowners for transaction proposals. Potential buyers of services, especially if not responding to strict regulatory requirements themselves, may not need highly precise prediction of the outcomes of specific transactions to undertake individual priority transactions or launch a program of transactions. Monitoring can then help verify, refine, or redirect a program over time. However, there will certainly be an ongoing and increasing need for better initial scientific information and validation over time for large-scale programs of payment for forest watershed services. Improved scientific information is also needed to allow greater confidence in the design of specific forest landowner requirements intended to secure watershed services through transactions.

2. Relationship to Regulatory Requirements

Policies for forest landowner conservation incentives, such as to secure watershed services, exist in an overall policy context that includes regulatory laws aimed at the same or similar objectives. Understanding that regulatory context and relationship and identifying a complementary role for incentives can be a major challenge for ecosystem services transaction systems. This dynamic was described above in the Policy Context section.

In the case of the Nisqually Pilot Project, the City of Olympia drinking water utility operates under the authority and requirements of state and federal drinking water and public health laws. The City expects to exceed those requirements in its operation of the McAllister Wellfield, and is pursuing a transactional strategy for source water protection to satisfy City and local interests in gaining a very high level of assurance of long-term drinking water safety and reliability. The strategy also aims to secure forest management and/or restoration commitments from landowners that clearly go beyond the requirements of the state Forest Practices rules and current Thurston County zoning.

In the upper Nisqually Watershed, the pilot project team has approached commercial forest landowners to gauge interest in levels of watershed protection beyond current Forest Practices stream buffer requirements aimed at salmon habitat protection. This raises questions about the future of regulatory requirements, since the Forest Practices

Adaptive Management Program is currently undertaking a scientific review intended to validate or determine necessary adjustments to current stream buffer requirements for providing salmon-friendly stream temperature conditions. Stakeholders have indicated some willingness to reward landowners for early adoption of possible future regulatory requirements, but not to pay for compliance with current regulatory requirements. If regulations are regularly adjusted, it's difficult to achieve a stable and understandable baseline from which to financially incentivize provision of additional ecosystem services. ESHB 2541 amended the Forest Practices Act to include assisting ecosystem service payments to forest landowners as one of a number of policy consideration in forest practices rulemaking.

In the Snohomish watershed, SWM has explored the idea of using up-stream stormwater protection actions by forest landowners to meet an increment of the stormwater mitigation obligations of down-stream developers under the county's stormwater permit. The idea is to use a portion of mitigation payments required of developers to secure the upstream actions. Stormwater program managers at Department of Ecology have indicated that such a transfer of mitigation effort from the site of development to an upstream forest area could only occur in the context of basin planning that demonstrates the upstream actions would provide actual mitigation of the development impacts comparable to what would be expected from on-site mitigation. Additionally, upstream forest stormwater protections induced by the payments would need to go beyond what would be eventually required anyway in the face of future development of the forested property. An issue which emerges from this consideration is how successful current and future application of regulatory requirements is assumed to be. Understandably, regulatory program staff feels accountable for assuming a high level of regulatory success; therefore, they tend to downplay the potential value of incentive programs aimed at similar objectives.

Lessons

Demonstration project participants have generally expressed a desire for regulatory stability and clarity as the best context for development of watershed service payment systems. This context would aid the identification of increments of forest watershed protection that can be confidently pursued through incentive payments, without fears of paying for already-required regulatory compliance or weakening regulatory standards. In addition, watershed service buyers would benefit from a regulatory environment of their own that acknowledges practical limits on direct regulatory systems alone to achieve environmental or public health outcomes efficiently, and encourages exploration of incentive programs that can complement underlying regulatory obligations. This could help motivate demand for watershed services transactions by potential buyers such as water utilities. Local governments themselves, as well as state and federal regulatory agencies such as Department of Ecology and the Environmental Protection Agency could contribute to a context of regulatory stability and clarity that promotes exploration of watershed service payment systems.

This demonstration project supports a judgment that drinking water protection and stormwater management may have regulatory environments both for potential utility-buyers and landowner-sellers that are more conducive to development of viable forest watershed service payment systems than would be the case for the "water quality trading" under the Clean Water Act's (CWA's) National Pollution Discharge Elimination System permit structure, which has been the focus of agriculture-centric watershed service market development outside Washington State. This is in part because the water quality regulatory structure of the CWA is met in Washington's forest sector by "compliance assurances" associated with implementation of state Forest Practices Rules, thus providing a less formal foundation for exchanging water quality protection "credits" among similarly regulated entities.

3. The Appropriate Conservation Niche for Payments for Watershed Services

Interest in payment for watershed services (PWS) programs arises from concern about retention of forest land for its own sake, and from economic efficiency objectives in carrying out the missions of the purchasers of watershed services. While PWS is in its infancy, it shows promise for both these purposes. An important question arises as to how significant a part of the solution to either of these concerns PWS will be, and where it can make its greatest contribution. As introduced in Policy Context earlier, PWS exists side-by-side not only with regulatory programs (See issue #2) but also with other policy approaches both long-standing and emerging, including conservation payment programs. For example, this is true for the water utilities and salmon recovery organizations toward which the demonstration project has gravitated as likely sources of new funded demand for PWS. To what extent should PWS supplement or supplant these other approaches? And is there an appropriate geographic focus for PWS within watersheds, which range from urban areas to wilderness? The demonstration project has focused on larger water utilities because their missions are conducive to PWS possibilities, and because they may have capital budget capability to fund PWS transactions in the short term. This concentrated focus comes at the potential cost of becoming too narrow and ignoring forest benefits not directly relevant to water utility missions. Doing so could result in ignoring other sources of demand and potential payment that might help induce sufficient actions by individual forest landowners and/or achieve results at a significant enough scale within a watershed.

Many advocates of ecosystem services markets support the idea of more comprehensive programs that are based on more comprehensive estimates of total ecosystem service value and that seek to involve as wide a range of potential beneficiaries as possible in paying for these services. One form of this broader focus is the idea of "stacking" multiple ecosystem services from the same land area – stormwater protection and carbon storage, for example – and providing multiple corresponding streams of payment to landowners from distinct buyers. Another example is the idea of an “ecosystem services district,” a utility in its own right, potentially with taxing authority that can translate general public benefit from ecosystem services into financial support to provide those services. These more comprehensive approaches are conceptually appealing, and simultaneously face significantly more complicated administrative, technical, and political hurdles to become established.

In the Nisqually pilot, the City of Olympia’s efforts to secure protection for its new drinking water aquifer may induce conservation actions that also provide open space and wildlife habitat benefits, which may or may not be of interest to the City’s rate-payers. In the Snohomish Watershed, SWM has both stormwater management and salmon recovery in its mission, but still must make clearly focused stormwater management investments with public funds.

Lessons

The project’s outcomes suggest that utility-based payment for watershed services and such payments generally can be an important element in the overall effort to retain forest cover, but that it is no panacea. Other policy tools will also continue to have their place, including both traditional and new financial incentive programs for forest landowners, technical assistance and education, and public or non-profit ownership of forest lands. Similarly, utilities can view payment for watershed services as one element of their overall capital and operating budget plans to carry out their missions.

Among ecosystem service “market” ideas currently explored across the country, some are primarily discretionary and value-driven, and may include public spending. To date, this kind of program has been limited due to funding constraints. In other initiatives, demand is driven by mandatory regulatory requirements, and more rigorous scientific justification is expected. Limitations on science can constrain the scope in these cases. Participant discussions in this demonstration project have raised the possibility of an intermediate approach, driven by policy directives and modeling based on existing knowledge, midway between purely values-driven or data-driven approaches, but incorporating available data and expressions of value. Such an approach might be integrated into infrastructure investment decisions, for example, to achieve a larger impact than has previously been possible.

Numerous policy tools are aimed at prevention of urban sprawl and providing natural spaces in or near urbanizing areas. In addition to local land use planning and zoning, they include public or non-profit land acquisition, purchase or transfer of development rights (PDR; TDR), ecological cleanup and restoration investments, and decision making for infrastructure development. In more remote commercial forest areas, forest practices regulations are the foundation of public resource protection, and in headwater areas, federal or other public conservation ownership often dominates. Payment for watershed services programs based on stormwater protection or drinking water protection might complement these other protection programs by focusing geographically on rural zones in the mid-range of watersheds. These are areas subject to some pressure for forest conversion to development, where need for payment for watershed services action relevant to water utility missions could be most apparent, and where existing or contrasting programs may not dominate. In this middle watershed region, the State as a forest landowner and some land trusts are pursuing an “anchor forest” strategy to use existing State land trust ownership along with private land with forest tax classifications as a foundation for efficiently securing adjacent forest retention. A well-targeted payment for watershed services system might complement this strategy.

In the evolution of ecosystem service transaction systems, an ultimate vision and goal may be of broad market demand, multiple services, and wide geographic extent. In the current early phases where demonstration of the basic feasibility of this approach is paramount, it may also be prudent to continue to develop payment programs for single services by single or small groups of buyers, such as utilities focused on limited geographic areas. The issue of scale-up is discussed in issue #11.

4. Capacities of Potential Buyers

Related to the previous issue, not all entities, including water utilities, that benefit from forest watershed services and thus could be buyers in payment for watershed services systems have the organizational and financial capacity to express that demand. Small rural drinking water systems with a narrow rate base are examples. In the Nisqually watershed, the town of Eatonville uses the Mashel River as its drinking water source and is thus sensitive to forest management in that basin. However, the town does not at present have the financial capability to make payments to significantly influence forest management upstream of its water intake. Similarly the State Department of Health Office of Drinking Water has identified numerous small water systems in rural, forested areas that do not own their source water protection areas, and are unable to pay for watershed services to protect these areas. The Nisqually pilot project gravitated toward the City of Olympia, with its new groundwater source in a partially forested area in the lower watershed, largely because of the City’s interest in and financial ability to engage in land protection transactions. Even for Olympia, however, the analytical studies necessary to provide the foundations for the transaction program would be an administrative challenge for the City’s staff. In the Snohomish Watershed, SWM has the size, breadth, and financial capacity to not only undertake payment for watershed services transactions, but also to carry out analytical studies and bear some transactions costs. However, SWM also has limited resources, and has benefited from federal and state financial grants for some of this work. SWM, like Olympia, must balance the benefits of watershed services transactions with other objectives and mandates.

Lessons

Outside assistance will certainly be necessary for small water utilities in low income communities to participate in payment for watershed services programs. Some pooling of efforts may be helpful, as long as multiple participants can each see a benefit. The lessons for moving to broader, more comprehensive programs mentioned in the previous issue also apply here.

5. Multiple Funding Sources

Inherent to discussions about using payment for watershed services transactions as a form of financial incentives for working forest retention is the concern for adequate funding for payments. This concern is especially relevant to the previous discussion about complementary incentive systems, comprehensive PES programs, and the inability of small utilities to adequately express their interests financially. Many ideas have surfaced during this demonstration project about fund sources. Both pilot project “buyers” are water utilities with rate-payer-derived capital budgets likely to be used to fund initial transactions. Although the City of Olympia and Snohomish County are comfortable considering these investments of public funds, both also feel a strong sense of accountability for prudence in spending decisions, and this fund source for future PWS is not guaranteed. As mentioned previously, Snohomish County SWM has also considered developer impact mitigation fees as a fund source, and mitigation fees are a popular concept for conservation funding in general. Acquisition of development rights, either through purchase alone or purchase and transfer to developers (PDR; TDR), is a related funding mechanism that could either exist in parallel to or be a part of PWS. Federal funding programs are also potentially available, such as the USDA Conservation Reserve Program and water-quality funds like the Drinking Water and Clean Water State Revolving Funds, although these federal funds have other dominant uses now. General state bond-financed capital spending is another potential fund source, including expansion of closely related programs like the farmland preservation and riparian protection elements of the Washington Wildlife and Recreation Program. Diverse private funding sources are also frequently mentioned, including corporate funding associated with generating brand support in a conservation context, especially for corporations that visibly consume or market water. Investment by foundations or other philanthropic entities is also anticipated, especially where below-market return rates are acceptable and a conservation-related stream of revenue can be anticipated.

Lessons

At present, while most additional fund sources are possible contributors to payment for watershed services, in all cases there are constraints on making these contributions a reality. The primary constraints are the priority of current uses of existing conservation funds and the need for a logical connection and a clear demonstration and documentation of value added for contributions to PWS. Use of funds derived from mitigation obligations of development projects must always overcome local reluctance to see the benefits of mitigation shifted away from the immediate vicinity of the associated impact, and mitigation is usually not required for forest loss in and of itself. In general, the most favorable situation would be for local PWS project proponents to have a menu of funding options available to tailor to specific circumstances. Current recipients of the funding programs listed above could form partnerships through which to pursue PWS.

6. Communication and Education

Payment for watershed services, or for ecosystem services generally, is not a familiar or well-understood concept. Marketing studies have demonstrated relatively low salience for the phrase among members of the public, and various alternatives like "nature's benefits," "natural capital," or "green infrastructure" are also used. Widespread use of payment for watershed services will require strenuous and carefully designed public outreach efforts. In addition, support for public or private expenditures for payment for watershed services may depend on a sense of urgency or threat, while on the other hand, incentive systems such as PWS can be positively framed as inducing "goods," which may be a more appealing message. Communication and framing are sensitive to the issue discussed in #3 above regarding whether payment programs are tightly focused on the mission of individual utilities or broadly concerned with comprehensive values of "natural capital." Appropriate communication for one may not be highly relevant to communication for the other. Although both pilot watershed partners have produced initial communication materials, both are waiting until the most appropriate time to engage in a broad program of communication to the general public about proposed pilot transactions.

Lessons

Communication about payment for watershed services needs to be designed to be both comprehensible and persuasive to the relevant public, and accurate about the benefits of individual transactions and programs of transactions. Multiple considerations can pull framing in different directions, so efforts at integrating multiple messages may be helpful.

7. Connecting Buyers and Sellers

A primary theme of the demonstration project has been to reach out and locate interested and capable payment for watershed services buyers, to make transaction possibilities real beyond the general interest of forest landowners in receiving additional streams of revenue. A corollary has been to work with potential buyers, understand their perspective, and fill in missing project pieces guided by their perspective. Water utilities who may wish to participate in PWS do not necessarily have established relationships with large or small forest landowners, and probably do not have communication resources aimed toward those PWS sellers. In addition, buyers and sellers may not occupy the same watershed, in the case of corporate or philanthropic buyers seeking broad social objectives or approval through their participation in PWS, rather than direct water benefits.

Since achieving watershed services provision at an adequate scale will usually require participation by multiple landowners in a basin, efficiency could be gained by developing the means to aggregate landowner interests, especially for owners of smaller parcels. Also it's likely in some cases that inducing landowner activities to secure desired services at a large enough scale will require coordinating demand from multiple buyers. Buyer and seller coordination will take deliberate effort. This intermediary role includes helping buyers and sellers understand one another's circumstances, objectives, capabilities and specific interest in PWS.

The Nisqually Watershed Team includes organizations skilled at landowner outreach, including the Nisqually Land Trust. This has been an asset to the City of Olympia in making effective contact with forest landowners in the McAllister source water protection area. In the Snohomish Watershed, SWM does not have in-house outreach resources focused on upstream forest landowners. SWM has discussed partnering for landowner outreach with Forterra, Northwest Natural Resources Group, and the WSU County Extension office.

Lessons

Buyers and sellers both need assistance and support in organizing themselves and in locating one another to understand each other's objectives and explore payment for watershed services possibilities. Existing organizations such as land trusts and county extension offices can help provide that support. Coordinating with existing outreach programs will also be important. In the absence of deliberate, focused outreach between sellers and buyers, payment for watershed services transactions are unlikely to occur.

8. Negotiating Needed Landowner Requirements

In order to secure positive increments of forest watershed services, water utilities or other buyers need tangible assurance that payments they make will result in the necessary activities by landowners. In addition to scientific understanding (See issue #1), this entails an understanding of landowner circumstances, interests, and limitations. Meanwhile, landowners must understand that payments cannot be received without commensurate commitments. Gaps between buyer desires and landowner willingness must be anticipated and negotiated. A common example of the gaps involving conservation easements is the desire by conservation buyers for perpetual easements and the desire by landowners to keep future options open for themselves or their heirs.

In the Nisqually watershed, initial contacts with the two commercial forest landowners who own most forest land in the upper Mashel Basin, to seek conservation commitments beyond expanded stream buffers and included harvest rate or forest cover retention requirements across the ownership. Landowner responses indicated that even if such commitments were financially compensated at the apparent market value, a lingering perceptual cloud on the property's manageability could harm the ultimate marketability of the property. This response reflects in part the global nature of the timber and timber land market in this watershed and Washington State as a whole. However, alternative transaction designs were discussed which may be able to achieve conservation objectives while preserving clearly marketable assets, such as timber cutting rights, for the original landowner as a transitional strategy prior to fully transferring ownership to another entity. Payment for watershed services transactions can also present landowners, especially family forest landowners, with technical analysis burdens and transaction costs they may find difficult to bear.

Lessons

Flexibility by negotiators will increase the likelihood of successfully completing transactions meeting all parties' needs. Preserving long-term or ultimate real estate market options for landowners can be important. Landowners must be prepared to make real conservation commitments in order to receive payments for watershed services. Intermediaries can help landowners with technical requirements and other transaction costs, thereby simplifying the transaction. Active intermediaries with funding may actually participate in the transactions so as to provide a one-time, up-front payment to current landowners, and then receive a stream of performance-based watershed services payments over time. Integrity and trusting relationships among buyers, sellers, and intermediaries will help build confidence that the true interests of buyers and sellers are the real focus of proposed transactions, making successful transactions more likely. Third-party objectives not central to the specific buyer-seller relationship should be identified and removed from primary consideration. These could include conservation outcomes other than watershed services, provision of unnecessary technical services, or inflexible commitment to a specific market mechanism.

9. Time Considerations

Closing any complicated real estate transaction requires time for negotiations and for due diligence by all parties. Involving novel concepts and novel configuration of property interests, terms, and payments can be especially time consuming. However, the urgency associated with loss of forest cover, changing forest land ownership, and the emergence of climate change effects, motivates many supporters of ecosystems services transactions initially to want to learn quickly and move to larger-scale transactions.

In the watershed pilot projects, early hope for relatively prompt transactions has subsided in the face of analytical complexities and uncertainty, evolving objectives, and more accurate expectations for transaction time requirements. Neither pilot project has progressed to the point of launching specific transaction proposals to specific landowners. See Next Steps section below.

Lessons

Watershed services transaction programs must build in realistic expectations about time requirements for prudent transactions that meet the needs of all parties. At the same time, experience and dissemination of information can perhaps speed transactions in the future. More fluid transactions can also be brought about as payments for watershed services programs settle on the most appropriate niche for this type of conversation incentive (See issue #3), scientific knowledge advances, and market mechanisms tailored to PWS programs emerge.

10. Transaction Mechanisms and Instruments

An important original purpose of this demonstration project was to use actual pilot transactions to explore the need for, and characteristics of, mechanisms to support novel payment for watershed services transactions. For example substantial work has been done in Oregon to develop a market platform for ecosystem service credit transactions, including services related to water temperature, salmon habitat, wetlands, and prairie habitat. An element of the Nisqually pilot has been the development of a formal transaction protocol that establishes rules for participation in PWS. Previous stakeholder discussions raised the idea of "reverse auctions" or buyer auctions (somewhat akin to issuing a Request for Proposals). At the same time, land trusts and others have long-standing experience with conservation easements based on fairly conventional appraisals as the basis of conservation transactions. The question arises as to the basis for, and appropriate timing of, transitions from known methods and instruments to novel and/or more elaborate transactions platforms. One justification for a larger market mechanism would be the development of a supply of and demand for somewhat standardized ecosystem service "credits" with a relatively set price, rather than a series of individual negotiated deals, each with unique characteristics.

Lessons

At this early stage of payment for ecosystem services development, transactions will remain primarily case-by-case rather than standardized. There is room for both "top-down" rules for efficiency, predictability, and security; and "bottom-up" flexibility and diversity to respond to and learn from case-specific details. Conservation easements are the most likely transaction mechanism for watershed service payments, but other kinds of agreement may also be suitable. Meanwhile, efforts should continue, perhaps on a regional basis, to advance more standardized credit-trending systems.

11. Expanding to a Larger Scale

The present demonstration project will have value if technical information and lessons learned are used to expand on the pilot transactions and implement larger scale payment for watershed services activities. Achieving both desired forest conditions and desired water resource benefits depends on broader application of these watershed conservation incentives. Hoped-for broader application should also be understood to take place within an appropriate niche for this method and alongside other forest conservation methods (See issue #3).

At least two possible pathways can be envisioned for moving from limited pilot demonstration projects to larger scale application. One pathway follows an incremental approach, adding more individual projects to enlarge case-by-case learning, incorporate diverse new transaction scenarios and participants, and work carefully toward a future that is as yet unclear. This pathway avoids possibly premature commitments to one or a few models. However, the incremental approach likely entails continuing high transaction costs, due to less ability to achieve economies of scale in developing a common scientific, economic, and institutional foundation for transactions.

The other possible pathway starts at the policy level to establish legal direction, reliable funding sources, scientific knowledge, and implementation structures at the outset. This approach also seeks early engagement from multiple sources of demand for multiple ecosystem services. Efficiency and the potential for earlier watershed-scale outcomes are the attractions of this "build it and they will come" pathway. However, experience shows that a more "top-down" approach won't fit every site-specific circumstance, and individual tailoring may still be needed.

Lessons

The most prudent path toward larger scale application of payment for ecosystem services (PES) probably involves a combination of incremental and system-building methods. Public and decision-maker confidence in novel conservation strategies is unlikely in the absence of some demonstrated success stories. However, needed momentum demands more than a series of isolated individual examples of transactions.

Each of the lessons in this section describes important pre-requisites for scaling up. These include better scientific understanding (Issue #1), specific integration of incentives with a clear and stable regulatory baseline at a larger scale (Issue #2), appropriate partnering with complementary conservation incentives and policies (Issue #3), broader mobilization and linkage of transaction participants and funding (Issues #4-7), and development of appropriate transaction models (Issues #8-10).

This demonstration project supports the need for priority attention to an explicit "business case" for potential buyers contemplating PES transactions, to bring available technical information to bear on the buyer's objectives. In some cases this will make clear the attractiveness of a PES transaction. In other cases, such a transaction may not be prudent. And, potentially, a clear look at available information may lead to a flexing in objectives themselves to accommodate a PES approach. Water utilities should consider their mission and objectives; regulatory requirements; technical, managerial, and financial capacity; and partnership possibilities when determining whether to participate in payments for watershed services. Attention should be paid to the ultimate results of this demonstration project, whether the participating water utilities ultimately conclude transactions, and what can be learned from the transactions specifics.

In Washington State, the work of developing mechanisms for multiple, stacked ecosystem services and multiple categories of buyers on a large scale has not really begun, except in theory. There is an obvious need for better scientific understanding of how multiple ecosystem services relate to one another, which may engage multiple buyers with distinct objectives related, for example, to watershed services, carbon sequestration credits, or habitat mitigation. If, alternatively, a broad multi-faceted ecosystem service is marketed to the general public, such as through a PES "district," comprehensive estimates of true economic value will be very helpful, and policy and political issues about revenue mechanisms must be addressed. Credit trading for individual watersheds inherently faces challenges of sufficient scale. Aggregating watersheds to the scale of Puget Sound, for example, may open possibilities for much greater demand to be expressed. This could justify larger, more standardized credit trading systems.

Strong interest in large scale systems for ecosystem service transactions exists among a relatively small number of people in Washington State. However, the urgency of protecting forest cover and working forest lands is recognized more broadly. The demonstration project is serving to reinforce the value of ecosystem service payments in serving the critical public purpose of retention of forest cover in the Puget Sound region and Washington State. The evident benefits of a large scale application of PES will now require broader outreach in support of some specific larger scale steps.

LEGISLATIVE RECOMMENDATIONS

Participants are still accumulating experience from this demonstration project (see Next Steps below). However, from lessons learned so far, knowledge of expert advisors, and lessons from other regions, project participants have raised a number of possibilities for legislative action. Many of these were discussed at the recent Northwest Environmental Forum at the University of Washington in December 2012.

Two general areas of legislative initiative are possible at this stage: First, authorizing individual payment for ecosystem service transaction participants, especially potential buyers who are public entities such as water utilities, to more confidently explore PES transactions as part of their public mission; Second, beginning to lay improved technical foundations for larger scale transaction programs, such as at the watershed level.

General Authorizing Actions

- The legislature could provide general statutory authorization for water utilities to explore and engage in watershed services transactions as part of carrying out their missions. This could entail placing appropriate language in the enabling statutes of utilities, such as Titles 35 and 36 RCW for cities and counties, Titles 54 and 57 RCW for public utility districts and water and sewer districts, Titles 80 and 86 RCW for public utilities and flood control districts, and RCW 90.48 for stormwater management. Such action would establish broad legislative intent concerning the legal basis and appropriateness of utility exploration of transactional approaches.
- The legislature could authorize specific government entities to participate in the development of market or transaction mechanisms where initiated by private or non-profit entities. These could include general natural resource agencies, such as the Department of Natural Resources through RCW 76.13 relating to stewardship of nonindustrial forests and woodlands. This could also include agencies with more targeted missions such as the Puget Sound Partnership, whose Action Agenda already includes attention to market mechanisms for working forest

retention, and the Recreation and Conservation Office, which administers much state capital investment in conservation.

- The legislature could also begin deliberation concerning broader state-authorized funding sources for public entities to carry out transactions, including appropriate targeting of mitigation payments to upstream conservation actions where efficiencies and multiple conservation benefits can be gained.

Laying Technical Foundations

- The legislature could provide funding or other support for applied, well-targeted scientific study to better understand specific forest watershed relationships in Puget Sound watersheds or more broadly, such as identifying the increment of forest protection, restoration, or management actions that are not provided by other public programs but are most relevant to the missions, needs, and circumstances of drinking water utilities, stormwater managers, or other potential buyers of watershed services.
- The legislature could encourage the use of economic analysis and estimates of the value of ecosystem services, either specific or aggregated, in public investment analysis, such as in public infrastructure investments. This could help allow the true economic contributions of these services to be more explicitly accounted for in a broader range of contexts than is currently the case.
- The legislature could direct and fund studies of the available and likely scale of economic demand for ecosystem services by public utilities in the Puget Sound Basin or elsewhere in comparison to the likely value of transactions sufficient to secure such services from a necessary threshold level of landowners within specific watersheds. The applied scientific results previously described could be one indication of the threshold level of landowner participation.
- The legislature could establish guidelines for the appropriate scientific and economic rationale necessary to encourage and support ecosystem services transactions by public agencies.

Consistent with the legislature's direction in ESHB 2541, because DNR has not secured sufficient non-state sources of funding, it has not studied and is not making legislative recommendations for other working forest conservation incentives mentioned in that legislation. These other incentives include using conservation easements for habitat and biodiversity, and using tax incentives, technical assistance, and market recognition or certification systems. As discussed in Issue #3 in the previous section, all these forms of incentives have a role to play in retaining Washington's working forest land base, and ecosystem service payment systems will find their niche in relation to the entire suite of incentive mechanisms. However, the priority of the legislature in ESHB 2541 was clearly to concentrate on the possibilities for payment for ecosystem service programs, which the department has done.

FINAL STEPS FOR PROJECT COMPLETION

In the December 2011 Progress Report, DNR advised that completion of this demonstration project would be documented in a December 2012 year-end report. Due to delays in grant funding and the untried, innovative nature of this project's activities, DNR and its partners, while making substantial progress toward project completion, have final steps remaining. Most tasks leading up to final consideration of one or more pilot transactions will be finished by spring 2013. This section describes completion of those funded tasks in the two pilot watersheds, pulling from information in the Project Activities section. The City of Olympia and Snohomish County will make final decisions on completing transactions with forest landowners, based on completion of this work.

Nisqually Watershed

The grant received for the Nisqually core team extends throughout 2013; however, the team's current workplan envisions completion of most pilot watershed services transaction work before summer of 2013, with a possible transaction following. The following are major tasks:

▪ Complete economic feasibility analysis.	January
▪ Complete USGS modeling analysis.	April
▪ Identify probable specific requirements for landowner conservation easements.	April
▪ Gain official City of Olympia funding approval for a transaction.	Early 2013
▪ Complete transaction program protocol.	Early 2013
▪ Make contact with final candidate forest landowner(s), confirm interest and begin negotiation.	Feb-Mar
▪ Based on successful negotiation, conduct appraisal.	April
▪ Gain City of Olympia decision on completing a final transaction, that includes a monitoring plan, and record the easement.	Late spring to fall 2012

Snohomish Watershed

The DNR-Snohomish County Interlocal Agreement for pass-through of federal project funds describes a workplan for completing a pilot transaction if favorably indicated by project work. The following are major tasks:

▪ Complete initial hydrologic modeling.	Completed
▪ Complete follow-up modeling.	Late winter
▪ Complete initial parcel prioritization in test sub-basin.	Completed
▪ Conduct follow-up prioritization in additional sub-basins .	Completed
▪ Complete economic feasibility analysis.	February
▪ Complete final reporting.	March

SWM expects to launch outreach to priority forest landowners in coordination with Forterra and others in spring 2013 to gauge interest in watershed service transactions. Later in 2013, Snohomish County will decide whether to proceed with a pilot transaction, based on completion of analytical work and results of landowner outreach. If proceeding, the county will select a priority parcel, negotiate with the landowner, complete an appraisal, and then execute the transaction.

The expiration of DNR's watershed grant is currently set for April 30, 2013. DNR's scope of work includes preparation of a final project report. That report, expected in April, will document completion of remaining project work, anticipate the likelihood of completing final transactions in 2013, and describe potential strategies for moving to expand beyond this demonstration project. Issue #11 in Major Issues and Lessons Learned, above, and the Legislative Recommendations section lay some groundwork for that forward-looking discussion.

The nature of DNR's further involvement in developing payment for ecosystem services programs aimed at working forest land retention depends on the results of the demonstration project, as well as further discussions with project partners, stakeholders, and the legislature, and the availability of appropriate authorization and funding. Protecting working forests and forest cover is a major goal in DNR's 2010-2014 Strategic Plan.

Appendix B – Snohomish Final Report

Snohomish Basin Forest Ecosystem Services Pilot Project

Final Report

June 2013

Snohomish County Public Works Department
Surface Water Management Division

This final report on the Snohomish Basin Forest Ecosystem Services Pilot Project partially fulfills the terms of Interlocal Agreement (ILA) 13-136 between the Washington State Department of Natural Resources (DNR) and Snohomish County. The source of funding for the ILA is a National Estuary Program (NEP) grant awarded to DNR in April 2012 (NEP Grant Agreement Number G1200439).

Note: The majority of work documented in this report was conducted without the benefit of either a draft or final, approved Quality Assurance Project Plan (QAPP), as required in Task 2.1 of the Statement of Work for the ILA.

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1. Introduction

Working forests are valuable resources for the citizens of Snohomish County. In addition to producing jobs and revenue, sustainably managed forestlands provide a wide range of environmental benefits. These benefits, which are also called "ecosystem services," include the natural regulation of stormwater. Healthy forests are excellent stormwater managers. They act like giant sponges, absorbing water from rain and snow and slowly releasing it into streams. Scientific studies show that intact forestlands play a key role in attenuating stream flows, thereby helping to reduce downstream flood risks and protect water supplies for drinking, fish and wildlife habitat, and irrigation. Given the importance of working forests and the ecosystem services they provide, Snohomish County has partnered with the Washington State Department of Natural Resources (DNR) to explore how voluntary programs based on payments (or "transactions") for ecosystem services might incentivize the maintenance and restoration of forest cover on privately owned lands.

2. Project Background

In April 2012, the Washington State Department of Natural Resources (DNR) received a $200,000 National Estuary Program (NEP) grant to fund the agency's Watershed Services Market Demonstration Project. The primary objective of the DNR demonstration project is to develop technical tools, metrics, and market mechanisms that will facilitate pilot transactions for ecosystem services within the Nisqually and Snohomish River watersheds. In November 2012, through Interlocal Agreement (ILA) 13-136 between DNR and Snohomish County, DNR transferred $80,000 of its NEP grant award to the County's Surface Water Management Division (SWM) to support the initial phases of the Snohomish Basin Forest Ecosystem Services Pilot Project ("the Snohomish Pilot Project", or "the Project"). This final report documents the results and conclusions of work carried out by SWM under the terms of the ILA[1], as well as lessons learned.

Purpose and Goals

The purpose of the Snohomish Pilot Project is to assess the viability of using payment-based mechanisms (e.g., conservation easements) to encourage private landowners to protect forest cover on their properties and thereby maintain or enhance the delivery of ecosystem services. The short-term goal of the Project is to prioritize and target one parcel within the Snohomish River watershed for a potential ecosystem services transaction in which the landowner will receive financial compensation for implementing specific actions such as transferring development rights or adopting more sustainable forest management practices. The long-term goal of the Project is to produce useful information—"transaction evidence"—that will support future efforts to develop and implement a broad market-based program to protect working forests and the ecosystem services they provide across the Puget Sound region.

[1] It should be noted that this report documents work done without the benefit of an approved QAPP, as required in Task 2.1 of the Statement of Work for this ILA.

3. Project Organization

The project team for the Snohomish Pilot Project is comprised of SWM planners and technical staff. Table 1 below lists the key SWM personnel involved in the Project and their roles and responsibilities.

Table 1. SWM staff project roles / responsibilities.

Name and Role	Primary Responsibilities
Debbie Terwilleger SWM Division Director	Establish priorities and overall direction for the project; provide final review and approval of all work products
Gregg Farris, P.E. Project Supervisor	Provide management oversight; review work products to ensure consistency with SWM standards and ILA commitments.
Beth Liddell Project Manager	Administer the project; monitor progress; coordinate activities with DNR and other partners.
David Ojala, P.E. Technical Project Manager	Provide technical oversight and analysis; coordinate and report on modeling work.
Dr. Gi-Choul Ahn Project Team Member	Prioritize sub-basins and parcels; conduct land use / land cover analysis for modeling work.
Tao Xiong, P.E. Project Team Member	Carry out hydrologic modeling tasks; provide post-processing and technical analysis.

4. Project Tasks

Task 1: Project Initiation and Administration

Under the terms of ILA 13-136, foundational activities for the Snohomish Pilot Project included:

- Conducting background research on ecosystem services markets;
- Designating a project manager;
- Assembling a project team;
- Developing and refining a project work plan;
- Selecting a target ecosystem service;
- Monitoring progress on ILA work items; and
- Communicating and coordinating with DNR staff.

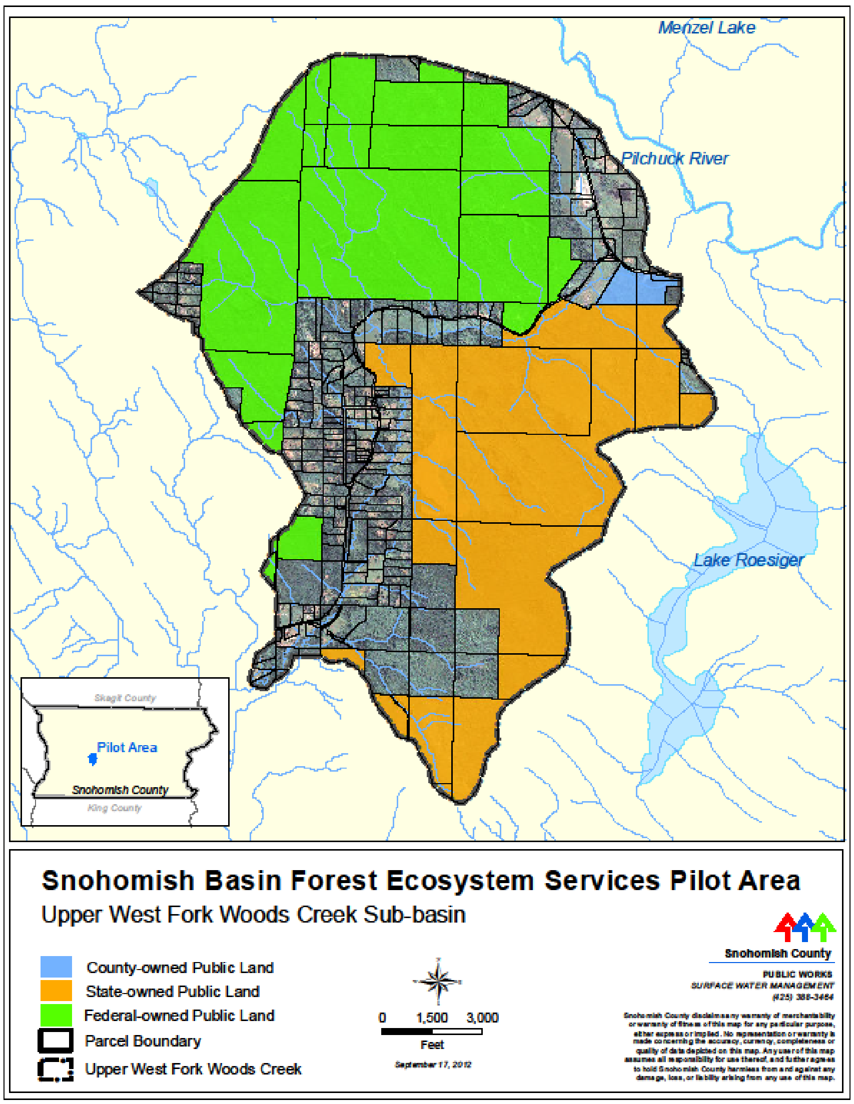
Task 2: Metric Development

Metrics play a key role in the development of market-based strategies to protect forest cover. They are, in essence, parameters that can be measured over time in order to evaluate (and ideally quantify) the delivery of ecosystem services within a watershed. As the first step in establishing metrics for the Snohomish Pilot Project, “flow attenuation” was chosen as the target ecosystem service. This service can be defined as the stabilization of stream flows and associated processes (e.g., bank erosion) which influence habitat conditions in small stream systems. Once the target ecosystem service had been selected, a hydrologic model was used to evaluate potential metrics for the Project. The primary goal of this exercise was to establish appropriate metrics for assessing the delivery of the target ecosystem service by forestlands. A secondary goal was to produce useful data that could help SWM and DNR gauge how specific landowner actions to protect forest cover might affect the provisioning of flow attenuation.

Pilot Sub-Basin

The study area—or “pilot sub-basin”—chosen for the modeling exercise was the Upper West Fork Woods Creek sub-basin, as shown in Figure 1 below. This sub-basin is located east of the City of Lake Stevens and ultimately drains into the Skykomish and Snohomish Rivers. It is approximately 5,303 acres (8.3 square miles) in size, with elevations ranging from 305 to 1,040 feet. It was selected as the pilot sub-basin largely because (1) it is characterized by a mix of rural residential properties and commercial forestlands (both public and private); (2) most of it is currently undeveloped; (3) it contains important habitat for steelhead, coho, and other salmon species; and (4) it encompasses many small parcels which are zoned for residential land use and are at risk for future development.

Figure 1. Map of the pilot sub-basin.



Methodology

Based on a literature search, three potential flow metrics—stream channel stability, relative stream power, and high pulse count—were selected for evaluation. A Hydrologic Simulation Program-Fortran (HSPF) model was then constructed to simulate how these metrics would be affected by reductions in forest cover and increases in impervious area in the pilot sub-basin. SWM employed an HSPF model for the Snohomish Pilot Project for several reasons. First, HSPF is the standard for basin planning in Puget Sound lowlands and is the model suggested by the Washington State Department of Ecology to meet flow control standards for development. Second, HSPF includes a forest land cover class, so conversion from forest to non-forest can be explicitly modeled. Third, HSPF models can be used to extract flow data from specific geographical areas within a watershed. This data can be statistically analyzed, much like stream gauge data, for a suite of metrics. Finally, the literature generally supports the use of HSPF for assessing the impacts of hydrologic change on stream channel stability, relative stream power, and high pulse count.

The following seven scenarios were modeled:

- 90% forest cover retention, 0% effective impervious area (pristine conditions)
- 80% forest cover retention, 1% effective impervious area (existing conditions)
- 70% forest cover retention, 1% effective impervious area
- 60% forest cover retention, 1% effective impervious area
- 50% forest cover retention, 1% effective impervious area
- 66% forest cover retention, 5% effective impervious area
- 64% forest cover retention, 10% effective impervious area

For the purposes of the modeling exercise, effective impervious area (EIA) was used as a proxy for residential development. For the scenarios with 50-70% forest cover retention, parcels with the highest Conservation Priority Index (CPI) ranking were converted from forest to non-forest until the target percentage of forest cover retention was achieved. For more information on CPI rankings, see the section below entitled "Task 3: Parcel Prioritization."

Results

As detailed in Appendix A of this report, the modeling results for the selected metrics trended in the expected direction for all seven modeling scenarios. In sum, as forest cover in the model decreased:

- The stream channel stability metric showed a slight trend towards instability, though not as much as expected. This trend was more pronounced as EIA increased.
- The relative stream power metric showed a slight trend towards more degraded habitat / biological conditions. This trend was also more pronounced as EIA increased.
- The high pulse count metric showed a slight trend towards more degraded habitat / biological conditions. This trend was more dramatic with the 5% and 10% EIA scenarios.

Limitations

The results of the modeling exercise are consistent with those predicted by the scientific literature; however, they should be evaluated with consideration of the following limitations and caveats:

- Analysis of the results focused on trends in the data, rather than accuracy.
- Many land use activities associated with clear-cutting, such as the building and maintenance of forest roads, were not modeled. If these activities had been incorporated into the HSPF model, they likely would have had an additional impact on the selected flow metrics.
- Regulatory requirements (e.g., stormwater detention, riparian buffers) which are designed to mitigate the impacts of forest conversion and additional EIA on hydrologic processes were not considered in the modeling scenarios.
- The HSPF model was not calibrated because there are no stream gauges in the Upper West Fork Woods Creek sub-basin.
- The hydrologic parameters used in the model, such as precipitation patterns and soil conditions, were generalized. In other words, they represented regional "averages," and were not specific to the pilot sub-basin.
- For the seven modeling scenarios, forest was converted to "pasture" because HSPF includes a limited number of land use classes. The pasture condition was assumed to be the closest to a clear-cut condition.
- The literature provides general guidance about the thresholds—or break points—between stable / unstable or degraded / highly degraded conditions for the selected metrics, but this is not precise.

Conclusions

As expected, the modeling results indicate that increased forestland conversion within the pilot sub-basin would cause an increase in stream flows, a decrease in channel stability, and a trend towards more degraded biological / habitat conditions. Furthermore, the results imply that the addition of impervious surface to forestlands—development—would have a much more dramatic impact on the selected flow metrics than forest clearing by itself. Due to uncertainty in the model and a limited scope of work, the point at which forestland conversion would cause a specific metric to cross a threshold (e.g., move from stable to unstable) could not be determined. However, the goal of establishing appropriate metrics for assessing the delivery of flow attenuation was achieved.

Lessons Learned

Three major lessons emerged from the metric development task. First, given that the addition of impervious surface seems to have a greater effect on the delivery of flow attenuation than the loss of forest cover alone, forestlands which are most likely to be developed should be given high priority when considering ecosystem services transactions for hydrologic benefits. Second, efforts to model the effects of timber harvesting on hydrologic processes should incorporate the potential impacts of road construction and other accompanying activities. They should also take into account the federal, state, and local regulations designed to mitigate such impacts. Third, if an HSPF model will be employed to evaluate the impacts of forestland conversion on flow metrics, the sub-basin of interest should be gauged (or flow monitoring should be performed) so that the model can be calibrated.

Recommendations

If additional modeling is conducted to further evaluate how forest cover retention affects stream flows and associated processes, the following is recommended:

- Additional and more detailed analysis should be carried out to determine if parcel location relative to stream location significantly impacts the selected flow metrics.
- Further analysis should be conducted on the appropriateness of using the HSPF land use class "pasture" to represent cleared forestland. It is uncertain if HSPF accurately predicts hydrologic changes between forested and clear-cut conditions.
- Additional analysis is recommended to determine if forest cover loss by itself has a significant impact on flow attenuation, or if activities typically associated with forestland conversion (such as road-building or the addition of EIA) have a much more substantial impact.

Task 3: Parcel Prioritization

Prospective buyers of ecosystem services, such as utility providers, typically have limited funding for programs aimed at protecting forest cover. Therefore, if they decide to pursue ecosystem services transactions, they must first establish a process for prioritizing land parcels based on their capacity to deliver target ecosystem service(s). After flow attenuation was chosen as the target ecosystem service for the Snohomish Pilot Project, various tools and datasets were employed to prioritize parcels, as well as entire sub-basins, for forest protection efforts. The primary goals of this exercise were to assess the utility of these tools and datasets and to develop a strategy for prioritizing privately owned parcels within the Snohomish River watershed for potential ecosystem services transactions.

Methodology

Based on discussions with DNR staff, the Conservation Priority Index (CPI) was evaluated as a potential parcel prioritization tool. The CPI, in short, is a Geographic Information System (GIS)-based method for identifying forestlands with the highest conservation value. It incorporates existing environmental data into a scoring and ranking process and produces results that are relatively easy to interpret. As detailed in Appendix B of this report, the CPI was employed to rank privately owned land parcels in the pilot sub-basin based on the extent to which they provide hydrologic benefits, including flow attenuation. Once parcels most important to the delivery of the target ecosystem service were identified, these parcels were prioritized by incorporating budget limitations and development pressure data from the SERGoM (Spatially Explicit Regional Growth Model) and the University of Washington Rural Technology Initiative (RTI). More information on both SERGoM and RTI data, including how these data were applied in the prioritization exercise, can be found in Appendix B.

Once the utility of the CPI had been tested, a decision was made to expand the focus of the Snohomish Pilot Project beyond the Upper West Fork Woods Creek sub-basin, largely because most of the land in the pilot sub-basin is now owned by DNR or other public agencies, rather than private landowners. The Washington State Department of Ecology Watershed Characterization (WC) was subsequently evaluated as a possible tool for prioritizing sub-basins for potential ecosystem services transactions. As described in Appendix B, the WC map for the Snohomish River watershed was analyzed and sub-basins which are classified as both high in importance and low in degradation were identified. The CPI was then used to score, rank, and map all of the sub-basins within the watershed. Finally, a visual comparison was made between the WC and CPI-based maps and several new priority sub-basins were selected based on the following criteria:

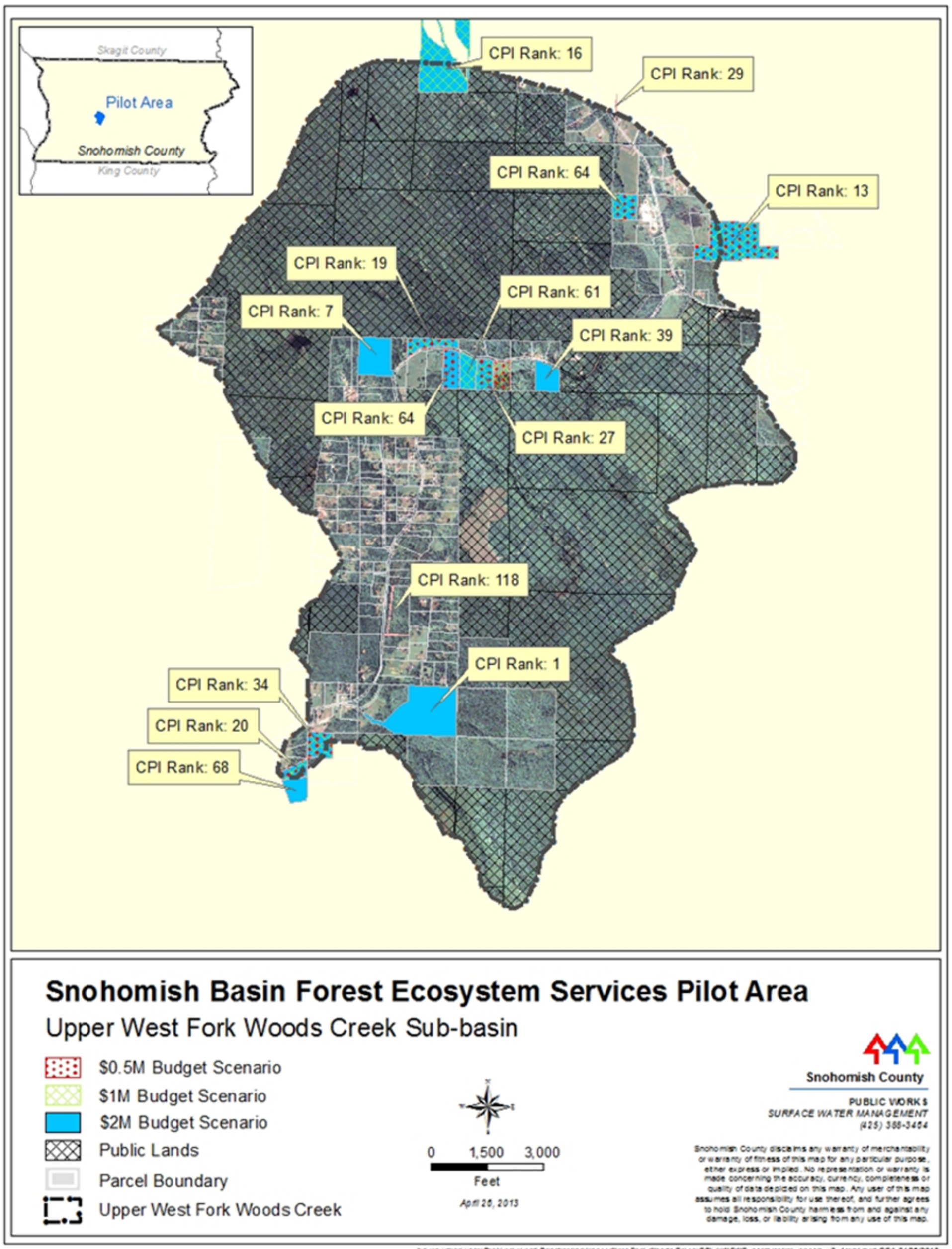
- High importance for protection according to the WC;

- A relatively high CPI ranking;
- Closer proximity to rural residential (developed) lands; and
- A relatively high percentage of privately owned land.

Results

The result of the CPI parcel prioritization process was the identification of fifteen top-priority parcels in the pilot sub-basin, as listed in Table 5 of Appendix B. These parcels, which are shown in Figure 2 below, ranged in size from 0.3 to 72.1 acres.

Figure 2. Map showing the fifteen top-priority parcels and their CPI rankings.



The result of the combined WC-CPI sub-basin prioritization process was the identification of three new sub-basins of interest: the North Upper Pilchuck River sub-basin, the Lower Olney Creek sub-basin, and the South Upper Mainstem Skykomish sub-basin. Maps of these sub-basins are included in Appendix C of this report.

Limitations

The results of the land prioritization exercise should be evaluated with consideration of the following limitations and caveats:

- The data inputs used for the CPI scoring and ranking process were not ideal. For example, the wetland data were outdated and contained significant errors and the soils data were generated by a model.
- Due to the limitations commonly associated with input data, the literature recommends that the CPI be applied to parcels larger than twenty acres. Most parcels in the pilot sub-basin (including eleven of the fifteen top-priority parcels) are less than twenty acres in size.
- The datasets utilized for the development pressure analysis were not ideal. For example, RTI data is outdated and excludes parcels enrolled in the state Designated Forestland program. In addition, SERGoM data is most appropriately used to evaluate regional development patterns, rather than to assess development pressure at the parcel scale.
- The WC assumes that sub-basins classified as high in importance are uniform and “unaltered” across the entire landscape. No sub-basins in the Snohomish River watershed actually fit this description.
- Selecting priority sub-basins by utilizing the WC in combination with CPI rankings and other factors involves a fair amount of subjectivity.

Conclusions

The results of the prioritization exercise demonstrate that the CPI can be used to prioritize land parcels for ecosystem services transactions and that the CPI and WC tools can be used in tandem to prioritize sub-basins within a watershed. In addition, the results indicate that development pressure data can help inform parcel prioritization strategies by highlighting forestlands most at risk for conversion to developed uses. Due to time and resource constraints, the CPI and WC were not compared to other potential prioritization tools. Therefore, a “best” strategy could not be established for prioritizing land parcels within the Snohomish River watershed for potential ecosystem services transactions. However, the goal of evaluating the utility of various tools and datasets for selecting priority parcels was achieved.

Lessons Learned

The main lesson that emerged from the prioritization task is that both the CPI and WC can be integral components of a defensible strategy to prioritize lands for ecosystem services transactions, particularly when they are employed in combination with factors such as development pressure. It should be noted, however, that the WC tool is inappropriate for use at the parcel scale, and that the CPI—which focuses on hydrologic benefits—is not well-suited for scoring and ranking lands based on the biological / habitat benefits they provide or their capacity to mitigate climate change.

Recommendations

If additional land prioritization efforts are undertaken, the following is recommended:

- Incorporate additional landscape characteristics into the CPI scoring process. For example, total river miles or forest type (deciduous versus evergreen) could be used to calculate CPI scores for specific sub-basins or land parcels.
- Use local information to augment RTI and SERGoM development pressure data.
- Evaluate alternative sources of development pressure data, such as the SLEUTH (Slope, Land use, Excluded land, Urban extent, Transportation) model, the Smart Growth Index, or the Land Transformation Model.
- Further research the limitations and appropriateness of applying the CPI to parcels less than twenty acres in size.
- Develop a methodology to fully integrate the CPI and WC tools, rather than rely on visual comparisons of maps.

Task 4: Final Report

With the submission of this report to DNR, SWM fulfills its obligations under the terms of ILA 13-136.

Appendix A
Technical Memorandum: Metric Development

SNOHOMISH COUNTY
Public Works Surface Water Management

Technical Memorandum

Project Name: Snohomish Basin Forest Ecosystem Services Pilot Project
Project Task: Metric Development and Hydrologic Modeling in Upper West Fork Woods Creek
Date: May 15, 2013
Staff: Tao Xiong, David Ojala, Gi-Choul Ahn

1. Purpose

The goal of this work was to help the project team understand how the benefits of potential ecosystem services transactions can be measured. To do this, appropriate metrics needed to be established to measure the hydrologic benefits of protecting forest cover. Three metrics, or hydrologic indicators, were selected and tested using the results of a non-calibrated hydrologic model of the Upper West Fork Woods Creek sub-basin (the "pilot sub-basin").

2. Literature Search and Flow Metrics

The three stream flow metrics evaluated for the pilot sub-basin were chosen based on a limited literature search. One of these metrics is an indicator of stream channel stability and the other two are indicators of habitat / biological integrity. It was found that the literature generally supports the use of non-calibrated hydrologic modeling results for channel stability indicators; however, the literature recommends using non-calibrated hydrologic modeling results for habitat / biological indicators with caution and only for general trends.

Stream Channel Stability

$Q_{10\text{-pristine}}/Q_{2\text{-Current}}$

The stream channel stability metric is the ratio of the pristine (fully forested) 10-year hourly flow rate to the current (forest retention scenario) condition 2-year hourly peak flow rate. This empirical relationship for channel stability was developed by Booth and Jackson (1997) as referenced in Booth, Hartley, and Jackson (2002).

Generally stable channels occur when the ratio is above 1.0, and generally unstable channels occur when the ratio is below 1.0. They also reported a "zone of uncertain stability" based on uncertainty in hydrologic modeling parameters for watersheds with varied effective impervious area (0% to 8%).

Booth, Hartley, and Jackson (2003) used a non-calibrated Hydrologic Simulation Program-FORTRAN (HSPF) model to determine a threshold for forest cover retention and channel stability. They found that *"using generalized model parameters and a range of effective impervious areas typical of rural areas, 65 percent forest cover is a plausible, but by no means definitive, value for meeting the presumed* *'stability criterion' on moderately sloping till soils."* They concluded that *"the apparent 'threshold' of observed stream-channel stability has no correlative in measured biological conditions; for any given watershed, additional development tends to produce additional aquatic-system degradation".*

The metric described above was used in this study as an indicator of channel stability. Uncertainty in the modeling results was expected due to uncertainty in the hydrologic modeling parameters. Therefore, the results were used to observe general trends across forest retention modeling scenarios, not as an exact indicator of stream channel stability.

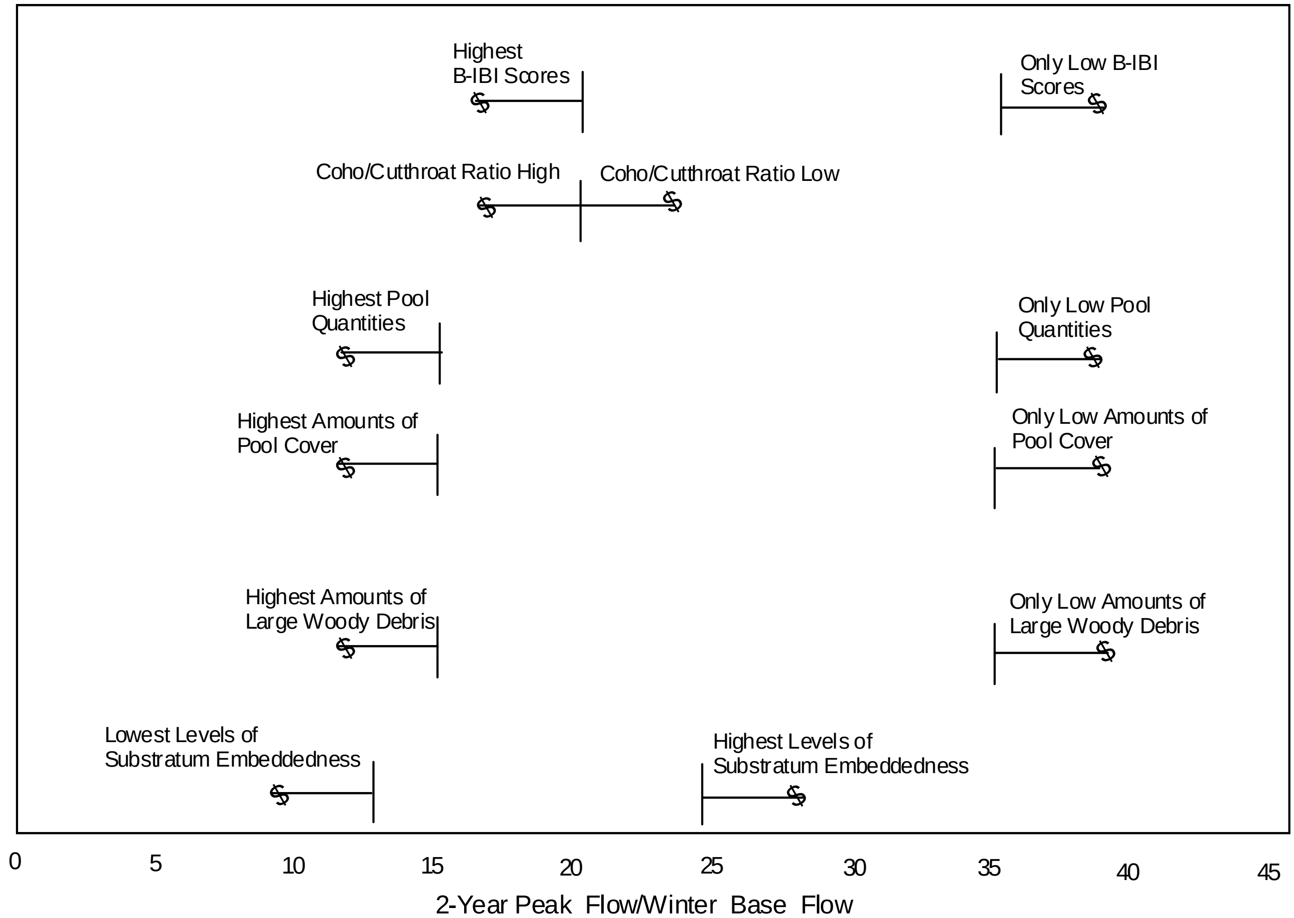
Relative Stream Power

$Q_{2\text{-}Current}$/Winter Base Flow

Relative stream power is the ratio of 2-year annual peak flow frequency to the winter base flow of the forest retention scenario. Winter base flow is estimated per nhc (2006) as the average of the 80% and 95% exceedance flow level during the season extending from November 1 through March 31.

The flow ratio is defined as being proportional to the relative stream power, and per nhc (2006), "represents the short-term maximum increase in physical stress experienced by the channel and its habitats and biota."

According to nhc (2006) and May (1997) and as depicted in Figure 1, *"Habitat changes were found to occur with ratios as low as 13 although generally, ratios less than 20 maintain biologic integrity. Flow ratios between 20 and 35 were correlated with degraded conditions, while flow ratios greater than 35 were correlated with highly degraded in-stream habitat and biotic integrity."*



<u>Figure 1</u>. Relationship between relative stream power and habitat / biological indicators for Puget Sound streams (reproduced from May, 1997)

Figure 1 shows that as the relative stream power increases, the quality of habitat and biological indicators decreases. This flow metric is used in this study to observe general trends across forest retention modeling scenarios, not as an exact indicator of habitat or biological integrity.

<u>High Pulse Count</u>

Hydrologic pulses are defined for this study per Richter (1996) as “those periods within a year in which the daily mean water condition (flow) … rises above the 75th percentile (high pulse) ... of all daily values for the pre-impact period”. Pre-impact is existing condition for our study.

In general, higher pulse counts correspond with lower Pacific Northwest Benthic Index of Biological Integrity (B-IBI) scores. Lower B-IBI scores indicate degraded habitat and biological conditions.

DeGasperi (2009) found that a calibrated HSPF model could “reliably predict” six hydrologic metrics (including high pulse count) that were also “significantly correlated” with B-IBI scores. They also noted that although *“High Pulse Count and High Pulse Range are the individual hydrologic metrics with the greatest potential for biological relevance” that “at best these metrics could discriminate between the worst and best B-IBI locations.”*

The high pulse count modeled by DeGasperi (2009) for a fully forested watershed (Miller Creek) was seven times per year. For the 16 urbanizing streams in their study, the minimum high pulse count was two, the mean was ten, and the maximum was 22, based on analysis of stream gauge data.

Cassin (2005) found that high pulse count results were not significantly different when comparing stream gauge data and HSPF model results. However, they state that *"simulation models should be used with caution until they can be specifically calibrated for flow metrics of biological interest."*

For this study, high pulse count was used to compare forest retention scenarios, with a higher pulse count generally indicating more degraded habitat and biological conditions. It was not used as an exact indicator of habitat or biological conditions.

3. Hydrologic Modeling

To inform the project team about the effects of forest practices on the three stream flow metrics, an HSPF model was developed for seven forest cover retention scenarios within the Upper West Fork Woods Creek sub-basin.

Characterization of Pilot Sub-basin

Basins, Sub-basins, and Sub-areas

West Fork Woods Creek is a 17,537 acre (27.4 square mile) basin within the Snohomish River watershed, as shown in Figure 2 below. The pilot sub-basin—the Upper West Fork Woods Creek sub-basin—is the upper 5,303 acres (8.3 square miles) of the West Fork of Woods Creek basin. This sub-basin is bisected by Carpenter Road and extends from Creswell Road in the south to Robe Menzel Road to the north.

For this study, the pilot sub-basin was divided into 23 sub-areas, as shown in Figure 3. There are ten central portions (CP) which represent sub-areas along the main Carpenter Creek channel, six sub-areas on the right (facing downstream) overbank (RT), and six sub-areas on the left overbank (LT). The remaining sub-area (Trib) is a tributary that enters downstream of the Creswell Road crossing.

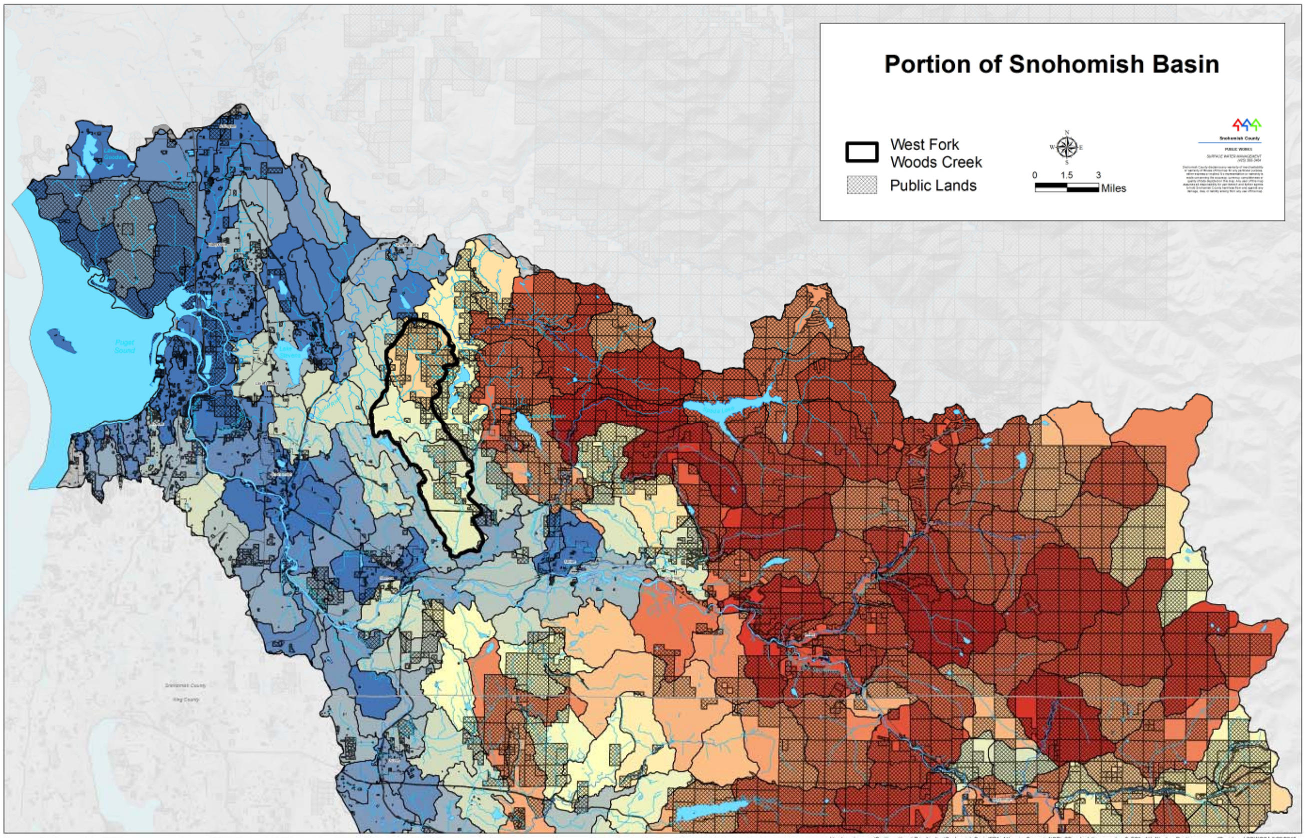


Figure 2. A portion of the Snohomish River watershed with the West Fork Woods Creek basin outlined in black

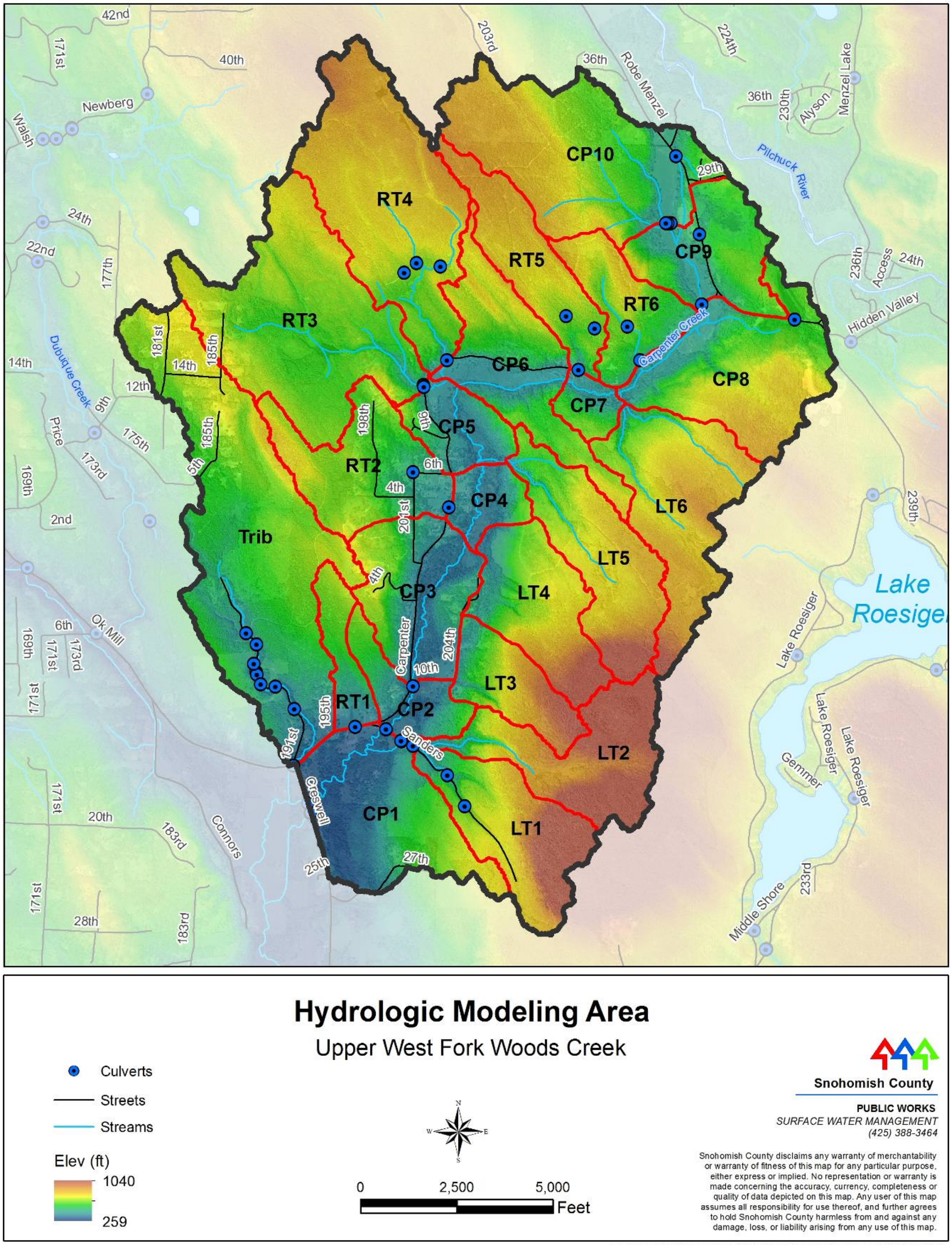


Figure 3. Sub-areas within the Upper West Fork Woods Creek sub-basin

Slope and Elevation

The Upper West Fork Woods Creek sub-basin varies in elevation from approximately 250 feet to 1,040 feet (NAVD 88). Since the elevations are below 1,500 feet, it is considered a lowland sub-basin, and the influence of snow or snow melt is not considered in hydrologic modeling. Due to the varied elevations, precipitation varies significantly across the sub-basin and was adjusted accordingly (see precipitation discussion). Each of the sub-basins was characterized based on slope for input into the HSPF model. Figure 3 above shows the slope variation.

Hydrologic Model Inputs

HSPF (Hydrological Simulation Program-FORTRAN) is a comprehensive model for simulation of watershed hydrology (Aqua Terra, 2005). Inputs to the model consisted of precipitation and evaporation time series, land use / land cover data, hydrologic parameters, slope data, soils data, and stage-storage-discharge relationships for each sub-area. ArcGIS was used to analyze the land use, soil, and slope coverages for each sub-area and to generate SCHEMATIC blocks (input) for the HSPF model.

Precipitation

The long term precipitation record used was a 15-minute precipitation time series from 10/1/1948 to 9/30/2012 generated from the NWS (National Weather Service) Everett gauge (10/1/1948 to 1/14/1992) and Snohomish County's Soper Hill gauge (1/15/1992 to 9/30/2012). The precipitation was scaled from the gauge sites to each sub-basin by multiplying a factor to the recorded precipitation. The factor was estimated by long-term mean annual precipitation provided by Washington State Department of Transportation (WSDOT, 2006).

Evaporation

The daily pan evaporation time series was generated from available daily records for water years 1960 through 1997. For the most part, the station only measured pan evaporation during the growing season. Data for winter months was filled using the Jensen-Haise equation per Snohomish County Hydrologic modeling protocols (Snohomish County, 2002). Evaporation data for water year 1960 was transposed without change to water years 1949 through 1959 and 1998 through 2011 per the same protocols.

Land Use / Land Cover Inputs

Land use and land cover were grouped into eleven categories—Open Water; Forest; Pasture; Grass; Rural-, Low-, Medium-, and High-density Single Family Residence; Multi-family Residence; Commercial; and Roads—based on 2006 land use / land cover data from the National Oceanic and Atmospheric Administration (NOAA). This data was produced using 30 meter resolution Landsat Thematic Mapper and Landsat Enhanced Thematic Mapper satellite imagery. Current land use categories were converted to pervious (PERLND) and impervious (IMPLND) categories specific to HSPF using a computer program and remote sensing-based land use data. Similarly, forest retention scenarios, including the pristine condition and 50%, 60%, 70%, 80%, and 90% forest retention conditions, were computed. In addition, the percent imperviousness for different hydrologic models was adjusted according to land development scenarios until 5% and 10% EIA scenarios were achieved. The computer program simulated forest loss vs. pasture; grass and impervious gains / losses in different soils; slope; and existence of wetlands. This was based on procedures outlined in Snohomish County SWM, November 2012.

Hydrologic Parameters

Each land cover category was assigned a series of hydrologic parameters which the model uses to partition the flow inputs into surface runoff, shallow groundwater flow, and deep groundwater flow. The hydrologic parameters were the generalized HSPF model parameters for lowland areas adopted from Dinicola (1990) for Puget Sound in western Washington State. The HSPF model was not calibrated.

Slope Data

Surface slope was graded into three classes: Flat (0 to <6%), Moderate (6% to <15%), and steep (greater than 15%) for input into the HSPF model. The slope was based on USGS National Elevation Dataset (NED) digital elevation model (DEM).

Soils Data

Soil was classified into four types: Till, Custer-Norma, Outwash, and Saturated based on HSPF input requirements. Soil typing was based on United States Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) Soil Survey soil classifications, which are converted to the HSPF soil classifications per Snohomish County protocols (2002).

Stage-Storage-Discharge Tables (FTABLEs)

FTABLEs for routing reaches within HSPF were created by Manning's equation or HY-8 (Federal Highway Administration). No other hydraulic modeling was performed. A limited inventory of culverts in the sub-basin was available from a previous habitat survey. A field visit to the study area was conducted to hand measure and verify all the major culvert crossings. No detailed survey was performed.

Channel Routing Linkages

The linkages between sub-areas in the HSPF model are shown below in Figure 4.

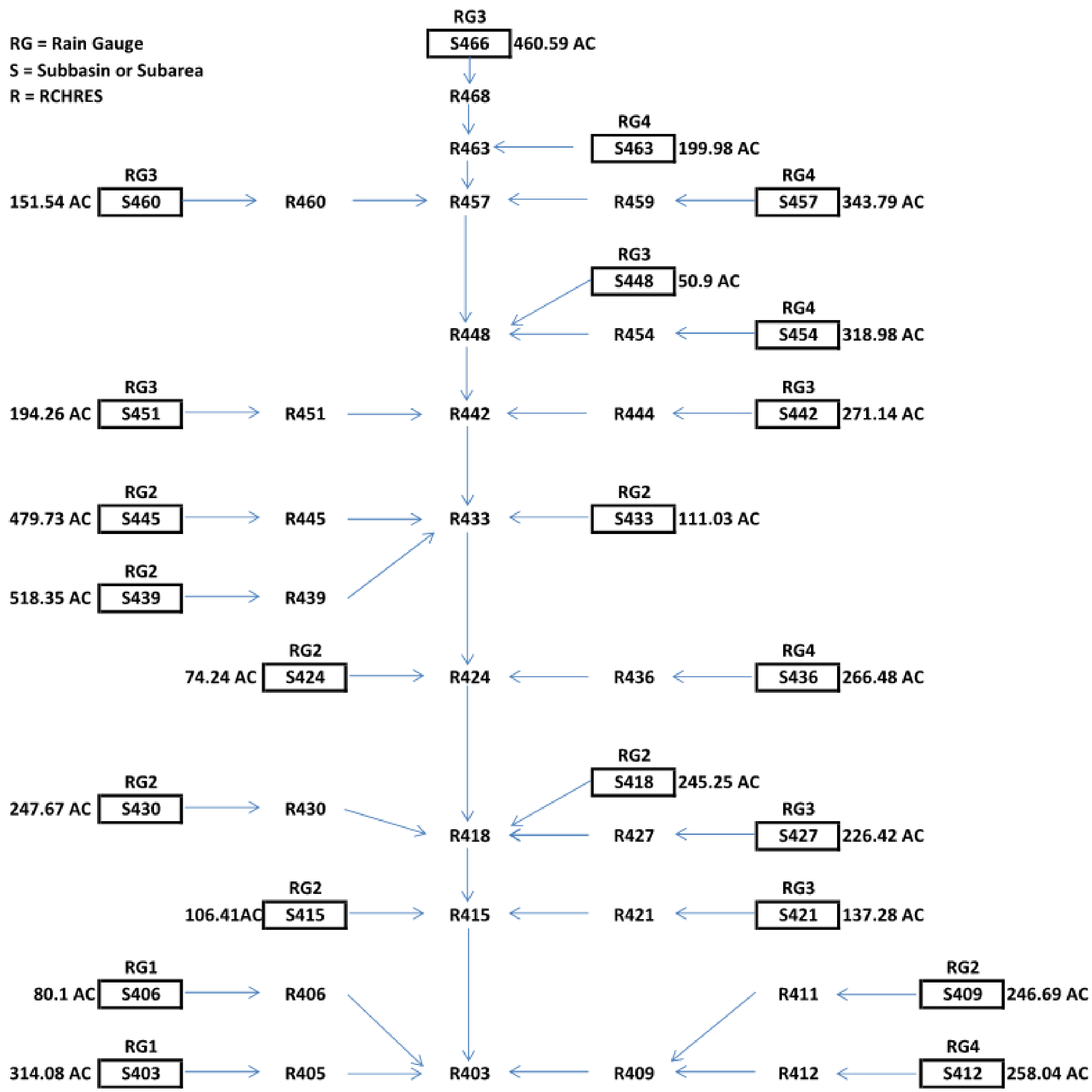


Figure 4. HSPF model channel routing linkages

Land Cover Scenarios

Seven forest cover retention scenarios within the pilot sub-basin were studied. For all seven scenarios, forestland was converted to pasture, which for the purposes of this study represented a logged or clear-cut condition without the effects of forest roads or other development.

The first five scenarios consisted of pristine conditions (90% forest retention), existing conditions (80% forest retention), and 70%, 60% and 50% forest retention. Each of these scenarios had approximately 1% effective impervious area (EIA). Two additional forest cover retention scenarios were 66% forest retention with 5% EIA and 64% forest retention with 10% EIA. These scenarios represented conversion of forest to impervious surface and grass (i.e., residential development).

Forest retention percentages were based on the entire Upper West Fork Woods Creek sub-basin. To produce specific retention percentages for the scenarios, land parcels with the highest Conservation Priority Index (CPI) ranking within the pilot sub-basin were converted until the target percentage of forest retention was achieved (Snohomish County SWM, July 2012). Depending on the spatial distribution of parcels converted for the scenarios (see maps in Attachment 1), some of the individual sub-areas had larger or smaller forest retention percentages compared to existing conditions.

Figure 5 below depicts all seven modeling scenarios at selected sub-areas within the pilot sub-basin. Refer to Figure 3 for the locations of these sub-areas.

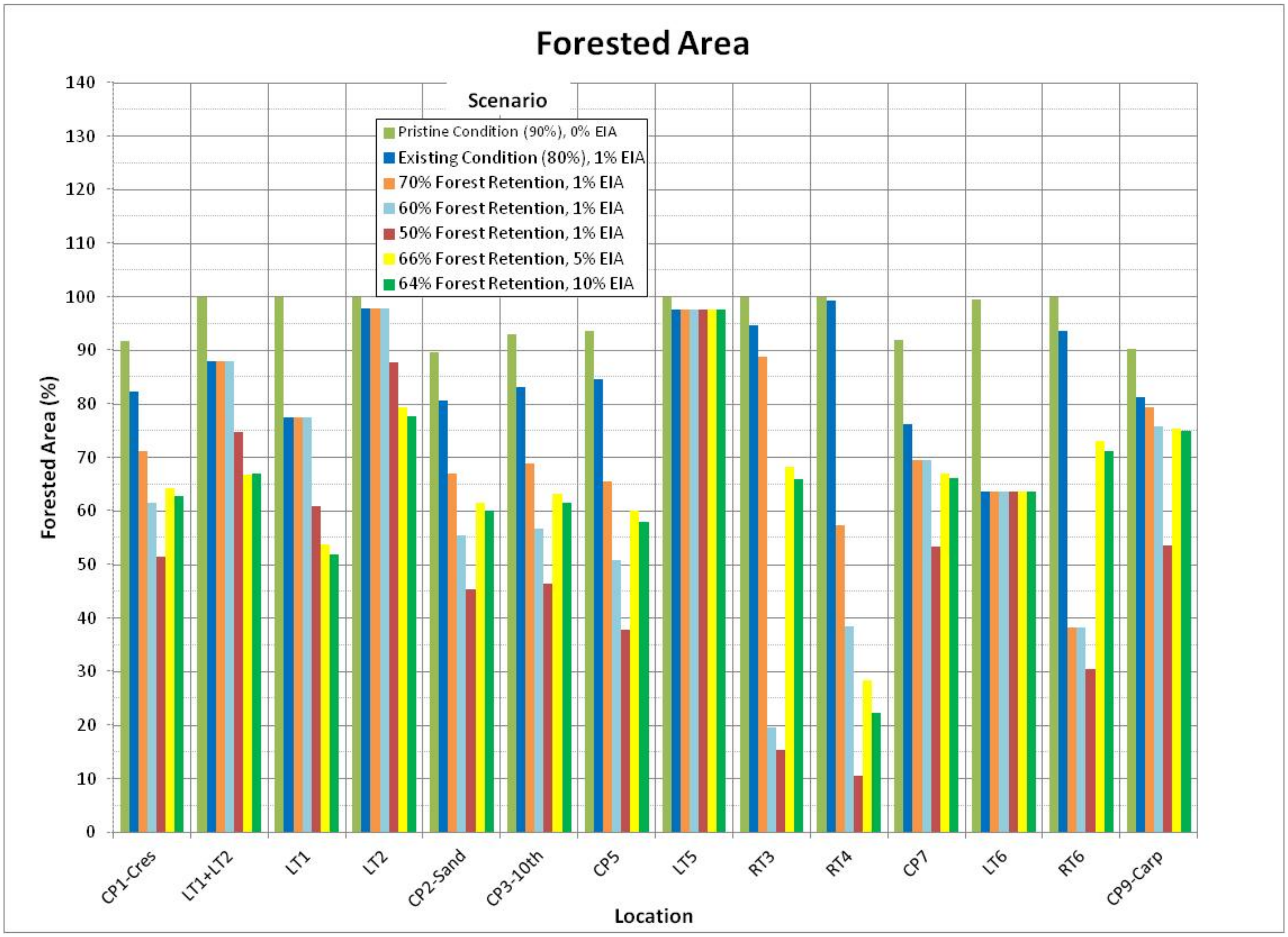


Figure 5. Forest cover retention scenarios at 14 selected sub-areas

Figure 5 shows that sub-area RT4 experiences the most forest conversion in the model, while sub-area LT5 experiences no forest cover loss. Sub-area CP1-Cres is at the downstream end and represents average forest retention for the entire pilot sub-basin.

Hydrologic Model Output

The result of each simulation was a 64-year time series history (10/1/1948 to 9/30/2012) of the runoff flow rate at any sub-area location at 15-minute intervals. The time series data was stored in a watershed data management (WDM) file.

4. Data Post-Processing

Time series data generated by HSPF for the seven forest cover retention scenarios were post-processed using public and proprietary software programs to calculate values for the three flow metrics described in Section 2 of this memorandum.

Stream Channel Stability

Stream channel stability is the ratio of the 10-year hourly flow rate of the pristine (90% forest retention) scenario to the 2-year hourly peak flow rate for a different forest retention scenario. The annual peak flows was estimated from hourly flows and the flow frequency was performed following USGS Bulletin 17B Guidelines using the Data Analysis System for Hydrology (DASH) program (2012). The ratios were calculated in Microsoft Excel for each of the seven scenarios.

Relative Stream Power

Winter base flow was estimated (per nhc, 2006) as the average of the 80% and 95% exceedance flow level during the season extending from November 1 through March 31. The exceedances were found using a duration analysis on mean daily flow from November 1 to March 30 in HSPF. The ratios were then calculated in Microsoft Excel for each of the seven scenarios.

High Pulse Count

High pulse count was calculated by computing periods within a year where the daily mean flow rose above the 75th percentile (high pulse) of all daily values for the existing condition. The mean daily flow was calculated from the 15-minute time series and stored in the WDM file. The high pulse was generated using Indictors of Hydrologic Alteration (IHA) (Nature Conservancy, 2009).

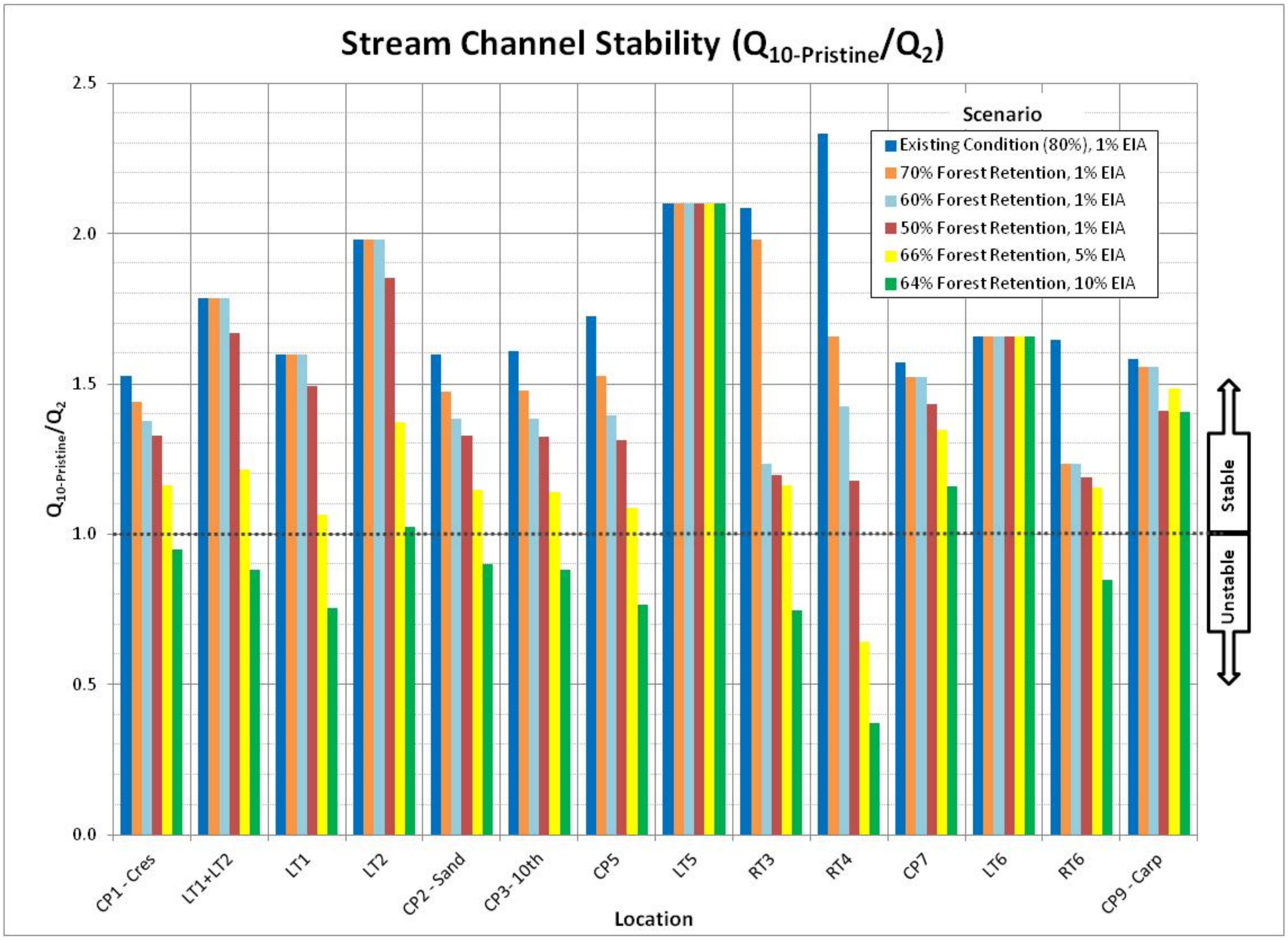
IHA is an easy-to-use tool for calculating the characteristics of natural and altered hydrologic regimes. The method and software work with any type of daily hydrologic data, and summarize long periods of daily hydrologic data into a more manageable series of ecologically relevant hydrologic parameters. The non-parametric statistical analysis method was selected to calculate 33 IHA parameters. One out of the 33 IHA parameters—high flow (pulse) count—was used to describe flow regime alteration for this study.

5. Modeling Results

The flow metric results were plotted for each of the seven forest cover retention scenarios. The plots were used to show trends for the metrics and to test if there are transitional points where percent forest conversion has a marked effect on the metrics. The plots were also used to show how the location of converted forestland affects stream flows. For each metric, two types of figures were produced: (1) a histogram plot of the metric value against the forest cover retention scenario for all 14 selected sub-areas and (2) a scatter plot of the metric value against the percentage of forested area for specific sub-areas.

Stream Channel Stability

Figure 6 below is the histogram plot for the stream channel stability metric. It shows a trend towards channel instability as forest retention in the pilot sub-basin decreases. It also shows greater instability with increased EIA.



<u>Figure 6</u>. Stream channel stability at 14 selected sub-areas for all forest cover retention scenarios

The trend towards instability with decreased forest retention is also evident in the two scatter plots. Figures 7 and 8 show that the 5% and 10% EIA scenarios have a more pronounced effect on channel stability. It should be noted that, according to Booth (2002), there is a zone of uncertainty for the stream channel stability metric. This zone of uncertainly occurs between 30 and 50% forest retention for a 1% EIA watershed and between 45 and 75% forest retention for a 5% EIA watershed.

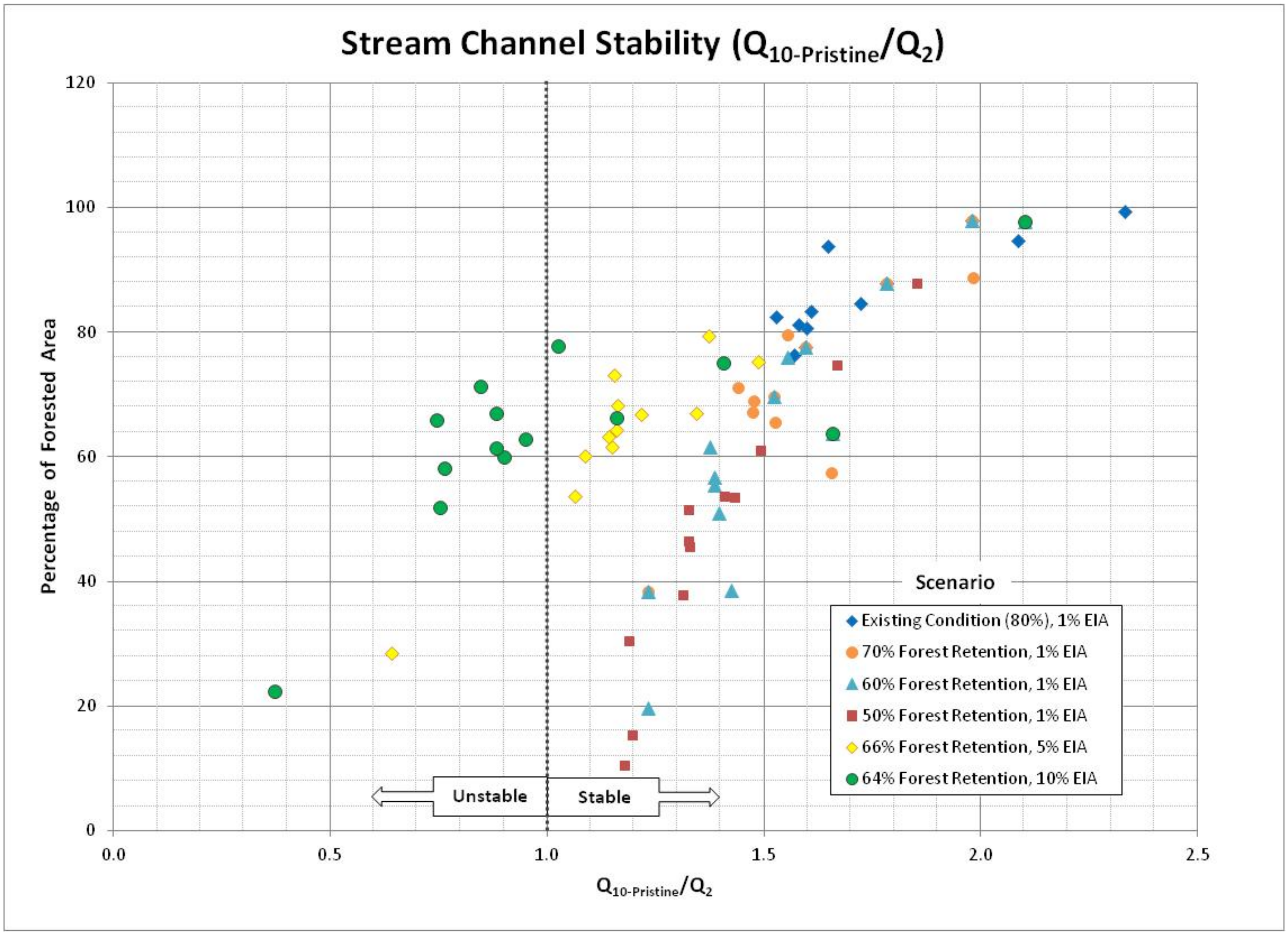


Figure 7. Stream channel stability versus percentage of forested area at 14 selected sub-areas

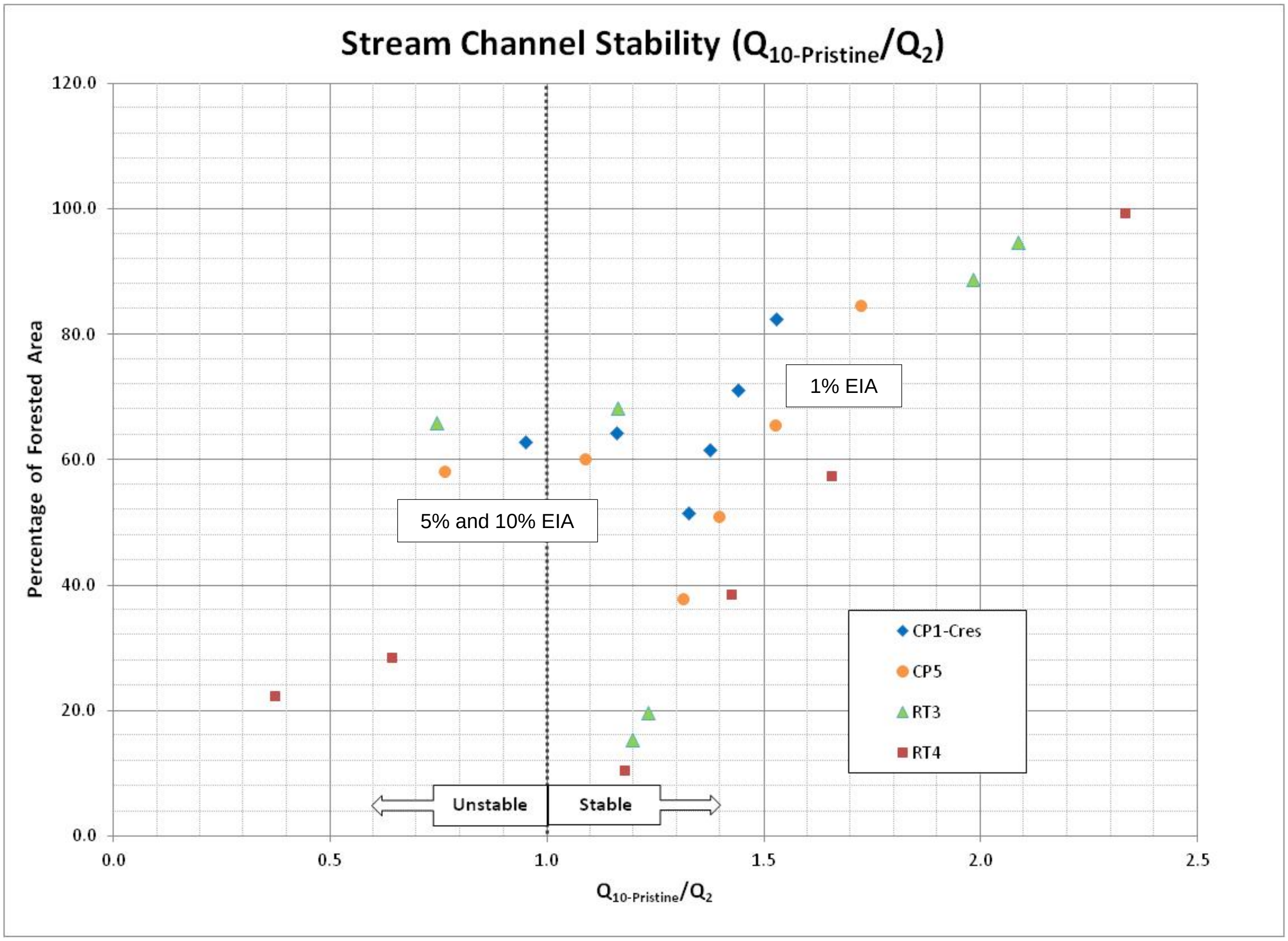
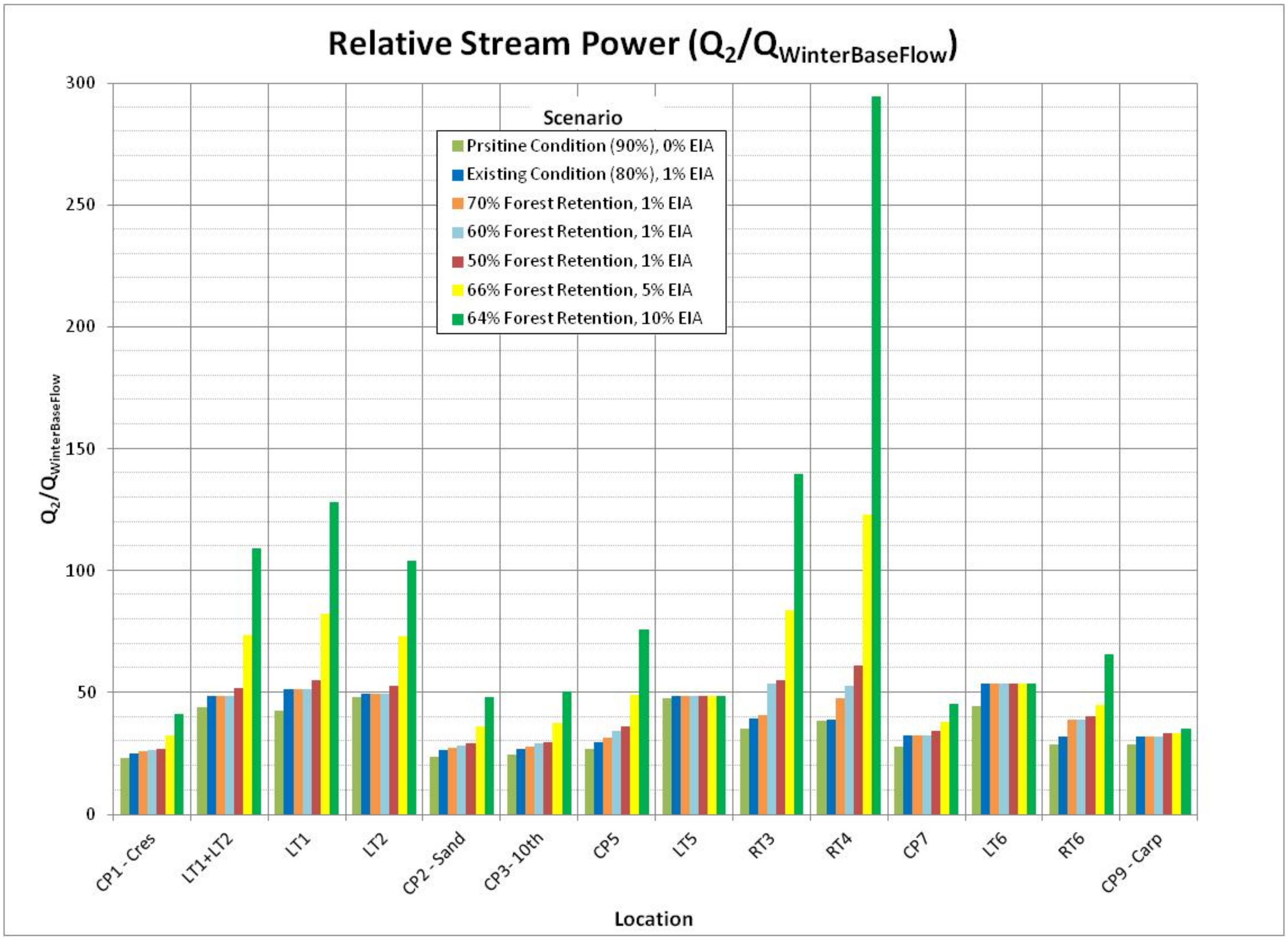


Figure 8. Stream channel stability versus percentage of forested area at four sub-areas

Figure 8 is a subset of the data plotted in Figure 7. It shows that for 1% EIA scenarios, the stream channel stability metric does not cross into the unstable region at any of the sub-areas, even with less than 30% forest retention. This is likely due to additional modeling uncertainty. We expect that channels in sub-areas with levels of forest conversion this high would be unstable. The 5% and 10% EIA scenarios result in a definite move towards unstable channels in the four sub-areas.

Relative Stream Power

Figure 9 below is the histogram plot for the relative stream power metric. It shows a trend towards higher ratios (degraded habitat / biological conditions) as forest retention in the pilot sub-basin decreases. It also shows a greater effect with increased EIA.



<u>Figure 9</u>. Relative stream power at 14 selected sub-areas for all forest cover retention scenarios

Figure 10 shows the same data as Figure 9 in a different manner. It shows a consistent trend towards degraded conditions with decreased forest retention at 1% EIA. The 5% and 10% EIA forest retention scenarios produce more degraded conditions than the 1% EIA scenarios at comparable forest retention percentages.

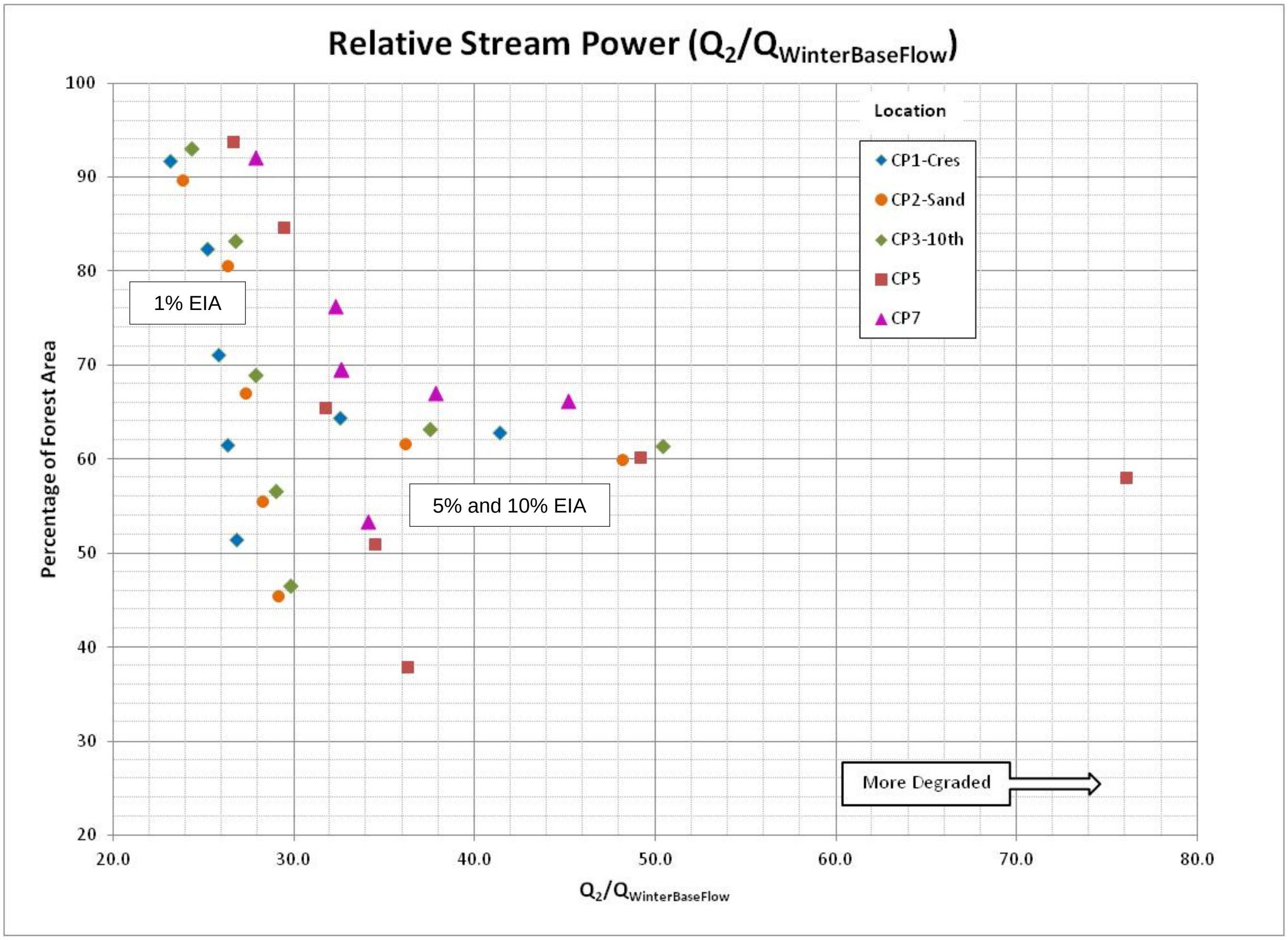


Figure 10. Relative stream power versus percentage of forested area at five sub-areas

High Pulse Count

Higher pulse counts are an indicator of lower B-IBI scores which indicate degraded habitat / biological conditions. Figure 11 below is the histogram plot for the high pulse count metric. It shows a trend towards higher pulse counts (more degraded conditions) as forest retention in the pilot sub-basin decreases. A more pronounced trend towards degraded conditions occurs with the 5% and 10% EIA scenarios.

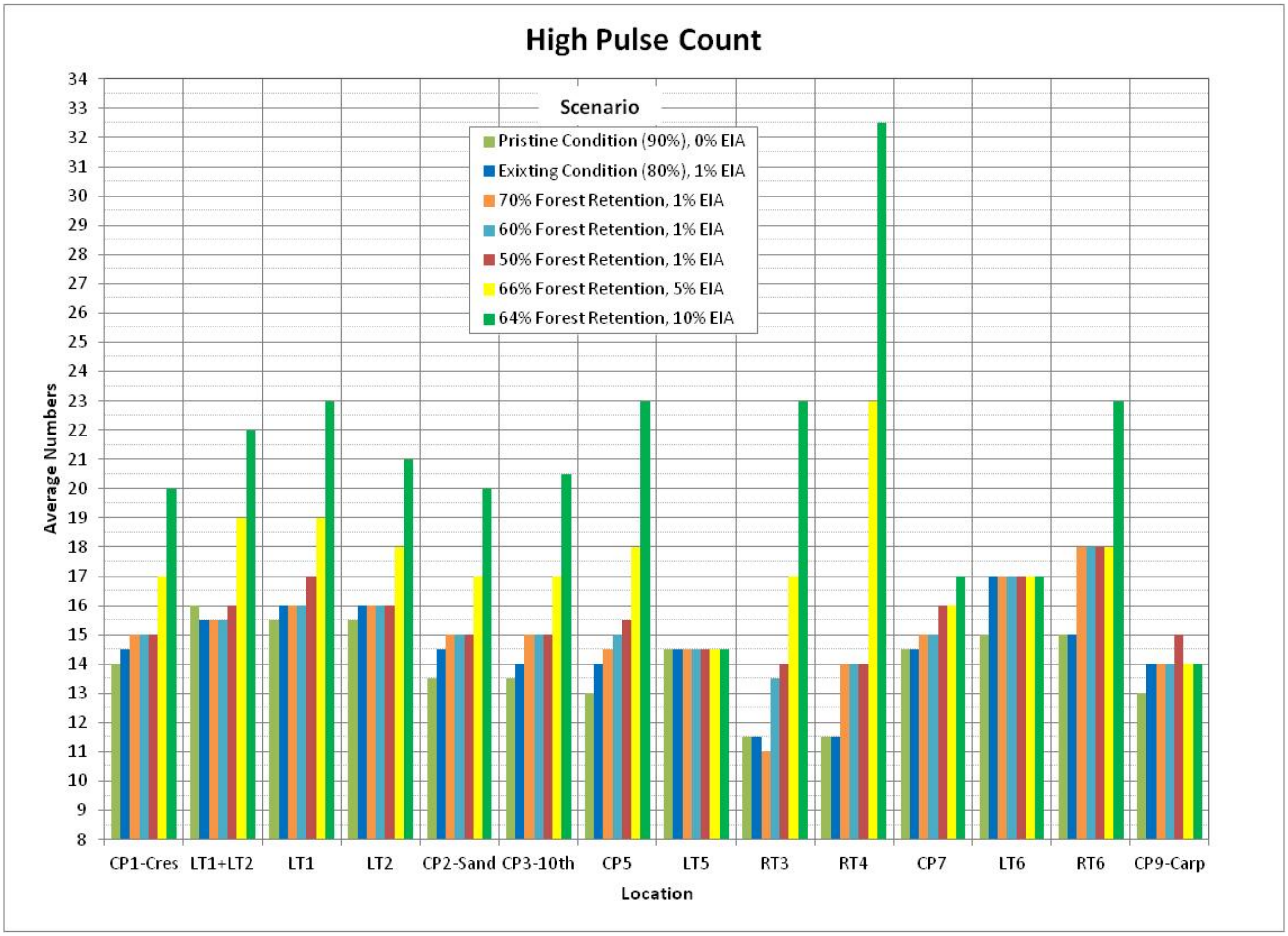


Figure 11. High pulse count at 14 selected sub-areas for all forest cover retention scenarios

Figure 12 shows the same data as Figure 11 in a different manner. It shows a consistent trend towards degraded conditions with decreased forest retention at 1% EIA. The 5% and 10% EIA forest retention scenarios produce more degraded conditions than the 1% EIA scenarios at comparable forest retention percentages.

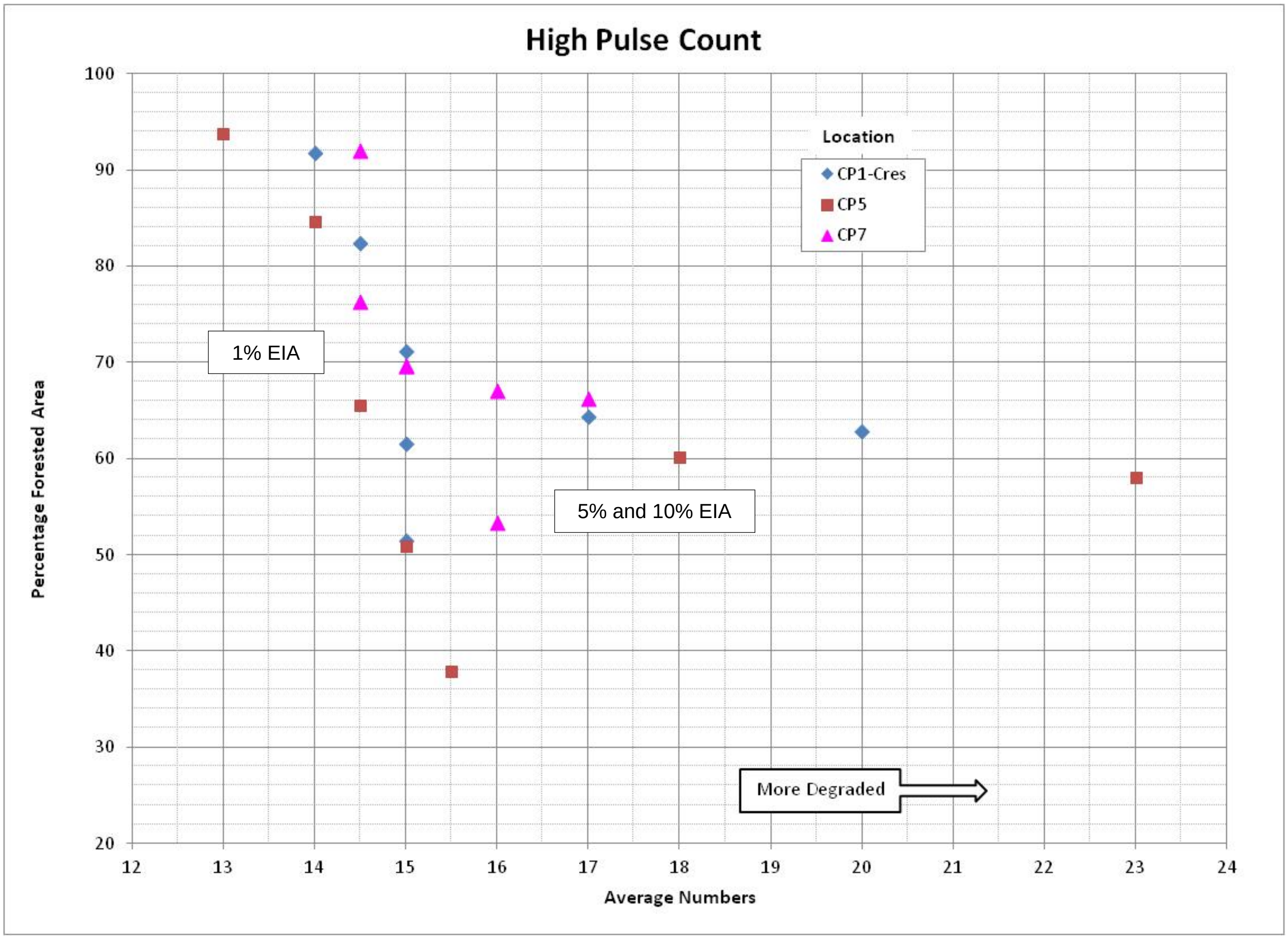


Figure 12. High pulse count power versus percentage of forested area at three sub-areas

6. Conclusions

As expected, the modeling results indicate that increased forestland conversion within the pilot sub-basin would cause an increase in stream flows, a decrease in channel stability, and a trend towards more degraded biological / habitat conditions. Furthermore, the results imply that the addition of impervious surface to forestlands—development—would have a much more dramatic impact on the three flow metrics than forest clearing by itself. Due largely to modeling uncertainty, the point at which forestland conversion would cause a specific metric to cross a threshold (e.g., move from stable to unstable) could not be determined. However, the goal of establishing appropriate metrics for measuring the hydrologic benefits of protecting forest cover was achieved.

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USGS National Elevation Dataset (NED) DEM (available at http://seamless.usgs.gov/). Scale/Resolution: 10-m or 30-m for conterminous United States. 10-m DEM is readily available in Snohomish County GIS data server and was re-sampled to 30-m DEM for CPI calculation.

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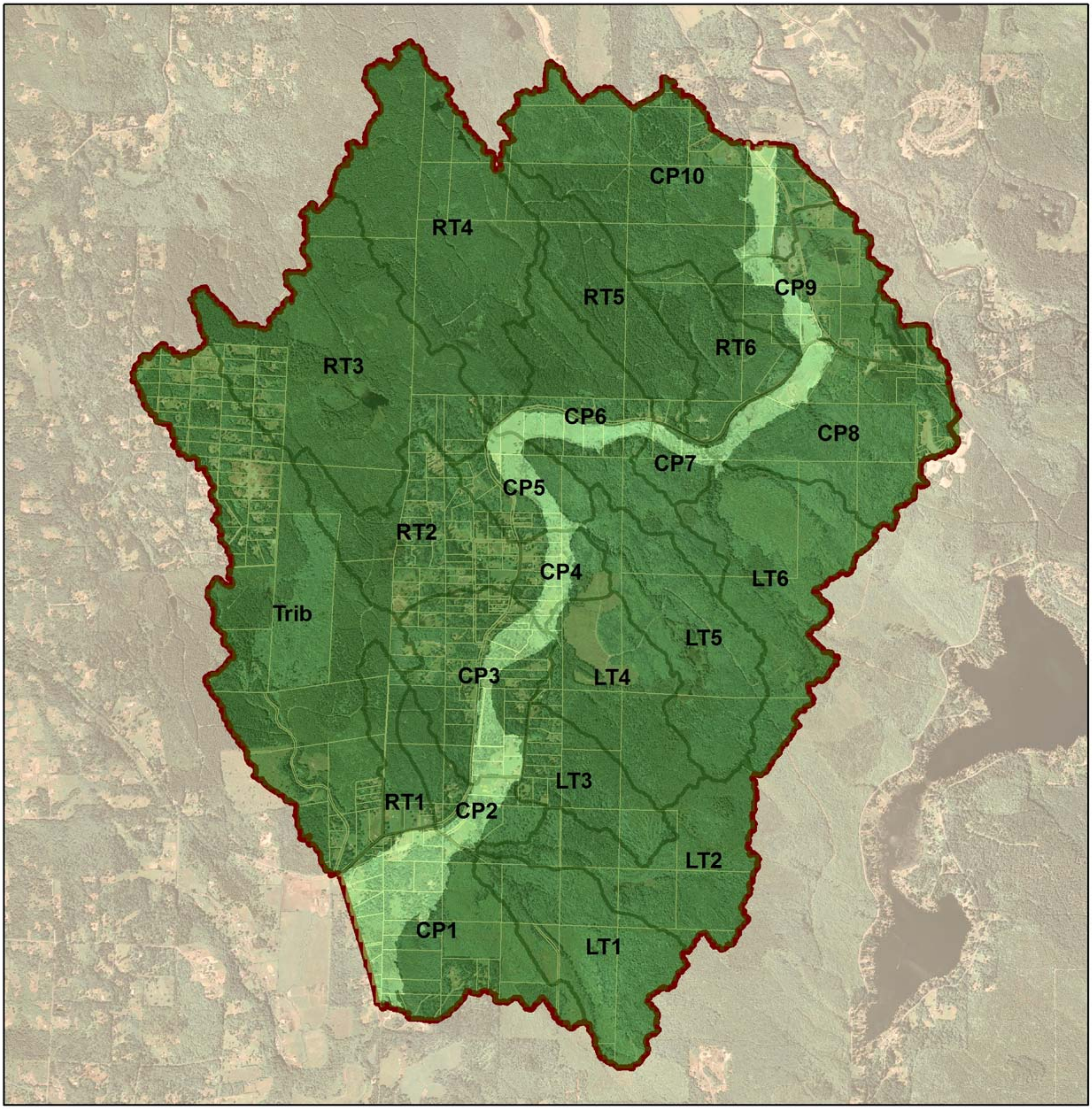
Attachment 1:
Five Forest Cover Retention Scenarios
in the Upper West Fork Woods Creek Sub-basin



Snohomish Basin Forest Ecosystem Services Pilot Area

Pristine Condition

Land Use

FOREST

PASTURE

0 2,500 5,000 Feet

Snohomish County

PUBLIC WORKS

SURFACE WATER MANAGEMENT

(425) 388-3464

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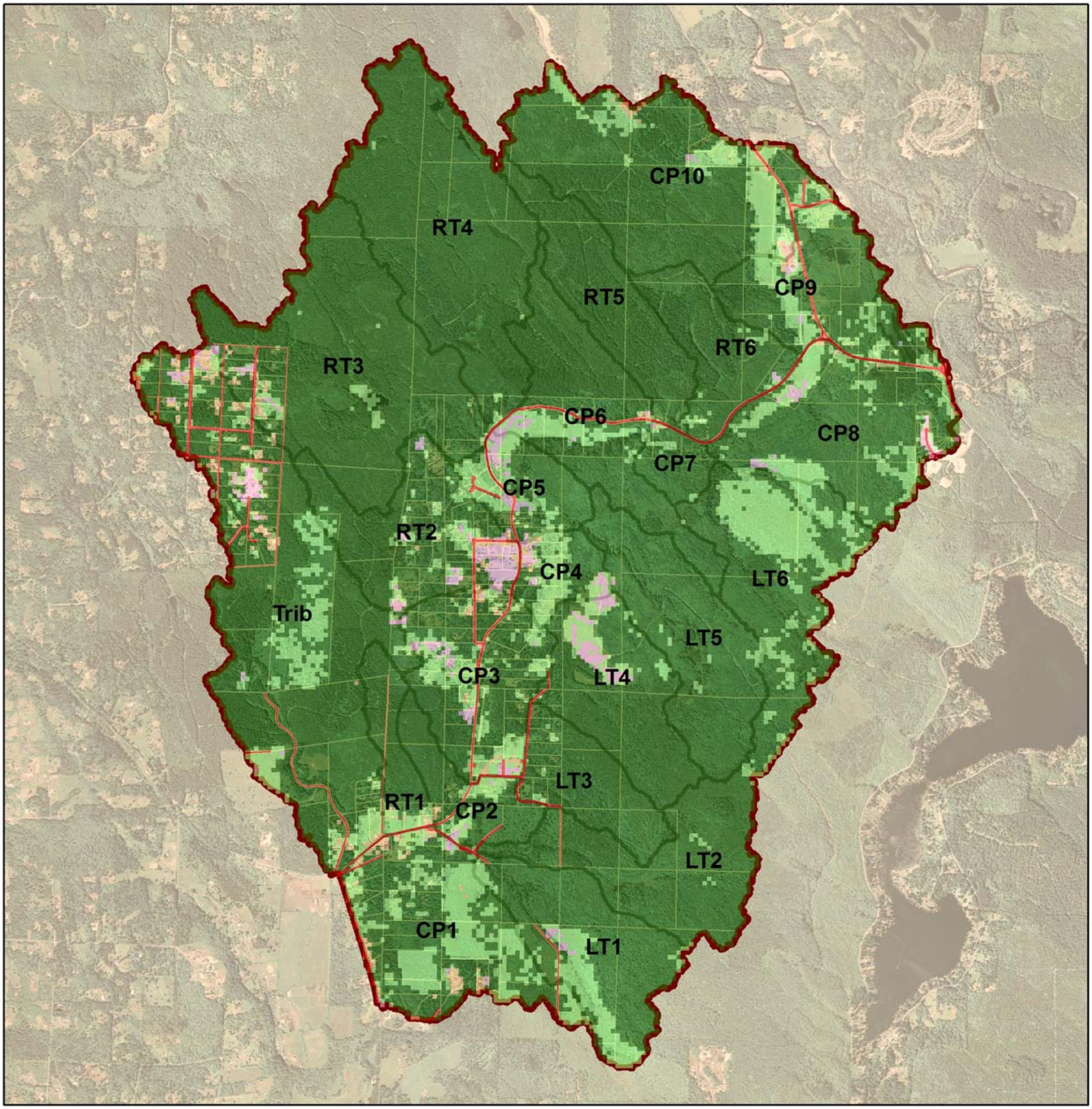

Snohomish Basin Forest Ecosystem Services Pilot Area

Existing Condition (80% Forest Retention)

Land Use

- FOREST
- GRASS
- PASTURE
- SFR-HIGH
- SFR-LOW
- SFR-MED
- TRANSPORTATION

N W E S

0 2,500 5,000 Feet

Snohomish County

PUBLIC WORKS
SURFACE WATER MANAGEMENT
(425) 388-3464

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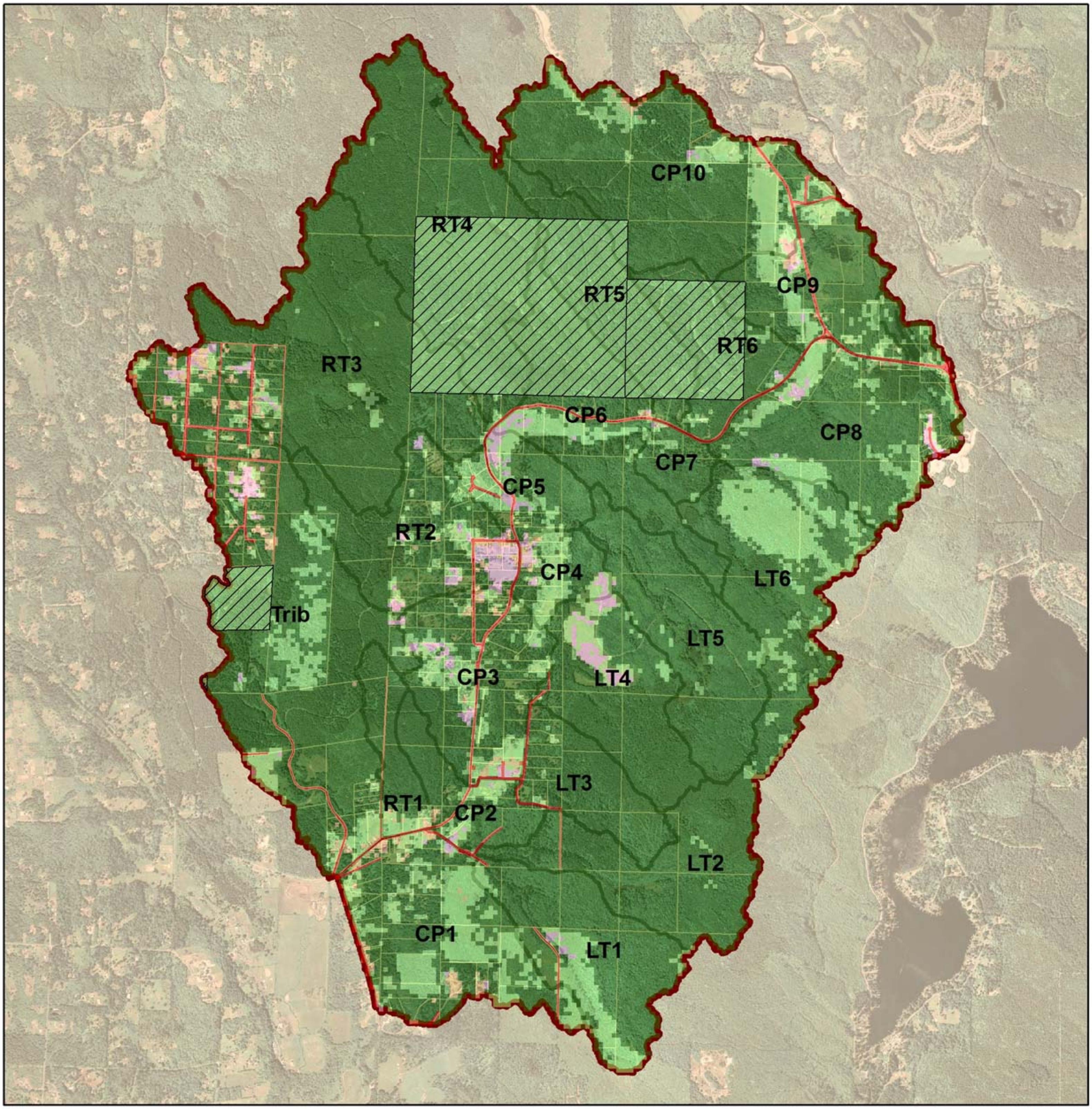

Snohomish Basin Forest Ecosystem Services Pilot Area

70% Forest Retention Scenario

Land Use

- FOREST
- GRASS
- PASTURE
- SFR-HIGH
- SFR-LOW
- SFR-MED
- TRANSPORTATION

Priority Parcels Converted

N
W
E
S

0 2,500 5,000 Feet

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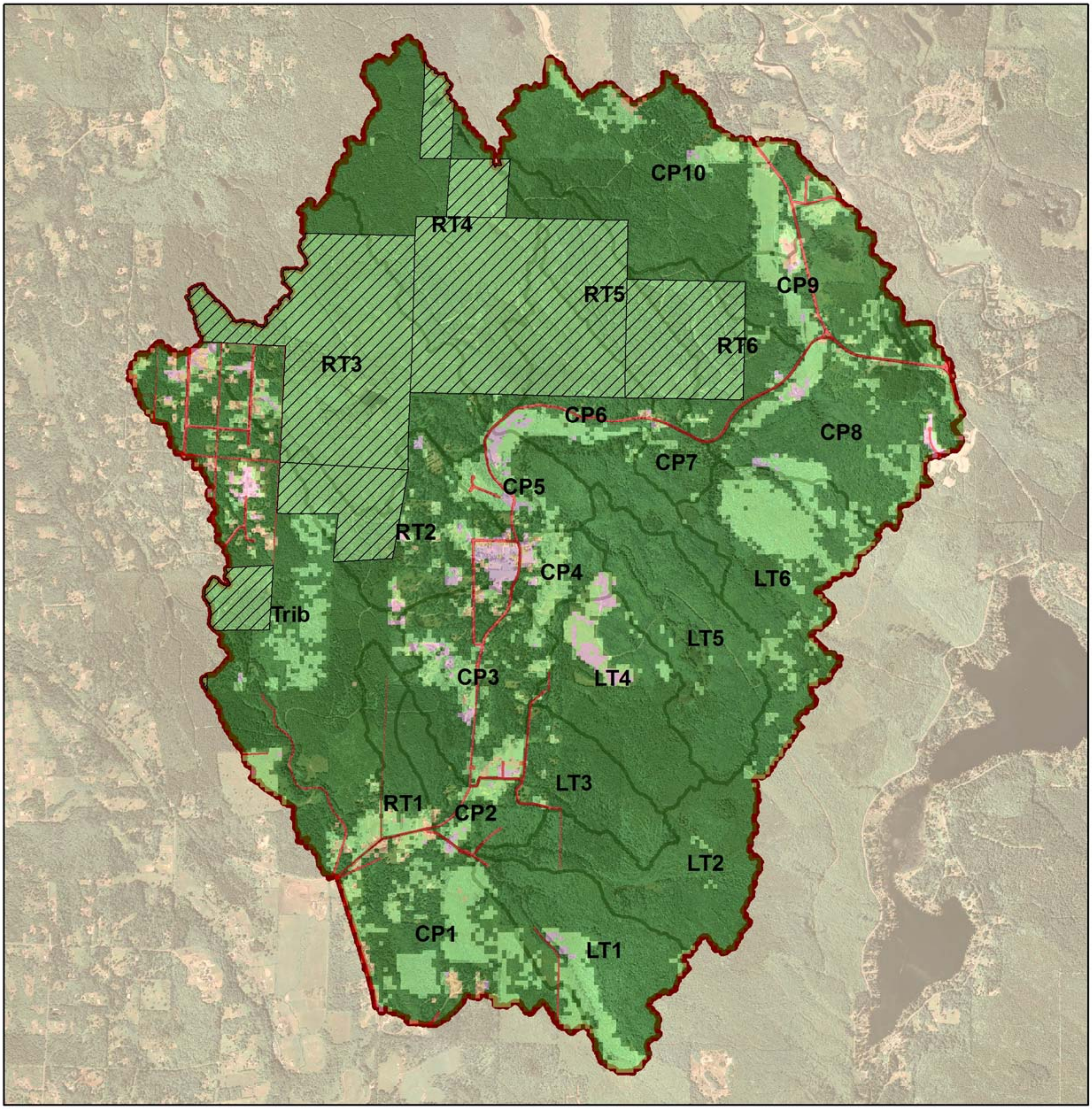

Snohomish Basin Forest Ecosystem Services Pilot Area

60% Forest Retention Scenario

Land Use

- FOREST
- GRASS
- PASTURE
- SFR-HIGH
- SFR-LOW
- SFR-MED
- TRANSPORTATION

Priority Parcels Converted

N W E S

0 2,500 5,000 Feet

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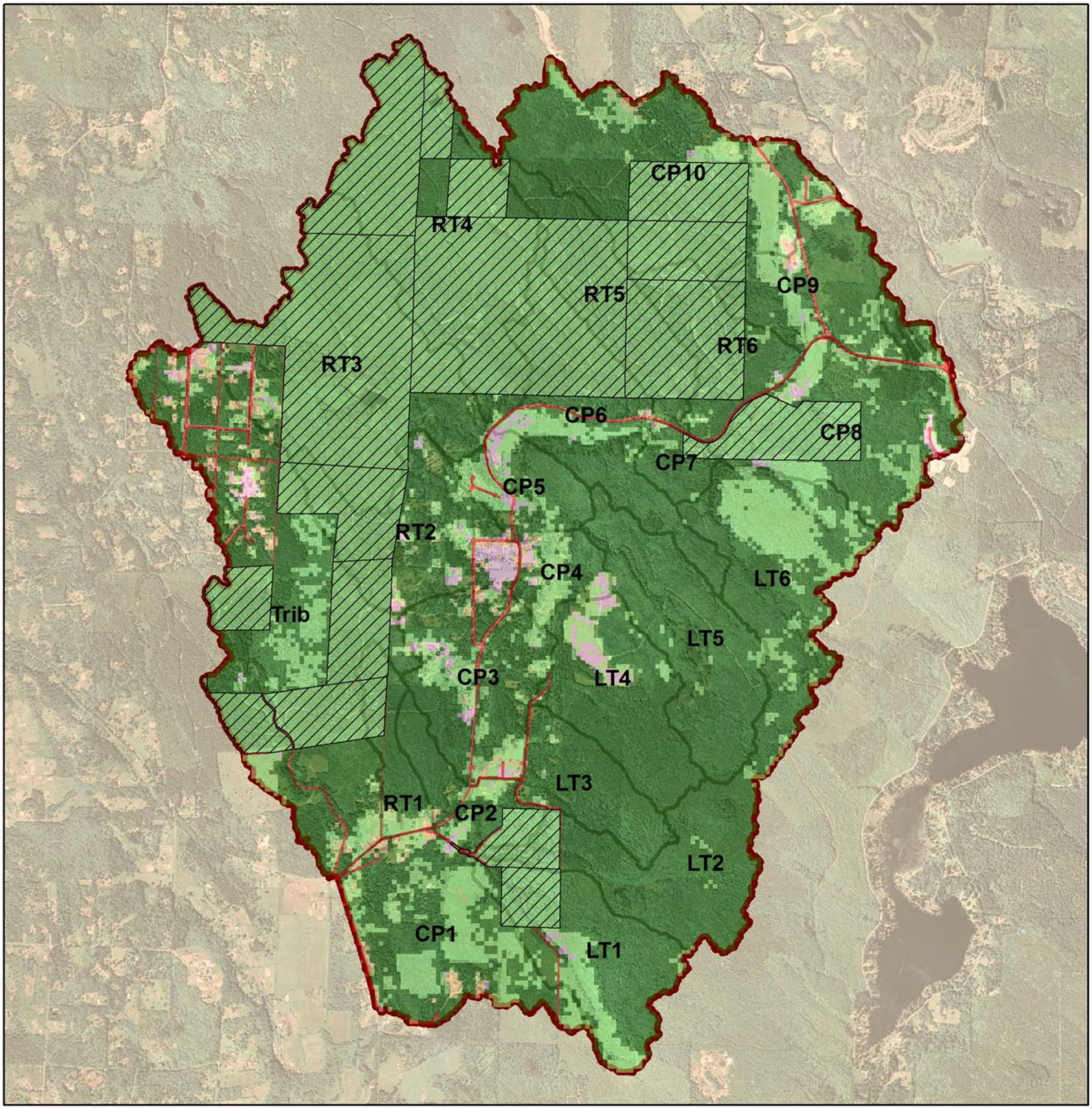

Snohomish Basin Forest Ecosystem Services Pilot Area

50% Forest Retention Scenario

Land Use

- FOREST
- GRASS
- PASTURE
- SFR-HIGH
- SFR-LOW
- SFR-MED
- TRANSPORTATION

Priority Parcels Converted

N W E S

0 2,500 5,000 Feet

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Appendix B
Technical Memorandum: Parcel Prioritization

SNOHOMISH COUNTY
Public Works Surface Water Management

Technical Memorandum

Project Name: Snohomish Basin Forest Ecosystem Services Pilot Project
Project Task: Parcel Prioritization
Date: May 15, 2013
Staff: Gi-Choul Ahn

1. Purpose

Prospective buyers of ecosystem services, such as utility providers, typically have limited funding for programs aimed at protecting forest cover. Therefore, if they decide to pursue ecosystem services transactions, they must first establish a process for prioritizing land parcels based on their capacity to deliver target ecosystem service(s). The purpose of this work was to assess the utility of various tools and datasets for prioritizing privately owned parcels within the Upper West Fork Woods Creek sub-basin (the “pilot sub-basin”) for potential ecosystem services transactions.

2. Tools and Datasets

The tools and datasets evaluated for parcel prioritization were selected based on discussions with staff at the Washington State Department of Natural Resources (DNR). These tools and datasets include the following:

- Conservation Priority Index (CPI)
- Spatially Explicit Regional Growth Model (SERGoM)
- Rural Technology Initiative (RTI) conversion risk data
- Watershed Characterization (WC)

Conservation Priority Index (CPI)

The Conservation Priority Index (CPI) was developed by Drs. Yanli Zhang and Paul Barten at University of Massachusetts at Amherst in cooperation with the United States Forest Service, the Trust for Public Land, and the Unites States Environmental Protection Agency. The CPI is a Geographic Information System (GIS)-based method for identifying forestlands that provide the greatest protection for hydrologic functions and therefore represent the highest conservation value. It incorporates existing environmental data—GIS inputs—into a scoring and ranking process and produces results that can be readily interpreted. These GIS inputs include the following landscape characteristics:

- Land use
- Streams / rivers
- Lakes / ponds
- Wetlands
- Soils (depth to water table and permeability)
- Elevation
- Roads

The analysis is raster-based, with the resolution of the analysis limited by the input with the coarsest resolution.

Spatially Explicit Regional Growth Model (SERGoM)

The SERGoM model, formerly known as the Western Futures Model (WFM), was developed by David Theobald at Colorado State University to map and forecast development pressure at a relatively high (100m) resolution. SERGoM assumes that future growth patterns are similar to past patterns, taking into consideration proximity to urban lands and accessibility of protected lands. SERGoM is a demand / allocation / supply model, where supply is the area of land that can accommodate population growth, demand is the number of new housing units needed based on population projections, and allocation is the redistribution of projected growth in each census block group based on growth patterns from the previous time period. Inputs for the model include census block data, compiled land ownership data for undevelopable lands, data on road and groundwater well density, population projection data from each county, and National Land Cover Database (NLCD) data. SERGoM forecasts residential development by establishing a relationship among housing density, population growth rates, and transportation infrastructure. SERGoM scores for development pressure SERGoM range from 0 to 10, where 0 means no pressure and 10 means highest pressure.

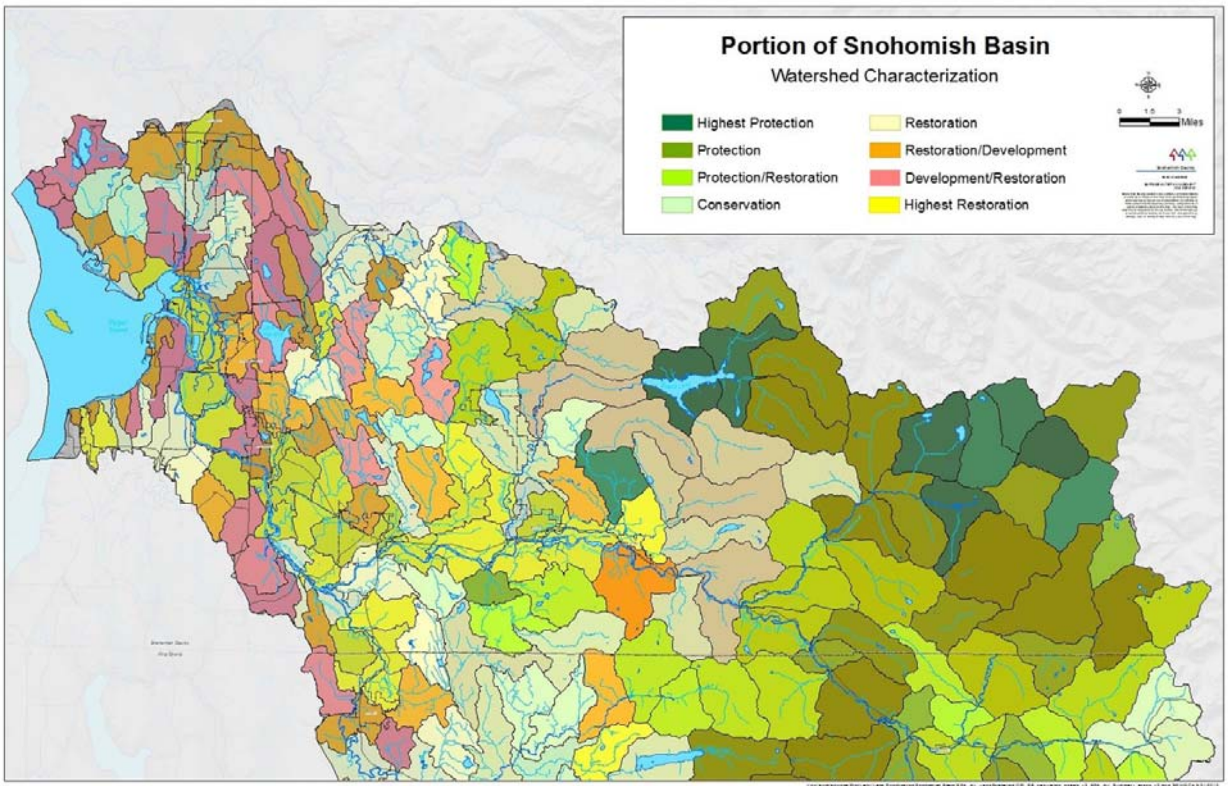
Rural Technology Initiative (RTI) Conversion Risk Data

In 2009, the University of Washington Rural Technology Initiative (RTI) produced conversion risk data for private forestlands in Washington State. RTI mapped high conversion risk, high value private forestlands by using the parcel-based Washington State Forest Land Database to extract real estate values, acreages, improvement values, and land uses for forested areas in Washington. RTI assumed that parcels with the largest difference between the real estate value (REV) and the working forest value (WFV) were likely candidates for conversion. The WFV was calculated from the sum of the forest value (FV) in the buffers and upland areas, and the REV was assigned as the market value that county assessors have assigned to each parcel. The FV was the land value plus the added economic value of any standing timber (the total economic value of the forest).

Watershed Characterization (WC)

The Watershed Characterization (WC) methodology was developed by the Washington State Department of Ecology for the purpose of characterizing landscape-scale attributes influencing water flow processes within and among Puget Sound watersheds. The WC methodology, or tool, was designed to help identify and map areas most important to protect and restore, as well as areas most suitable for development (see Figure 1 below). The WC essentially provides a two-faceted view of an ecosystem: (1) the “unaltered” state, which assumes a uniform land cover across the landscape, and (2) the “altered” state, which has been impacted by human activities. The model for the unaltered state, which is called the importance model, has four levels: highest protection, protection, protection / restoration, or conservation. The model for the altered state, which is called the degradation model, has two development levels and two conservation levels. Because the WC is based on coarse-scale data inputs, it is most appropriate for regional and watershed-level planning, rather than making decisions about a specific site.

Figure 1. Example Watershed Characterization restoration and protection map



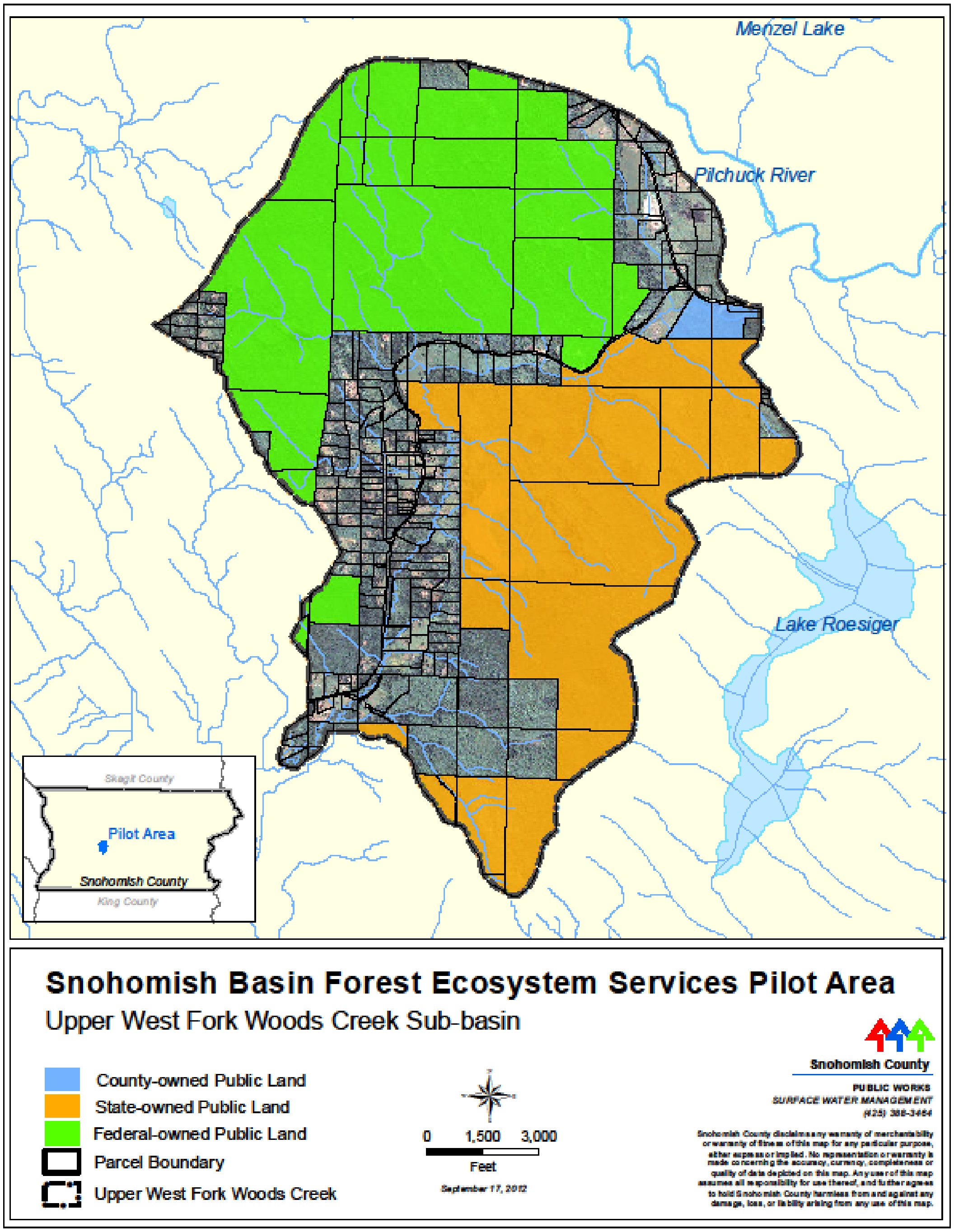
3. Parcel Prioritization

The CPI was employed to rank privately owned forestland parcels in the Upper West Fork Woods Creek sub-basin based on the extent to which they provide hydrologic benefits. Once ranking was completed, the 20 highest ranked parcels were prioritized for potential ecosystem services transactions by incorporating budget limitations and development pressure data from the SERGoM (Spatially Explicit Regional Growth Model) and the University of Washington Rural Technology Initiative (RTI). Finally, the Washington State Department of Ecology Watershed Characterization (WC) was used to identify three additional sub-basins of interest in the Snohomish River watershed.

Characterization of the Pilot Sub-Basin

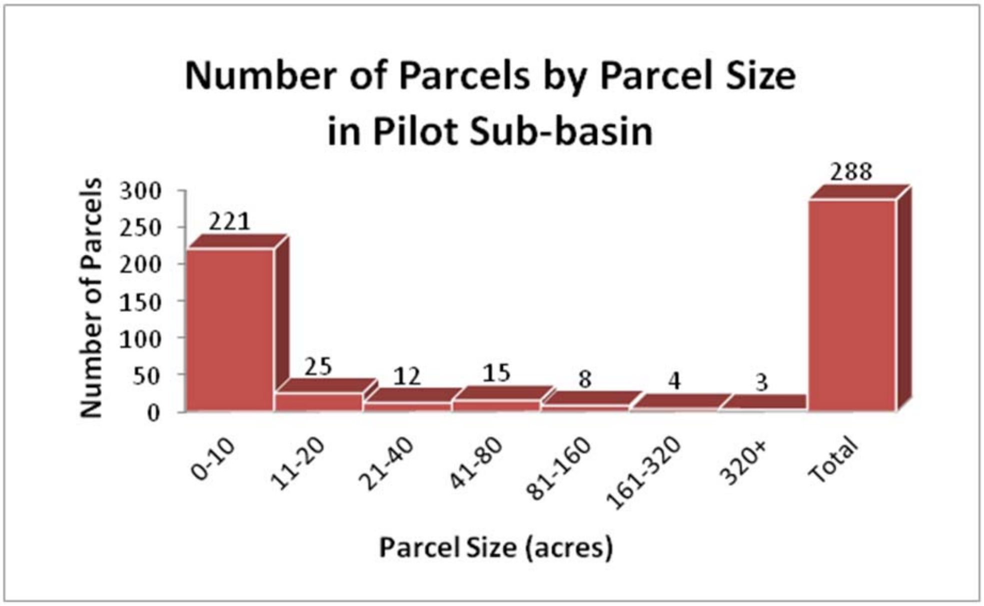
The study area—or “pilot sub-basin”—chosen was the Upper West Fork Woods Creek sub-basin, as shown in Figure 2 below. This sub-basin is located east of the City of Lake Stevens and ultimately drains into the Skykomish and Snohomish Rivers. It is approximately 5,303 acres (8.3 square miles) in size, with elevations ranging from 305 to 1,040 feet.

Figure 2. Map of the pilot sub-basin



A total of 288 parcels fall at least partially within the boundaries of the pilot sub-basin. Most of these parcels are between zero and ten acres in size, as shown in Figure 3 below.

Figure 3. Parcel size information for the pilot sub-basin



CPI Data Inputs

The ArcGIS 9.3 extension for the CPI tool (http://www.forest-to-faucet.org/software_downloads1.html) was utilized for this study. Table 2 below summarizes the GIS inputs (landscape characteristics) and data sources used to generate CPI scores for the pilot sub-basin.

Table 2. GIS data layer inputs and data sources for CPI scoring

Landscape Characteristic	Data source
Land use	2006 NOAA C-CAP
Streams	Snohomish & King County's streamline data
Ponds/wetlands	Snohomish & King County's waterbody layers and wetlands data
Depth to water table	USDA SSURGO soils data
Permeability	USDA SSURGO soils data
Slope	10-m USGS DEM
Roads	Snohomish & King County's roads data

The GIS inputs were downloaded and processed for further analysis. Post-processing was necessary to create a seamless GIS layer. For instance, since the soils data came from three sources and were collected for different purposes using different methodologies, the data were merged. Data merging was performed by linking relevant attributes and reclassifying attribute values in such a way that soil classification (permeability and depth to ground water table) was smoothly transitioned in overlapping areas.

It should be noted that the CPI was applied to forestland only. Deciduous, Evergreen, and Mixed Forest and Palustrine Forested Wetlands land use / land cover classifications from 2006 NOAA CAP data were used to calculate CPI scores for the pilot sub-basin. Shrub / small trees were not included, as they were considered to be a non-imminent factor in forest management. Table 3 below describes the GIS inputs and scoring protocol for the CPI scoring process.

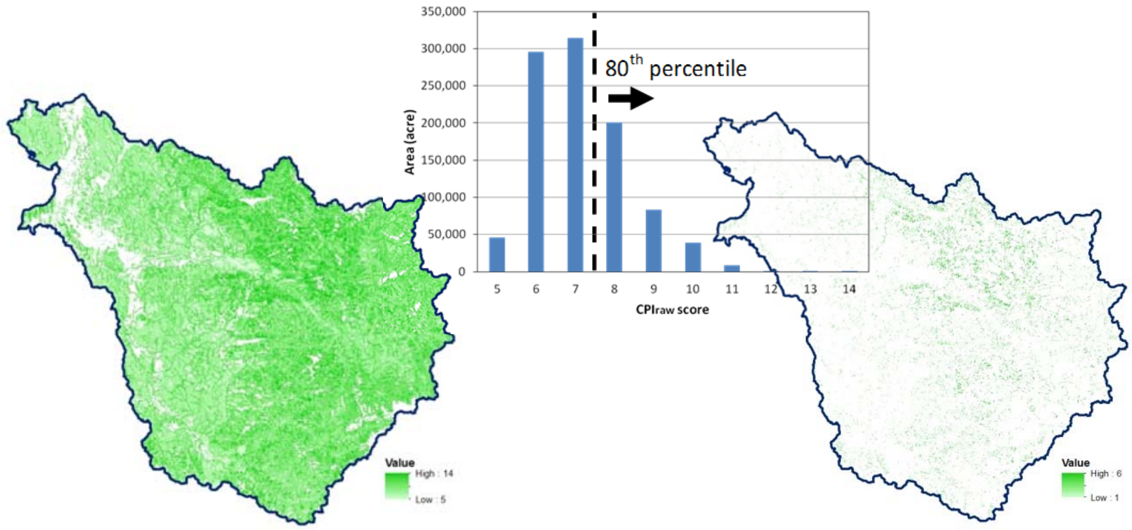
Table 3. Input GIS data layers for CPI scoring (after Nicolson, 2010)

Landscape Characteristic	Score (Importance)			
	3	2	1	0
Land use	Forest/wetland			All others
Distance to streams (m)	0 – 60	60 – 120	120 – 180	> 180
Distance to ponds/wetlands (m)	0 – 30	30 – 60	60 – 90	> 90
Depth to water table (soils)	Shallow (0-0.48m)	Intermediate (0.49-1.22m)	Deep (> 1.22m)	-
Permeability (soils)	Poorly drained (Ksat < 5.66 μm/s)	Intermediate (Ksat 5.85-83.52 μm/s)	Well drained (Ksat > 83.52 μm/s)	-
Slope	Steep (>15%)	Intermediate (6 – 15%)	Gentle (< 6%)	-
Water-Forest-Roads	Yes	No	No	No

The CPI scores for the pilot sub-basin were calculated on a by pixel-by-pixel basis. The CPI score, or CPI_{raw} score, of any pixel (30 meter x 30 meter ≈ 0.22 acre) in the spatial database can range from five to 21.

For this study, there was a desire to only prioritize forestlands with the highest CPI scores. Therefore, pixels with CPI_{raw} scores in the 80th percentile, or top 20%, were targeted for further analysis and ranking. These pixels are referred to as CPI_{80} cells. Figure 4 below shows the total acreage and locations of these cells within the entire Snohomish River watershed.

Figure 4. Total acreage and locations of CPI_{80} cells in the Snohomish Basin



Development of Metrics

The following five metrics were developed for parcel prioritization:

- Parcel acreage
- $\sum CPI$
- CPI_{resid}
- $CPI_{normalized}$
- $\sum CPI_{80}$

Parcel acreage is simply parcel size in acres, $\sum CPI$ is the sum of CPI_{raw} scores within a parcel, CPI_{resid} is the residual of the regression of parcel area and $\sum CPI$, $CPI_{normalized}$ is calculated by dividing CPI_{resid} by the $\sum CPI$, and $\sum CPI_{80}$ is calculated by summing CPI_{80} rasters within a parcel.

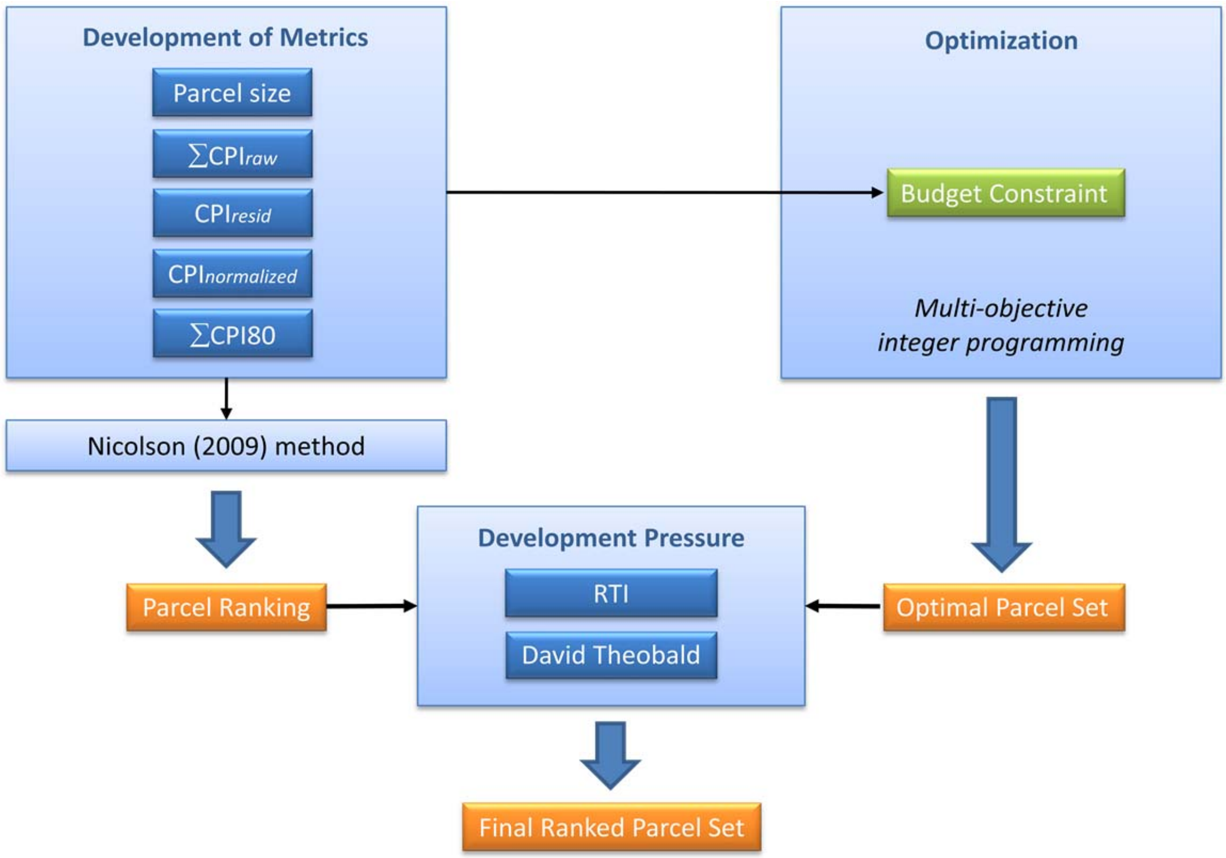
Parcel Ranking

Using a process developed by Nicolson (2009), land parcels within the pilot sub-basin were assigned a score for each of the metrics described above. Once scoring was complete, the parcels were ranked in descending order based on the number of metrics for which they ranked in top 5%, the number of metrics for which they ranked in the top 5-15%, and by their $\sum CPI_{80.}$

Parcel Optimization

Once the parcels were ranked, they were prioritized by incorporating budget limitations and development pressure data from the Spatially Explicit Regional Growth Model (SERGoM) and the University of Washington Rural Technology Initiative (RTI), as depicted in Figure 5 below. The result of this prioritization process was a final ranked parcel set.

Figure 5. Parcel optimization flow chart



Budget Constraint

The budget constraints tested in this study were $500,000, $ 1 million, and $2 million. The $2 million constraint was used to generate the final ranked parcel set.

Development Pressure

One national-scale model that has been widely used to assess conversion risk for forestlands is the Spatially Explicit Regional Growth Model (SERGoM). The SERGoM was designed to detect development in rural to urban areas. David Theobald from Colorado State University used this model to generate a development pressure dataset for land areas based on road density, land value, and distance from urban centers. In this dataset, a score of zero translates to no risk of conversion while a score of ten translates to highest risk of conversion.

A local development pressure dataset was produced by the Rural Technology Initiative (RTI) at University of Washington. RTI mapped high conversion risk, high-value private forestland using real estate and forest values. As noted previously, RTI assumed that parcels with the largest difference between the real estate value (REV) and the working forest value (WFV) were likely candidates for conversion. It should be noted that RTI's dataset does not include land parcels enrolled in the state Designated Forestland Program.

For this study, SERGoM and RTI conversion risk data were combined to create a single dataset. First, the SERGoM model was run for the entire Snohomish River watershed. The highest development pressure score for any parcel within the watershed was seven. Next, a score of ten was assigned to parcels which RTI designated as high conversion risk, high-value private forestland. The SERGoM development pressure scores were then recoded to ten whenever the RTI-based scores were also ten. Finally, the combined data was used to create a map based on five development pressure classifications: Low (1-2), Medium Low (3-4), Medium (5-6), Medium High (7-8), and High (9-10).

Identification of Additional Sub-basins

Once the utility of the CPI had been tested, a decision was made to expand the focus of the Snohomish Pilot Project beyond the Upper West Fork Woods Creek sub-basin, largely because most of the land in the pilot sub-basin is now owned by DNR or other public agencies, rather than private landowners. The Washington State Department of Ecology Watershed Characterization (WC) was subsequently evaluated as a possible tool for prioritizing sub-basins for potential ecosystem services transactions.

Comparison of the CPI and WC Tools

The Conservation Priority Index (CPI) and the Washington State Department of Ecology Watershed Characterization (WC) are both useful tools for evaluating ecosystem conditions within a watershed; however, they offer distinctly different information. The CPI, in short, provides a "snapshot" of the current hydrologic conditions within a forested land area. In contrast, the WC categorizes watershed sub-basins in terms of whether they are most important for protection, restoration, and conservation, or if they are instead most suitable for development. The importance model of the WC is comparable to the CPI, as the CPI represents the current landscape's hydrologic characteristics and the importance model of the WC represents the undisturbed landscape's hydrologic characteristics. Despite the differences between the CPI and the WC, they are highly complementary and can be used in combination to prioritize sub-basins for potential ecosystem services transactions.

Combining the CPI and WC Tools

For the Snohomish Pilot Project, both the CPI and the WC were used to identify additional sub-basins of interest. First, the WC map of the Snohomish River watershed was analyzed and sub-basins which are classified as both high in importance and low in degradation were identified (Figure 6). The CPI was then used to score, rank, and map all of the sub-basins within the watershed (Figure 7). Finally, a visual comparison was made between the WC and CPI-based maps and several new priority sub-basins were selected based on the following criteria:

- High importance for protection according to the WC;
- A relatively high CPI ranking;
- Closer proximity to rural residential (developed) lands; and
- A relatively high percentage of privately owned land.

Figure 6. Locations of three new sub-basins of interest on the WC-based map

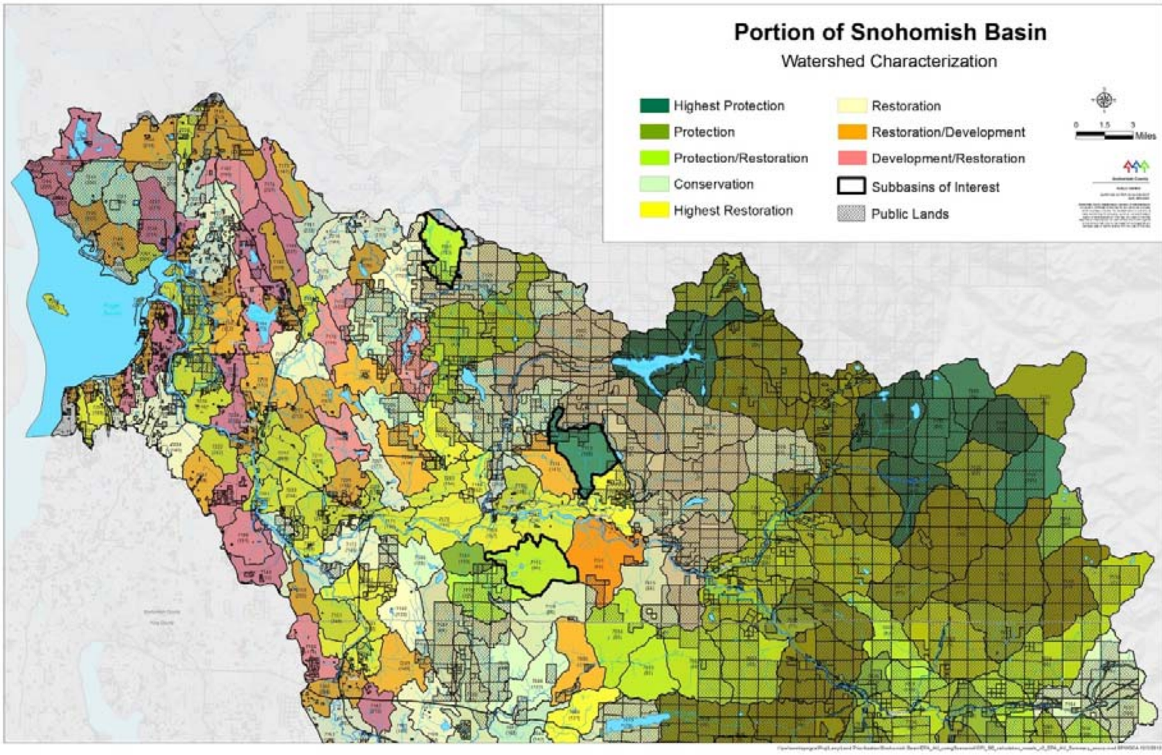
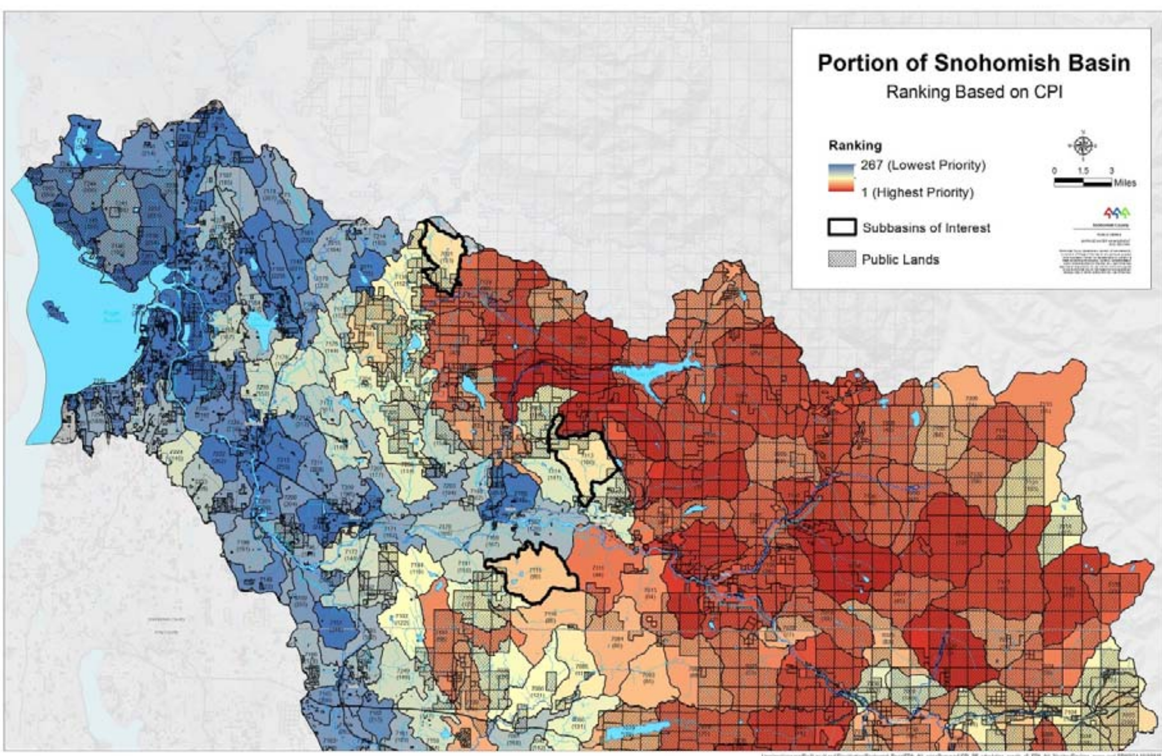


Figure 7. Locations of three new sub-basins of interest on the CPI-based map



5. Results

Table 4 below shows the results of the parcel ranking process.

Table 4. Parcels with the highest CPI rankings, using the Nicolson (2009) method

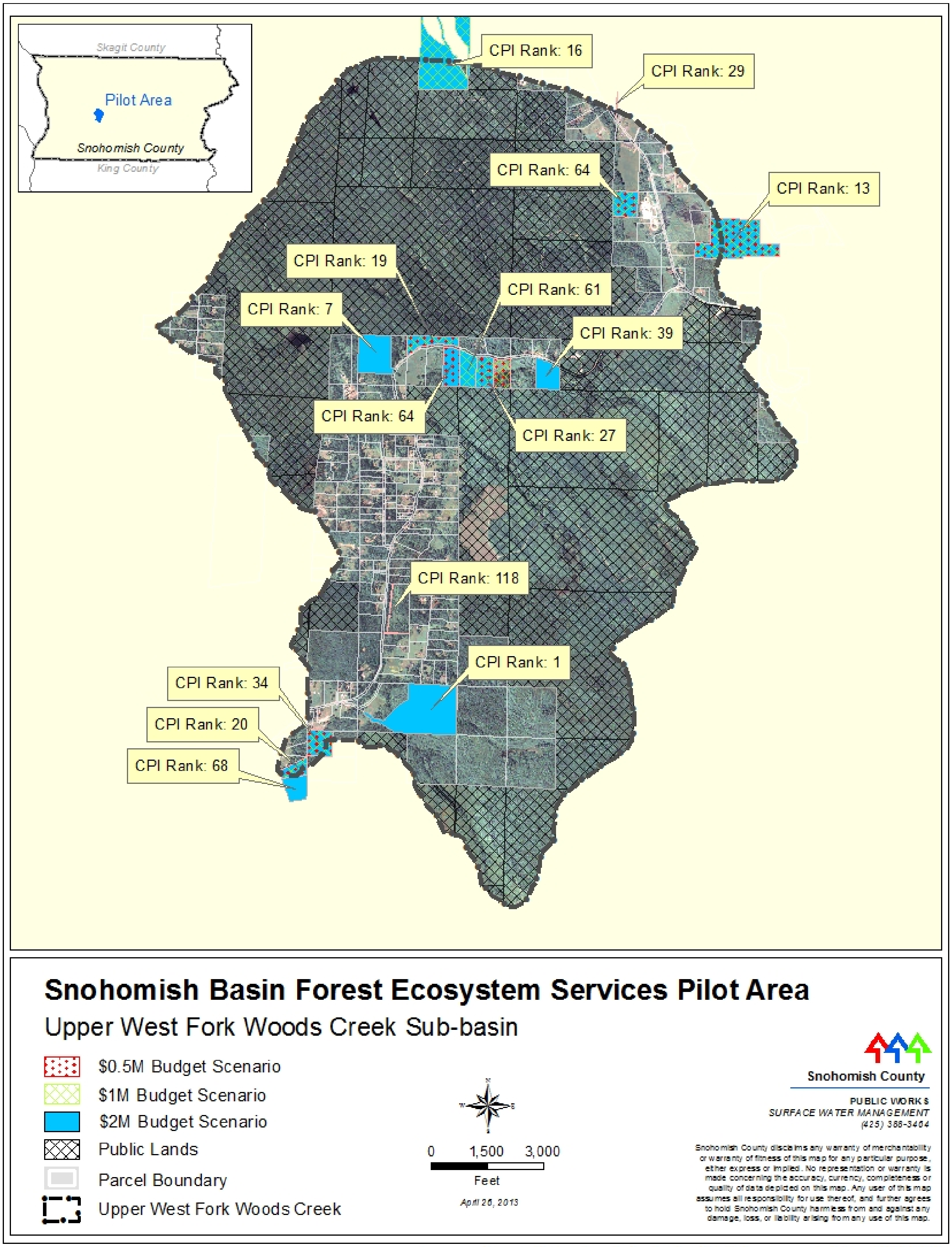
Site Number	Area (ac)	CPI Rank
1	49.2	1
2	40.1	2
3	40.3	3
4	40.2	4
5	41.1	5
6	40.5	6
7	20.6	7
8	40.1	8
9	121.7	9
10	40.0	10
11	20.3	11
12	17.6	12
13	39.2	13
14	41.1	14
15	60.9	15
16	72.1	16
17	18.2	17
18	6.2	18
19	8.5	19
20	5.8	20

Table 5 and Figure 6 below show the results of the parcel optimization process.

Table 5. Final ranked parcel set

Site Number	Area (ac)	CPI Rank	Priority
7	20.6	7	1
1	49.2	1	2
27	8.5	27	3
39	10.6	39	4
61	9.3	61	5
20	5.8	20	6
64	10.7	64	7
68	8.2	68	8
34	10.6	34	9
29	0.3	29	10
64	10.0	64	11
19	8.5	19	12
16	72.1	16	13
13	39.2	13	14
118	1.0	118	15

Figure 8. Map of the fifteen top-priority parcels (i.e., the final ranked parcel set)



Limitations

The results of this study should be evaluated with consideration of the following limitations and caveats:

- The data inputs used for the CPI scoring and ranking process were not ideal. For example, the wetland data were outdated and contained significant errors and the soils data were generated by a model.
- Due to the limitations commonly associated with input data, the literature recommends that the CPI be applied to parcels larger than twenty acres. Most parcels in the pilot sub-basin (including eleven of the fifteen top-priority parcels) are less than twenty acres in size.
- The datasets utilized for the development pressure analysis were not ideal. For example, RTI data is outdated and excludes parcels enrolled in the state Designated Forestland program. In addition, SERGoM data is most appropriately used to evaluate regional development patterns, rather than to assess development pressure at the parcel scale.
- The WC assumes that sub-basins classified as high in importance are uniform and “unaltered” across the entire landscape. No sub-basins in the Snohomish River watershed actually fit this description.
- Selecting priority sub-basins by utilizing the WC in combination with CPI rankings and other factors involves a fair amount of subjectivity.

6. Conclusions

The results of the prioritization exercise demonstrate that the CPI can be used to prioritize land parcels for ecosystem services transactions and that the CPI and WC tools can be used in combination to prioritize sub-basins within a watershed. In addition, the results indicate that development pressure data can help inform parcel prioritization strategies by highlighting forestlands most at risk for conversion to developed uses. Due to time and resource constraints, the CPI and WC were not compared to other potential prioritization tools. Therefore, a “best” strategy could not be established for prioritizing land parcels within the Snohomish River watershed for potential ecosystem services transactions. However, the goal of evaluating the utility of various tools and datasets for selecting priority parcels was achieved.

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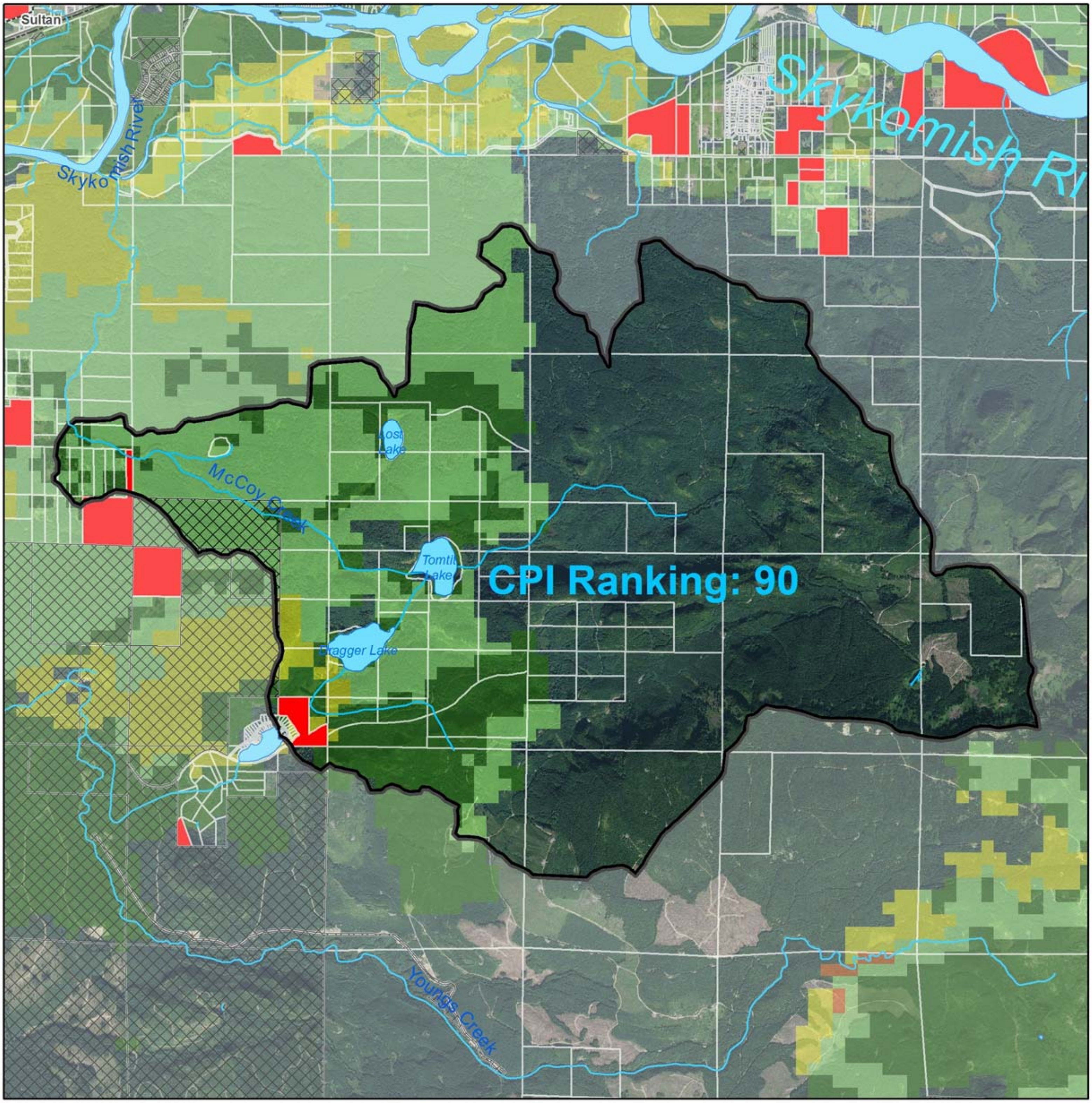
Appendix C
Supplemental Maps: Additional Priority Sub-basins



South Upper Mainstem Skykomish Sub-basin

Development Pressure

- Low (CSU)
- Medium Low (CSU)
- Medium (CSU)
- Medium High (CSU)
- High (RTI)
- Public Lands

RTI stands for the Rural Technology Initiative and CSU stands for Colorado State University.

N W E S

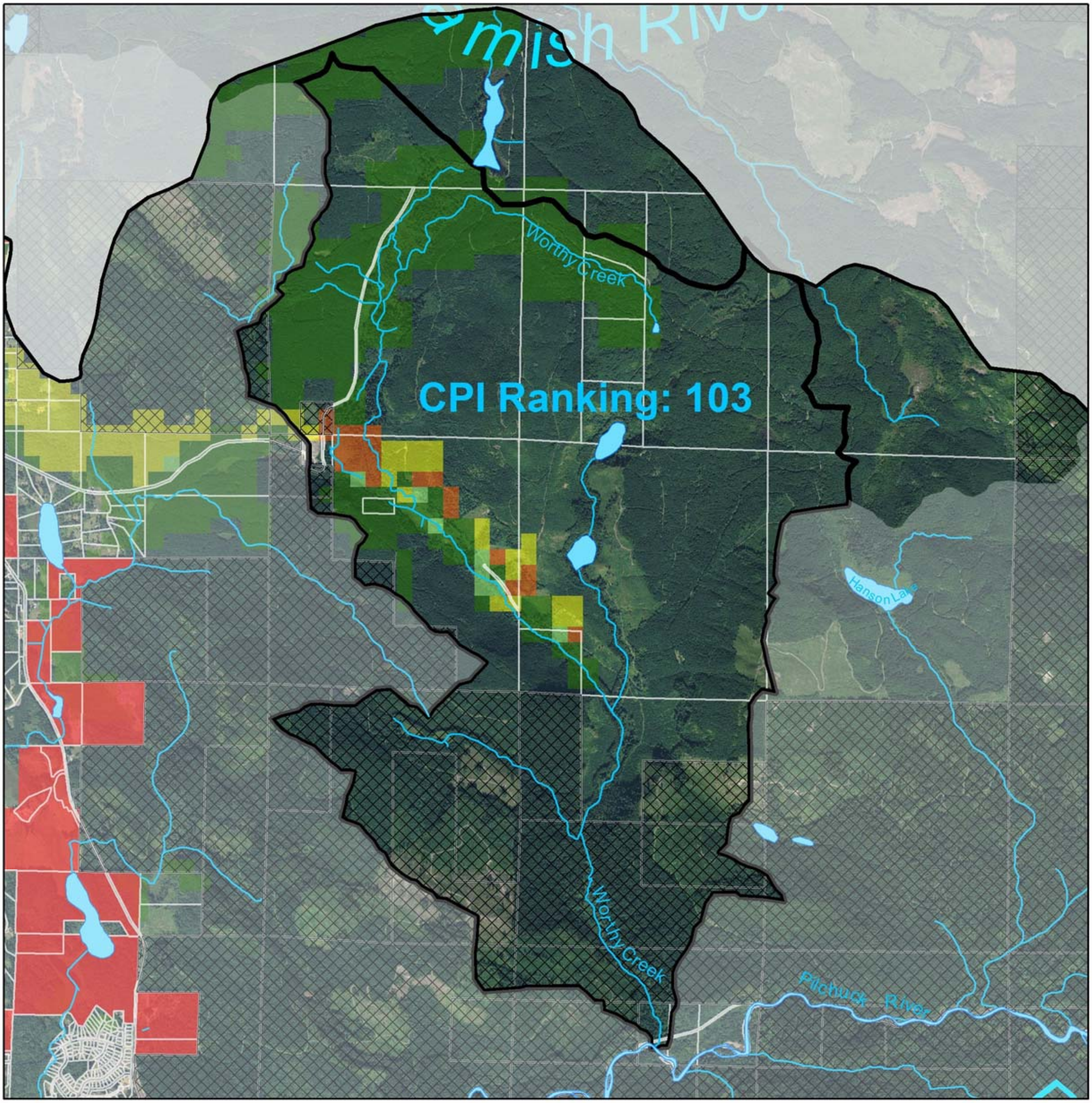
0 2,050 4,100 Feet

*Background image: 2011 aerial photography

Snohomish County

PUBLIC WORKS

SURFACE WATER MANAGEMENT
(425) 388-3464



North Upper Pilchuck River Sub-basin

Development Pressure

- Low (CSU)
- Medium Low (CSU)
- Medium (CSU)
- Medium High (CSU)
- High (RTI)
- Public Lands

RTI stands for the Rural Technology Initiative and CSU stands for Colorado State University.

N
W E
S

0 1,650 3,300
Feet

Background image: 2011 aerial photography

Snohomish County

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(425) 388-3464

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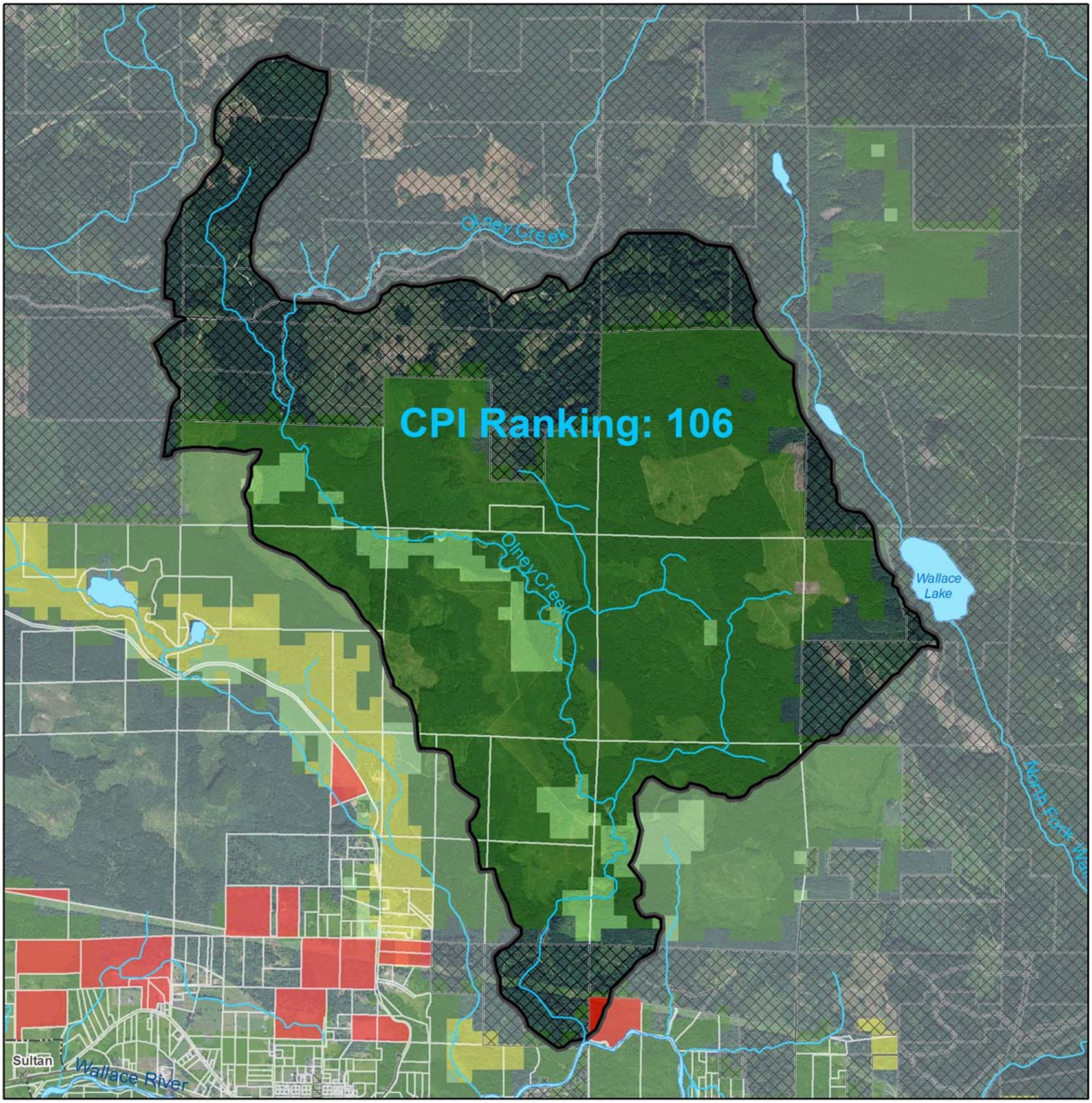

Lower Olney Creek Sub-basin

Development Pressure

- Low (CSU)
- Medium Low (CSU)
- Medium (CSU)
- Medium High (CSU)
- High (RTI)
- Public Lands

RTI stands for the Rural Technology Initiative and CSU stands for Colorado State University.

0 2,000 4,000 Feet

*Background image: 2011 aerial photography

Snohomish County

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Appendix C – USGS Slide Show

Watershed Services Modeling update: June 11, 2013

Ken Johnson

US Geological Survey, Washington Water Science Center

USGS science for a changing world

Background

- Purpose – to estimate impacts to groundwater systems from possible residential development
- Based on previous work:
  - Original model was Drost et al. 1999 (USGS)
  - Revised groundwater flow model ("comp20d") obtained from Anchor QEA and Shannon & Wilson
  - License to run "MODFLOW – SURFACT"
  - Checked reproducibility
  - Developed particle tracking and graphics

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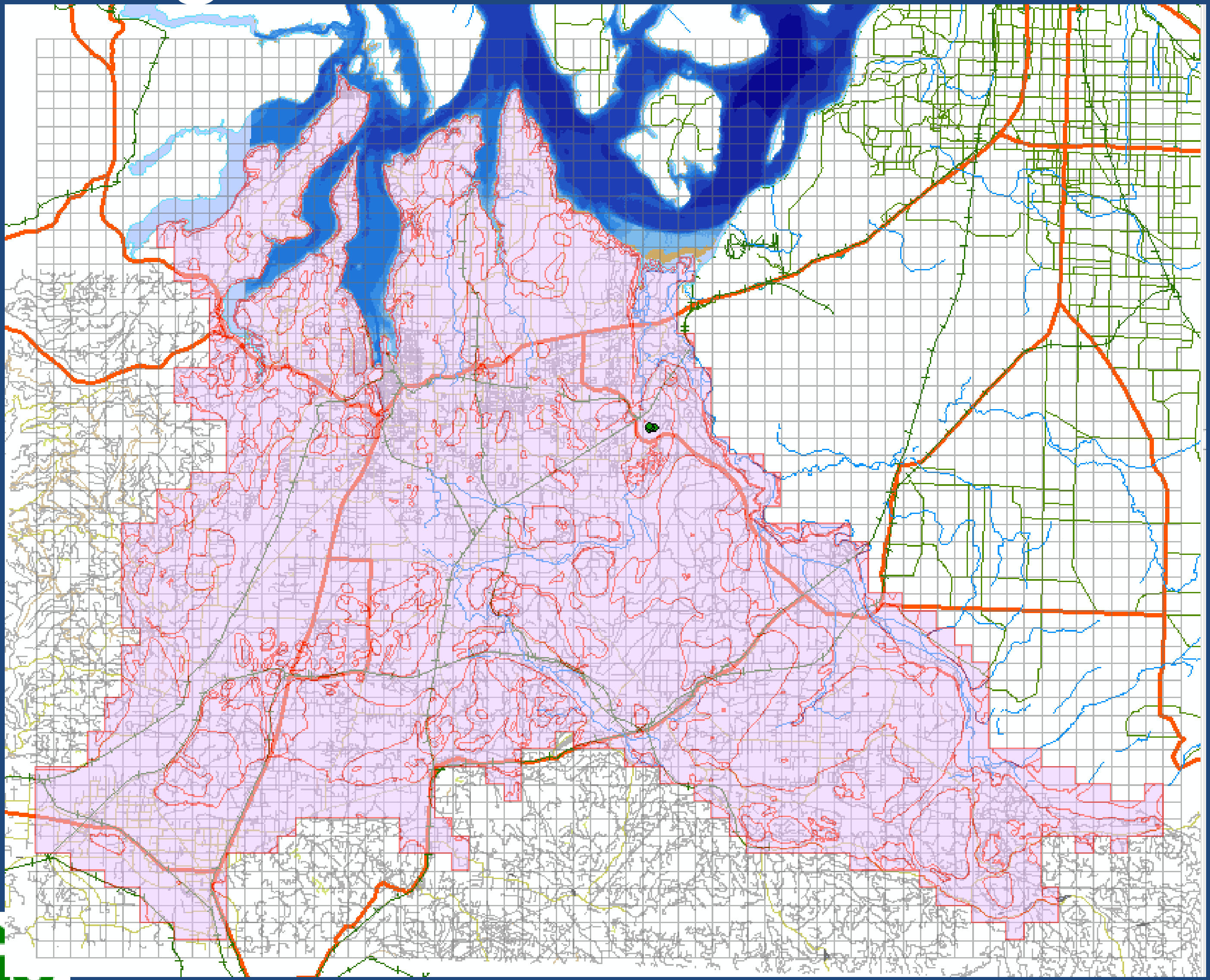
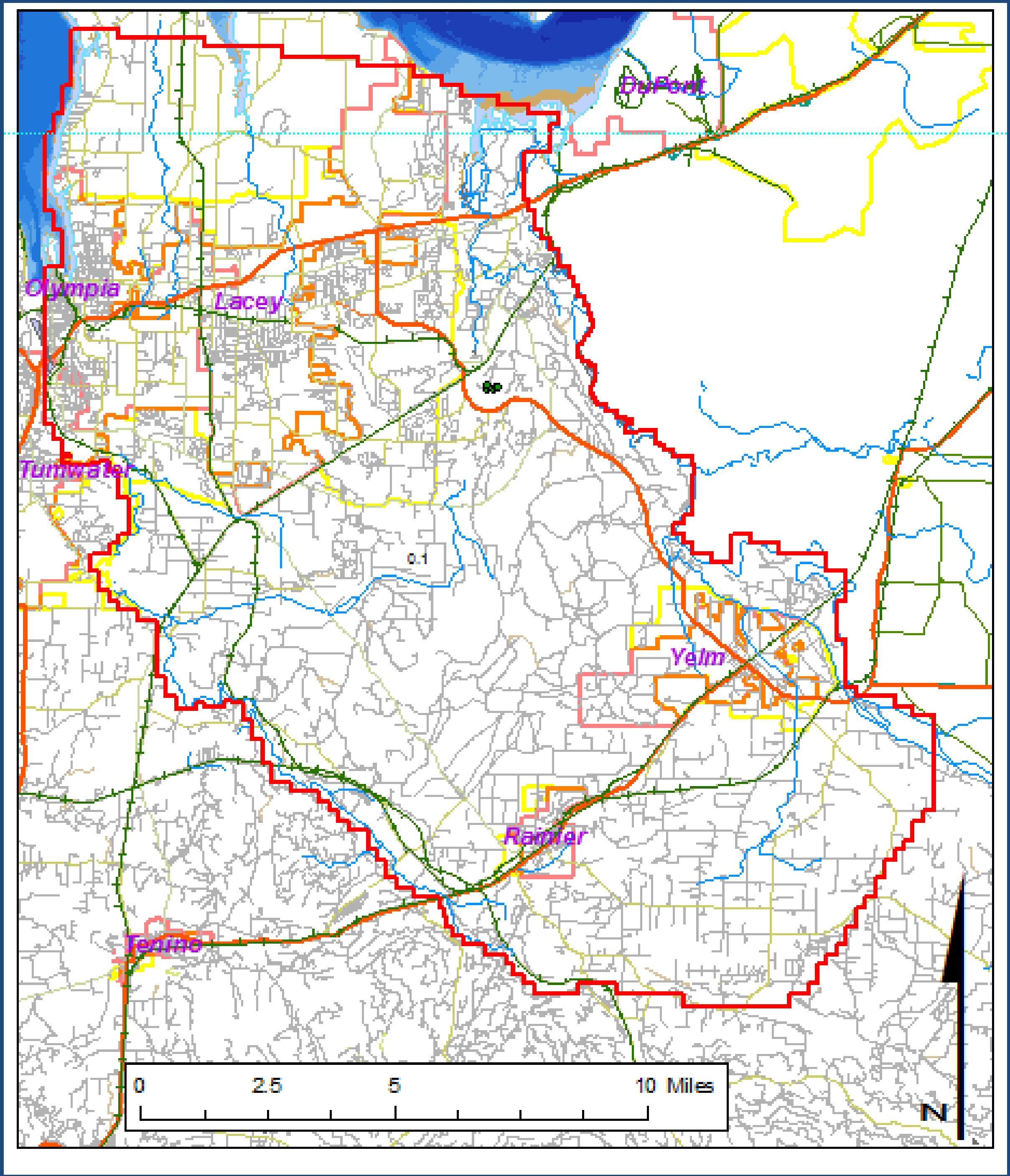
Original Drost Model extent



Revised Model Extent

present study area



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Revised Recharge Calculation

- Precipitation from PRISM (NRCS, Oregon State)
- Geology from Divn of Geology and Earth Studies (100K scale mapping)
- Canopy from Ecology (NOAA estimates for 2006)
- Recharge equations from Puget Sound regressions
- Developed / Impervious from Ecology Landcover

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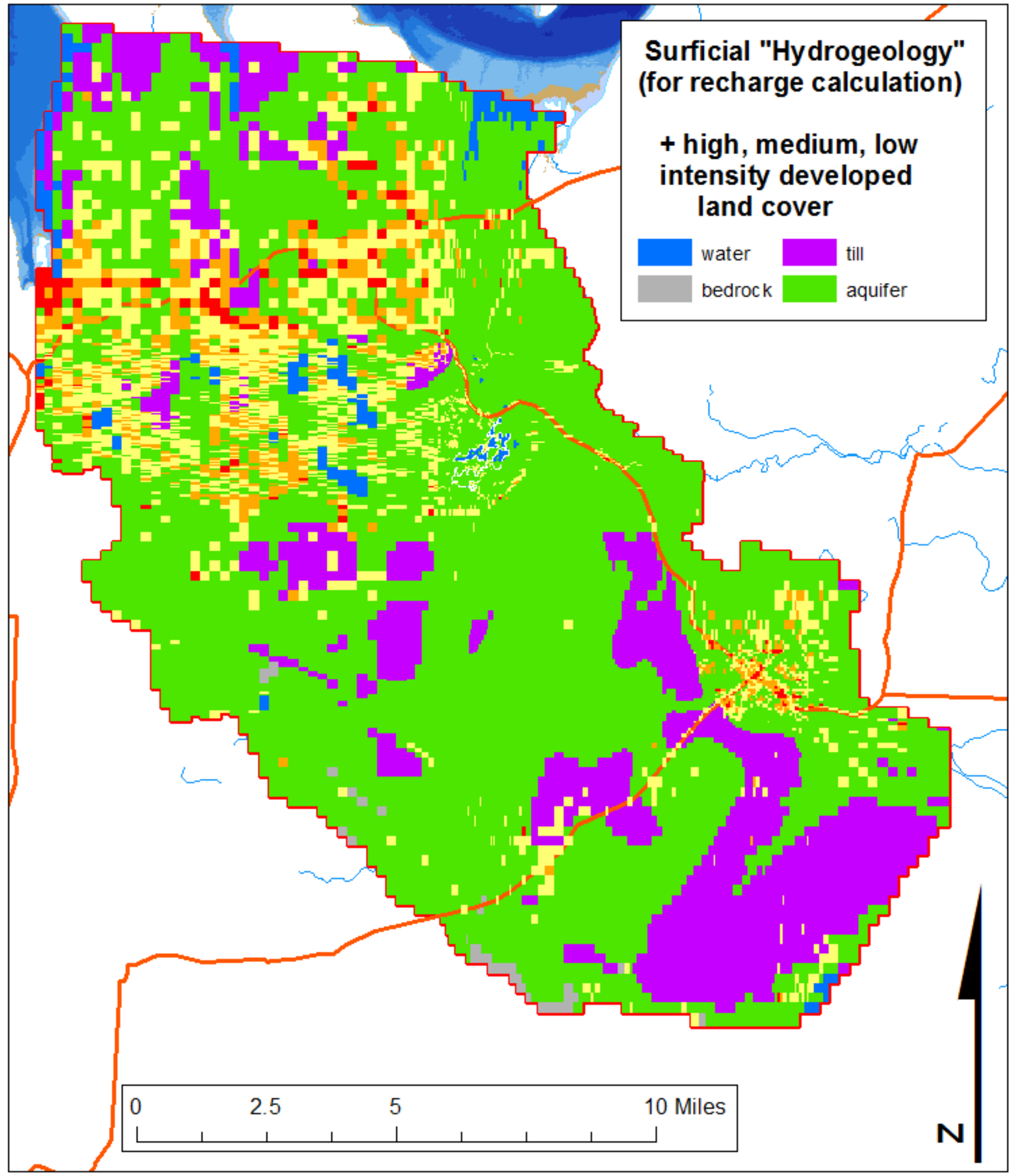
“Hydro-geology”

Surficial HG unit and land cover

categories of recharge regression equations



Surficial "Hydrogeology" and developed land cover
Thurston County Groundwater Model

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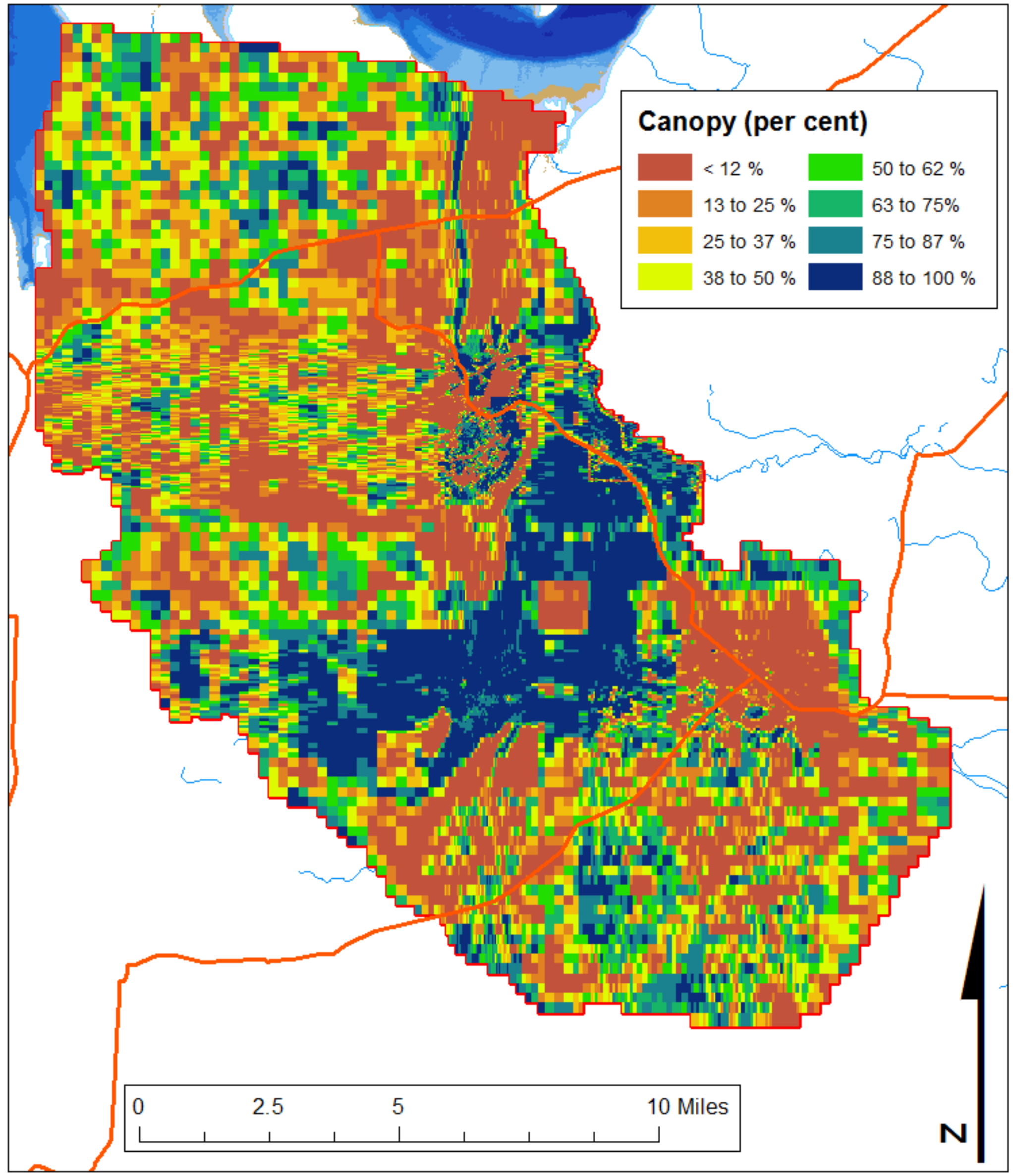
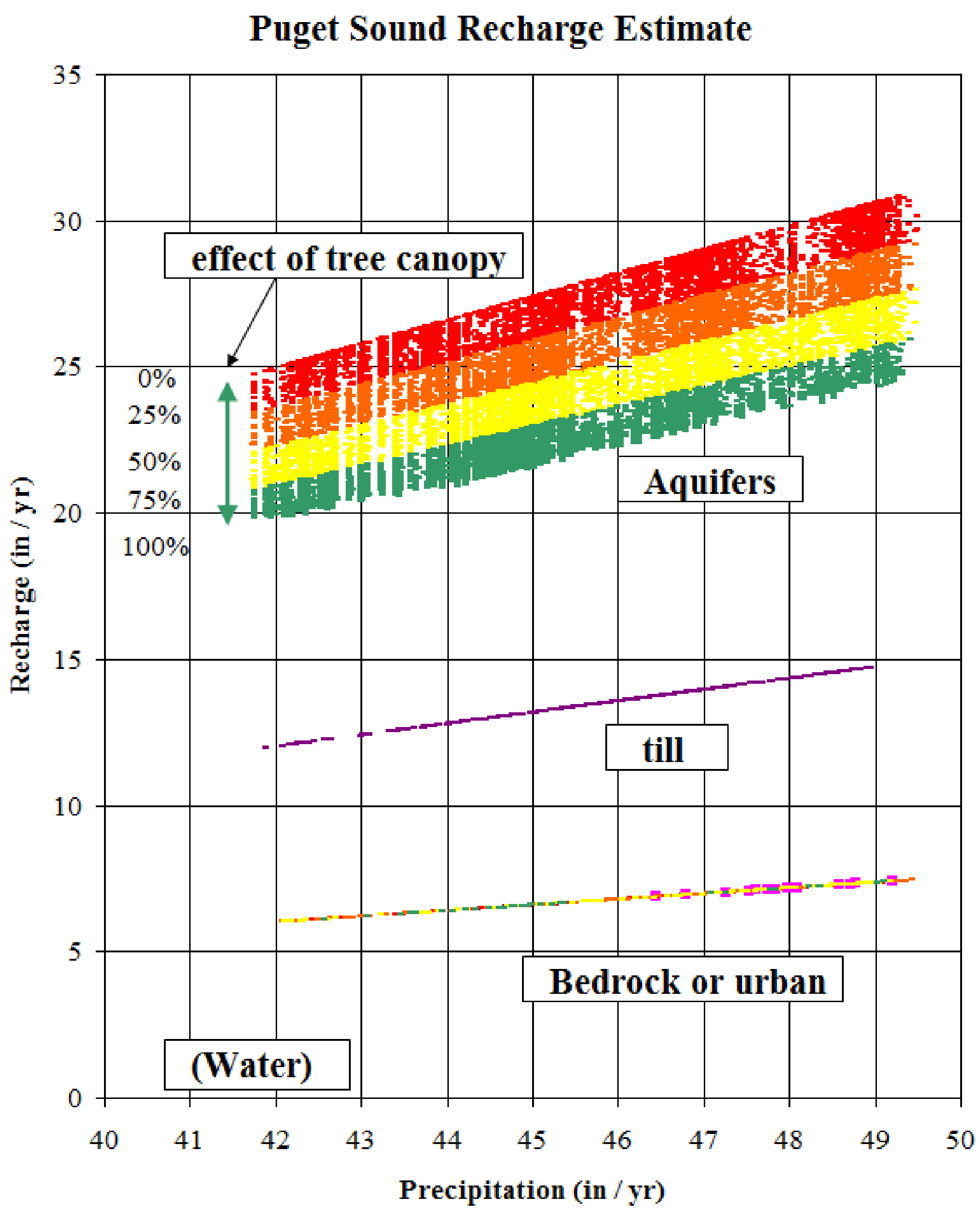
Existing Canopy



Present day canopy
Thurston County Groundwater Model

Calculation of Recharge



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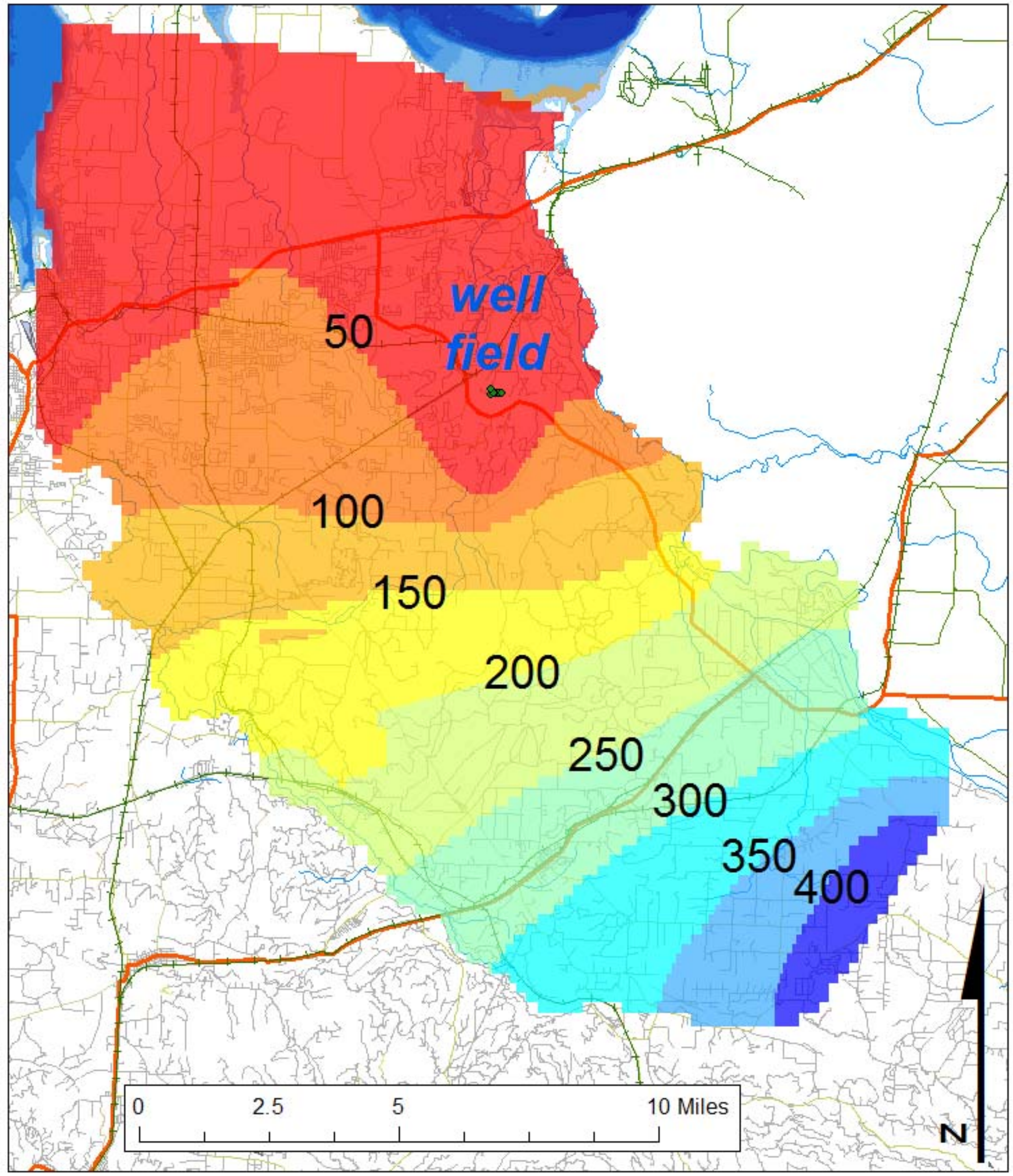
Model Application

- Converted model to steady state
  - Kept pumpage and mitigation features
- Applied new recharge relationship
- Parcel database to select recharge changes
- Base ("test") case (Scenario 1) using present-day land use
- Extreme case (Scenario 2) = remove all tree cover
- More realistic scenarios: remove tree cover by parcel and just in capture zone area

Groundwater levels with existing recharge
(ft msl)

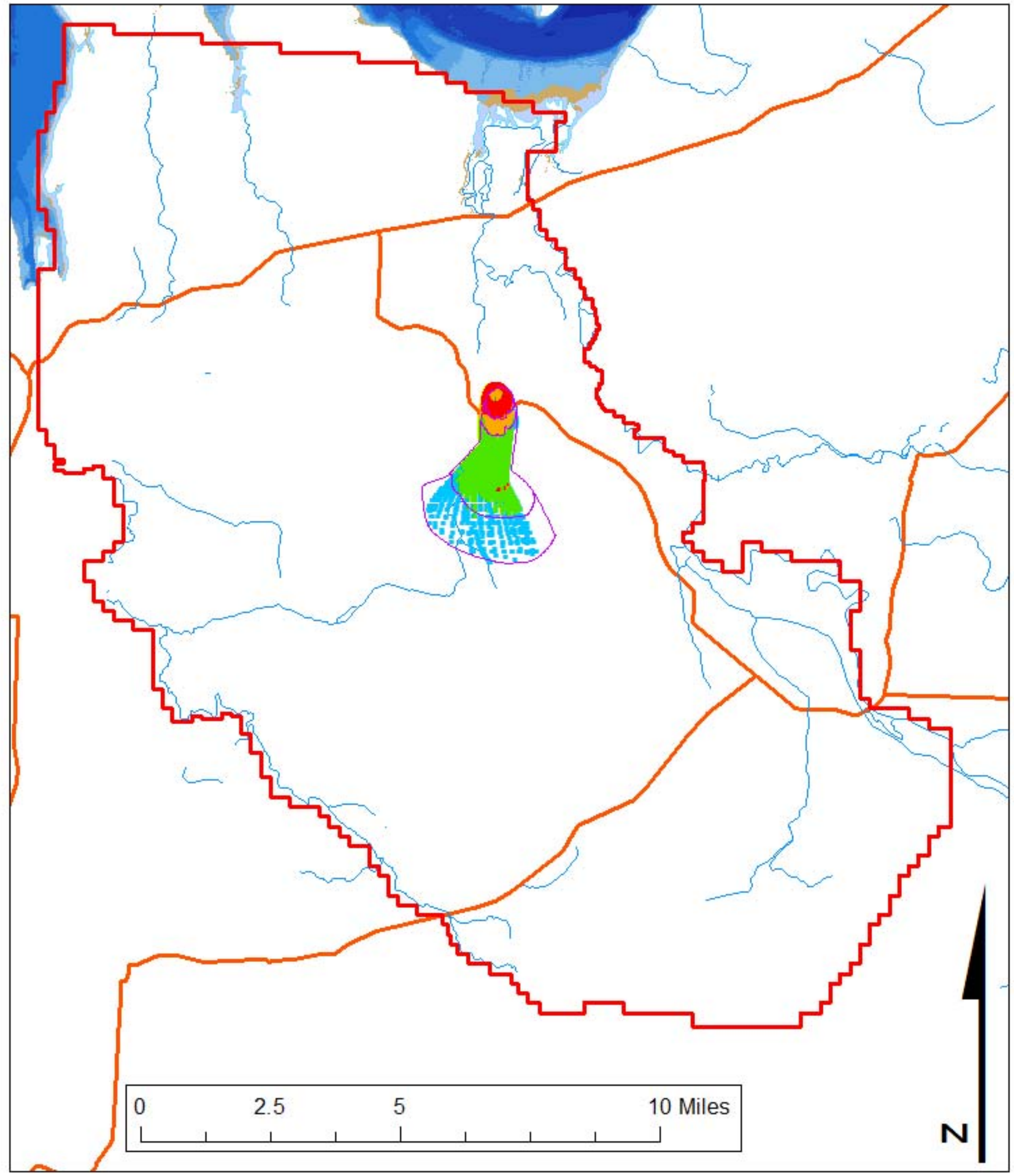
Total recharge = 190 mgd



Water levels in Layers 7 and 8
Thurston County Groundwater Model

Present Capture zone

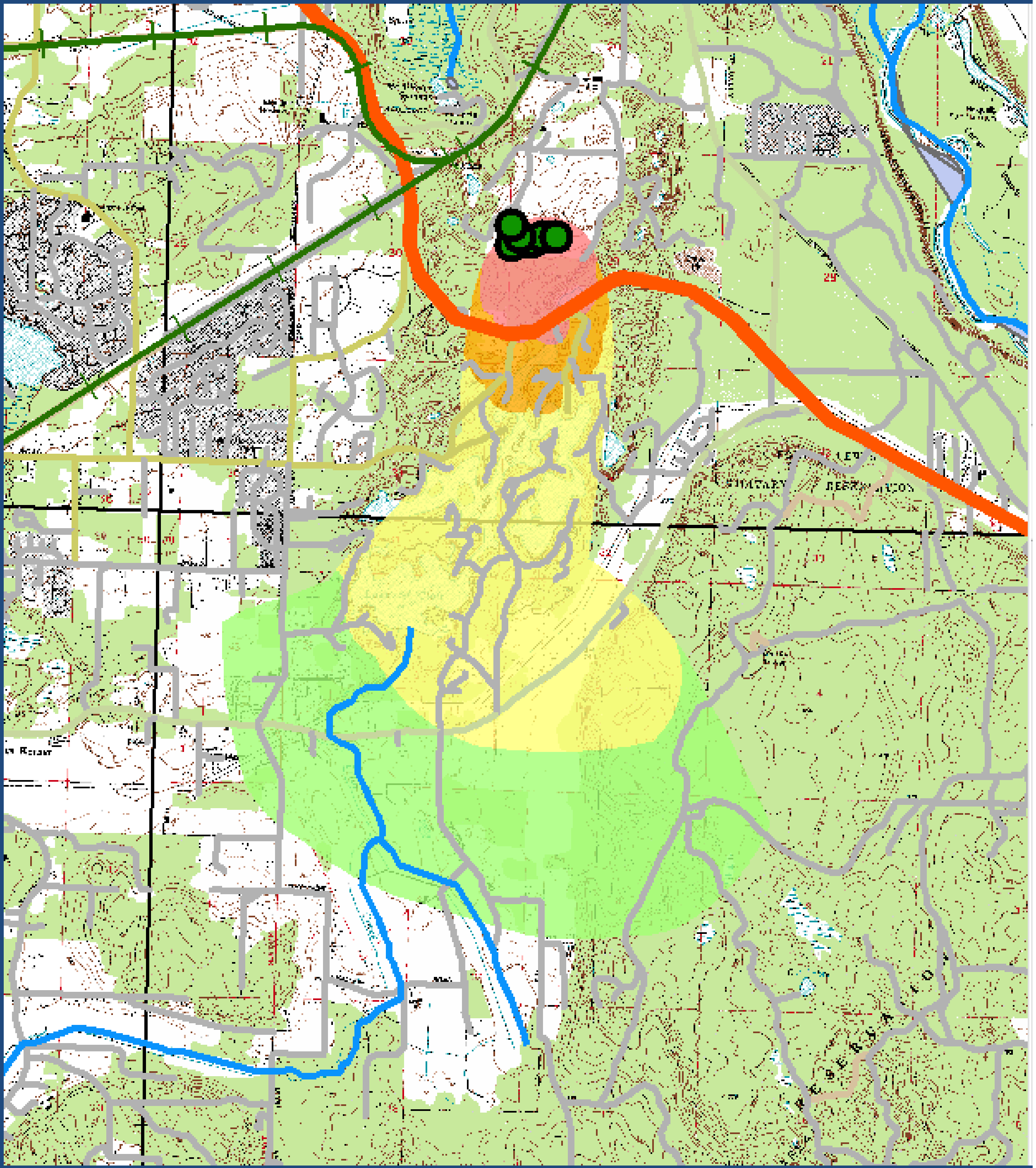
note: 6 wells, total = 16 mgd



Capture zone -- present canopy
Thurston County Groundwater Model

Zoom in -- Capture Zone

(previously derived: 6 month, 1 year, 5 years, 10 years)



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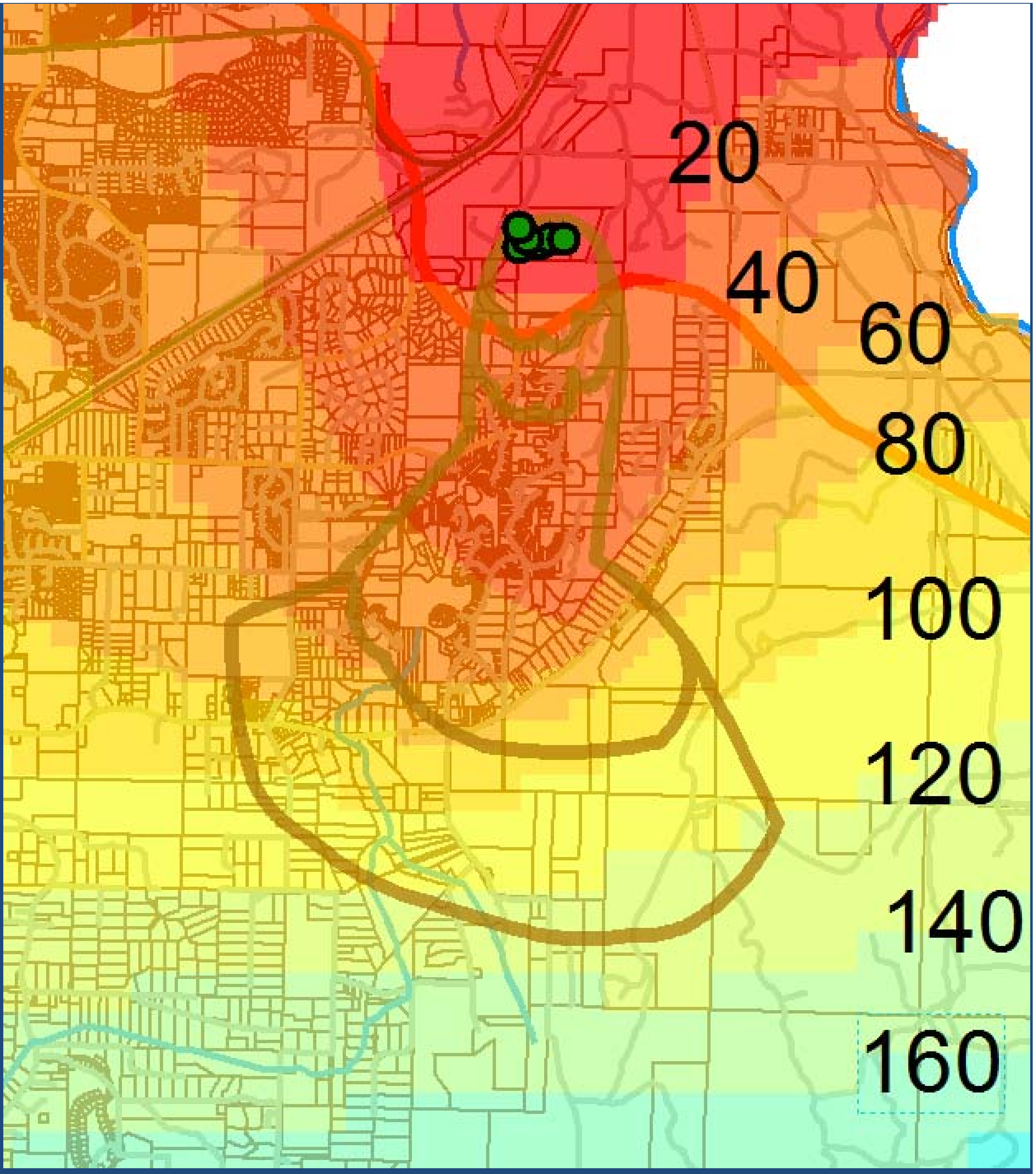
Local water levels

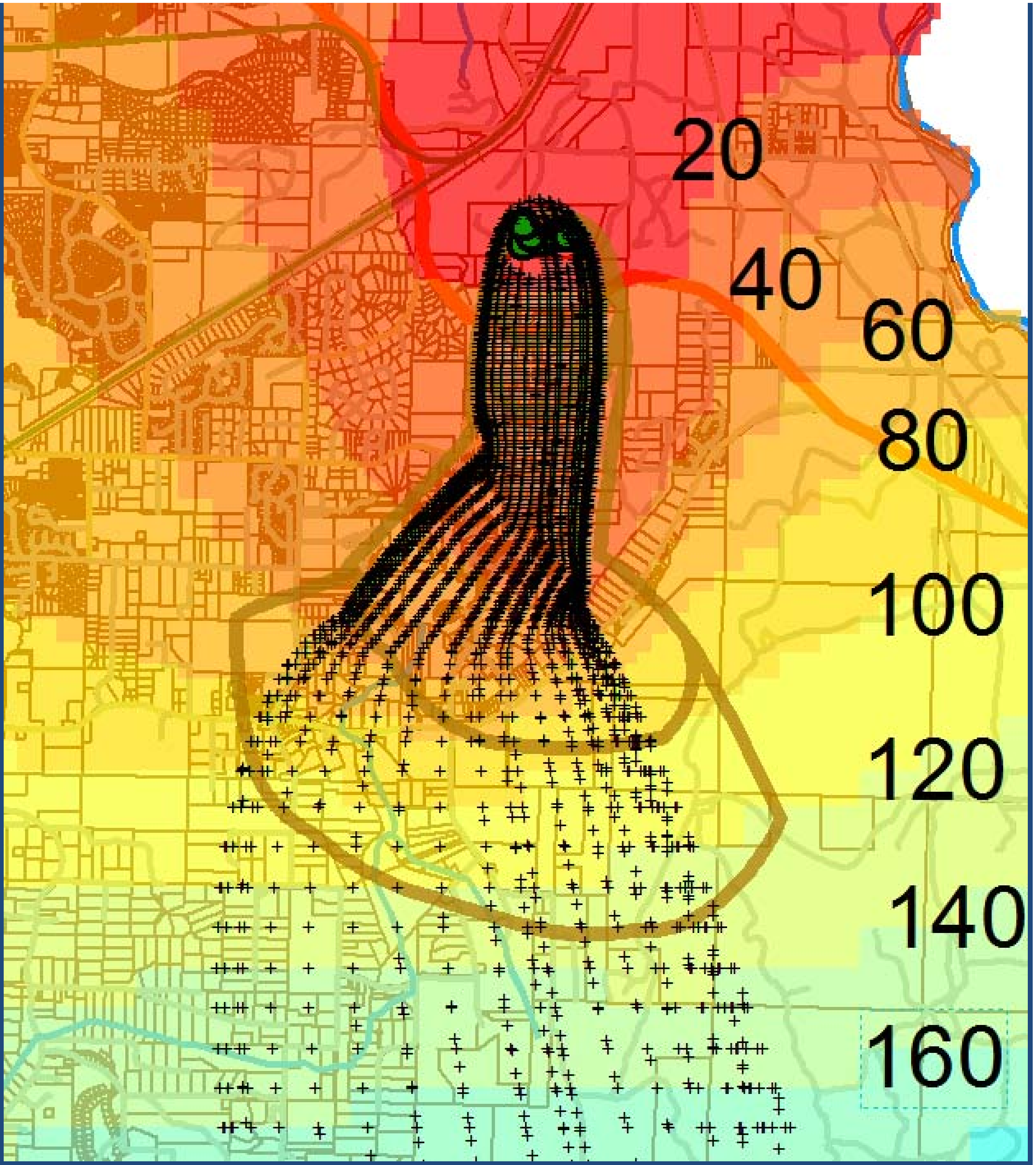
(ft msl)

present day conditions, layers 7-8



Particle paths

(layers 7-8)



Scenarios

- Present-day land cover (scenario 1)
- Extreme: remove all tree cover (scenario 2)

More realistic scenarios …

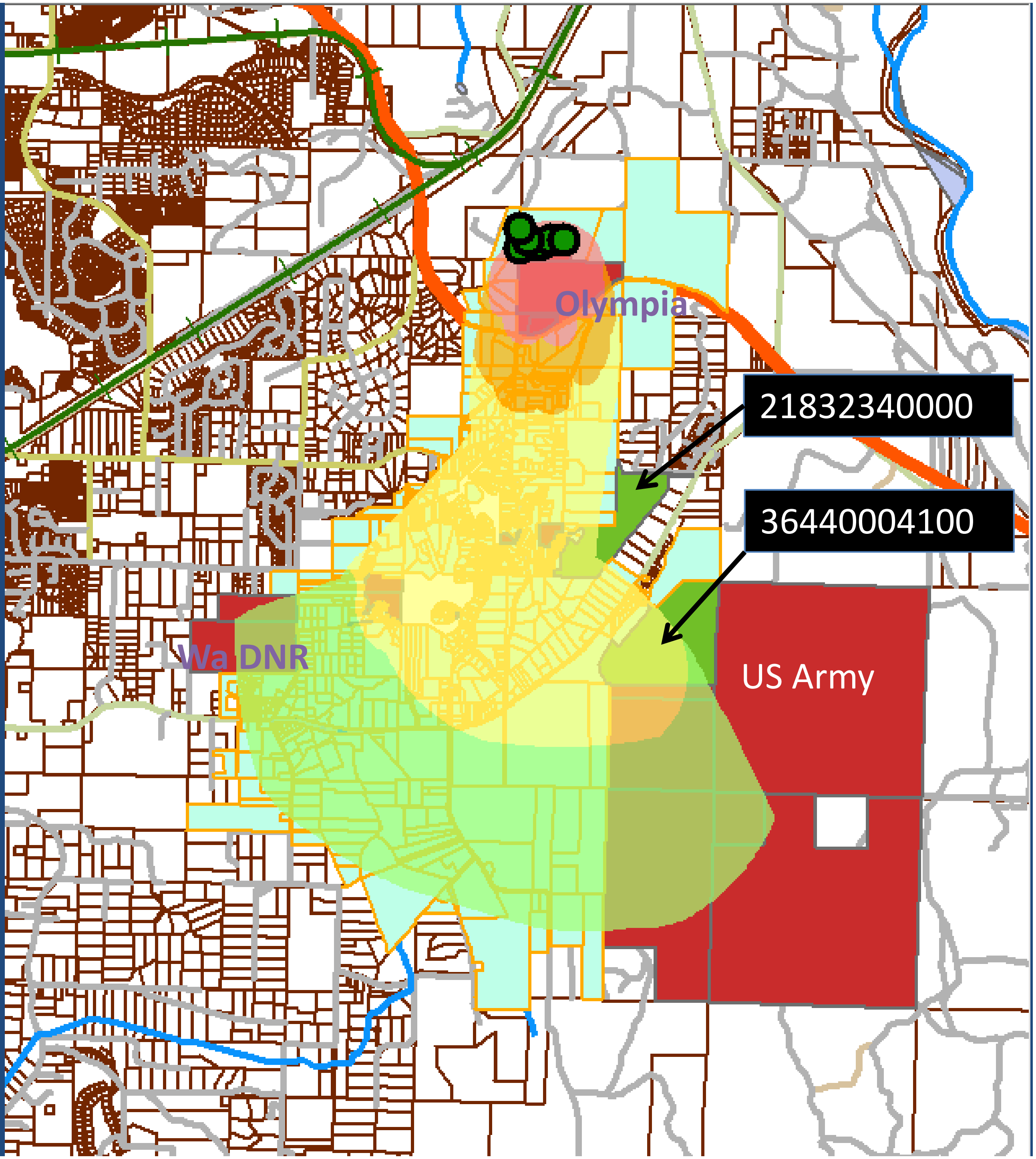
- Scenario 3: Remove tree cover from all privately-owned parcels in capture zone
- Scenario 4: Remove tree cover only from two parcels 36440004100 and 21832340000

Parcels

Publicly owned parcels (shown in red):

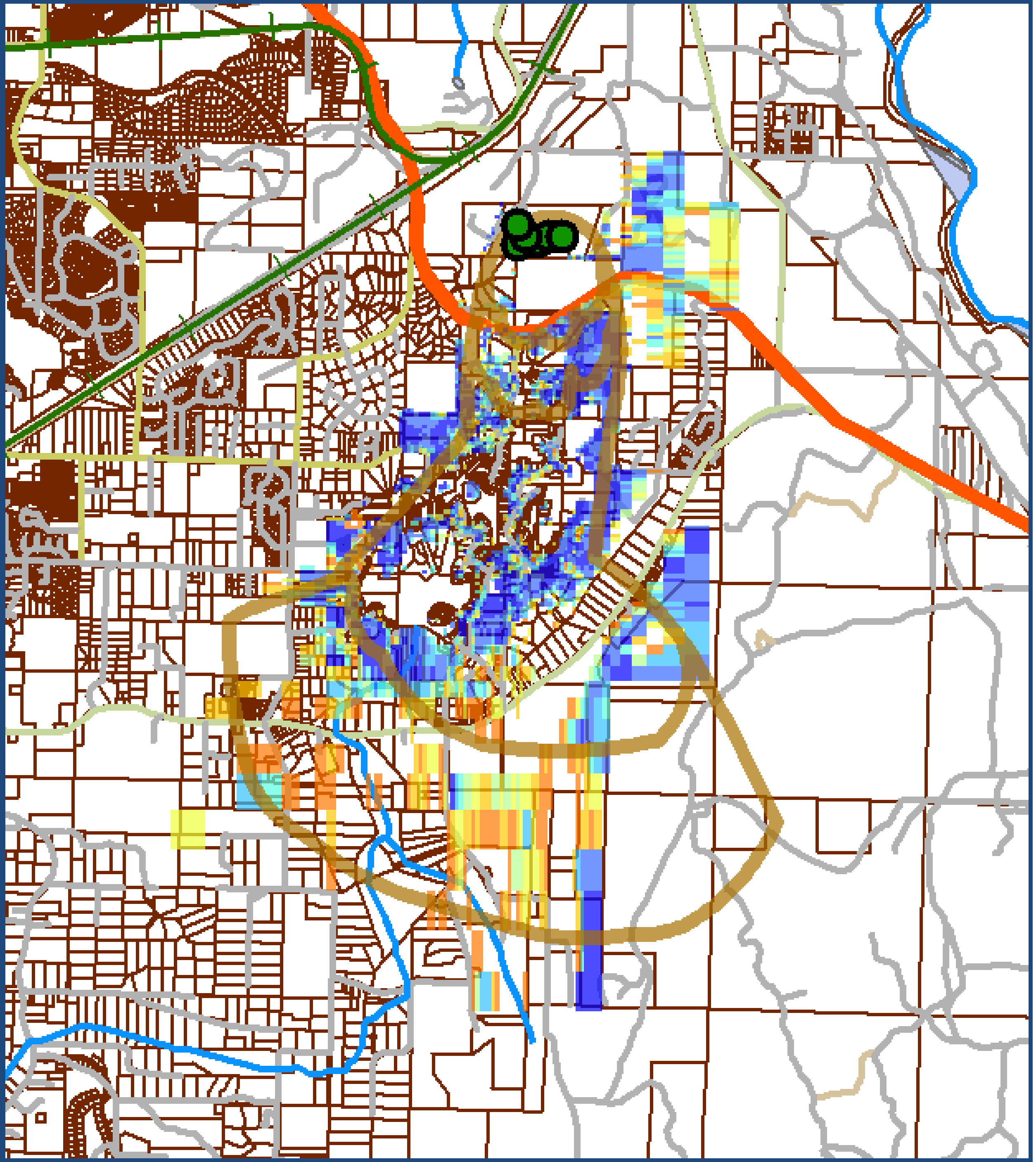
- USA Army
- Wa DNR
- Olympia
- Nisqually Indian Tribe
- Thurston County
- Wa Game Dept

About 900 total parcels in capture zone



Change of recharge
(Scenario 3)

(Arbitrary units: blue is greatest increase)

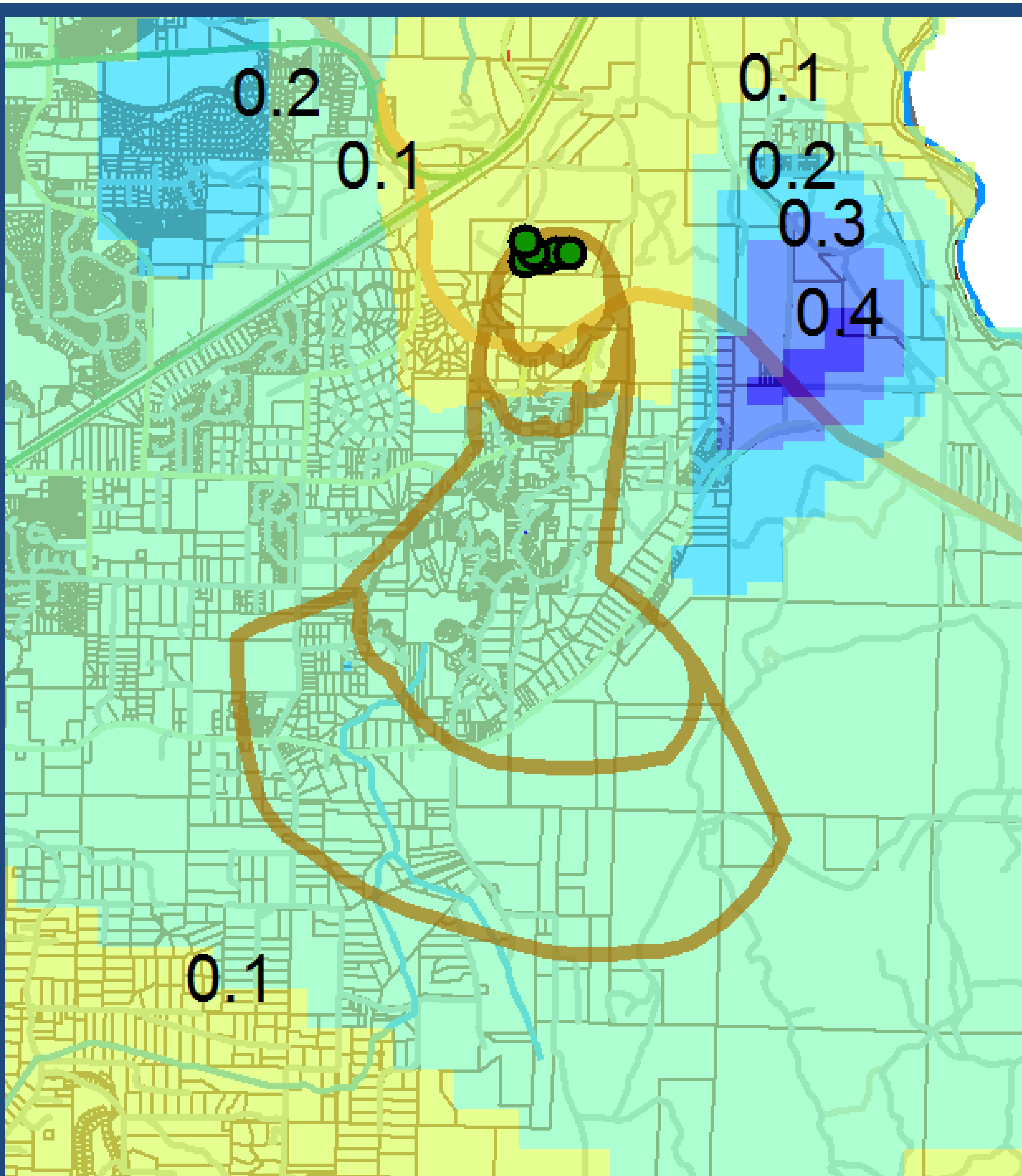


Change of water level

Scenario 3 – scenario 1 (rise)

(layers 7,8)

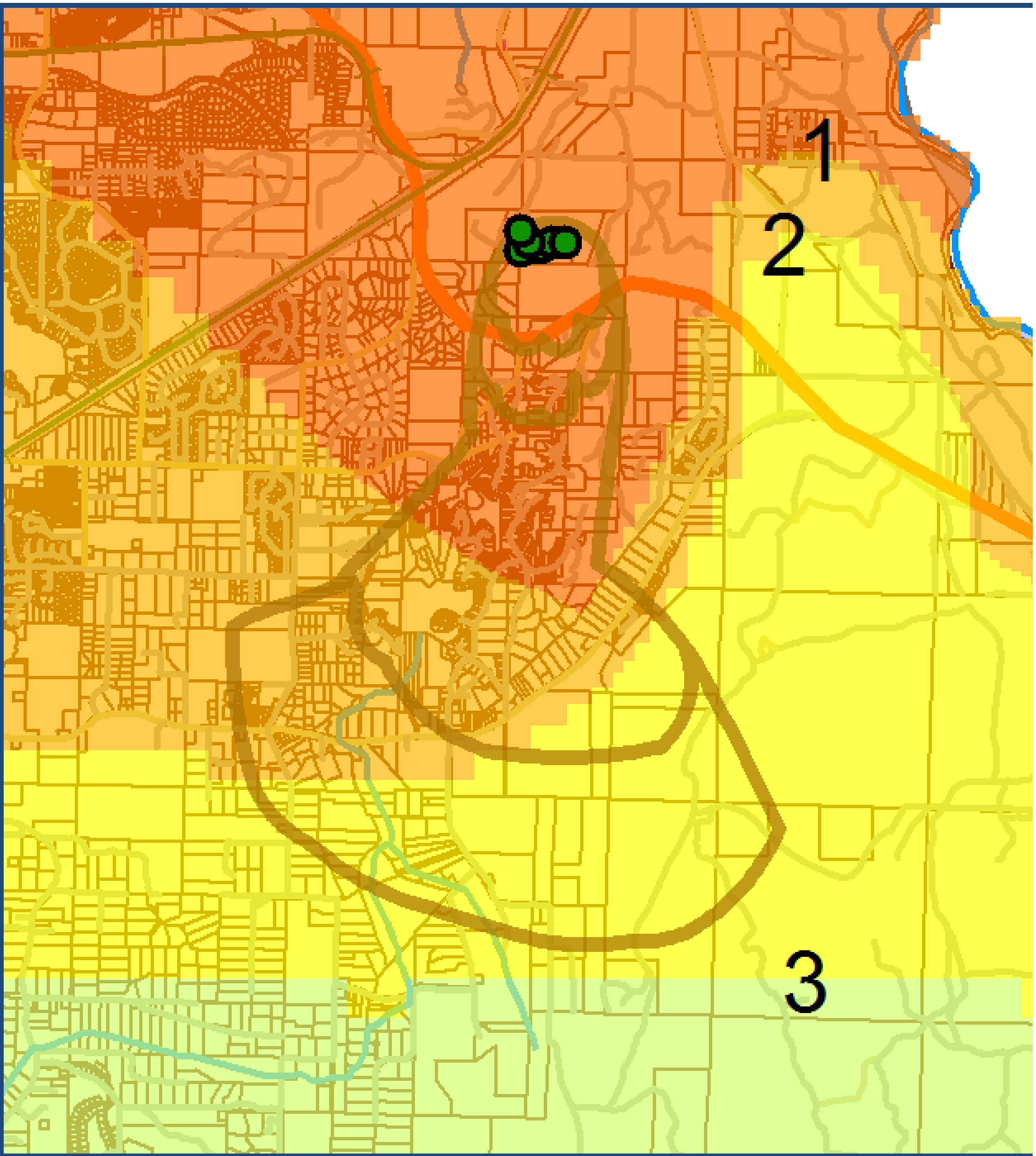
interval = 0.1 ft



Change of water level -- most severe change

Scenario 2 – scenario 1

interval = 1 ft



Changes in flows

- Removal of canopy increases recharge
- Changes in recharge
  - Scenario 2 (most severe) = 18 mgd
  - Scenario 3 (local, all private) = 0.5 mgd
  - Scenario 4 (local, 2 parcels) = 0.05 mgd

    Note that total new Olympia well field pumping = 16 mgd
- Results in higher heads, increased outflows, to rivers, lakes, Puget Sound, springs

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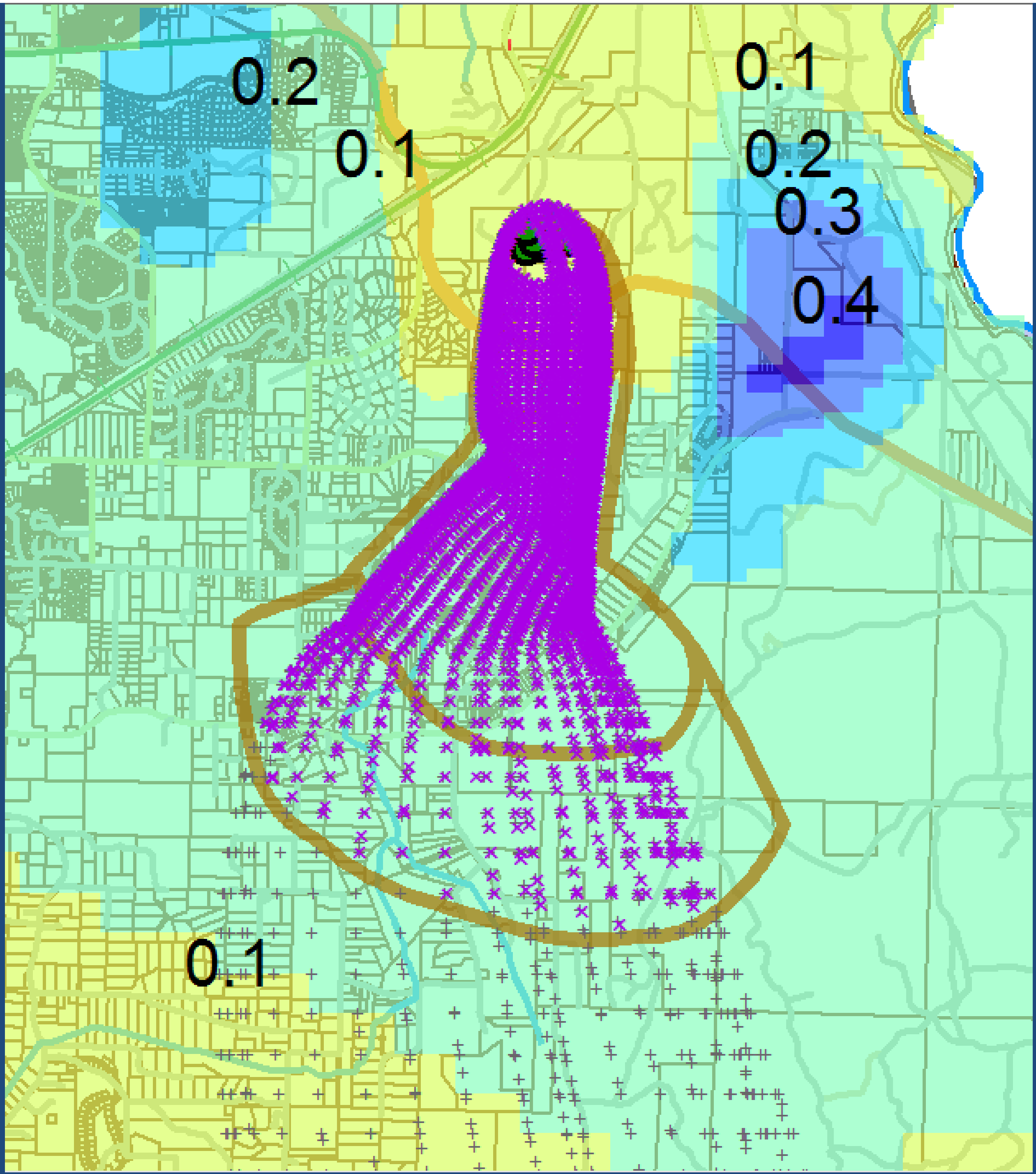
Changes in particle tracks

Scenario 3 in purple

(Base case pathlines in gray, but carried further)



Conclusions

- Changes in canopy can be modeled for changes in recharge, and groundwater flow
- Effects from recharge changes on surface become dispersed at depths of 300 feet
- Resulting changes to capture zone can be shown but are minimal
- Can also demonstrate impacts to streams

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Next steps

- Review / approval by committee
- Prepare report to post on web, provide to partners
- Longer term -- improve model:
  - Recalibrate with newer data and stresses
  - Extend across Nisqually basin
  - connect with Chambers – Clover model

Questions ?

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Appendix D – Nisqually Economic Analysis

Nisqually Forest Watershed Economic Analysis for the City of Olympia

Economic Benefits of Protecting McAllister Aquifer Recharge Zones: Forestland Protection vs. Contamination Response

This economic analysis is a prominent component of a demonstration pilot project led by the Washington Department of Natural Resources in response to legislative direction in ESHB 2541 (2010), to bring about one or more "ecosystem services" transaction in pilot watersheds. DNR worked with a wide range of partners to explore such payment systems, and discovered that project goals were uniquely aligned with the missions and capital spending plans of the City of Olympia's Drinking Water program. The pilot project provides the City of Olympia the opportunity to model change in land use and impacts to groundwater. In this case, the watershed service provided is the protection and filtration of drinking source water in the McAllister Aquifer. While this analysis is intended to stand alone as a support document for the City's groundwater protection land acquisition strategy, it also serves as part of an interdependent suite of pilot-related efforts exploring multiple angles, including; GIS modeling by USGS (groundwater geology), landowner outreach by the Nisqually Land Trust (land use and zoning), and forested watershed-source water protection research by Swedeen Consulting (conservation easement protocol guidance). As part of the pilot, this economic analysis demonstrated risk to groundwater, cost of contamination and prevention, and forest health impacts on the McAllister aquifer.

Groundwater Background and Risks

The City of Olympia is developing the new McAllister Wellfield to replace McAllister Springs, which has served as Olympia's primary water source since the early 1940s. This new site will be significantly more protected, more productive, and will meet water supply needs for generations to come (Hoey & Cushman, 2010). One component of the City's Groundwater Protection Plan includes implementation of a strategy to purchase land for conservation, restore natural habitats, and improve nearby river and stream flows. Funds will be used to acquire parcels or conservation easements in McAllister Aquifer capture zones. By owning land or easements, the City can control land uses and associated activities near its water sources and help prevent contamination of critical groundwater resources.

The purpose of this study is to support the drinking water protection activities being developed and implemented by the City of Olympia Drinking Water Utility. The City understands that protecting forested lands will help protect water quality and are working to prevent possible future increases in treatment and response costs through targeted land conservation. This report attempts to quantify the economic benefits of a source land protection and acquisition program by comparing land development and the costs of associated potential contamination events with the costs of land and forest conservation.

According to a 2005 United States Geological Survey (USGS) study, about 20 percent of total national water use comes from groundwater sources (USGS, 2013). While the majority is used for irrigation, a significant percentage is for public and private drinking water supply. Other fresh groundwater uses are for the production of electric power, food, beverages, and material production. Groundwater is not only important for human use, it also is critical to ecosystem health of surface water, such as ponds, marshland, swamps, streams, rivers and bays.

Aquifers are water-bearing rocks and sediments that are an important source of groundwater supply. Water enters the aquifer via precipitation and infiltration. It percolates through the aquifer at varying rates depending on the type and amount of ground cover, gradient, climate and porosity of the sediment. About half of this water soaks into the ground through the land above to recharge the aquifer, while the rest either remains on the surface in the form of runoff or undergoes evaporation. This land is commonly referred to as the "recharge zone," and the presence of impervious surfaces highly influences the rate at which water recharges the aquifer.

Communities must be aware of the many ways human activities can affect groundwater resources. The most common concern involves overuse, as it results in the decline of water quantity. In coastal areas, overuse poses the risk of saltwater intrusion, which contaminates fresh groundwater with saltwater from the sea. Humans have also been known to introduce hazardous liquids and chemicals originating from parking lots, roads, agricultural lands and underground storage tanks to recharge zones where they may enter aquifers. Activities that disturb the land and increase soil movement, such as residential development and clear-cut forestry, can increase the potential for harmful particles to travel through the soil and into the water table. Businesses, homeowners and recreationists may use, store, and incautiously dispose of hazardous materials and wastes. These include gasoline or diesel fuel, used motor oil, heating oil, cleaning products, septic effluent, pesticides, herbicides, and fertilizers. Some of these chemicals have been found in groundwater and are known to cause cancer and other illnesses.

Groundwater contamination has historically been a point of discussion among watershed residents; between those upstream releasing contaminants and those downstream using the groundwater supply. In order to avoid disputes among residents, while also protecting ecosystem health, communities may implement regulations aimed at preventing contaminants from entering streams and aquifers through best management practices, vegetated buffer zones, and the reduction of impervious areas. Health and zoning regulations can also control potential sources of contamination. The possibility of long-term or permanent damage from contamination, along with the uncertainty of if or when an event will occur, are two key reasons why groundwater quality protection is essential.

The Federal Safe Drinking Water Act addresses this issue by requiring every state to develop a wellhead protection program. The "wellhead" is defined as that land area around the well from which the well is recharged and draws its water. "Wellhead Protection" is a program for protecting the quality of water drawn from public groundwater wells, and includes actions that will ensure land use within the wellhead area will not contribute pollutants to the groundwater (Garrett, 1993). Such programs give local governments and agencies the responsibility of helping water systems protect their community's drinking water supply, and coordinating wellhead protection measures (DOH, 2010). The water system's costs for wellhead protection depend on the number of connections, vulnerability, hydrogeological setting, desired accuracy of groundwater modeling, and the extent and nature of the wellhead protection plan. According to Washington State's wellhead protection guidance document, there are three sources of potential funding for local wellhead protection: local taxes or fees, private sector investments, and intergovernmental assistance (grants/loans) (DOH, 2010). Utilities may request assistance from both federal and state government agencies. U.S. EPA provides federal funding and technical assistance to local governments implementing wellhead protection programs. The Natural Resources Conservation Service (NRCS) offers technical assistance, as well as funding in certain cases. Washington Department of Health, the Department of Ecology, the Department of Commerce, U.S. Department of Agriculture, and Rural Community Assistance Corporation are some of the common funding sources for wellhead protection and drinking water infrastructure projects.

Facing Uncertain Costs of Groundwater Contamination

Cities with drinking water supplied by aquifers that are experiencing increased development pressure are conceivably at risk of increased contaminants. Communities, states and consumers bear the economic burden when drinking water sources are contaminated. In addition to adverse health and ecological effects, costs can include the need for testing, monitoring, and treatment, as well as a potential loss of productivity to the landowner responsible for the contaminant source. Over the long term, treatment systems often must be expanded to meet new regulatory requirements or to address new contamination threats, but these are only temporary solutions to maintaining drinking water quality. Conventional land use and protection decisions are often based on short-term (one to five years) revenue and expense projections. The impacts of development on water quality and treatment costs are realized over the long term— five to ten years and longer, and are often ignored in land use planning processes (TPL, 2004). Contamination events often result in short-term, larger impacts to a utility's budget and staff. Alternatively, prevention costs can be distributed over a longer time span, which can be more manageable at the utility level. Long-term planning also allows utilities more flexibility to adapt and apply latest prevention technological improvements. In order to address this understanding, drinking water providers are educating themselves on how to make informed assessments about the costs, both long- and short-term, of source protection in relation to other approaches of dealing with contamination events.

Implementing local wellhead protection programs helps public water suppliers avoid costs associated with a contaminated public water supply. Studies show that it is generally more cost effective to implement a proactive pollution prevention program to guard against groundwater contamination rather than pay for alternate drinking water or for contaminated water treatment efforts. Wellhead protection regulations call on States to design, adopt and manage a Wellhead Protection program to include:

- delineation of the wellhead area,
- identification of potential contamination sources,
- planning for management of those sources in various ways,
- contingency planning, and
- education and training.

The Washington Department of Health outlines the direct costs associated with well contamination in its 2010 Washington State Wellhead Protection Program (WHPP) Guidance Document. The list includes, but is not limited to the following:

- provision of emergency water supplies,
- hydrogeologic studies to locate alternate water sources,
- construction of replacement wells,
- treatment of contaminated groundwater,
- aquifer remediation,
- public information and education,
- increased monitoring requirements, and
- various additional costs.

Many communities that have experienced the increased treatment and capital costs of degraded water are now implementing regulatory and non-regulatory strategies to protect land and encourage more sustainable development patterns (TPL, 2004). It is estimated that annual costs associated with pesticide contamination of groundwater in the United States are approximately $2 billion (Pimentel, 2005). A study that assessed residential willingness in Cape Cod to pay to protect potable groundwater from possible nitrate contamination focused on several scenarios representing different levels of risk of future contamination. The present value of protecting the aquifer ranged from $5 million to $25 million per 1000 households. This represents a willingness to pay from $500 to $2500 per year per household for groundwater protection (O'Neil, 1990).

Forest Cover and Groundwater Health

Maintaining or restoring forest cover is important for groundwater protection, as forests provide a number of benefits – including water flow regulation, flood control, water purification, erosion control, and freshwater supply filtration (Hanson et al., 2011). These services could be increasingly valuable as climate change intensifies and the Pacific Northwest is potentially faced with changes in the timing and magnitude of water runoff and water flows. Excessive pathogens and nutrients may enter aquifers and streams from landscapes that have been converted to more intensified use, such as from forest lands to rural or urban use (also referred to as "converted" landscapes). This pollution can trigger effects that impact water quality and ecosystem health in a variety of ways (Hanson et al., 2011). Increased development in forested areas can also lead to loss of other services provided by healthy forest ecosystems such as water storage, air filtration, carbon sequestration, nutrient cycling, soil formation, and wildlife habitat (TPL, 2004).

A program guidance document created by Swedeen Consulting for City of Olympia Groundwater Protection easements reviews research on the interaction between forest cover and pesticides (Swedeen, 2013). Findings indicate that pesticide residue levels in groundwater are lowest in areas of forest cover versus urban and agricultural lands, including pasture. Research specific to the Puget Sound found that pesticide levels were associated with increased development and associated road-side spraying programs. Relevant research also suggests that preventing development in currently forested areas, and restricting the use of certain chemicals in wellhead protection areas would likely reduce the risk of groundwater contamination from these chemicals.

The Nisqually River Watershed

The Nisqually River Watershed bordering Thurston and Pierce Counties in Washington State provides a wide variety of services to residents in the 721 square mile Nisqually River Basin. The health and vitality of the river system is being threatened by forest land conversion and development pressure. Despite the well-established watershed protection efforts that have been implemented over the past decade, several drivers are expected to affect Nisqually watershed forests, which include suburban encroachment, climate change, short-rotation industrial forest management practices, and invasive species (Hanson et al., 2011). Forest conversion to non-forest land uses means the loss of vital forest watershed benefits — including water flow regulation, water purification and erosion control, biodiversity, decreased property values, recreation, timber supply and non-timber forest products, jobs, tax revenues, and loss of citizens' confidence in their drinking water, public utilities and community leaders. Increasing development also contributes to point and nonpoint source pollution, which results in declining water quality as the river and the aquifer carry water downstream (Batker et al., 2009).

McAllister Wellhead Protection Program

Utilities, such as the City of Olympia's Drinking Water Program, understand that protecting water quality means protecting land, and are working to prevent future increases in treatment costs through revised water system plans and targeted land conservation (TPL, 2004). Located at the headwaters of McAllister Creek, McAllister Springs is vulnerable to potential contamination (City of Olympia, 2013). The McAllister wellhead protection groundwater investigation identified transportation spills, including a major upstream rail line, as the most significant potential threat to the Springs. Climate change impacts, such as sea level rise and subsequent saltwater intrusion, along with shifting precipitation and runoff patterns, may result in changes in water quality, which poses additional challenges to the City's drinking water utility in fulfilling their public health and environmental mission. In response to these risks, the City decided to move away from McAllister Springs and is developing the McAllister Wellfield as the primary drinking water source. The well field is less vulnerable to contamination risks due to its depth, as well as its further distance from the rail line, which is significantly more protected from likely spills than the springs.

Olympia has relied on McAllister Springs since the early 1940s. According to the City's 2012 Water Quality and Efficiency Report, McAllister Springs provided 76% of the City's drinking water. The other 24% was provided by groundwater drawn from five wells. In total, 2.7 billion gallons (BG) of water produced was used by City metered customers, City of Lacey and Thurston County wholesale customers, and unmetered public uses (Reimers, 2012). Had the City continued to rely on McAllister Springs, it would have been required to install an expensive ($6-8 million) ultraviolet (UV) treatment facility. Retiring the Springs will also allow the City to use its full water right as the McAllister aquifer provides a more productive water supply (Buxton, 2012).

Studies of the McAllister Wellfield showed that the chosen site taps a large sustainable aquifer with high quality water. With the purchase of the site, as well as 100 acres of adjacent development rights, the City began the long-term process of developing the wellfield into its primary source of drinking water.

City of Olympia and Nisqually Tribe officials celebrated the McAllister Wellfield groundbreaking ceremony in September of 2012.

This new site will be significantly more protected, more productive, and will meet water supply needs more effectively than the Springs. Wellhead protection plans were developed to enhance prevention of contamination of the drinking water supply through structural and nonstructural programs, which includes purchasing land for conservation, restoring natural habitats, and improving nearby river and stream flows. The City anticipates pumping from the new McAllister Wellfield by spring of 2014.

ANALYSIS

Study Purpose and Methods of Investigation

In an effort to assist the City of Olympia in meeting their Wellhead Protection Program objectives, staff at the Department of Natural Resources, along with a consortium of Nisqually Watershed protection partners including the Nisqually Tribe, Nisqually Land Trust, Northwest Natural Resources Group, and Swedeen Consulting, developed this report as a forecast of potential costs from responding to possible contamination of the McAllister Wellhead groundwater source, compared to the costs of a land conservation program that would reduce the risk of contamination. This cost-avoidance analysis is based on contamination and pollution scenarios resulting from land use and management practices in the McAllister Wellhead area. Two alternative land use scenarios are considered: 1) current wellhead protection efforts and full development build-out to current Thurston County zoning allowances; and 2) enhanced wellhead protection efforts on parcels which have been prioritized based on groundwater flow travel time. (Recharge rates on priority parcels vary from 6 -months to 10 years of travel time; that is, time measured from when water enters overlaying soils, until the point where water is extracted from the City's wells.)

Data for this cost-avoidance analysis was obtained by interviews, surveys, literature review, and project specific metrics analysis. Washington Department of Ecology Toxics Cleanup Program staff was interviewed regarding likely groundwater contamination response measures and general costs. The Department of Natural Resources Environmental Services staff provided general cost data regarding local contamination events. Washington Department of Health Source Water Protection Program Manager initiated a project-specific email survey to members of the Association of State Drinking Water Administrators (ASDWA). ASDWA's Executive Director carried out the survey; responses accounted for a list of various financial burdens involved in actual U.S. wellhead contamination cases. These data were reviewed, compiled, and presented for comparison in a cost summary matrix (See Appendix).

City of Olympia staff and a regional conservation easement expert from the Nisqually Land Trust gave cost estimates for land conservation through easements. Swedeen Consulting guided this research and reviewed it for accuracy. Study results are intended to be of use as City of Olympia decision makers consider the wellhead protection land conservation strategy.

In many cases, it is difficult to distinguish all of the specific costs related to not having wellhead protection measures in place. Therefore, this study assumes total cost reflects average totals based on infrastructure and labor costs. The cases included in this study were chosen to illustrate the most typical types of contamination to groundwater sources, and representative ranges of costs for the most typical response measures. This comparison of prevention program costs with those of remediation, replacement or treatment programs is not adjusted for the probability of their actual occurrence, present value, or for inflation.

Comparing the costs of prevention with remediation alone does not always accurately depict contamination scenarios, as there is always a possibility for groundwater contamination. Also, neither is contamination assured at every potential source. Therefore, groundwater protection programs are similar to insurance policies, as a catastrophe is never a certainty. Although risk of significant contamination is relatively low in the case of the McAllister Wellfield, the City of Olympia receives 100 percent of its drinking water from the ground, and therefore its Groundwater Protection Program aims for protection standards meant to assure very high water quality and consistent supply.

Investors are becoming more aware of this range of risks. A 2010 Ceres report explores growing risks to water utility-related municipal bonds. The report demonstrates why investors should treat water availability as a growing concern for both public water and electric power utilities, and how associated risks are not currently reflected in public utility bond ratings. The report provides a quantitative framework for assessing water utility risk exposure to help investors gain a more complete picture of a bond's risk profile (Leurig, 2010). Water risks may soon be reflected in water utility investments, impacting utility budgets. Thus, payments for ecosystem services programs are a proactive means of addressing this forecasted financial circumstance.

Although health effects are a primary concern in cases of groundwater contamination, research on the total health care costs and associated damages is currently lacking. However, Michael Beach from the Center for Disease Control and Prevention authored a 2010 study exploring the hospitalizations for three common waterborne diseases – Legionnaire's, Cryptosporidiosis, and Giardiasis - and resulting health care costs. Legionnaires' disease is the only disease included in the study that is commonly found in groundwater, and is therefore relevant to this analysis. Estimated national costs for hospitalization for Legionnaires' disease from 2004 to 2007 was between $101 and 321 million. According to the CDC, the average cost to each patient for an average of 10 days of hospital treatment was $31,000. Total estimated cost for the three diseases was over $500 million annually in the U.S. Beach explains that the impacts of contamination and waterborne disease outbreaks should also be measured in human terms, such as the suffering endured by those who were infected, and losses endured by their families and friends (WQH, 2010).

Abundant empirical national data is available on containment, remediation, treatment, and replacement costs to inform the cost comparison provided in this report. Costs for containment action can vary widely depending on the site characteristics, the type of contaminant, and the extent of the plume. An example from Minnesota's Groundwater Policy Education Project analyzes containment options at a hypothetical 10-acre landfill Superfund site, which included $4 million for sealing the bottom, $1.4 million for installing a grout curtain, and $200,000 for an injection barrier. The average cost for this type of effort was cited at around $8 million (O'Neil, 1990). Superfund sites are extreme case scenarios, and are for the most part avoided in this report. This economic analysis attempts to explore only the most likely, less-extreme contamination scenarios.

Potential Contaminant Risks to Olympia's Groundwater

Contaminants that may be present in source water include microbial contaminants, inorganic chemical contaminants, organic chemical contaminants, and sediments. Of these four basic types of contaminants organic chemicals such as petroleum, fuels, pesticides, herbicides (including Atrazine), solvents and VOCs (including Tetrachloroethene (PCE)), pose the greatest risk to the McAllister Aquifer. Inorganic chemicals such as nitrates, sodium, chloride, nutrients, and heavy metals, are also present in the Nisqually Basin. Use, storage and disposal of hazardous materials, potential transportation-related spills, stormwater runoff and infiltration, onsite sewage systems, agriculture practices, and animal waste pose the highest potential risks to groundwater in Olympia's drinking water protection areas (City of Olympia, 1995). As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals, as well as harmful substances and waste resulting from animal and human activity. Soils that are abundant in micro-organisms, such as those found in forest soils, help decompose most synthetic organics.

Water and contamination can move easily through highly porous Northern Thurston County surface soils. Thus, the primary drinking water source for the City of Olympia is susceptible to contamination. The outermost boundary of the McAllister Wellhead Protection area reaches 3.3 miles south of the wellfield. However, when the Department of Ecology's Toxics Cleanup Program database analyzed a 5-mile radius centered on the wellfield, it revealed 13 sites that were either awaiting cleanup or in the process of cleanup during the initial data collection phase of this study. While many types of contaminants are present in the McAllister Wellfield recharge area, the degree of risk varies based on the underlying geology, the variability of soils and surfaces, and land use activities.

In 1993, the City of Olympia conducted a groundwater investigation to inform the wellhead protection program. Data from this investigation did not indicate water quality problems, but did reveal a likely source of contamination in the original McAllister Springs' recharge area - accidental releases of hazardous materials along the adjacent Burlington Northern Railroad main line. While the likelihood of occurrence is relatively low, the potential nevertheless exists. This potential problem catalyzed the City's decision to move to a wellfield, tapping groundwater that is further beyond the reach of potential spills from this type of contaminating event.

Olympia's drinking water standards

Olympia's 2009-2014 Water System Plan presents priorities for the Drinking Water Utility, including;

- Developing the more protected and productive McAllister Wellfield as the City's major water supply source.
- Developing other water supply sources to improve system reliability.
- Continuing alternatives to additional supply, including aggressive conservation programs.
- Protecting the groundwater supply through acquisition of land or easements in source protection areas, preventing pollution from stormwater infiltration, monitoring to track potential contamination and building public awareness.

Table 1: The City's 2013 McAllister Wellfield contaminant test results were substantially below Washington Department of Health's Maximum Contaminant Levels (MCL):

Contaminant Type	MCL	Olympia Standard	Olympia Actual
Nitrate	10 ppm	5 ppm	.43 ppm
Arsenic	10 ppm	.010 ppm	.002 ppm
Coliform Bacteria	4 ppm	0 ppm	0 ppm
Turbidity	5 NTU	1 NTU	0.21 NTU

In addition to switching to wells, which showed significant water quality improvements since the 2012 McAllister Springs test results, the City has applied various other conservation actions through its Wellhead Protection Program. A newly implemented corrosion control program reduces pumping and energy consumption rates. A well-blending and treatment process raises the water's pH levels, thereby reducing the rate of pipeline, tank and liner deterioration. The City's leak-detection program is also a highly effective conservation program that tracks unaccounted-for water and locates leaks, thereby reducing overall pumping and conserving water.

Economic Data

It is important to put a realistic price on damages resulting from groundwater contamination. As referenced earlier from the DOH State WHPP Guidance Document, costs may include items such as provision of emergency water supplies, treatment of contaminated water, and public education campaigns.

According to WA DOH's WHPP Guidance Document, communities that are aware of the vulnerability of their water supplies and the high costs associated with contaminated water are increasingly improving decisions on the management and use of groundwater resources. While the probability of groundwater pollution occurrences is site and scenario specific and is therefore difficult to quantify, reports on contamination incidences across the country reveal the range of response costs to specific contamination events.

The ecosystem services of water filtration provided by healthy watersheds are difficult and very expensive to replace. A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association in 2002 found that more forest cover in a watershed lowered the surface water supply treatment costs. According to the study:

- For every 10 percent increase in forest cover in the source area, treatment and chemical costs decreased approximately 20 percent, up to about 60 percent forest cover.
- Approximately 50-55 percent of the variation in treatment costs can be explained by the percent of forest cover in the source area.

The table below shows the range of contamination response costs from U.S. case studies. These figures were collected via an email survey conducted specifically for purposes of this study by the National Association of State Drinking Water Administrators (ASDWA). Survey participants were asked if their own drinking water utilities had conducted studies or evaluations of what they have spent, or might have to spend, to address drinking source contamination. They were also asked if they had access to any case studies of actual costs spent by real water systems in real contamination emergencies, as well as projections or models of theoretical costs to water systems to handle potential contamination events. The remaining data included in Table 2 was compiled through a literature review of U.S. contamination response cost studies, which was conducted by project staff at DNR (See Appendix). The data demonstrates a wide variance in costs.

Table 2: Common Groundwater Contaminants and Cleanup Costs

Contaminant Type	Low	Median	High
Nitrates	$250k	$1.5 million	$6 million
Chlorinated Solvents	$510k	$2 million	$8 million
VOCs	$100k	$1.7 million	$7 million
Petroleum/fuel	$3k	$440k	$1.09 million
Agricultural Nutrients	$34k	$1.2 million	$5 million

Utility Case Studies

This section describes choices made by selected communities for corrective action and associated costs. Wellhead protection program implementation teams should consider this information when weighing the merits and costs of preventative actions. Through conservation measures, the City of Olympia can reduce risks of contamination, while avoiding the costs associated with treatment and other remedial steps. Responding to contamination problems can be complicated and expensive. It should be noted that the City of Olympia utilizes a first response emergency well blending process to ensure drinking water safety. Well blending techniques are efficient for instances where low traces of contaminants may exist in one of the City's wells. In more extreme cases, a new well may be needed, while in others, treatment may be the only feasible option. Various other response methods may be utilized to protect wellheads in the most efficient way. Table 2 shows a summary of 32 water contamination cases and their clean-up costs. The following cases are from that group, but are described in more detail:

- Nitrate Contamination Cases
  - According to a Minnesota Department of Health dataset from 1999 – 2004, nitrate concentrations were above 3 ppm in 64 of the state's 954 water utilities. Clear Lake was one of five communities with concentrations above 5 ppm, and was incurring costs associated with the contamination. With a population of 414, the community of Clear Lake responded to the nitrate issue with an anion exchange system, three new test wells, resident notifications and more frequent monitoring. Total contamination response cost the community over $250,000 (Lewandowski et al., 2007).
  - Melrose, Minnesota was also among the five communities that experienced nitrate concentrations above 5 ppm when the above study took place. Melrose supplies water to a population of over 3,000 residents, and invested a significant amount of its resources into the education and notification portion of their response strategy. These costs, combined with the cost of installing an

advanced nitrate removal system, totaled $5-6 million (Lewandowski et al., 2007).

- Chlorinated Solvents Contamination Cases
  - Sanford, Maine established an industrial park over a sand and gravel aquifer that provided recharge to two high-yielding wells. Although Sanford had already pioneered several steps towards a wellhead protection program, the efforts were not sufficient to remove sources of low levels of contamination by chlorinated solvents. Dealing with them has cost the city $510,000 in total to date (Garrett, 1993).
  - Nevada's Central Truckee Meadows Remediation District Program was implemented in response to high levels of PCE in the groundwater, a common solvent in dry cleaning, auto repair and industrial operations. Before being acquired by the Truckee Meadows Water Authority, Sierra Pacific Power Company's water business installed air strippers at 5 municipal wells in the late 1990s at a cost of $6.5 million, with ongoing O&M costs of roughly $250,000/year. Remainders of the fees collected now go towards ongoing characterization; monitoring and potential source area investigation feasibility studies (G. Lovato, survey respondent, October 3, 2012).

- VOC Contamination Cases
  - The Minnesota Department of Health (MDH) staff in the Public Water Supply Unit compiled a list of community public water systems where monitoring indicated that contaminant concentrations exceeded the U.S. EPA MCL. Twenty-six systems were identified, and required to immediately notify their customers of health implications associated with consuming contaminated water, provide a safe and temporary water supply to consumers, and enter into a compliance agreement with MDH to develop and implement a suitable permanent solution. Volatile Organic Compounds are the most common contaminants in groundwater, resulting from various urban and agricultural land-use activities in the vicinity of the wells. A telephone survey resulted in estimates of total costs incurred.
    - The majority of these water suppliers constructed new wells, with costs ranging from $100k - $660k.
    - In the few communities that implemented treatment facilities, costs ranged from $1 - $7 million (MDH, 1994).

- Petroleum/ Fuel Contamination Cases
  - A common source of petroleum and fuel pollution in groundwater comes from leaking underground storage tanks (USTs) that store these hazardous substances. Washington Department of Ecology requires that leaking USTs be cleaned up to restore and protect groundwater sources. A direct inquiry to Ecology's Spills Program staff revealed the factors involved in quantifying the removal of a leaking tank, which includes: city regulations; size of tank; scope of work; and whether the tank would be filled with sand or foam fill, or be completely removed, along with contaminated soil. The concluding estimates for a normal tank pull and soil removal ranges from $3k to $60k per site (Shriver, personal communication, November 16, 2012).

    - In 1990, residents of Gilbert, Louisiana began noticing the smell of gasoline in their water. The LA Department of Health and Hospitals tested the wells and discovered that benzene had leaked from an underground storage tank at an abandoned gas station. The tank had been removed in 1987, but left behind an excessive amount of benzene in the soil. As of 1995, the total cost of responding to the contamination was $426k, and remedial costs were $648k, which equaled over $1 million in total costs to the village of Gilbert (EPA, 1995).

- Agricultural Nutrients Contamination Cases
    - Lake Springfield is the largest municipally owned lake in Illinois and serves as the source of drinking water for the City of Springfield. A near violation of the Illinois EPA drinking water requirements of 3 ppm or less of Atrazine led the Watershed Committee to coordinate research and education efforts. In 1994, when the contamination was discovered, the City's water utility spent $143,000 to remove 14.0 ppm of Atrazine through a powdered activated carbon process. In 2010 (16 years later), Atrazine levels were lower, but still present at 3.7 ppm, and cost the City $34,000 to remove (Skelly et al., 2011). This case demonstrates how long it often takes to clean up groundwater contamination and the long-term nature of the commitment a utility may have to make when a contaminating event happens.
    - In 2000, the water treatment facility in Danville, Illinois added an ion exchange filtration system. The project upgrades cost the city $5 million to deal with an increase in agricultural runoff in their watershed.

The preceding cases reveal several valuable lessons regarding groundwater contamination responses and costs, some of which include:

- Land uses can lead to a variety of water quality contamination events.
- Costs are borne by a combination of: responsible parties, Water Districts, rate-payers, State and Federal government agencies, and tax-payers (Garrett, 1993).

Costs of Wellhead Protection

Groundwater pollution risk is a consequence of subsurface contaminant load. Even in a highly vulnerable aquifer, there is no risk of pollution until a contaminant load is applied. The basis of all groundwater pollution control policies is to eliminate, or to reduce to a tolerable level, the subsurface contaminant load generated by a given polluting activity.

Aquifer protection is, in effect, incurring a cost to reduce the probability (or risk) of groundwater pollution. It is a question of whether a utility would rather pay now or pay potentially much more later. The U.S. EPA's Office of Ground Water and Drinking Water published a study in 1995 exploring the benefits and costs of community wellhead protection. The report demonstrates that in the long run, the cost of responding to a contamination incident significantly exceeds the cost of developing and implementing a wellhead protection program.

The six case study communities that experienced contamination and developed a WHPP showed cost differences that ranged from 5:1 and 200:1 per well (EPA, 1995). The Norway, Maine and Tumwater utility case studies presented in this report also reveal significant cost savings gained with wellhead protection.

The following case studies offer cost comparisons between remediation and prevention:

- The City of Tumwater, Washington is experiencing significant growth, and has sixteen wells that tap three aquifers to serve its 13,000 residents. During routine monitoring, the city discovered trichloroethylene in three of its wells and spent over $900,000 in response costs over the following ten years, a calculated average of about $90,000 per year. This contamination event encouraged Tumwater to pursue a Wellhead Protection Program (WHPP) in 1993, and as of 1995, the cost of the WHPP totaled about $348,000 (EPA, 1995).

- The following describes a water system in Maine that implemented wellhead protection as a contamination response measure – A well serving 2,000 of the 5,000 residents in the town of Norway, Maine was discovered to have a gas station with a pipe leaking hydrocarbons into the drinking water. The total cost of responding to the contamination was about $536,000. Because of the ground water contamination, Norway developed a WHPP in coordination with an adjacent community. The program has cost the two communities a total of $115,715 (Garrett, 1993).

<u>Co-Benefits Analysis</u>

This section examines the benefits of conserving forests in the City of Olympia's McAllister well field wellhead protection area beyond the drinking water quality benefits already analyzed. Forests as ecological systems do many things that people rely on and enjoy. For example, they moderate local temperatures, absorb storm water, provide habitat for pollinators that are important to local agricultural crops, sequester carbon dioxide and therefore store this greenhouse gas in a form that reduces climate change, and they provide us with recreational and aesthetic opportunities like hiking, hunting, fishing, and bird-watching.

These benefits have both economic and non-economic values for the residents of Olympia and Thurston County. Monetary valuation is only one dimension of these benefits because people attach moral, spiritual, and cultural values to forests as well. However, when policy decisions involve trade-offs to a community in the form of whether or not new homes or businesses will be built, or whether or not to charge fees to individuals and businesses that either use or degrade ecosystem services, economic valuations can provide important information to help make these decisions.

In the case of protecting forests in the well-head area, the primary driver of decisions on spending utility fees is to protect water quality for drinking water, and assessing cost-effective ways of doing so. A co-benefits analysis can help elucidate what values can be secured above and beyond water quality protection. This can therefore help a project proponent ascertain what additional economic benefit can be obtained for the cost of securing water quality, or what additional resources may be brought to bear to protect forests based on additional benefits.

Approaches to Valuing Environmental Services

Most services that forests (and other ecosystems) provide, beyond timber, are not directly traded in markets. This is because nature's services tend to have two characteristics that make them difficult to treat like more familiar commodities. Generally, they are what economists call "public goods" because they are either non-rival, or non-excludable, or both (Daly & Farley, 2004). Non-rival means that if one person uses the service, it does not diminish the ability of someone else to use it. Watching wildlife and appreciating the beauty of a landscape are two examples of this. Non-excludable means that if the service is produced for one person, it can't be denied to someone else. Climate moderation is a good example of this characteristic: forests make the surrounding area cooler in the summer – not just for one person, but anyone and everyone who lives or goes near that forest. Because of these traits, economists cannot directly measure a price – there is no way to know how much of non-rival goods someone uses, and no way to exclude people from using the services, so no way to establish a direct market price. This situation leads to the need to use other means of establishing economic value. These characteristics also lead to the need for some sort of policy intervention to create payment mechanisms because they will not in most circumstances arise on their own as is the case for excludable and rival goods. The only type of exception to this is when an ecosystem service provides a definable input to a private entities production process, such as the provision of clean water for bottled soft drinks.

The two basic categories of valuation techniques are indirect pricing and direct survey methods. Indirect pricing is done through figuring out what portion of some other price can be attributed to the ecosystem services in question. For instance, people will travel to go fishing, hiking, or wildlife viewing. Economist use data from how much people spend to do something in nature to assess the partial value of a place, like a river or a wilderness area. This is called the travel cost method. Another approach is to use statistical analysis to figure out how much of the sales price of a home can be attributed to the proximity of that home to water, or a park or some other open space. This is called hedonic pricing. And, there are ways to measure how much it would cost to replace a particular function of a natural system, like having to build a levee to keep back storm surges when coastal wetlands are lost. This is the avoided cost approach and is the method used in this report to estimate the direct benefits of protecting drinking water sources in terms of how much it costs to replace or clean up drinking water sources that have been contaminated.

However, there are several aspects of ecosystem services that cannot be measured this way. Economists have developed two ways to get at these hard to measure values, collectively known as stated preference methods. One is called contingent valuation, where people are asked what they are willing to pay (WTP) to protect some aspect of a natural system, or a place; or how much they would be willing to accept (WTA) to give something up. A second method is the "choice experiment." This method uses a highly structured questionnaire to tease out more precisely how people trade-off different values and can be applied to certain ecosystem services. See Birol et al., (2006) for a concise summary of all of these valuation methods. These methods are summarized in Table 3.

Table 3. Summary of Methods for Deriving an Economic Value for Ecosystem Services.

Method Type	**Method**	**Example**
Indirect Market		
	Travel Cost	Recreation value of a river
	Hedonic Pricing	Aesthetic value of open space
	Avoided Cost	Waste processing of wetlands
Direct Survey		
	Willingness to Pay	Endangered species conservation
	Willingness to Accept	Subsistence fishing grounds
	Choice Experiments	Landscape conservation

Stated preference methods are not always viewed favorably, either due to technical issues (many of which have been overcome) or because some economic research, especially in the field of economic psychology, shows that when it comes to some aspects of the natural world, a statistically significant portion of the population is unwilling to trade off compensation or payments for loss of ecosystem function. These reasons can be due to unequal livelihood impacts, or because people attribute moral and cultural values to nature that they feel are not in the same category as money. In other words, for some people, you could not pay them enough under any circumstance in exchange for the loss of an entire species, or a beloved place. In addition, there is the argument that the efficient functioning of private markets should not guide all aspects of community and public interest-based decision making. For a review of these issues, see Spash et al. (2005).

Despite these objections, and the fact that no one valuation technique can cover all values of any particular ecosystem service, valuation studies continue to be produced, and policy makers find them useful in some decision-making contexts. It should be noted then that ecosystem service valuation studies should properly be viewed as one piece of information in any decision involving ecosystem management, especially when decisions involve an irretrievable commitment of resources, or transformation of an ecosystem from one state to another, such as conversion of forest to non-forest uses like housing developments or agriculture. Social and cultural issues, and the fact that much is still not known about how ecosystems support human well-being dictate that caution be used when interpreting valuation numbers. In addition, such studies usually produce an underestimate of actual economic value because several ecosystem services simply have not been valued.

Benefits Transfer Study of the Value of Forests in Thurston County

Most ecosystem types on the planet have had some form of valuation study. However, no ecosystem has had all of its ecosystem services valued. Because of this knowledge gap, economists who are trying to help decision makers often employ what is know as "benefit-transfer" where they use values generated from several studies in different places and times to derive an aggregate value for as many ecosystem services as possible for a particular system in a particular place. The technique involves standardizing values to units of area, like acres, and accounting for currency and inflation when the studies were done in different times and nations. Good benefit transfer studies also try to ensure that economic and social contexts are taken into account so that inappropriate studies are not applied (see Wilson and Hoehn, 2006 for a review of the method). Recently, massive databases of ecosystem service valuation studies have been constructed to be able to more readily conduct valuation studies around the world, and at the global scale (Trucost, 2013). Closer to home, the non-profit Earth Economics is developing a valuation tool based on a similar database, but that is user-friendly and readily accessible (http://www.esvaluation.org).

A benefits transfer study, or "rapid ecosystem service valuation" was conducted by Earth Economics for 14 ecosystem cover types found in Thurston County in 2012 (Flores et al., 2012). They estimated that services provided by forests are worth between $1899 and $8,055 per acre per year (in 2010 dollars), including drinking water supply. The estimates for this report are largely based on the Flores (2012) study with the following exceptions: There are at least two areas in which these values are likely an underestimate based on 1) available studies of storm water runoff prevention, and 2) from the author's estimate of avoided damages from releasing CO_2 upon conversion of forest to non-forest vegetation. Because the objective of the estimate is for non-market values, commodity market values of timber are not included. In addition, because private forests are not likely available for public use for the gathering of non-market raw materials, no assessment of these resource values is included. For the remainder of the values, refer to the Earth Economics report (Flores et al., 2012) for a full explanation of the benefits transfer approach they used, a description of relevant ecosystem services as they apply to Thurston County, and the sources of the valuation estimates.

<u>Estimate of Ecosystem Service Values of Private Forests in Addition to Drinking Water in the McAllister Wellhead Protection Area</u>

For water regulation, Hill et al. (2010) estimated that rural counties on the urbanizing fringe of Atlanta that retained or restored forest cover avoided costs of $976 per acre per year (in 1996 dollars) from impacts of storm water runoff due to the much higher infiltration and water storage capacity of forests compared to non-forest vegetation, and due to the lack of impervious surface which speeds the overland flow of water. This translates to $1,356 per acre per year in 2010 dollars (same metric used in Flores et al., 2012). For comparison, the Earth Economics study puts the high value of forests for water regulation at $588.87 per acre per year (see Flores et al. 2012, Table 7, p. 27). Including this value from the urbanizing portions of Atlanta as an estimate seems appropriate given the proximity of forests in the wellhead protection area to the urbanizing portions of Thurston County, and the fact that lawns, pasture and cultivated farmland, all of which have increased in area at the expense of forest cover loss in wellhead protection areas, absorb and retain less water. In addition, a portion of the wellhead protection area is within Thurston County's NPDES storm water permit area.

On the climate benefits side, the Earth Economics study puts the high value of $1,066.61 per acre per year. The report does not detail how this figure was derived. An approach to an estimate of the climate benefits of forests is to value the mitigation potential of carbon stored in region's forests. Economists have derived a value of the social cost of a ton of carbon dioxide. This value encompasses the cost of the damages from climate change. While the U.S. government uses an estimate of between $12 and $129 per ton of CO_2 as the social cost per ton of emissions, Johnson and Hope (2012) provide evidence that this value is a large underestimate, and put the value between \$55 and \$266 per ton of CO_2. When forests are converted to non-forest uses, CO_2 is emitted in the process of cutting down the forest due to soil disturbance, short-term decomposition of slash, and either burning non-merchantable trees, or loss of carbon during processing for wood products. Furthermore, the forest ecosystem is no longer available to sequester CO_2 in the future. Therefore, the sum of net emissions plus lost future sequestration had the forest been left standing can be used as the basis for an estimate of avoided costs of climate damages from forest conversion.

Privately owned forests in the Puget Sound Basin contain an average of about 143 metric tons of CO_2 per acre when counting carbon in live trees and underground roots (CARB 2011, Appendix F). The U.S. Forest Service estimates that forest soils on private lands in Washington contain on average 132 metric tons of CO_2 per acre, and Brown et al., (2010) state that up to 50% of soil carbon can be lost from agricultural and urban conversion. A conservative estimate for this calculation is 40% loss from ground disturbing conversion. The value of retaining that carbon versus converting the land to non-forest uses is the number of tons of CO_2 emitted per acre upon conversion, minus the tons stored in wood products, as a one time event, plus the amount of additional carbon that could have been stored in the forests over time had they not been converted, multiplied by the social cost of emitted tons of CO_2. The amount of CO_2 lost per acre is 176 tons (143 live tree tons of carbon dioxide plus 53 tons of soil carbon dioxide emissions minus 20 net tons stored in wood products per acre over 100 years) at the time of conversion. We estimate the amount of CO_2 storage forgone to be approximately 6.3 tons per acre per year. This assumes some harvest, about half of annual biomass accumulation, and some portion of the harvested trees going into wood products – about 14% of original live tree carbon in the forest, based on wood products carbon calculation procedures used in the California Air Resources Board forest carbon offset protocol (CARB, 2011).

The average of the impacts of conversion plus loss of annual sequestration over 100 years is 8.1 tons of CO_2 per acre per year. In reality the emissions and their damages would occur in a pulse in the year of conversion, 176 tons plus that year's net growth, for an impact of 182.3 tons per acre, then an annual impact of 6.3 tons per acre per year. The annualized approach yields a social cost of damages from climate change of between \$445 and \$2,155 per acre per year, using \$55 per ton of CO_2 emitted as the low estimate and \$266 as the high according to Johnson and Hope (2012). The low and high values are both higher than the low and high values in the Earth Economics estimate. The time-realistic calculation would be that initial damages would be between \$10,026 and \$48,491 per acre in the initial year of clearing, then between \$347 and \$1,676 per acre year thereafter.

This approach to valuing the climate benefits of forests does not include the value of local climate moderation – like keeping temperatures in the vicinity of forest cooler than they otherwise would be. Because people live and farm close to the remaining forest in the wellhead protection area, this is probably an important service, and the lack of an assigned value means that the overall estimate of forest values is likely too low. Table x below shows other services for which values were not included because they are not available.

If we remove the ecosystem service value for drinking water, which is dealt with through avoided cost estimate in the rest of the paper, and substitute the above values for storm water flow and climate impact cost avoidance, an estimate of the economic value of non-market ecosystem services from forests in the wellhead protection area is between $941 per acre per year and $8,139 per acre per year.

Based on the City's identification of important properties within the wellhead protection area, and an analysis of the amount of forest cover remaining on these parcels, there are approximately 490 acres of forest cover on privately owned priority parcels. **In addition to the drinking water protection functions of these forests, acquiring protective easements on the remaining private forests would yield additional benefits of between $461,000 and $4 million per year.** These monetary benefits could increase if some currently non-forested acres were restored to forested vegetation.

A summary of values per acre per year by ecosystem service is in Table 4.

Table 4. Economic Values per acre per year from a Benefits Transfer Approach for Ecosystem Services Provided by Forests in the McAllister Well Field Wellhead Protection Area. Except for Gas and Climate Regulation and Water Regulation, values are from Flores et al., 2012.

	Forests	**Forests**
Ecosystem Service	Low	High
Aesthetic and Recreational	$0.21	$2,174.80
Biological Control	$9.69	$10.04
Disturbance Regulation	$1.40	$5.14
Erosion Control	$112.58	$112.58
Food Provision		
Gas and Climate Regulation	$455.00	$2,155.00
Habitat Refugium and Nursery	$1.22	$538.95
Nutrient Cycling	$74.28	$1,135.64
Pollination	$67.84	$413.73
Science and Education	$39.72	$68.37
Soil Formation		
Waste Treatment	$169.01	$169.01
Water Regulation (stormwater runoff)	$10.35	$1,356

Medicinal		
Total	**$941.30**	**$8,139**

Comparison of McAllister Wellhead Protection Land Use Scenarios

Scenario I: Current Zoning - The first land use scenario to explore sensitivity of Olympia's McAllister Wellfield to development is based on the full build-out and associated impacts of current zoning allowances enforced by Thurston County in the McAllister Geologically Sensitive Area, which is one unit per five acres (1:5). We assume that the rate of development will ultimately meet zoning restrictions and that traditional development practices will be utilized. Impact data for this scenario is drawn from national scientific literature on sourcewater protection. Full build out results in the following potential impacts to contamination risk:

- Chemical run-off from impervious surfaces
- Loss of filtration capacity of forest soils
- Underground Storage Tanks
- Increased number of septic systems
- Increased number of exempt wells
- Increased number of roads/ higher rate of traffic
- Facilities storing hazardous materials
- Increased use of agricultural and household garden chemicals

While the complete list of development-related contamination sources is extensive, the features included above are primarily recognized as potential contaminant sources, which is adequate for our study. The number of potential contamination events from any one source is difficult to predict, so for the purpose of our comparison we will use an informed proxy scenario as a "base case".

Scenario II: Conservation Easements - The second land use scenario is based on retaining all existing forest cover and possibly restoring at least 50-60% forest cover on some lands that have been cleared for agricultural use instead of 1:5 build out. Conservation easements included in this scenario may allow restricted development using best management practices. The activities in Scenario II include:

- Study impacts of forest cover and McAllister aquifer protection (USGS)
- Analysis of priority parcels for conservation
- Analysis of existing zoning restrictions
- Analysis of development rights and assessed land values
- Consult appraisal expert for total land values

Based on currently available data, we are able to describe likely development and its impacts on the structure and function of forest, riparian, and aquifer ecosystems, and subsequently on the economic well-being of entities dependent on services of these ecosystems. The following compares probable costs of proactive groundwater protection measures with costs of reactive contamination responses.

After a thorough review of priority parcels located within the aquifer capture zone that were previously delineated by City of Olympia, the project team identified four parcels as the best candidates for a conservation easement transaction demonstration project. Located to the southeast of the new wellfield, Property #1 is a larger forested plot, with constraints on water rights, which implies less development potential. Property #2 is a certified by the Forest Stewardship Council, thus the landowners are good potential candidates for negotiations. The owners of property #3 are also highly likely to engage in negotiations, and portion of the property has development potential. Property #4 is currently designated as commercial timberland, but the project team may choose to pursue conservation on a portion of the property.

Table 3 shows property size and the number of development rights, an estimated total cost that includes the value of the development rights, the cost of appraisals, and surveys. Again, this economic study was conducted prior to consulting appraisal experts, thus the numbers below are estimated proxies based on best professional judgment.

Table 5. Properties for conservation easement transaction demonstration project.

Properties	Acreage	Development Rights	Total Cost
1	128.83	6	$330,000
2	24	4	$220,000
3	36.73	4	$220,000
4	68.72	6	$330,000

City of Olympia staff is awaiting results from various project consultants to assist in determining the optimal amount of acres in the wellhead protection area they aim to protect. For purposes of this study, two parcels have been arbitrarily selected from the list above to be compared with the average cost of contamination clean up events described previously in the literature review. This acquisition comparison is based on the unknown risk that a contamination event would occur on one of these parcels, and that this risk could be significantly reduced by conservation action prescribed by the City. The estimated cost for the City of Olympia to implement groundwater resource protection and related forest conservation on property #1 and property #3 totals $550k. More generally, any combination of two of the four parcels listed above would range from $440k to about $660k. When compared to the median cleanup costs of the various contaminant spills presented in Table 2, which range from $440k for one fuel-related event to $2 million for a chlorinated solvent leak, the cost savings for proactive measures can be quite significant.

Pollution prevention and risk reduction are directly dependent on both the size and geographic characteristics of the conservation area, as well as on the adopted easement guidelines. For example, if development is restricted on 25 percent of the priority protection land, the probability for nitrate contamination from septic systems and farm chemicals is also reduced by 25%. The fewer the septic systems and acres converted to hobby or real commercial farms, the lower the risk of recurring events.

EPA's Source Water Protection report addresses the problem of determining the probability of well contamination; "… any public well has some probability of being contaminated because of the complex nature of the subsurface and the variable but widespread use of chemicals in the manufacturing, agriculture and residential applications" (EPA, 1995). The report explains, "… the expected value of the probability of contamination may be low in a particular location, once contamination occurs (even in a low probability situation), the community must face the full cost of contamination (e.g., an unlikely chemical spill occurs in a recharge zone or near a well), and should consider the probability to be 100 percent for planning purposes" (EPA, 1995).

Going Forward: Concluding Thoughts

The provision of drinking water is an ecosystem service influenced by water quality and by the land use patterns that affect water quality. Increased contaminants in water can result in higher costs borne by water treatment facilities. This estimation of ecosystem benefits uses previous research to produce plausible economic values for sites of interest. Ecosystem services economic studies can inform decision makers and promote better ecosystem management. This study provides an estimated range of benefits of water quality improvements for drinking water through source land protection, and indicates that specific wellhead protection program strategies can result in significant potential risk avoidance for a drinking water utility with benefits for both public health and public expense.

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Appendix. Studies of Source Water Contamination

Groundwater Cleanup Cost ASDWA Survey Literature Review

October 2, 2012

State	Contaminant	Cleanup/response activities	Response Cost	O & M Cost	Total Cost	Population	Paying Water Utility Name	Year
MN	Nitrates	New Well - construction and pumping			$600,000	2,700	City of Perham	2002
	Nitrates	Treatment - Nitrate removal			$362k - $1.7 million	425 - 4,100	5 Municipal Water Suppliers in MN	1994-2002
MN	Nitrates	New wells			$250,000	414	Clear Lake, MN	2006
	Nitrates	New Well and treatment			$2,177,500.00	3,275	Park Rapids, MN	2005
	Nitrates	New well	$352,000		$355,000	1,030	Edgerton, MN	2006
	Nitrates	Treatment - Fe, Mn, Radon removal			$5-6 million	3,091	Melrose, MN	2003
	Nitrates	Treatment - Reverse Osmosis	$1.7 million		$2 million	1,062	Lincoln-Pipestone Rural Water	2004
	Nitrates	New Well			$611,000	1200	Adrian, MN	1999
	VOCs	Treatment			$1 - $7 million		Public Water Utility	
	VOCs	New wells		about $1,000/year	$100k - $660k		26 suppliers	1980-1993
NV	Chlorinated Solvents	Treatment - Air strippers at 5 wells	$6.5 million	$250k/year	$6.5 million		Washoe County Dept of Water Resource	mid-90s
	Chlorinated Solvents	Source Management Plan (WHPP)		Saved $90.55/mill. gals. treated			Truckee Meadows Remediation District	2005 vs. 2011
	Chlorinated Solvents	Treatment - PCE removal		$8,300/gallon	~ $ 8 million		Utility & customers	2011
WA	Metals	Cleanup	$964k - $3.5 million total				Utility & customers	2012
	Nutrients	Cleanup	$4.3 - $17.5 million total					
	Bacteria	Cleanup	$2.4 - $2.7 million total					
WA	Petroleum	Treatment - Underground Storage Tank removal	$3k - $60k				Thurston County	2012
	Pesticides	Treatment - Soil removal	$500k	$3-5k/year ($100k t	$600k		EPA	1996 (ongoing)
	Fuel	Treatment - Bioremediation	$370k total		$370k		EPA	1998 (ongoing)
ME	Salt	New Well - construction and pumping	$500k total		$500k	4,000	Sabbatus Water District	1993
	Gasoline	Remediation	$387k	$113k	$600k	2,748	Norway Water District	1990
	Chlorinated Solvents	Treatment - Filter system	$860k total		$865k	9,200	Electronics factory in Town of Lisbon	1988
	Flame-retardent	Pumping/water provision/sampling and analysis			$236k	2,200	Guilford and Sangerville Water District (GSWD)	
	Fuel/NO3/Solvents	investigation , monitoring, etc.			$510k	17,000	Sanford water district	1980s
MI	HazMat/NO3/etc.	Replacing wells, new storage tank & water main	$1.5 million		$1.5 million		community	2009
	Nitrates	Treatment - Nitrate removal (anion exchange system	$745k		$745k	3,223	Village of Blissfield	2004
	Nitrates	Replacement of storage tank and Nano/UV filtration	$916k		$1.75 million	1,006	Village of Deerfield	2012
	VOCs	Treatment - Air strippers at 5 wells	$1 million	NA	$20 million	40,891	Plainfield Township - State Funded	mid-80s
IL	Phosphorous and Nitrate	Removal - Powdered Activated Carbon	$143k		$143k		City of Springfield	1994
	Nutrients	Anion exchange system			$5 million		City of Danville	2000
	Atrazine	Removal - Powdered Activated Carbon	$34k	NA	$34,000		City of Springfield	2010
NC	Nutrients	Protection - Easements and land acquisition	$54 million (w/$95 million ROI over 10 years)				Upper Neuse Clean Water Initiative	2005
	Nutrients		$76 million bond measure				Catawba River, NC	
	Nutrients							
LA	Benzene	Investigation and response	$426k	$648k total for follo	$109,645		City and Government grants	1995
ME	Hydrocarbons & MTBE	Investigation and response	$536k	$10k total for following 10 years			City and DEP funds	1995
WA	VOCs	Increased pumping at healthy wells and installed nev	$787,541	$915k total for following 10 years			City paid half and EPA	1993-1995
PA	VOCs	Air strippers and ground water treatment system	$1.7 million	$2.3-$2.9 million for following 10 yrs			City and PADER	1986-1996
PA WHPP	119 potentials listed	WHP program among 4 communities	$66k	$351k total for following 10 years			EPA and PADER	1995-2005
MA	VOCs at 2 wells	study, cleanup by airstrippers, and water replacemer	$1.7 million	$583k for following 10 years			City	1995-2005
OH	VOCs	Responding to incident and drinking water provision	$1.5 million				Middletown and Manufacturer	1993-2005
NC	General protection	Contingent Value study (WTP)	$133/household/year				Catawba River, NC	2001
US EPA Stu	VOCs	Pump and treat			$3,600,000	18 sites in US	US Superfunds	2001
	Metals, PCBs, Solvents	Pump and treat			$8,900,000	9 sites in US		2001

Appendix. Studies of Source Water Contamination
Groundwater Cleanup Cost ASDWA Survey Literature Review
October 2, 2012

Source															
MN Dept. of Ag. Drinking water fact sheet															
Lewandowski - Interviews with water suppliers															
Lewandowski - Interviews with water suppliers															
MN Dept. of Health															
Central Truckee Meadows RMP 2011 Report Card															
Email from Greg Lovato, Chief at Bureau of Corrective Actions, NV Division of Environmental Protection															
Econ. Benefits of Protecting Healthy Watersheds															
Direct communication - Howard Zorzi at Ecology															
Direct communication - John Felder at DNR															
Direct communication - John Felder at DNR															
Costs of No Wellhead Protection in Maine															
The Costs of No Wellhead Protection in Maine - Garrett															
Email from Jean Shekter - MI DEQ															
Alliances for Sourcewater Protection															
The Cost of Not Protecting Source Waters															
Alliances for Sourcewater Protection															
North Carolina's Return on the Investment in Land Conservation															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Benefits and Costs of Prevention - EPA 1995															
Estimating the economic value of water quality protection in the Catawba River basin															
EPA cost analyses for groundwater cleanup															
EPA cost analyses for groundwater cleanup															

Appendix E – Snohomish Economic Analysis

Snohomish Basin Forest Watershed Economic Analysis for Snohomish County
Surface Water Management

Forestland Protection as a Flood Risk-Avoidance Mechanism

This economic analysis is a component of a demonstration project led by the Washington Department of Natural Resources (DNR) in response to legislative direction in ESHB 2541 (2010), to bring about one or more “ecosystem service” transactions in pilot watersheds. DNR worked with a wide range of partners to explore payment systems for carrying out such transactions, and discovered that project goals were aligned with the mission and broader basin plans of Snohomish County’s Surface Water Management (SWM) division. The Snohomish Basin pilot project provides SWM the opportunity to model how changes in land use impact stream flows in prioritized sub-basins of the Snohomish River watershed. In this pilot, the ecosystem service provided is the attenuation of stream flows. This economic analysis serves as part of an interdependent suite of pilot-related research documents exploring multiple aspects of Snohomish Basin forest ecosystem services. Other pilot-related efforts include hydrologic modeling, parcel prioritization, landowner outreach, and rate-structure studies. As part of the pilot project, this economic analysis assessed flood risks to communities and streams, cost of flood response and protection, and the general relationship of forest cover to flood risks in the Snohomish Basin.

Surface Water Background and Risks

Flooding is a natural part of river and stream systems. Weather patterns and land uses are the primary factors affecting flooding in Snohomish County. While flooding has some environmental benefits, it can also damage property and habitat and create public safety hazards. Two main factors contribute to flood hazards: the size and frequency of peak flows, and the amount of floodplain development that is exposed to damage when the river banks overtop. Typical hazards to local communities include large trees and other debris being flushed down the river, damaged crops and livestock, and destroyed homes. Flood damages are generally due to inundation, erosion, flood control structure failure, or any combination of the three. In November 2006, Snohomish County experienced a Phase 4 flood event that was one of the most dramatic recorded flood events in the valley. At the peak of the flood event, the river was raging at over 100,000 cubic feet per second. That flood event caused several communities to be cut off for several days due to the high flood waters, and resulted in major damages and associated costs (Biermann, 2010). Dramatic flood events occurred again in 2008 and 2009.

Snohomish River floods are caused by various events such as intense Pacific storms that bring rainfall to the mountains, and rising temperatures that cause rapid melting of snowpack. Although floods in the basin are naturally occurring, a 45-year trend analysis of annual peak stages shows that river fluctuations are becoming more dramatic. This is partially due to levee construction projects, but experts argue that this increase may also be the result of sea level rise, climate change, and the conversion of forests to development with impervious surfaces (SWM, 1991). The lower Snohomish River is also highly influenced by the tides of Puget Sound. Effects can be observed up to 16 or 17 miles up the river. Impacts from high tides are becoming more significant as sea level rises from climate change, and studies indicate that sea level may rise another four feet by 2100 (Landis, 2013).

Higher amounts of precipitation are expected to result from large storms, which will fall too rapidly for soils to absorb, thus leading to increased flooding and faster runoff into marine waters. The Snohomish

Basin, like other Pacific Northwest river basins, is already experiencing more precipitation in the region's mountains in the form of rain rather than snow, which is reducing snowpack and significantly increasing flood risks. Earlier and more rapid peak spring runoff results in higher peak flows, lower and warmer summer stream flows, and increased channel erosion (Parker et al., 2006). Current and projected changes in hydrologic processes in the Snohomish Basin have significantly impacted salmon habitat and populations. Reduced infiltration, resulting from high volumes of water flows, leads to higher rates of erosion, which degrades in-stream habitats (Williams and Hardison, 2006).

In response to serious flood hazards throughout the county, Snohomish County Surface Water Management (SWM) has developed a suite of goals, principles and program priorities to supplement its comprehensive approach to minimizing future flood damage. Snohomish County is working with other key watershed stakeholders including the Tulalip Tribes, King County, the National Marine Fisheries Service, landowners, and various other stakeholders to develop more effective tools to address flood management and habitat protection measures included in the Puget Sound Recovery Plan. For example, SWM has partnered with several of the stakeholders listed above to develop the Snohomish Basin Protection Plan (SBPP). This plan will address habitat protection by focusing on the protection of hydrologic processes that play a key role in sustaining salmon habitat health.

The decision to focus the SBPP on hydrology was based on two important factors. First, the Snohomish Basin is one of the most rapidly developing regions in the Puget Sound. The impacts of development (e.g., increased stormwater runoff from impervious surfaces) can cause or exacerbate ecological problems such as degraded water quality, loss of wetlands and riparian forests, altered hydrologic processes, and degraded shoreline conditions. Second, climate change predictions reveal a significant reduction in snowpack, an increase in the magnitude of peak flows, reduction of spawning levels, lengthened time of persistent low flow, and raised stream temperatures. These impacts will increase strains on water resources, which threaten salmon populations and working farms and forests (SWM, 2012).

Purpose

The purpose of this economic analysis is to support SWM efforts to assess the viability of using payment-based mechanisms to encourage private landowners to protect forest cover and thereby maintain or enhance flow attenuation services. The County understands that protecting forested lands contributes to flood mitigation and is considering using targeted land conservation as one strategy to reduce possible future flood response expenditures. This report attempts to quantify the economic benefits of a forestland protection and acquisition program by comparing the costs of implementing standard flood control and response measures with the costs of conserving working forests.

Flood Control and Response Efforts

The Surface Water Management (SWM) Division of Snohomish County Public Works provides a comprehensive approach to managing surface water in order to:

- protect and preserve the County's streams, lakes and other water bodies;
- protect water quality;
- control, accommodate and discharge storm runoff;
- provide for groundwater recharge;

- control sediment;
- stabilize erosion;
- establish monitoring capability; and
- rehabilitate stream and drainage corridors for hydraulics, aesthetics, and fisheries benefits (SWM, n.d.).

SWM provides on-site investigations, technical assistance, flood warning programs, planning services and emergency response to citizens, businesses, and agencies to prevent flooding and respond to flood emergencies.

One of SWM's goals is to reduce the potential for physical injury and property damage associated with flooding. To achieve this goal, SWM works to prevent the creation of new flood hazards and to reduce existing hazards. Projects proposed to meet this goal are evaluated to ensure that they are cost-effective, do not increase upstream or downstream flooding, and benefit environmental functions. SWM's flood hazard management programs include flood hazard management plans (including river monitoring and flood warning), capital improvement projects (including maintenance and emergency response), and public outreach (SWM, 2010).

Snohomish County works with the Federal Emergency Management Agency (FEMA) and county residents to reduce flood risks and long-term flood damage. This includes educating residents on flood protection measures such as home elevation, buying properties that have experienced multiple flood losses, and offering SWM staff assistance to residents who wish to apply for FEMA federal grants to cover 75% of total costs of certain flood protection projects.

Traditional flood control measures refer to engineering projects intended to control flood waters, such as the building of levees and dikes and dredging rivers. The county's floodplain management actions include:

- Participation in the National Flood Insurance Program (NFIP)
- Adoption of floodplain development regulations that meet NFIP requirements
- Participation in a Community Rating System (CRS)
- Emergency preparedness plans, and
- Comprehensive flood hazard management plans for the main rivers, which propose actions to minimize future flood damage.

CRS is a voluntary incentive program of FEMA's National Flood Insurance Program (NFIP) that recognizes community floodplain management activities exceeding minimum NFIP requirements. The CRS program recognizes, encourages, and rewards community activities that:

- Reduce and avoid flood damage to insurable property
- Strengthen and support the insurance aspects of NFIP
- Foster comprehensive floodplain management

Snohomish County has earned a rating of Class 4 out of 10, with 1 being the highest class. This class offers a 30% discount on annual flood insurance premiums for Snohomish County properties located in high flood risk zones.

Flood Funding Sources

Snohomish County residents who are owners of flood-prone homes may qualify for federal and state grant funding for local projects to reduce flood damage. SWM is primarily responsible for managing grants and is the conduit of funds between the private property owners and grant-funding agencies. The County chooses the most cost-effective projects to bring forward for consideration. Grant funds can be used for elevation and/or relocation, or acquisition of the home.

In addition to funding from federal and state agencies, a portion of SWM infrastructure projects come from fees collected from development activities in the urban growth areas (UGAs). All development activities that change or affect drainage patterns by grading or creating new impervious surfaces, require a storm water drainage plan, and permit. After initial drainage plan proposals are evaluated, SWM charges a processing fee between $100.00 and $350.00. More targeted drainage plans may exceed $350.00, primarily if culvert requirements are involved (SWM, 2013).

Because development tends to be more restricted outside of UGAs, permits and associated fees are less commonly collected in this area. While rural communities in the floodplain are generally in most need of flood protection funding, it is difficult to justify spending funds collected from urban residents on rural projects. In the past, the County collected a real estate excise tax, and used funds to cover administration costs for related stormwater assistance. This program no longer provides funds to support adequate staffing, as the real estate market has experienced a significant downturn in recent years.

Forest Cover and Flood Protection

Forest management impacts on stream flows are a topic of discussion among scientists, governments, and industry leaders. Scientific studies show that intact forestlands play a key role in attenuating high stream flows, thereby helping to reduce downstream flood risks and protect water supplies for drinking, fish and wildlife habitat, and irrigation. Forestland conversion and land use development can lead to increases in impervious surface area and affect hydrologic flows. SWM is exploring the use of stream flow modeling as a means to augment their already rigorous flood hazard management planning strategies.

A healthy forest can reduce the amount of runoff and pollutant loading in receiving waters in four primary ways:

1. Through evapotranspiration, trees draw moisture from the soil ground surface, thereby increasing soil storage potential.
2. Leaves, branch surfaces, and trunk bark intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
3. Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.
4. Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces. (CUFR, 2002).

The CRS program manual, which was updated in 2013 to strengthen support for effective floodplain management techniques and to address the contemporary challenges of climate change in the Puget Sound, recognizes the issue of forestland conversion, and the impacts it has on stormwater runoff. It explains that, "stormwater runoff from new development throughout a watershed can affect floodplains by causing more frequent flooding, greater flood depths, and longer-lasting floods. As forests, fields and farms are covered by impermeable surfaces, such as streets, rooftops, and parking lots, more of the rain runs off at a faster rate" (FEMA, 2013). Forestry is the dominant land use in the mountainous headwaters of the Snohomish Basin, and its effects on flooding can be an important factor in large river watersheds. With approximately 75% of its lands in forestry, Snohomish Basin citizens realize the importance of working forests to their economy and environment.

When land is paved over or covered, it causes rain that would have soaked into the ground to run across the surface, eventually making its way into Puget Sound. The influence of forests and forest conversion on water yield and timing is complex and is often a topic of debate among forest hydrologists. Yet, it is broadly accepted that, "where forests were the original land cover, the protective effect consists in maintaining as far as possible the natural flow regime, which inevitably consisted of both flooding and low flows…" (FAO, 2005). With regards to floods, it is now clear that forest cover reduces stormflow peaks and delays them better than any land cover or engineered stormwater management structure, but this effect is primarily believed to occur close to forests and diminishes further downstream in the watershed (FAO, 2005).

Although the specific details surrounding the relationship between forests and floods continue to be up for debate, Snohomish County has chosen to base its flood prevention strategies on a precautionary principle. This is why the County is exploring a pilot project to encourage private landowners to protect forest cover on their properties and thereby maintain or enhance the delivery of protective forest ecosystem services. The Snohomish Basin pilot project team, including SWM planners and technical staff, developed hydrologic models to measure parameters showing "flow attenuation" associated with forestlands. After running seven scenarios with varying forest cover retention percentages and percentages of impervious surfaces, the team concluded that modeling results indicate increased forestland conversion would cause an increase in stream flows and a trend towards degraded habitat. The results also imply that converting forestland to development would have significantly higher impact than forestland clearing alone.

Benefits and Costs of Prevention

Floods are one of the most common natural hazards in the United States. According to the National Weather Service, the U.S. experienced 28 fatalities and $495 million in damages in 2012 alone (NWS). In 2011, damages amounted to over $8 billion, with 113 fatalities. It is up to residents and decision makers to make sound decisions to protect the lives and investments of everyone in the community.

The Snohomish Basin experiences severe floods with devastating effects several times per decade, and such flood events are likely to become more frequent with climate change. Strategic long term and integrated flood risk management must place real effort on prevention as far as possible to increase security. Measures which work with nature are becoming more important, as they help strengthen the resilience of nature and society to extreme weather events. Flood management measures also have myriad benefits for biodiversity and society, thereby increasing resilience to climate change related threats like water scarcity and drought (UN, 2012). According to an ecological economics study published by Earth Economics, the Snohomish Basin yields between $400 million and $5 billion in ecosystem service benefits annually (Batker et al. 2010). Some examples of the services provided by healthy forest ecosystems include moderation of local temperatures, provision of habitat for pollinators that are important to local agricultural crops, sequestration of carbon dioxide and associated reduction of climate change impacts, and provision of recreational and aesthetic opportunities like hiking, hunting, fishing, and bird-watching.

The number of Snohomish County residents affected by flooding has increased, while funding for flood hazard management has remained static for many years. The County has a limited ability to fund flood hazard reduction measures. Delaying repairs or enhancements until funds are available can increase long-term costs, since previously flooded structures risk new flood damage each winter. Long-term mitigation measures, such as home elevations and acquisitions, lift the burden of future flood damage (SWM, 2010).

The Snohomish River is bordered almost entirely by levees built relatively low and designed to overtop during flood events that exceed a 5-year return interval. Over 45 miles of levee protect about 20,000 acres of primarily agricultural lands. Most of these levees are maintained by diking and flood control districts. Damages along the Snohomish River are primarily the result of inundation and levee breaches. Costs to repair these breaches can easily run into the millions of dollars, and federal funding for such repairs has become much harder to secure. In the lower delta, deep weak soils have led to levee failures, which may occur even during non-flood times.

Less severe but more frequent flood events may also cause damage and disruption to society and the economy. These are the types of flood events explored in this report because they are more common and, according to the literature, are the only types of events that can be reasonably related to forest protection as a means of flood damage prevention.

Table 1. Some damage totals from recent Snohomish Basin extreme floods are shown below:

FEMA Flood Event	**FEMA Preliminary Damage Assessment**
2003 flood	$18,000,000
2006 floods	2/2006 - $1,975,369
	11/2006 - $18,772,675
2009 floods	$3,284,412

Source: "Flood Hazard Management Issues in Snohomish County" (SWM, 2010).

ANALYSIS:

Study Purpose and Methods

The Department of Natural Resources staff, with the help of staff at SWM, developed this report as a forecasted comparison of potential flood related costs to estimated implementation costs for a forestland conservation program that could diminish potential damages resulting from floods. This cost-avoidance analysis is based on flood scenarios resulting from land cover changes in pilot sub-basins in the Snohomish Basin. This report attempts to estimate flood damages, which include a wide variety of factors such as property damage, erosion/habitat damage, or transportation damage. Due to budgetary and timing constraints, hydrologic and hydraulic models showing localized flow levels and velocities were not included in the scope of this economic analysis. Thus, data was primarily obtained by interviews, literature review, and project specific forestland flow attenuation metric analysis completed by SWM staff. Snohomish County Floodplain Services engineering staff provided information regarding changes in flood flow levels and related infrastructure and response costs.

Costs of Flooding in Snohomish

For purposes of this report, engineering staff at SWM provided flood claim and frequency data on two private parcels in the Snohomish Basin, along with project costs for 14 flood mitigation projects that occurred between 2003 and 2012. Typically, a home must carry flood insurance and have two flood claims over $1,000 in a ten year period in order to receive assistance from the County and/or FEMA. In practice, homes may have as many as five flood claims in a 20-30 year period. Funds for flood mitigation projects primarily are put towards home elevations and buyouts.

Table 2. A summary of the data acquired from SWM flood protection staff are shown below:

Flood Year:	**Flood Flow:**	**Total Cost per Structure:**
2003	86,500 CFS	$33,200
2006	129,000 CFS	$76,000
2008	60,000 CFS	$15,000
2009	50,000 – 75,000 CFS	$68,300
2011	45,000 – 50,000 CFS	$8,225

Source: Snohomish Flood Frequency & Claims History data (Wilson, 2013).

The costs listed above apply to individual structures. The number of homes in need of flood assistance varies based on a variety of factors, including the flood flow levels, size of the structure, number of structures in flood-damaged area, etc. At times, a flood event will only result in major damages to one home, yet more often, damages impact homes in an entire community. Home elevations are more common than buyouts, as they tend to be less costly.

Due to workplan revisions for the Snohomish Basin pilot project, appraisals were not conducted in the target sub-basins. It was therefore difficult to determine property values for this analysis. Based on currently available data, primarily acquired through the Snohomish County Assessor's office, property values vary greatly in the basin. After a review of privately-owned parcels located near the prioritized sub-basins, project staff determined a generalized full purchase value of $5,000 to $15,000 per acre of developable land in the Snohomish Basin would provide an adequate range for purposes of this analysis. In addition, based on recent land and easement acquisition projects, SWM staff estimated that appraisals cost about $10,000 each. SWM would most likely pursue an easement on the land, which would only require the purchase of either development rights, or of assessed timber value. The value of an easement is often significantly less than the value of an outright land purchase. Because easement terms are so unique, and because easement language was not developed for this demonstration project, it was difficult to determine transaction costs.

Due to uncertainty of a variety of factors influencing costs related to both flood events and forestland conservation transactions in the Snohomish Basin, the following comparison presents a general estimate of values. It serves as a proxy for how a risk-avoidance analysis may look in a possible scenario that involves SWM undertaking an actual forest watershed service transaction. SWM staff would first need to review metrics developed through the pilot to adequately determine the optimal amount of acres needing protection in the prioritized sub-basin. For purposes of this study, one hypothetical parcel has been selected to demonstrate a comparison with average cost of flood response. The comparison is based on the assumption that the unknown risk of a flood event would be reduced within the local vicinity of the conservation action prescribed on the demonstration parcel.

The estimated cost for SWM to implement flood hazard protection measures via forestland conservation on a hypothetical 30 acre property may range between around $150,000 and $450,000. The actual value depends on the location, number of development and water rights, timber value, and a variety of complex factors connected to the parcel being considered. Based on Table 2, the average cost for downstream flood protection projects for structures is close to $40,000 per structure. In order to directly balance the cost of forest land conservation on the hypothetical 30 acre parcel, the associated flood hazard reduction would have to be assumed to eliminate the need for protection on from four to seven structures. If it's assumed that the hypothetical 30 acre property is zoned for one dwelling unit per five acres, then conservation in the form of purchase of all development rights would retire six development rights. The value per development right removed is roughly equivalent to the cost of protecting one downstream structure for flood damage. Decision makers must also account for the co-benefits of protecting forestland, and the immeasurable benefits of avoiding suffering resulting from major flood events.

Summary of Co-Benefits

The following section is an analysis of co-benefits of forest land conservation, borrowed from the other watershed involved in the DNR demonstration project.

This section examines the benefits of conserving forests in the Snohomish Basin, beyond high flow attenuation already analyzed. Forests as ecological systems do many things that people rely on and enjoy. For example, they moderate local temperatures, provide habitat for pollinators that are important to local agricultural crops, sequester carbon dioxide and therefore store this greenhouse gas in a form that reduces climate change, act as filters to drinking water sources, and they provide us with recreational and aesthetic opportunities like hiking, hunting, fishing, and bird watching.

These benefits have both economic and non-economic values for the residents of Snohomish and King County. Monetary valuation is only one dimension of these benefits because people attach moral, spiritual, and cultural values to forests as well. However, when policy decisions involve trade-offs to a community in the form of whether or not new homes or businesses will be built, or whether or not to charge fees to individuals and businesses that either use or degrade ecosystem services, economic valuations can provide important information to help make these decisions.

In the case of protecting forests in the Snohomish watershed, the primary driver of decisions on spending utility fees is to protect communities from flood risks, and assessing cost-effective ways of doing so. A co-benefit analysis can help elucidate what values can be secured above and beyond flood protection. This can therefore help a project proponent ascertain what additional economic benefit can be obtained for the cost of securing water quality, or what additional resources may be brought to bear to protect forests based on additional benefits.

Approaches to Valuing Environmental Services

Most services that forests (and other ecosystems) provide, beyond timber, are not directly traded in markets. This is because nature's services tend to have two characteristics that make them difficult to treat like more familiar commodities. Generally, they are what economists call "public goods" because they are either non-rival, or non-excludable, or both (Daly and Farley, 2004). Non-rival means that if one person uses the service, it does not diminish the ability of someone else to use it. Watching wildlife and appreciating the beauty of a landscape are two examples of this. Non-excludable means that if the service is produced for one person, it can't be denied to someone else. Climate moderation is a good example of this characteristic: forests make the surrounding area cooler in the summer – not just for one person, but anyone and everyone who lives or goes near that forest. Because of these traits, economists cannot directly measure a price – there is no way to know how much of non-rival goods someone uses, and no way to exclude people from using the services, so no way to establish a direct market price. This situation leads to the need to use other means of establishing economic value. These characteristics also lead to the need for some sort of policy intervention to create payment mechanisms because they will not in most circumstances arise on their own as is the case for excludable and rival goods. The only type of exception to this is when an ecosystem service provides a definable input to a private entities production process, such as the provision of clean water for bottled soft drinks.

The two basic categories of valuation techniques are indirect pricing and direct survey methods. Indirect pricing is done through figuring out what portion of some other price can be attributed to the ecosystem services in question. For instance, people will travel to go fishing, hiking, or wildlife viewing. Economists use data from how much people spend to do something in nature to assess the partial value of a place, like a river or a wilderness area. This is called the travel cost method. Another approach is to use statistical analysis to figure out how much of the sales price of a home can be attributed to the proximity of that home to water, or a park or some other open space. This is called hedonic pricing. And, there are ways to measure how much it would cost to replace a particular function of a natural system, like having to build a levee to keep back storm surges when coastal wetlands are lost. This is the avoided cost approach and is the method used in this report to estimate the direct benefits of protecting forest lands in terms of how much it costs to respond to or mitigate for flood events.

However, there are several aspects of ecosystem services that cannot be measured this way. Economists have developed two ways to get at these hard to measure values, collectively known as stated preference methods. One is called contingent valuation, where people are asked what they are willing to pay (WTP) to protect some aspect of a natural system, or a place; or how much they would be willing to accept (WTA) to give something up. A second method is the "choice experiment." This method uses a highly structured questionnaire to tease out more precisely how people trade-off different values and can be applied to certain ecosystem services. See Birol et al., (2006) for a concise summary of all of these valuation methods. These methods are summarized in Table 3.

Table 3. Summary of Methods for Deriving an Economic Value for Ecosystem Services.

Method Type	**Method**	**Example**
Indirect Market		
	Travel Cost	Recreation value of a river
	Hedonic Pricing	Aesthetic value of open space
	Avoided Cost	Waste processing of wetlands
Direct Survey		
	Willingness to Pay	Endangered species conservation
	Willingness to Accept	Subsistence fishing grounds
	Choice Experiments	Landscape conservation

Stated preference methods are not always viewed favorably, either due to technical issues (many of which have been overcome) or because some economic research, especially in the field of economic psychology, shows that when it comes to some aspects of the natural world, a statistically significant portion of the population is unwilling to trade off compensation or payments for loss of ecosystem function. These reasons can be due to unequal livelihood impacts, or because people attribute moral and cultural values to nature that they feel are not in the same category as money. In other words, for some people, you could not pay them enough under any circumstance in exchange for the loss of an entire species, or a beloved place. In addition, there is the argument that the efficient functioning of private markets should not guide all aspects of community and public interest-based decision making. For a review of these issues, see Spash et al. (2005).

Despite these objections, and the fact that no one valuation technique can cover all values of any particular ecosystem service, valuation studies continue to be produced, and policy makers find them useful in some decision-making contexts. It should be noted then that ecosystem service valuation studies should properly be viewed as one piece of information in any decision involving ecosystem management, especially when decisions involve an irretrievable commitment of resources, or transformation of an ecosystem from one state to another, such as conversion of forest to non-forest uses like housing developments or agriculture. Social and cultural issues, and the fact that much is still not known about how ecosystems support human well-being dictate that caution be used when interpreting valuation numbers. In addition, such studies usually produce an underestimate of actual economic value because several ecosystem services simply have not been valued.

Benefits Transfer Study of the Value of Forests in Snohomish County

Most ecosystem types on the planet have had some form of valuation study. However, no ecosystem has had all of its ecosystem services valued. Because of this knowledge gap, economists who are trying to help decision makers often employ what is known as “benefit-transfer” where they use values generated from several studies in different places and times to derive an aggregate value for as many ecosystem services as possible for a particular system in a particular place. The technique involves standardizing values to units of area, like acres, and accounting for currency and inflation when the studies were done in different times and nations. Good benefit transfer studies also try to ensure that economic and social contexts are taken into account so that inappropriate studies are not applied. Recently, massive databases of ecosystem service valuation studies have been constructed to be able to more readily conduct valuation studies around the world, and at the global scale (Trucost, 2013). Closer to home, the non-profit Earth Economics is developing a valuation tool based on a similar database, but that is user-friendly and readily accessible (http://www.esvaluation.org). [1]

A benefits transfer study was conducted by Earth Economics for 11 ecosystem cover types found in the Snohomish Basin in 2010 (Batker et al., 2010). They estimated that services provided by forests are worth between $1,677 and $2,236 per acre per year (in 2010 dollars), including water flow regulation.

A Snohomish Basin-specific co-benefits report was not pursued, as Snohomish pilot project priorities varied from the Nisqually project. For a full explanation and description of Snohomish Basin ecosystem services analyzed to date, refer to the Earth Economics report (Batker et al., 2010), and the sources of the valuation estimates.

<u>Next Steps</u>

Snohomish County is proactively pursuing strategies which aim to reduce flood risks, protect habitat, and result in cost savings. There are opportunities for the pilot project to inform Snohomish Basin projects that are currently in development or under way, such as the SBPP. Additionally, SWM is currently conducting a Surface Water Service District Reassessment Study, which could result in the assessment and collection of service charges on private and public parcels within a broader area than SWM's current service area. The rate study reflects new utility activities proposed for compliance with the 2008 National Pollutant Discharge Elimination System permit, which required a substantial increase in service charges to ratepayers. This watershed service pilot project may be included as an avenue SWM can pursue to address the need for funding for protection and restoration work in floodplain areas outside of the Watershed Management Area (WMA)/ Clean Water District (CWD) boundaries.

[1] Swedeen, P. 2013. "Co-Benefits Analysis." Nisqually Forest Watershed Economic Analysis for the City of Olympia.

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