Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds

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Timeframe covered by the report: August 28, 2006- August 28, 2010

Grant #: 68-3A75-6-131

Deliverables:

1. Compilation of existing environmental service assessment tools into a single tool
2. Development of a monitoring protocol
3. 120 data sets collected (2 per year for each of 20 sites)
4. Report documenting usability and cost of monitoring protocol
5. 4 workshops delivered to teach agencies and landowners to use the new assessment tool
6. Written/graphic ‘portfolio’ package- available to agencies and landowners for assessment of riparian restoration values

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Executive Summary:

Landowners are unlikely to enter into ecosystem service markets without quantitative estimates of the natural capital they process. However, it has been difficult for landowners to quantity the ecosystem services provided by their land or the degree to which management decisions alter these services. Models that estimate ecosystem service values are complex, operate on institutional computing platforms, output results at spatially or temporally inappropriate scales, or report service values in units not tradable in the market. These roadblocks have hindered efforts to engage landowners in addressing priority resource concerns identified by the NRCS such as water quality and riparian zone integrity.

Our project developed a more accessible ecosystem service quantification tool using a distributed computing framework that makes use of the growing availability of spatially indexed bio-physical data and the increasing ability to link diverse computing platforms using web services. It addresses several NRCS priority areas (CIG FY11 Announcement for Program Funding) including: 1) integrated tools that facilitate the development of ecosystem markets; 2) cloud based computational analysis and modeling to link resource concerns, conservation systems/practices, and quantifiable outcome-based metrics; 3)demonstration of new or novel technology that can easily and inexpensively be adopted by small-scale producers in order to address concerns or problems of the farmers, producers, or landowners.

The specific goals of our project were to:

1. Develop a single practical tool to evaluate the potential ecological value of riparian restoration in units that relate directly to ecosystem services that have known or potential buyers.
2. Integrate the tool into a restoration monitoring protocol to assess the current and future ecological value of restoration sites in terms of these defined ecosystem services.
3. Test the usability, cost, and transferability of the new tool.

The project accomplished the following with respect to meeting these goals:

A web-bases Stream Shade Calculator
http://groups.hort.oregonstate.edu/content/stream-shade-tool
Our quantification tool provides landowners with estimates of solar heat loading along user defined sections of streams. Users can assess the degree to which management practices such as adding or removing riparian trees creates heat loading credits or deficits. The tool consists of four components that are linked through web services: 1) a graphical user interface; 2) geodatabases that store spatially indexed parameter values; 3) process models that calculate ecosystem service values; 4) a reporting interface the returns model outputs to the user. We believe that this general framework can produce more robust and accurate quantification systems as well as more accessible ecological information to individual landowners.

Field validated outputs
We validated the accuracy of the webtool outputs with field measured estimates of stream vegetation characteristics, shade conditions and temperature. Data were collected at 22 sites and

included 173 point data sets. In addition, we made use of current and potential shade data that were previously collected by Clean Water Services as part of their temperature trading requirements. Field collected data indicate that the webtool provides a robust estimate of current shade conditions.

A user guide and integrated monitoring protocol
We produced a detailed website and associated user guide explaining the purpose of the tool and how to use it.
http://groups.hort.oregonstate.edu/content/stream-shade-tool
(See also Appendix IV)

We also developed a field assessment and monitoring protocol to allow landowners to update the webtool estimates of current shade and to monitor the progress of restoration sites in terms of shade provisioning.

We evaluated the usability of the webtool through focus groups and feedback at workshops. We also evaluated the associated protocol in the field for ease of use and cost. An average user takes about 1 hour to complete the protocol for a 1500 ft. reach of stream. The cost of equipment and supplies is minimal ranging from no cost (excepting incidentals like wet boots etc) to a few hundred dollars. Overall, the webtool itself attempts to minimize costs. For many reaches there is no user override required to receive accurate results from the webtool. In these cases the user costs are only those related to the internet connection and the computer.

An Ecosystem Credit Worksheet
We developed a simple worksheet for landowners to compile a portfolio of potential ecosystem services credits (Appendix VI). The worksheet introduces landowners to our Stream Shade Calculator as well as the USDA's Nutrient Trading Tool (Lal 2010). These two new webtools allow landowners to estimate the potential ecosystem service benefits that could accrue by conducting riparian restoration and other conservation practices. Both tools report these potential benefits in units that are directly applicable to ecosystem service markets being developed in the Willamette Valley.

Outreach Workshops and meetings
We conducted four primary workshops that introduced the tool to conservation organizations, land managers, regulatory agencies, and private landowners. In addition to these four primary workshops, we also conducted several project meetings with cooperators and other groups doing similar work to elicit feedback on project direction and development, and to coordinate effort.

The project required a one year no cost extension. The delay was caused by a significant change to our original tool design that allowed us to take advantage of cutting edge developments in the design of web-services and the ability to integrate GIS databases into a distributed computing framework. We saw this as a vastly significant improvement over our original plan that justified the delay.

Our results demonstrate that the general design framework we developed for this project can produce more robust and accurate quantification systems for ecosystem services. Just as importantly, the user friendly and web based design make complex ecological information more accessible to individual landowners. This information can empower individual landowners to make more informed decisions about how to manage the ecological and conservation values of their property in addition to the market and commodity based values. This will likely produce more direct participation in conservation programs and improvements in priority resource concerns identified by the NRCS.

Our experience with this project identified some recommendations that would facilitate the widespread implementation of the technology to more regions and ecosystem service types:

1. Development of systems optimized for cellular based data portals such as smart phones and tablets that avoid issues with rural internet access and allow for use of the tool in the field.
2. Development of more robust distributed cyber infrastructure that coordinates the interoperability of data
3. Greater availability of spatial and temporally high resolution data of parameter values required for quantification of key ecosystem services.

Introduction

This four year project (three years with a one year extension) developed an innovative web-based tool for estimating effective shade potential and incident solar radiation, key ecosystem service s provided by riparian zones in the Willamette Basin of Oregon (http://groups.hort.oregonstate.edu/content/stream-shade-tool). The project was lead by Oregon State University in direct collaboration with the Sustainable Plant Research and Outreach Center (SPROut). In addition, the project collaborated with regional agencies and non-profit organizations to integrate the new tool with broader efforts to develop an ecosystem service marketplace for Oregon.

The tool allows users to estimate the potential shade credit they could receive for planting trees along streams. They can use the tool's map interface to identify a stretch of stream that they are interested in analyzing. The tool then uses LIDAR data to estimate the existing tree canopy along the defined stream. The tool uses this description of the canopy to calculate the amount of solar radiation currently reaching the stream (contributing to warmer water), and estimates how much the tree canopy could potentially be improved. The tool does this by using the stream's location, soil type, and the historic vegetation structure to construct a potential tree canopy for and then calculates the amount of solar radiation that would reach the stream under this potential tree canopy. The difference between the stream's current conditions and the potential conditions is the potential shade credit.

The project combined the diverse expertise of several key personnel, including a plant ecologist, a software engineer, a program coordinator, and an education and outreach specialist:

John Lambrinos (PI). Assistant Professor, Dept. of Horticulture, Oregon state University
Key expertise: plant ecology, landscape ecology
http://hort.oregonstate.edu/faculty-staff/lambrinos

Michael Guzy (programming and technical lead). Assistant Professor Senior Research, Department of Biological & Ecological Engineering, Oregon State University
Key expertise: software engineering, ecological modeling
http://bee.oregonstate.edu/Faculty/guzy/Guzy.htm

Lisa Gaines (project coordinator). Associate Director, Institute for Natural Resources, Oregon State University.
Key expertise: project management and facilitation
http://inr.oregonstate.edu/about_staff.html

Renee Stoops (outreach coordinator). Director, Sustainable Plant Research and Outreach Center (SPROut).
Key expertise: education and outreach

The goals and objectives of the project were to:

1. Compile existing assessment models into a single practical tool to evaluate the potential ecological value of riparian restoration in units that relate directly to ecosystem services that have known or potential buyers.
2. Implement a restoration monitoring protocol to assess the current and future ecological value of restoration sites in terms of these defined ecosystem services.
3. Test the usability, cost, and transferability of the monitoring tool.

To meet these goals the project had several key tasks divided across two distinct phases. During the first phase of development, the project team operationalized a prototype Web Shade Tool for quantification of potential shading along streams. The purpose of the phase 1 work was to establish initial requirements, designs, and implement draft architecture. Architectural components included developing a link between Google Maps and GIS software (ESRI, ArcGIS), various interfaces to the core physical process model (HeatSource 7), and a database scheme supporting accumulation of information. The first prototype version used pre-calculated results obtained from Clean Water Services that were created for their TMDL work in the Tualatin area.

In the second phase of the project, we fundamentally increased the usefulness of the tool by operationalizing it for most of the Willamette Basin. We also improved and enhanced the prototype design by developing an improved user interface, integrating an improved biophysical process model (HeatSource 8), developing an innovative and improved method for estimating current shade by making use of newly available remotely sensed data, and developing an improved method for estimating potential shade. We tested the accuracy and usability of the Shade Tool with ground truthed data. We integrated feedback on tool design and usability from project collaborators and stakeholders, and we demonstrated the final tool to stakeholder groups.

This project was facilitated by several key collaborations that helped facilitate project development and ensure that the resulting tool was responsive to stakeholder needs and requirements. These collaborators provided in-kind support to the project that included:

Clean Water Services (CWS). CWS Provided space for project meetings, restoration monitoring protocols developed for the Tualatin basin that we adapted for use in our ground truth protocol, calculated HeatSource output for the Tualatin basin that we used in an initial version of our tool.

Willamette Partnership (WP). WP facilitated contacts with the Oregon DEQ and CH2M Hill, who helped provide GIS data to the project, provided input and guidance on project design, scope, and integration with other related projects, provided feedback on usability and integration with the broader development of an ecosystem services market for Oregon.

The project was funded by an NRCS CIG grant for $175,097 and this was matched with $178,200 in direct and in kind contributions.

Background

Regulatory controls and technological mitigation measures have improved water quality, preserved wetlands and protected endangered species. But these approaches can be complicated, costly and contentious to implement--and they don't always produce broad environmental benefits. Water quality trading is an emerging approach to arrive at less expensive and more effective solutions to complex watershed problems. Implementing water quality trades hinges on scientifically valid, consistent, and user-friendly protocols to quantify environmental services provided by alternative mitigation measures such as riparian vegetation projects.

In 2005, the Oregon Department of Environmental Quality (DEQ) published recommendations regarding water quality trades between and among point and non-point sources. The document defines concepts, explains eligibility and describes specific trading scenarios that DEQ anticipates and generally supports. The DEQ noted the need for standardized protocols to quantify pollutant loads, load reductions, and credits to account for the generation and use of credits in permits and discharge monitoring reports in order to track the generation and use of credits between sources and to assess compliance.

Landowners are unlikely to enter into ecosystem service markets without quantitative estimates of the natural capital they process. We have greatly improved our understanding of the benefits humans derive from natural systems, including improved frameworks for defining, classifying, and quantifying ecosystem services (cite Heinz report; Millennium Ecosystem assessment). However, it has still been difficult for landowners to quantity the ecosystem services provided by their land or the degree to which management decisions alter these services. Many ecosystem services (e.g. biodiversity) require enormous amounts of person hours and expert knowledge to assess accurately. Quantification is complicated by the fact that most services emerge from ecological and physical processes that interact in complex ways across space and time. Models that estimate ecosystem service values are complex, operate on institutional computing platforms, output results at spatially or temporally inappropriate scales, or report service values in units not tradable in the market.

The difficulty and expense of calculating ecosystem service values are significant roadblocks to the development of ecosystem service markets. While small and individual resource managers such as farmers provide the majority of potential ES capital (XXXX), they are often prohibited from entering markets because they have no inexpensive way of assessing the potential natural capital they posses or could create.

This project targeted this need by developing a more accessible quantification tool using a distributed computing framework that makes use of the growing availability of spatially indexed bio-physical data and the increasing ability to link diverse computing platforms using web services. Our quantification tool provides landowners with estimates of solar heat loading along user defined sections of streams. Users can assess the degree to which management practices such as adding or removing riparian trees creates heat loading credits or deficits. The tool consists of four components that are linked through web services: 1) a graphical user interface; 2) geodatabases that store spatially indexed parameter values; 3) process models that calculate ecosystem service values; 4) a reporting interface the returns model outputs to the user. We believe that this general framework can produce more robust and accurate quantification systems as well as more accessible ecological information to individual landowners.

Review of Methods

Rapidly evolving technology and a change in tool design.

Our original plan for developing a riparian restoration tool called for compiling existing evaluation and monitoring protocols into a low tech delivery mechanism such as an Excel spreadsheet or a handwritten worksheet. Early in the project development we realized that this actually was technically difficult and the resulting output was unsatisfactory in many ways. Instead, we realized that cutting edge developments in the design of web-services and integrating GIS databases into a distributed computing framework could allow the development of powerful, interactive, yet user friendly tool. We saw this as a vastly significant improvement over our original plan. During our annual reviews our grant officers (Todd Peplin and Kathryn Boyer) agreed that this represented a significant advance.

However, the shift in our design plan caused an initial delay in project development as we had to recruit a team member with the required high level programming and systems design skills. In addition because tool development now involved programming and sophisticated integration of GIS databases the pace of tool development progressed more slowly than originally planned. In our original plan we expected to have a working tool within the first year of the project. Because of delays in recruiting specialized personnel and in the slower pace of tool development we did not actually have a working prototype until well into the second year of the project. This delay pushed back execution of project elements that required a working tool prototype such as the design and implementation of field testing and grower outreach. This delay was the basis for our request of a no-cost one year extension of the project. The evolution of the project is described in detail in our semi-annual reports (Appendix II) and our request for a no cost extension (Appendix III).

An innovative approach to ecosystem service quantification

As described in the introduction, current methods for quantifying ecosystem service values are technically difficult, time consuming, and expensive. This is mostly because accurate quantification requires site and context specific information that is acquired through difficult field work or through multiple data repositories with their own interoperability and sharing requirements. This creates an enormous barrier to individual landowners to gain access to information needed to appropriately manage the ecosystem services on their land. Our innovative design overcomes this barrier by making use of increasingly available spatially explicit bio-physical data and models. It also incorporates recent advances in IT infrastructure and protocols to automate service quantification and to provide a non-technical interface and intuitive output.

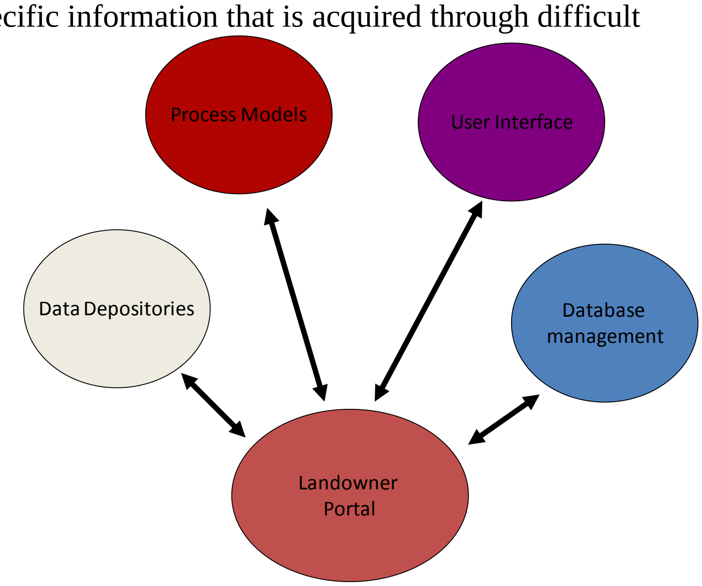

Figure 1. A distributed framework is a key design feature of the tool

Key innovations of tool architecture

A key design future of the tool is that it is built using a distributed architecture. Traditionally, ecosystem quantification and environmental assessments such as TMDLs and restoration assessments have been done as ad hoc projects. Each individual project entails the separate collection, compilation, analysis, and visualization of unique sets of data. This creates considerable redundancy in work (and cost) for each new project. It also means that project results and recommendations can easily become out of date as changes to the project components (such as new data or new methods) accrue. Our vision for the Web Shade Tool was for it to serve as an automated aggregator of information and analysis, rather than the repository of static ad hoc information. Each project component is linked and integrated via a web interface (Fig. 1). This distributed design allows for changes and updates to key components of the tool, and frees the end user (in this case the farmer) from having to directly administer each component of the complex process. For instance the Web Shade Tool can access soils data real time from the NRCS Web Soil Survey. This ensures that the most recent and updated soils information is used for the project.

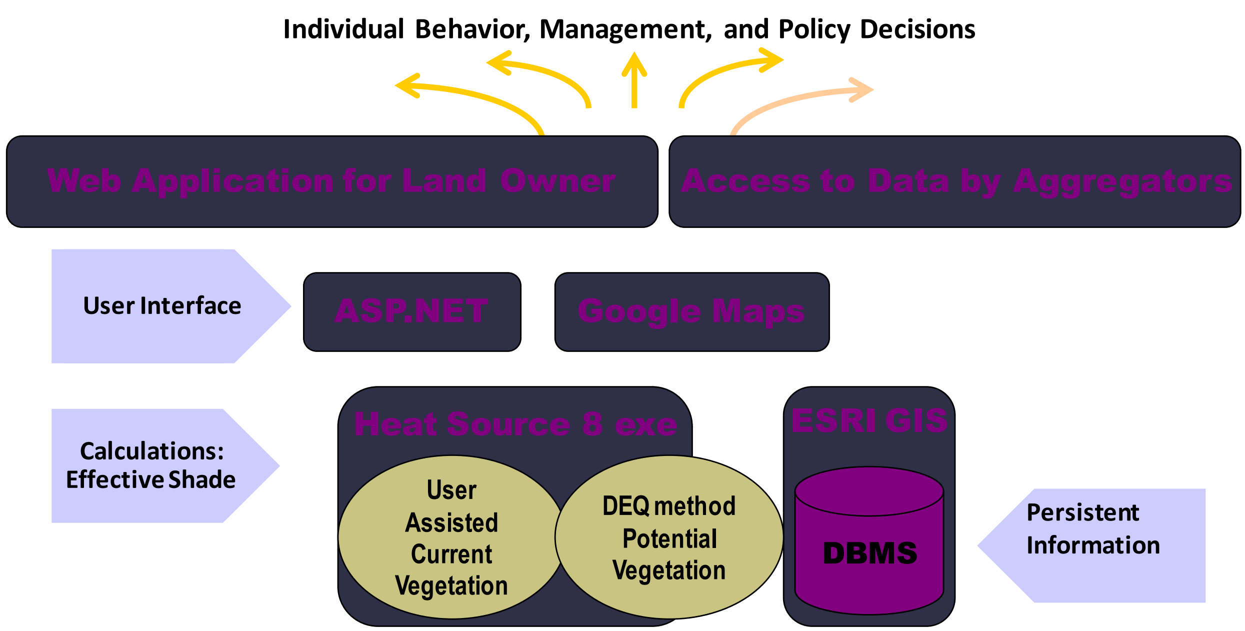

Fig. 2. Web Shade Tool design.

The Web Shade Tool integrates four components that are linked through web services (Fig. 2):

1. A graphical user interface.

The interface is based around Google Maps. This has two important advantages. First, it is an off the shelf well tested design. Second, it his highly intuitive and has a high level of familiarity across a range of users. The interface allows users to quickly identify a stretch of stream they are interested in analyzing (See Appendix IV).

2. Geodatabases that store spatially indexed parameter values

The tool uses a coupled assembly of an ESRI ArcSDE geodatabase associated with an ArcGIS server environment and a ASP.NET web service environment to store, manage, and distribute the parameter values needed by the process models as well as the calculated stream shading and incident solar radiation values themselves. Key features of this design include:

- Transactions Keyed to the USGS National Hydrological Data Set, which allows outputs to be associated with a wealth of other relevant spatial indexed data such as species incidence, stream flow data, and
- Secure Access Control
- Data source and date for each dataset and algorithm: provides for lineage tracking of each transaction.
- Scales to many users
- Dynamically links internet data sources

3. Process models that calculate ecosystem service values

The computational core of the tool is HeatSource 8.0, a bio-physical process model that estimates reach level shading and incident solar radiation (http://www.deq.state.or.us/wq/tmdls/tools.htm; Boyd and Kaspar 2003). The model uses input about physical relief (from a Digital Elevation Map) and vegetation characteristics (from a vegetation map linked to a look-up table of associated structural characteristics) to estimate the amount of solar radiation hitting the stream surface at a given location (spatial position, latitude). To predict potential shading following restoration along a section of an impaired stream, the same process is executed except using a model of potential vegetation instead of an existing vegetation map. The Oregon DEQ has developed a method for estimating potential vegetation for use in their TMDL obligations (http://www.deq.state.or.us/wq/tmdls/tools.htm). The potential vegetation model combines information about pre-settlement vegetation characteristics from an 1851 land survey with site specific geo-morphic characteristics that are known to influence vegetation type.

We made significant changes to this established methodology in order to make use of recently acquired remote sensing data and to better integrate the process model with the web-based architecture of the tool.

To estimate stream shading, HeatSource 8.0 requires estimates of reach scale vegetation structure, particularly height and canopy density. Previously this information has been acquired from GIS datasets of land use/landcover painstakingly developed through aerial photograph interpretation and ground truthing. Translating the land use/land cover layers into the appropriate input for HeatSource required a GIS analyst to sample a vegetation map using a specific sampling regime associated with the stream course. The resulting dataset describing stream vegetation is then converted into an estimate of vegetation characteristics using average values of height and canopy cover for specific vegetation types that are published by Oregon

DEQ (http://www.deq.state.or.us/wq/tmdls/tools.htm; Boyd and Kaspar 2003). This is a time consuming process that requires an expert GIS analyst to execute. For our tool we instead made use of recently acquired LIDAR data for the Willamette Valley. LIDAR is an optical remote sensing technology that can produce highly detailed three dimensional maps of tree canopy architecture. A key advantage of this new method to the previous technique is that LIDAR produces a vegetation model with a much higher degree of spatial precision (0.9) than the existing vegetation map (30 m). In addition, in the previous method the vegetation type information had to be converted to structure information (height, canopy density) using average values for particularly vegetation types. In contrast, by using the high resolution LIDAR data we can model vegetation characteristics directly for each stream reach.

4. A reporting interface returns model outputs to the user

The reporting interface has several key advantages over the existing way in which HeatSource output is presented. First, output is delivered real time for any stream section within the study area. Previously, detailed GIS analysis had to be accomplished for each new region. Second, output is user friendly and in units (% shade and heat flux before and after a restoration) that are relevant to actual management decisions. Third, users can override tool derived estimates of current vegetation and receive HeatSource output for the revised inputs in real time.

Project schedule and milestones

A detailed chronological description of project activities and milestones is provided in the biannual reports (Appendix II).

We list key milestones below:

Phase I

1. Consultation with collaborators and stakeholders about tool design, integration with other ongoing work, and integration with developing ecosystem service marketplace for Oregon/
Time frame: year 1

2. Development of a prototype tool with a working version of the user interface. Prototype used pre-calculated HeatSource outputs provided by Clean Water Services.
Time frame: years 1-2

3. Demonstrated the prototype to project collaborators and stakeholders; received feedback on tool design and future development.
Time frame: year 2

Phase II

4. Development of a final version of the tool from the prototype. This involved incorporating feedback from stakeholders, implementing the HeatSource 8 codes in the business logic layer of the web application, and implementing the associated dependencies including the DEQ method for potential vegetation calculation.

Time frame: years 3-4
5. Ground truthed and assessed the accuracy of the tool outputs. Outputs from the Web Shade Tool were compared with field collected information from streams in the Willamette Valley.
Time frame: year 3-4

6. Development of ecosystem service portfolio worksheet and protocols for implementing the Web Sade Tool and associated ground based restoration monitoring.
Time frame: year 4

7. Outreach and feedback from landowners and other stakeholders.
Time frame: year 4

<u>What worked and what didn't</u>
Our tool demonstrates the feasibility of automating some portions of ecosystem service quantification. This automation relies on several elements: sufficient high resolution (both in space and in time) spatial data for important parameter values, a robust process model, new software techniques and infrastructure that allow for data sharing and manipulation over the web. While integrating these elements was technically challenging, the outcome was a fully automated too that any user can use.

One aspect of our design concept that was not fully realized was a truly distributed design. Ideally, our tool would function as an aggregator of information and other tools (e.g. models) that are constantly being updated and maintained by their respective owners. While we demonstrated the feasibility of this concept with our tool, the infrastructure to fully realize this design goal in practice does not currently exit. For instance, the LIDAR data used by the Web Shade Calculator is collected and maintained by the Oregon Department of Geology and Mineral Industries. Ideally, the Web Shade Tool would be able to access these data sources via web services and would have access to the most up to date LIDAR coverages as they are progressively being developed for the state of Oregon. However, the LIDAR coverages are currently not maintained in a form that is directly usable by the Web Shade Tool. This required us to download the files to a local server. As these technologies developed, better frameworks for facilitating the interoperability of data will be needed. While there has been considerable progress in making the IT infrastructure and protocols more interoperable, more work is needed to make the underlying data themselves more accessible. One potential model would be to have a centralized repository for core earth systems data. Google has been one pioneer in this area with their development of Google Earth and the newly released Google Earth Engine.

Discussion of Quality Assurance

Study sites
We validated the accuracy of the webtool outputs by comparing them to field measured estimates of stream vegetation characteristics and shade conditions. Data were collected at 16 sites over two years (Appendix V). The number of sites used for field testing was slightly less than the estimate stated in the deliverables because data gaps in the remotely sensed data required that some sample locations be dropped from analysis. The total of sites surveyed during the study

was 22, but only 16 of these were subsequently used for analysis. The resulting data consisted of a total of 173 individual data sets.

The study sites were stream reaches in the Willamette Valley. Sites were chosen to represent a range of site conditions, histories, and restoration status. Sites were also chosen to encompass uniform reach sections. Streams flowed through both agricultural and urban landscapes. The vegetation along all streams was typical of riparian zones in the Willamette Valley. Dominant emergent trees included big leaf maple (*Acer macrophyllum*), Oregon Ash (*Fraxinus latifolia*), Oregon white oak (*Quercus garryana*), alder (*Alnus rhombifolia*), and cottonwood (*Populus trichocarpa*). Understories were typically dominated by Himalayan blackberry (*Rubus armeniacus*) with other shrubs e.g. hawthorne (*Crataegus douglasii*), snowberry (*Symphoricarpos alba*), willow (*Salix* sp.), hazelnuts (Corylus *cornuta*), and ocean spray (*Holodiscus discolor*).

Sampling Design

We measured vegetation characteristics approximately every 100 ft. along each stream reach (Fig. XX). This corresponds to the sample spacing used by the Web Shade Calculator. It's perfectly fine to adjust the sample spacing slightly to avoid obstacles like intense blackberry thickets or poison oak. You may also need to reduce the spacing if your stream reach is short. You want to take an average of at least three points for each reach. Here is a diagram of a typical stream sample design, with the stream section of interest divided into two reaches:

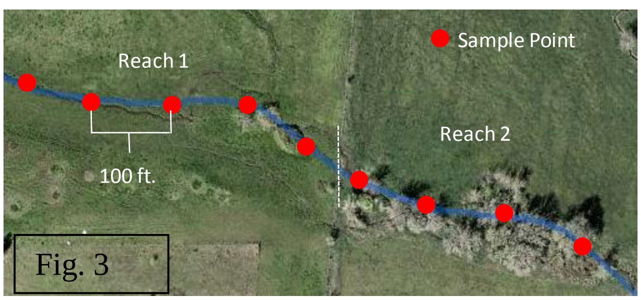

Fig. 3

At each sample point we measured the near stream canopy height in each of seven cardinal directions relative to the stream (NE, E, SE, S, SW, W, and NW) using a laser rangefinder. Canopy height values were average for each sample point. Also at each sample point we measured the vegetation overhang on opposite banks of the stream and the wetted width.

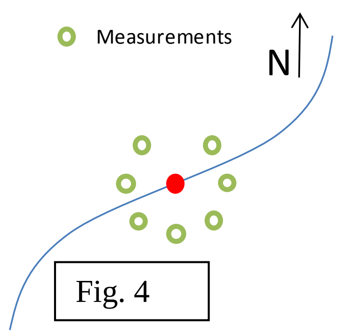

Fig. 4

We measured Angular Canopy Density (ACD) at each sample point using a spherical ACD meter (Beschta et al. 1987). They argued that for purposes of summertime stream heating, shade is most important between 10 AM and 2 PM in mid- to late-summer and that this should be the reference parameter for the exposure of streams to sunlight. At a given point on a stream, ACD is the percentage of time that it will be shaded between 10 AM to 2 PM local solar time (http://www.acdmeter.com/). The ACD meter was calibrated for the month of August and latitude of 44˚. We averaged ACD of each sample point over a stream reach.

The resulting data consists of vegetation characteristics at173 points along 22 stream reaches (Appendix V)

Analysis and results
To test the ability of the Web Shade Tool to accurately estimate actual current shade values along streams we compared the field measured ACD estimates with the web tool calculated stream shade values. There was a strong correlation between the field measures of stream shade and the web tool estimates based on the LIDAR data. The relationship was stronger when data points were averaged over a stream reach (Fig. 5). There were no differences in the relative strength of the correlation between field and web tool estimates across streams with different land use status or restoration history. These results indicate that the Web Shade Tool produces robust and highly accurate estimates of stream shading.

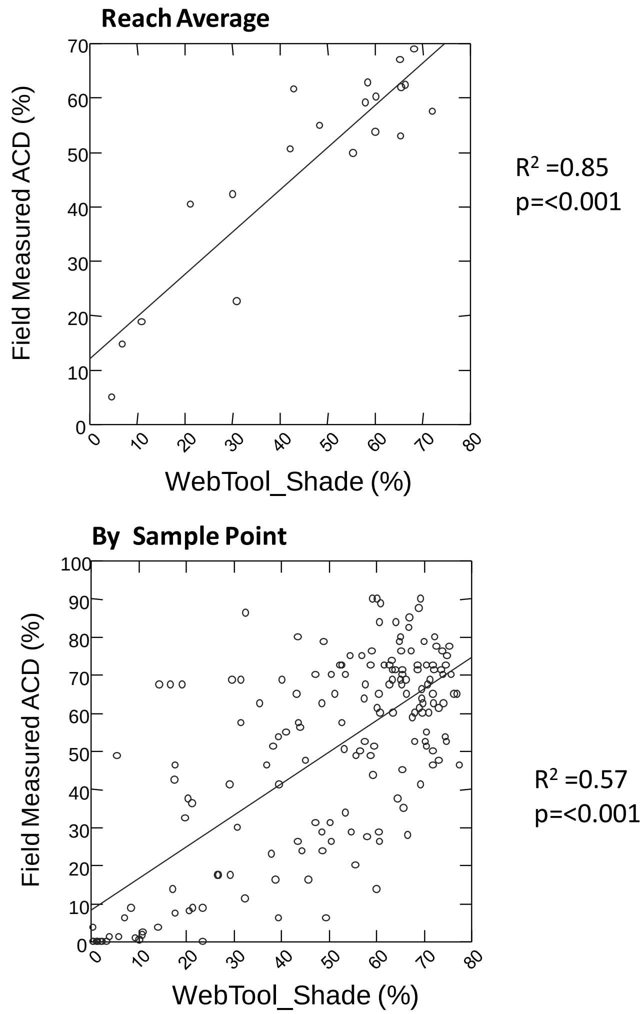

Fig. 5. Relationship between field measured and webtool calculated % current shade.

Findings

Our findings relative to the project goals and deliverables are as follows:

Web-based ecosystem service tools are feasible and potentially powerful (Goal 1, deliverable 1)
Our principal goal was to develop a more accessible quantification tool using a distributed computing framework that makes use of the growing availability of spatially indexed bio-physical data and the increasing ability to link diverse computing platforms using web services.

We accomplished this goal with an easily web accessible tool that is user friendly and provides accurate and high resolution results:
http://groups.hort.oregonstate.edu/content/stream-shade-tool

Our quantification tool provides landowners with estimates of solar heat loading along user defined sections of streams. Users can assess the degree to which management practices such as adding or removing riparian trees creates heat loading credits or deficits. The tool consists of four components that are linked through web services: 1) a graphical user interface; 2) geodatabases that store spatially indexed parameter values; 3) process models that calculate ecosystem service values; 4) a reporting interface the returns model outputs to the user. We believe that this general framework can produce more robust and accurate quantification systems as well as more accessible ecological information to individual landowners.

Web-based tools can provide highly accurate information (Goals 1, 2; deliverables 1, 3)
We validated the accuracy of the webtool outputs with field measured estimates of stream vegetation characteristics and shade conditions. Data were collected at 22 sites representing 173. The field collected data indicate that the webtool provides a robust estimate of current shade conditions at a very high spatial resolution (reach and even single point scales).

Of course, tool accuracy is ultimately dependent on the accuracy of the underlying data and biophysical models. In our case, we made use of newly developed LIDAR data and an existing well validated bio-physical model. However, the power of the distributed and web enabled design of our tool is the relative ease with which the most up to date data and models can be integrated. This general result suggests that future data and models should be organized and designed in ways that facilitate incorporation into a distributed web environment.

Web tools can facilitate restoration monitoring (Goal 2, 3; deliverables 2-4).
In our original proposal, we conceived of compiling existing models into a spreadsheet style tool that would facilitate compiling data and organizing the ecosystem outputs of a restoration. This type of tool still requires extensive field monitoring to acquire the data to parameterize the underlying ecosystem service models. However, as we developed our web-based tool we realized that the new design could automate much of the actual field monitoring. Our field testing confirmed that our tool produces results comparable to actual field measurements.

This new type of monitoring protocol is intuitive and easy to use. We produced a detailed website and associated user guide explaining the purpose of the tool and how to use it.
http://groups.hort.oregonstate.edu/content/stream-shade-tool

In addition, the web tool allows for data storage, updating, and user overrides of existing values. This can greatly facilitate tracking and monitoring restoration success. We developed a field assessment and monitoring protocol to allow landowners to update the webtool estimates of current shade and to monitor the progress of restoration sites in terms of shade provisioning (Appendix VI).

We evaluated the protocol in the field for ease of use and cost. An average user takes about 1 hour to complete the protocol for a 1500 ft. reach of stream. The cost of equipment and supplies is minimal ranging from no cost (excepting incidentals like wet boots etc) to a few hundred dollars. Overall, the webtool itself attempts to minimize costs. For many reaches there is no user override required to receive accurate results from the webtool. In these cases the user costs are only those related to the internet connection and the computer.

Web tools facilitate developing portfolios of ecosystem service values (deliverable 6).
The ability to automate ecosystem service calculation through easy to use and intuitive interfaces creates the ability to develop individualized portfolios of ecosystem service values for landowners. One of the key limiting restrictions to creating such portfolios currently is that ecosystem service quantification requires site and context specific evaluation and manipulation of complex models. Our tool demonstrates that these roadblocks can be overcome for estimating current and potential stream shade and thermal benefits. Other similar web tools are being developed that calculate other ecosystem service values and how they respond to varying management. One of these is the Nutrient Trading Tool developed by the NRCS West National Technology Support Center (Lal 2010). In our original project proposal, we envisioned integrating stream shade provisioning and nutrient buffering capacity calculations into a single tool. As we outline in our semi-annual reports (Appendix II), we realized that the WTSC was embarking on a similar web-based design for nutrient trading. For various technical and practical reason we agreed that the best approach would be to keep the software infrastructure for the two tools separate. Instead, we decided to integrate the tool outputs suing an easy to use worksheet that a landowner can use to compile a portfolio of values for the various services.

We developed a simple worksheet for landowners to compile a portfolio of potential ecosystem services credits (Appendix VII). The worksheet introduces landowners to our Stream Shade Calculator as well as the USDA's Nutrient Trading Tool. These two new webtools allow landowners to estimate the potential ecosystem service benefits that could accrue by conducting riparian restoration and other conservation practices. Both tools report these potential benefits in units that are directly applicable to ecosystem service markets being developed in the Willamette Valley.

Users from a range of stakeholder groups found the tool useful and easy to use (Goal 3; deliverable 5)
We conducted four primary workshops that introduced the tool to conservation organizations, land managers, regulatory agencies, and private landowners:

- 9/15/08. Workshop held at Clean Water Services. At the workshop we demonstrated a version of the tool to agencies and received feedback on gathered feedback on the tool design and directions for future development.
- 1/25/09. Workshop held as part of the Oregon Processed Vegetable Growers Meeting, Albany, OR. At the workshop we covered the importance of improving and conserving riparian habitat on farms, demonstrated the tool, and covered resources available to landowners for doing restoration.
- 8/19/10. Workshop held at the Oregon Garden. The workshop introduced the latest version of the tool, covered resources available for doing restoration and improving ecosystem services, and discussed emerging market based programs in Oregon. Workshop participants included representatives from local and regional agencies, city governments, and private landowners.
- 8/24/10. A second workshop same as above.

In addition to these four primary workshops, we also conducted several project meetings with cooperators and other groups doing similar work to elicit feedback on project direction and development, and to coordinate effort. These are outlined in the semi-annual reports.

We prepared information packets for participants that included general information about ecosystem services, developing marketplaces for them, the value and importance of riparian habitats, and technical information about restoration. The packet also contained a summary of the Stream Shade Tool functions and uses (Appendix VIII)
Participants of the four public workshops were generally enthusiastic about the tool. Values that they highlighted included:

- Ease of use
- Quick return of outputs
- High spatial resolution
- Ability to override initial values
- Clear reporting output

The main general concern expressed by participants was the limited working extent of the tool. There was great demand for the tool to work outside of its current coverage area in the Willamette Valley.

While individual landowners were interested in the idea that they could readily calculate stream shading values, they ultimately were more interested in how these values could be translated into incentives and payments to carry out restoration. At our workshops we had representatives from both the Willamette Partnership (http://willamettepartnership.org/) and the Freshwater Trust (http://www.thefreshwatertrust.org/) present to provide information about efforts to develop a functioning ecosystem service market that would facilitate restoration and conservation activities. While full engagement of private landowners awaits the development of these broader efforts, we think that tools like our Stream Shade Calculator are powerful ways of engaging individual landowners in the process. The ability to provide landowners with quick and explicit estimates of current and potential conditions on their property empowers landowners to integrate conservation and restoration into their site and farming plans.

Many of the participants of the workshops were from local and regional municipalities that have permitting requirements with respect to Oregon DEQ and the Clean Water Act. These participants were interested in how the tool could be used in their planning and reporting efforts. These stakeholders were most interested in the final outputs of the tool (current and potential shading) since these were among the primary metrics that they had to report to Oregon DEQ and mitigate for. Consequently, they were very receptive to the tool design that allowed very quick, yet accurate estimates of these values for particular stream reaches. One of the principal desires they expressed was for tools that would similarly calculate other service values such as bacteria loading.

Representatives of regional agencies such as Oregon DEQ were also present at the workshop. They largely had a desire for a tool that would fulfill specific regulatory requirements such as developing TMDL's. They offered feedback on aspects of tool design that would help them in these tasks. These included elements such as the ability to evaluate the vegetation on different banks of the stream separately and the ability to implement full temperature modeling. Some of the deficiencies in this regard were intentional design decisions on our part. There are always tradeoffs between tool/model functionality and ease of use. Because our tool was targeted at landowners we made a conscious effort to design for ease of use. As a consequence, we purposely omitted some functionalities that are only really important for higher end users such as those developing TMDL's for a watershed.

These varying comments among groups highlight the fact that different stakeholder and user groups vary in their requirements and needs. Web tools, like any other tool need to be designed with these potentially conflicting requirements in mind and with explicit users identified. However, the distributed design of our web tool likely facilitates the ability to design user specific tools. Much of the underlying infrastructure required to integrate data and calculate results is shared or similar, even if the specific functionalities are different. One design approach would be to vary the user interface of ecosystem services calculators for each particular user group. These interfaces could function like webpages (e.g. Amazon.com), that vary the information they display depending on the particular user.

Conclusions and Recommendations

We believe that the general design framework we developed for this project can produce more robust and accurate quantification systems for ecosystem services. Just as importantly, the user friendly and web based design make complex ecological information more accessible to individual landowners. This information can empower individual landowners to make more informed decisions about how to manage the ecological and conservation values of their property in addition to the market and commodity based values. This will likely produce more direct participation in conservation programs and improvements in priority resource concerns identified by the NRCS.

However, there are several obstacles that potentially hinder the widespread adoption of this technology. These obstacles apply both to the specific case of the Stream Shade Calculator as well as the more general applicability of web based ecosystem calculators. We outline these and offer recommendations to overcome them below:

Rural internet access
The most basic infrastructure needed to implement web based tools is a high speed internet connection. While there are still significant gaps in internet service (particularly in terms of affordability) in rural areas, affordable coverage is expanding rapidly. The expansion is partly a result of the development of cellar based data infrastructures. Web based ecosystem service tools should be designed with this in mind. While we did not have the resources to develop n smart phone "app" based on the Stream Shade Tool in this project, we would like to develop a version optimized for mobile devices in the future. This would allow users to get instant estimates of shade using their smartphone or tablet device while they are in the field over. The ability to get estimates of current and potential ecosystem service credits while actually looking at a project site would greatly help in planning and in visualizing the impact of a restoration.

Distributed computing cyber infrastructure
One of the main design goals of our project was to demonstrate the utility of a distributed design for integrating the myriad components needed to derive ecosystem service estimates. While we

successfully demonstrated the concept, fully implementing our distributed vision was not possible. This is because many of the data needed to do calculations were not stored in ways that made them directly accessible and usable by our tool. To have truly distributed information networks there needs to be greater coordination of data collection and management standards, as well as other aspects of interoperability. Many important ecosystem services such as nitrogen filtration or stream shading are derived from a finite set of underlying parameters. We need regional or national level plans to identify these data needs and to develop unified data collection and repository infrastructures. Greater coordination would greatly facilitate the development of truly distributed ecosystem service calculators.

These systems are increasingly being developed. The NRCS web soil survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) is a good example. Interestingly, the private sector led by Google has also been a leader in developing unified data storage and distribution for environmental and earth science data. Google Earth and the recently released Google Earth Engine (http://earthengine.googlelabs.com/#intro) are good examples. In the words of Google: "Google Earth Engine brings together the world's satellite imagery—trillions of scientific measurements dating back more than 25 years—and makes it available online with tools for scientists, independent researchers, and nations to mine this massive warehouse of data to detect changes, map trends and quantify differences to the earth's surface."

More data

One of the most frequent requests at our workshops was for the Stream Shade Tool to be operationally for more areas in Oregon. Our experience developing the tool exemplifies the general opportunities and challenges surrounding the basic data needed to make ecosystem service calculations. There has been a great increase in the availability of remotely sensed and field collected data. In particular, the increasing availability of data at high temporal and spatial resolutions has made it possible to quickly access site and time specific data. The Web Soil Survey (mentioned above) as well as Agrimet (http://www.usbr.gov/pn/agrimet/wxdata.html) are good examples. In our case, we made use of LIDAR data recently developed for the state of Oregon by the Oregon Department of Mines and Industry (http://www.oregongeology.org/sub/default.htm). These data allowed us to create highly detailed estimates of current stream shade at the reach scale.

Despite the explosion in availability of data, the absolute amount of it relative to potential needs and questions is still small. In the case of the Stream Shade Calculator, the LIDAR data it requires does not exist for much of Oregon, although fortunately the agricultural intensive Willamette Valley is a coverage focus. In addition to spatial coverage, temporal coverage can be important for many ecosystem services, if for no other reason than to track trends in service creation with respect to changing management practices, restoration, or climate change. We think that there should be a concerted effort to target parameters for data collection that have specific relevance to ecosystem service estimation.

APPENDIX I

References

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Lal, H. 2010. Nutrient credit trading – a market-based approach for improving water quality. *In* J.A. Delgado, and R.F. Follett (Eds.) Advances in nitrogen management for water quality. SWCS, Ankeny IA (*in press*).

APPENDIX II

Semi- Annual Reports

CONSERVATION INNOVATION GRANTS

Biannual Progress Report

<table>
<tr><td colspan="2">Grantee Name: John Lambrinos</td></tr>
<tr><td colspan="2">Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds</td></tr>
<tr><td colspan="2">Project Director: John Lambrinos</td></tr>
<tr><td>Contact Information:</td><td>Phone Number: 541-737-3484
E-Mail: lambrinj@hort.oregonstate.edu</td></tr>
<tr><td colspan="2">Period Covered by Report: 1 August 2006- 1 February 2007</td></tr>
<tr><td colspan="2">Project End Date: 30 June 2009</td></tr>
</table>

Summarize the work performed during the project period covered by this report:

1. Held two collaborator meetings to identify design needs and criteria for the tool.
2. Identified existing process models that could potentially be integrated into the tool.
3. Tested the usability of the different models, identifying ways models could be simplified.
4. Identified data sources that could be used to parameterize models.

Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

Significant results:
We have compiled a database of existing process models that relate to our five target ecosystem services (shade, nutrient, reduction, bacteria, carbon, habitat). We have

Changes from proposal:
1. We proposed to investigate the feasibility of developing a tool that was able to calculate credits in five areas (temperature, nutrients, bacteria, carbon, habitat). After our review of the available models we have decided to initially target two of these services: temperature and nutrients. For temperature, we have existing GIS data that will allow us to readily calculate temperature credits for stream sections in the Tualatin Basin using spatial data that we will get from farmers using a Google Maps based interface. For nutrients, Harbans Lal of the NRCS West National Technology Support Center (Portland OR) has developed a web-based Nitrogen budget tool using the NLEAP model. We plan to link our digitizing interface and temperature credit calculator with this N tool. This distributed computing method is an innovative approach to calculating multiple ecosystem service credits, and we think that it can serve as a general model for linking together different tools and process models. We have identified a model for Carbon credits (Comet VR) that could potentially be readily integrated into this framework.

However, we have decided to concentrate our efforts on developing a working prototype that can calculate N and shading credits first.

2. In our proposal, we underestimated the difficulty in translating the complex process models that describe ecosystem service credits into an easy to use framework. We have consequently had to invest considerable effort into re-evaluating our design concept for the tool. Our initial thought was that we would only need a relatively simple design that was based in Excel or used simple web forms and calculators. However, it has become clear that we need considerably more sophisticated programming skills to design the distributed computing and geodatabase architecture. These skills are rare, but we have identified an expert in this area (Michael Guzy, OSU). Re-evaluating our tool design and finding an appropriate programmer has taken unanticipated time. In addition, Michael Guzy's schedule has severely limited the time he could devote to the project until now. This has pushed our original schedule back by about 6 months.

Describe the work that you anticipate completing in the next six-month period:

1. Completion of a first working prototype of the web interface and tool that demonstrates basic functionality.

2. Demonstrate the tool to our collaborators to get feedback on tool design.

3. Revision of tool design based on feedback from collaborators.

4. Plan and schedule a demonstration for a select group of EQUIP eligible producers to test design and get feedback.

In the space below, provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

a. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

b. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biennial and cumulative payment amounts must be submitted.

c. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

None.

CONSERVATION INNOVATION GRANTS
Biannual Progress Report

Grantee Name: John Lambrinos	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Project Director: John Lambrinos	
Contact Information:	**Phone Number:** 541-737-3484 **E-Mail:** lambrinj@hort.oregonstate.edu
Period Covered by Report: 1 March 2007-1 September 2007	
Project End Date: 30 June 2009	

Summarize the work performed during the project period covered by this report:

1. Held two collaborator meetings to identify design needs and criteria for the tool.
2. Identified existing process models that can be integrated together into the tool.
3. Brought on to the team a programmer expert in distributed programming and geodatabase design that will program the web interface.
4. Completed design plan for the web interface
5. Acquired the necessary GIS data.

Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

Significant results:
We have developed the basic design for the landowner tool including the web interface design as well as the underlying data management and calculation structure. We have also acquired the GIS data layers that we need in order to calculate shading credits.

Changes from proposal:
1. We proposed to investigate the feasibility of developing a tool that was able to calculate credits in five areas (temperature, nutrients, bacteria, carbon, habitat). After our review of the available models we have decided to initially target two of these services: temperature and nutrients. For temperature, we have existing GIS data that will allow us to readily calculate temperature credits for stream sections in the Tualatin Basin using spatial data that we will get from farmers using a Google Maps based interface. For nutrients, Harbans Lal of the NRCS West National Technology Support Center (Portland OR) has developed a web-based Nitrogen budget tool using the NLEAP model. We plan to link our digitizing interface and temperature credit calculator with this N tool. This distributed computing method is an innovative approach to calculating multiple ecosystem service credits, and we think that it can serve as a general model for linking together different tools and process models. We have identified a model for Carbon credits (Comet VR) that could potentially be readily integrated into this framework. However, we have decided to concentrate our efforts on developing a working prototype that can calculate N and shading credits first.

2. In our proposal, we underestimated the difficulty in translating the complex process models that describe ecosystem service credits into an easy to use framework. We have consequently had to invest considerable effort into re-evaluating our design concept for the tool. Our initial thought was that we would only need a relatively simple design that was based in Excel or used simple web forms and calculators. However, it has become clear that we need considerably more sophisticated programming skills to design the distributed computing and geodatabase architecture. These skills are rare, but we have identified an expert in this area (Michael Guzy, OSU). Re-evaluating our tool design and finding an appropriate programmer has taken unanticipated time. In addition, Michael Guzy's schedule has severely limited the time he could devote to the project until now. This has pushed our original schedule back by about 6 months.

Describe the work that you anticipate completing in the next six-month period:

1. Completion of a first working prototype of the web interface and tool that demonstrates basic functionality.

2. Demonstrate the tool to our collaborators to get feedback on tool design.

3. Revision of tool design based on feedback from collaborators.

4. Plan and schedule a demonstration for a select group of EQUIP eligible producers to test design and get feedback.

In the space below, provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

a. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

b. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biennial and cumulative payment amounts must be submitted.

c. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

None.

CONSERVATION INNOVATION GRANTS
Semi-annual Progress Report

Grantee Name: Oregon State University, Dept. of Horticulture	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Agreement Number: 68-3A75-6-131	
Project Director: John Lambrinos	
Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 September 2007- 1 March 2008	
Project End Date: 30 June 2009	

A) Summarize the work performed during the project period covered by this report:

1. Designed and implemented a database management system that forms the computational core of the tool.
2. Designed and implemented a graphical user interface based on Google Maps.
3. Designed and implemented a report generator for the tool.
4. Implemented first working prototype of the tool (V 1.0)
5. Convened two design and outreach meetings between our team and other design teams working on related ecosystem service tools (CH2Mhill, Paramaterix) to better integrate our work.
6. Demonstrated prototype tool to project collaborators and stakeholders (Clean Water Services, Willamette Partnership) and gathered feedback on the tool design and directions for future development

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

<u>Significant results and accomplishments</u>

1. We completed the first working prototype (V 1.0) of the ecosystem service tool. The prototype is a proof of concept for our design architecture. The tool demonstrates that we can link three key elements to produce a unified user friendly tool: a graphical map based user interface, a robust data geodatabase management system, and distributed web services. The tool takes as user input in the form of a digitized section of stream. The tool then returns as output the potential stream shading credits that could be accrued by doing riparian restoration along that section of stream. The tool works for 5 pre-defined streams in the Tualatin basin.

2. We gathered feedback on or prototype from outside developers working on related tools as well as key project stakeholders such as the Willamette Partnership and Clean Water Services.

3. This feedback helped us developed a revised tool development plan.

<u>Lessons learned and changes</u>

1. Our original project goal was to produce a tool that worked for producers in the Tualatin basin. We realized that this was a rather limited area, but we believed that we needed to first provide a proof of concept that worked for a prescribed area. Our prototype did just that. However, we got strong feedback from the Willamette Partnership (a key stakeholder) that they needed a tool that was functional for the whole Willamette basin as soon as possible in order to help support the development of an ecosystem service market for the Willamette basin

2. We therefore decided that expanding the geographic scope of the tool should be a central development goal. At first we thought that this would be a straightforward and relatively easy development objective. We believed that we could use existing GIS layers of Heatsource output that were developed by Oregon DEQ. However, we soon realized that most of these existing datasets were unusable. At the same time we were consulting with other development teams that were working on related tools (in addition to our existing collaboration with the NRCS WNTSC). These discussions made us realize that there was a strong need to develop a more robust and adaptable design architecture that could better utilize updated data and user inputs.

3. As a result of this feedback and the realization that our original design strategy limited future development we decided to make a significant design change in the development of the next version of the prototype. Instead of using static, pre-calculated Heatsource output we will run the Heatsource model "on the fly" to generate estimates of shade credits. We believe that this approach is necessary to produce the required functionality that stakeholders want. But more broadly, we think that the approach will provide a state of the art model for how to develop this general class of distributed web-based ecosystem service calculation tools.

C) Describe the work that you anticipate completing in the next six-month period:

1. Complete development of tool prototype V. 2.0 that produces "on the fly" estimates of shade credits for any location in the Willamette basin.

2. Get feedback on this version of the tool from stakeholders and defined user groups.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

We have so far not engaged directly any EQIP eligible producers. We plan to involve these providers as part of the outreach portion of the grant once we have a more functional Beta version of the tool.

CONSERVATION INNOVATION GRANTS

Semi-annual Progress Report

Grantee Name: Oregon State University, Dept. of Horticulture	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Agreement Number: 68-3A75-6-131	
Project Director: John Lambrinos	
Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 March 2008 - 1 September 2008	
Project End Date: 30 June 2009	

A) Summarize the work performed during the project period covered by this report:

1. Designed and operationalized Heatsource 9.0 as an arcGIS web service.
2. Operationalized real time database query to the NRCS soils database.
3. Keyed tool inputs and outputs to the National Hydrologic Dataset (NHD).
4. Operationalized DEQ method of Potential Vegetation. Created a Graphical Model in ArcMap and published as geoprocessing web service.
5. Re-designed user interface
6. Demonstrated tool to an in-house focus group, and gathered feedback on tool usability and interface design.
7. Demonstrated prototype tool to project collaborators and stakeholders (Clean Water Services, Willamette Partnership, Oregon DEQ) and gathered feedback on the tool design and directions for future development

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

<u>Significant results and accomplishments</u>

1. We completed a major revision (v. 2.0) to our working prototype. This version allows a user to select any point along a stream course in the Willamette valley and receive an estimate of the potential stream shading that could be achieved at that point. The prototype allows the user to input current vegetation parameters and to recalculate the potential shade credit. The design of the prototype as several key advantages and innovations:
    - A distributed design allows real time exchange of information between the owners and maintainers of the system components (e.g. spatial data, models, registration). This is particularly valuable because many of the parameter values needed to calculate ES are highly dynamic.
    - Modular design also allows easy updates to system components such as new models, changes to spatial database management requirements, etc.

- Tool outputs are indexed to a national spatial database standard (the NHD). This allows easy access to other spatial data indexed to the standard.
- The design is capable of "versioning", allows easy data storage, retrieval, and sharing. This is a requirement ES estimates and market transactions that are traceable and defensible.

2. We gathered feedback on our prototype from outside developers working on related tools as well as key project stakeholders such as the Willamette Partnership and Clean Water Services.

3. This feedback helped us developed a revised tool development plan.

4. We presented our concept design at an international meeting:

Lambrinos, J.G., M. Guzy, H. Cover, H. Lal. 2008. A framework for calculating ecosystem service credits using distributed geodatabases. Annual Meeting American Association of Agricultural and Biological Engineers.

Lessons learned and changes

The original goal of our project was to produce a tool that would provide landowners an easy way of calculating the value of the ecosystem services that they could potentially generate on their land. We have successfully demonstrated a design concept that does this an important ecosystem service in Oregon. However, we now believe that our design is a good general approach to designing similar web based tools that serve a difference audience. We see aspects of our tool benefiting at least to potential user groups in addition to individual landowners:

- Regulatory agencies such as DEQ that need ways of doing TMDL development using an enterprise workflow.
- Other components of ecosystem markets such as aggregators and verifiers that need a way of organizing and compiling data about the services generated by individual landowners.

We see developing the tool in these areas as an important future direction for our tool development beyond the work under the current project.

C) Describe the work that you anticipate completing in the next six-month period:

1. Complete development of tool prototype v. 2.1. The goals we wish to attain in this version are:

- Develop a fine scale (0.5 ha mmu polygon map) current vegetation layer based on NAIP and LIDAR and extensive field sampling that is being developed by Jimmy Kagan of INR.
- Develop a more user friendly interface and reports that link explicitly to the landowner market registration form developed by the Willamette Partnership.
- Demonstrate ability to link user inputs and reports with the NTT.

2. Validate tool output with data from Clean Water Services that was developed using existing methodologies as well as field verification of tool outputs relative to existing conditions.

3. Conduct outreach and get feedback on this version of the tool from stakeholders, defined user groups, and EQIP eligible producers

4. Publish results of our work in peer reviewed publications.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;
2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.
3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

We have so far not engaged directly any EQIP eligible producers. We plan to involve these providers as part of the outreach portion of the grant in the upcoming biennium.

CONSERVATION INNOVATION GRANTS

Semi-annual Progress Report

Grantee Name: Oregon State University, Dept. of Horticulture	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Agreement Number: 68-3A75-6-131	
Project Director: John Lambrinos	
Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 September 2008 - 1 March 2009	
Project End Date: 27 August 2009	

A) Summarize the work performed during the project period covered by this report:
1. Compiled tree planting protocols (including recommended species lists) for incorporation into the tool.
2. Compiled tree planting costs for recommended species to allow us to incorporate general cost estimates into the tool.
3. Developed field testing and ground truth protocol to evaluate the accuracy of the tool.
4. Took preliminary ground truth data along a section of test stream on the OSU campus.
5. Began outreach coordination with EQIP eligible farmers associated with NORPAC grower cooperative.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

<u>Significant results and accomplishments</u>

1. We began work on v 2.1 of our prototype tool. The goals for this version are to incorporate new high resolution riparian vegetation layers and to improve the usability of the tool interface. As we describe below we encountered a delay in developing the new high resolution vegetation data, but we made significant progress on improving the tool usability. To this end we:

- Compiled existing restoration and planting protocols for riparian habitat in the Willamette Valley. These protocols will be incorporated as part of the user documentation for the tool.
- Compiled a database of tree planting costs for riparian restoration in the Willamette valley. These estimates are based on current nursery prices for recommended tree species, recommended planting densities, and estimates of associated costs derived from existing projects in the Willamette Valley. This database will allow us to produce rough installation cost estimates for user defined sections of stream. We will return these estimates along with the potential stream shading estimates

2. We developed a field testing and ground truth protocol to assess the accuracy of the tool. The protocol allows us to quickly collect the underlying parameter values needed to estimate stream shading. We have done a preliminary test of the protocol using a section of stream that runs through agricultural land on the OSU campus. The data from the ground testing protocol will allow us to evaluate the output accuracy of our prototype tool.

3. We developed contacts with Norpac, an Oregon-based farmer cooperative to conduct field testing and outreach efforts for the tool this summer with their EQIP eligible growers.

4. We had abstracts accepted to present results of our tool development at two national meetings (The Ecological Society of America Annual Meeting, The American Fisheries Society Annual Meeting) this summer:

Lessons learned and changes

Our original outreach plans called for working with EQIP eligible growers in the Tualatin basin who had previously worked with Clean Water Services as part of the CWS-DEQ temperature trading agreement. This party reflects the fact that the original tool design was meant only to cover the Tualatin Basin. However, as we developed the tool it became possible to expand the tool coverage area to include the entire Willamette Valley. We felt that it was necessary to correspondingly expand the geographical reach of our outreach efforts. Our revised outreach plan calls for engaging EQIP eligible farmers through Norpac, a large Oregon based grower cooperative.

We think that this revised outreach plan opens the door to some potentially innovated future directions. One promising approach to implementing more effective restoration is to engage farmers in cooperative networks that explicitly integrate individual efforts into a landscape-scale restoration plan. Existing grower cooperatives could be a powerful tool for doing this. Norpac has for 5 years conducted a sustainability program developed in cooperation with the Food Alliance and OSU. Recently, Norpac farmers identified wildlife conservation as one of their most difficult sustainability goals, and identified riparian restoration as their wildlife conservation priority. We think that our tool could be used to help design cooperative restoration strategies and to help quantify the collective benefits of restoration created by groups of farmers.

C) Describe the work that you anticipate completing in the next six-month period:

1. Complete development of tool prototype v. 2.1. As we describe above we have made significant progress in developing this version. However we need to do some final programming to integrate the databases we have developed into the user interface and reporting output functions of the tool. We also would like to integrate a more fine scale (0.5 ha mmu polygon map) current vegetation layer based on NAIP and LIDAR and extensive field sampling that is being developed by Jimmy Kagan of INR. We had planned to incorporate this layer earlier, but development of this new layer by INR was delayed.

2. Validate tool output using field sampling of streams on farms of EQIP eligible produces. We have developed a field sampling protocol and will implement it this summer. As we describe above we will engage EQIP eligible farmers through the Norpac cooperative.

3. Conduct outreach and get feedback on this version of the tool from stakeholders, defined user groups, and EQIP eligible producers.

4. Publish results of our work in peer reviewed publications.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

Although we have engaged in preliminary discussions with farmers through Norpac We have so far not engaged directly any EQIP eligible producers. We plan to involve these providers as part of our revised outreach portion of the project in the upcoming biennium.

The project does not include any direct or indirect payments to farmers.

CONSERVATION INNOVATION GRANTS
Semi-annual Progress Report

Grantee Name: Oregon State University, Dept. of Horticulture	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Agreement Number: 68-3A75-6-131	
Project Director: John Lambrinos	
Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 March 2009 – 1 September 2009	
Project End Date: 28 August 2010 (after one year extension)	

A) Summarize the work performed during the project period covered by this report:

1. Developed software components of the interface that generates spatially indexed data using Google Maps architecture.

2. Developed the software components of the communication between the interface tool and the servers where the geo-databases/process models reside.

3. Improved web-integrated interface that will engage farmers.

4. Conducted a workshop held as part of the Oregon Processed Vegetable Growers Meeting, Albany, OR. At the workshop we covered the importance of improving and conserving riparian habitat on farms, demonstrated the tool, and covered resources available to landowners for doing restoration.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

<u>Significant results and accomplishments</u>

We received significant feedback on the usability and value of the too from potential users at the Oregon Processed vegetable growers meeting. Feedback from this meeting was incorporated into revisions in the tool's user interface. Notably this involved changing the user interface to allow users to override the reporting estimates of current vegetation conditions derived from the remote sensing data.

We made additional software improvements to the tool, including speeding the calculation and processing times, improving database communications, and completing extensive debugging and user testing.

We also established field sites and started to deploy our field monitoring protocol in order to test the validity of tool outputs with actual field measurements.

<u>Lessons learned and changes</u>

We learned through our farmer outreach that being able to override initial tool reported conditions was an important design feature. Another important design feature identified by farmers was the ability to track the performance of the site over time.

C) Describe the work that you anticipate completing in the next six-month period:

1. Improve tool hosting and maintenance
   - A. Web portal and functional components
   - B. Sustaining tool and maintenance on components: Internet webserver, component web services, webpages, low level ESRI code.

2. Implementing testing program for system evaluation and quality assurance
   - A. Test for bugs and usability
   - B. Ground truth tool outputs using various data sources with real time estimates of shade on the ground

3. Develop outreach and feedback programs and associated materials; Incorporate demo feedback.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

We have engaged EQIP eligible producers as part of outreach workshop at the Oregon Processed Vegetable Growers Meeting.

The project does not include any direct or indirect payments to farmers.

CONSERVATION INNOVATION GRANTS
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Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 September 2009- 1 March 2010	
Project End Date: 28 August 2010 (after one year extension)	

A) Summarize the work performed during the project period covered by this report:

1. Improved tool hosting and maintenance of the core software components (internet webserver, component web services, webpages, low level ESRI code.

2. Implemented testing program for system evaluation and quality assurance
   A. Tested for bugs and usability

3. Develop outreach and feedback programs and associated materials; Incorporate demo feedback.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

Significant results and accomplishments
We completed the final working version of our tool. Our quantification tool provides landowners with estimates of solar heat loading along user defined sections of streams. Users can assess the degree to which management practices such as adding or removing riparian trees creates heat loading credits or deficits. The tool consists of four components that are linked through web services: 1) a graphical user interface; 2) geodatabases that store spatially indexed parameter values; 3) process models that calculate ecosystem service values; 4) a reporting interface the returns model outputs to the user. We believe that this general framework can produce more robust and accurate quantification systems as well as more accessible ecological information to individual landowners.
http://delphi.bioe.orst.edu/cig/

We did extensive in-house de-bugging of the final tool version and refined aspects of usability.

Lessons learned and changes
At this stage in the project we have already incorporated many lessons (see previous biannual report).

C) Describe the work that you anticipate completing in the next six-month period:

1. Validate tool output using field sampling of streams on farms of EQIP eligible produces. We have developed a field sampling protocol and will implement it this summer.

2. Conduct outreach and get feedback on this version of the tool from stakeholders, and defined user groups.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

We have engaged EQIP eligible producers as part of outreach workshop at the Oregon Processed Vegetable Growers Meeting. We have also established monitoring sites on three EQUIP eligible farms.

The project does not include any direct or indirect payments to farmers.

CONSERVATION INNOVATION GRANTS
Semi-annual Progress Report

Grantee Name: Oregon State University, Dept. of Horticulture	
Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds	
Agreement Number: 68-3A75-6-131	
Project Director: John Lambrinos	
Contact Information:	Phone Number: 541-737-3484 E-Mail: lambrinj@hort.oregonstate.edu
Period Covered by Report: 2 March 2010 – 28 August 2010	
Project End Date: 28 August 2010 (after one year extension)	

A) Summarize the work performed during the project period covered by this report:

1. Validated tool output using field sampling of streams in the Willamette Valley.

2. Conduct two outreach workshops for stakeholders, and users.

3. Develop printed and web-based outreach and materials.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

Significant results and accomplishments
We validated the accuracy of the webtool outputs with field measured estimates of stream vegetation characteristics, shade conditions and temperature. Data were collected at 22 sites. Field collected data indicate that the webtool provides a robust estimate of current shade conditions.

We produced a detailed website and associated user guide explaining the purpose of the tool and how to use it.
http://groups.hort.oregonstate.edu/content/stream-shade-tool

We also developed a field assessment and monitoring protocol to allow landowners to update the webtool estimates of current shade and to monitor the progress of restoration sites in terms of shade provisioning.

We developed a simple worksheet for landowners to compile a portfolio of potential ecosystem services credits. The worksheet introduces landowners to our Stream Shade Calculator as well as the USDA's Nutrient Trading Tool. These two new webtools allow landowners to estimate the potential ecosystem service benefits that could accrue by conducting riparian restoration and other conservation practices. Both tools report these potential benefits in units that are directly applicable to ecosystem service markets being developed in the Willamette Valley.

We conducted two workshops held at the Oregon Garden. The workshops introduced the latest version of the tool, covered resources available for doing restoration and improving ecosystem services, and discussed emerging market based programs in Oregon. Workshop participants included representatives from local and regional agencies, city governments, and private landowners. Approximately 25 participants attended each workshop.

<u>Lessons learned and changes</u>
These will be enumerated in detail in the final report.

C) Describe the work that you anticipate completing in the next six-month period:
With the exception of writing the final report and publishing results in peer reviewed journals, the project is complete.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;
2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.
3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

We have engaged EQIP eligible producers as part of the outreach workshops, and we have also established monitoring sites on three EQUIP eligible farms.

The project does not include any direct or indirect payments to farmers.

APPENDIX III

Request for No Cost Extension

Dear Ms Leonard:

This is a request for a no-cost extension for the following CIG project:

<table>
<tr><td colspan="2">Grantee Name: Oregon State University, Dept. of Horticulture</td></tr>
<tr><td colspan="2">Project Title: Landowner tool for quantifying multiple environmental services of riparian vegetation buffers for use in water quality trading in Oregon Watersheds</td></tr>
<tr><td colspan="2">Agreement Number: 68-3A75-6-131</td></tr>
<tr><td colspan="2">Project Director: John Lambrinos</td></tr>
<tr><td>Contact Information:</td><td>Phone Number: 541-737-3484
E-Mail: lambrinj@hort.oregonstate.edu</td></tr>
<tr><td colspan="2">Project End Date: 27 August 2009</td></tr>
</table>

1. Length of additional time requested and justification

We request a one year extension to complete our project goals and objectives.

As described in our original proposal our project's objects are to: 1) Compile existing assessment models into a single practical tool to evaluate the potential ecological value of riparian restoration in units that relate directly to ecosystem services that have known or potential buyers. 2) Implement a restoration monitoring protocol to assess the current and future ecological value of restoration sites in terms of these defined ecosystem services. 3) Test the usability, cost, and transferability of the monitoring tool. We expected to complete these objectives over the following schedule:

Project Action	Time Frame	Milestone
Compilation of protocol database	July 2006-Dec. 2006	
Evaluation of protocols	July 2006-Dec 2006	
Development of assessment tool interface	July 2006-March 2007	Working version of assessment tool: **March 2007**
Implementation of monitoring protocol	March 2007-July 2009	Establishment of monitoring sites: **March 2007**
Evaluation of monitoring costs and transferability	March 2007-July 2009	Final report: **July 2009**

We have made significant progress toward broadly fulfilling these objectives. However, as we describe in our semi-annual reports we have adjusted several aspects of our project design and this has caused delays in our project execution by about one year. We have completed a working prototype of our tool and are beginning field testing with cooperating EQIP eligible producers this summer. We request a year extension to complete the remaining outreach goals of our project including feedback from EQIP eligible producers on tool functionality.

We believe that the changes we made to the project caused delays but also produced a significantly more advanced restoration tool and have greatly improved the overall value of our project over what was originally envisioned.

We briefly outline these improvements to project design and their impact on the project schedule:

A. Significant change to tool design. Our original plan for developing a riparian restoration tool called for compiling existing evaluation and monitoring protocols into a low tech delivery mechanism such as an Excel spreadsheet or a handwritten worksheet. Early in the project development we realized that this actually was technically difficult and the resulting output was unsatisfactory in many ways. Instead, we realized that cutting edge developments in the design of web-services and integrating GIS databases into a distributed computing framework could allow the development of powerful, interactive, yet user friendly tool. We saw this as a vastly significant improvement over our original plan. During our annual review our grant officers (Todd Peplin and Kathryn Boyer) agreed that this represented a significant advance.

However, the shift in our design plan caused an initial delay in project development as we had to recruit a team member with the required high level programming and systems design skills. In addition because tool development now involved programming and sophisticated integration of GIS databases the pace of tool development progressed more slowly than originally planned. In our original plan we expected to have a working tool within the first year of the project. Because of delays in recruiting specialized personnel and in the slower pace of tool development we did not actually have a working prototype until well into the second year of the project. This delay pushed back execution of project elements that required a working tool prototype such as the design and implementation of field testing and grower outreach.

B. Revised grower outreach plan. The delay in tool development caused a concomitant delay in the implementation of field testing and outreach plan. The changes in tool design also caused us to re-evaluate our outreach plan. Our original outreach plan called for working with EQIP eligible growers in the Tualatin basin who had worked previously

With Clean Water Services as part of the CWS-DEQ temperature trading agreement. This party reflects the fact that the original tool design was meant only to cover the Tualatin Basin. However, as we developed the tool it became possible to expand the tool coverage area to include the entire Willamette Valley. Indeed, we got strong feedback from key project stakeholders that expanded coverage was a key tool requirement. We felt that it was necessary to correspondingly expand the geographical reach of our outreach efforts. Our revised outreach plan calls for engaging EQIP eligible farmers through Norpac, a large Oregon based grower cooperative.

We think that this revised outreach plan opens the door to some potentially innovated future directions. One promising approach to implementing more effective restoration is to engage farmers in cooperative networks that explicitly integrate individual efforts into a landscape-scale restoration plan. Existing grower cooperatives could be a powerful tool for doing this. Norpac has for 5 years conducted a sustainability program developed in cooperation with the Food Alliance and OSU. Recently, Norpac farmers identified wildlife conservation as one of their most difficult sustainability goals, and identified riparian restoration as their wildlife conservation priority. We think that our tool could be used to help design cooperative restoration strategies and to help quantify the collective benefits of restoration created by groups of farmers.

These changes in our outreach plan combined with the delay in tool development have caused an approximately one year delay in our outreach and field testing plans. We are currently working with Norpac growers in cooperation with our local NRCS office to implement begin implementing our plan this summer.

2. Summary of progress to date.

As outlined in our semi-annual reports we have produced a working prototype of our restoration tool. Specific milestones are:

A. We have completed v. 2.0 of our working prototype. This version allows a user to select any point along a stream course in the Willamette valley and receive an estimate of the potential stream shading that could be achieved at that point. The prototype allows the user to input current vegetation parameters and to recalculate the potential shade credit. The design of the prototype as several key advantages and innovations:

- A distributed design allows real time exchange of information between the owners and maintainers of the system components (e.g. spatial data, models, registration). This is particularly valuable because many of the parameter values needed to calculate ES are highly dynamic.
- Modular design also allows easy updates to system components such as new models, changes to spatial database management requirements, etc.
- Tool outputs are indexed to a national spatial database standard (the NHD). This allows easy access to other spatial data indexed to the standard.

- The design is capable of "versioning", allows easy data storage, retrieval, and sharing. This is a requirement ES estimates and market transactions that are traceable and defensible.

B. We gathered feedback on our prototype from outside developers working on related tools as well as key project stakeholders such as the Willamette Partnership and Clean Water Services. This feedback was used to develop our revised tool development and outreach plan, which has contributed to the delay in the project schedule.

C. We presented our concept design at the annual meeting of the American Association of Agricultural and Biological Engineers in 2008. We also have abstract accepted for two upcoming meetings this summer: the Annual Meeting of the Ecological Society of America and the Annual Meeting of the American Fisheries Society.

D. We began work on v 2.1 of our prototype tool. The goals for this version are to incorporate new high resolution riparian vegetation layers and to improve the usability of the tool interface. We made significant progress on improving the tool usability. To this end we have:

- Compiled existing restoration and planting protocols for riparian habitat in the Willamette Valley. These protocols will be incorporated as part of the user documentation for the tool.
- Compiled a database of tree planting costs for riparian restoration in the Willamette valley. These estimates are based on current nursery prices for recommended tree species, recommended planting densities, and estimates of associated costs derived from existing projects in the Willamette Valley. This database will allow us to produce rough installation cost estimates for user defined sections of stream. We will return these estimates along with the potential stream shading estimates

E. We developed a field testing and ground truth protocol to assess the accuracy of the tool. The protocol allows us to quickly collect the underlying parameter values needed to estimate stream shading. We have done a preliminary test of the protocol using a section of stream that runs through agricultural land on the OSU campus. The data from the ground testing protocol will allow us to evaluate the output accuracy of our prototype tool.

F. We developed contacts with Norpac, an Oregon-based farmer cooperative to conduct field testing and outreach efforts for the tool this summer with their EQIP eligible growers.

3. Estimate of funds expected to remain unobligated on the scheduled expiration date.

We expected to have $50,000 unobligated on 27 August 2009, the scheduled project expiration date. This represents the remaining funds allocated for field implementation and testing (mostly travel to field locations) and outreach activities such as grower meetings and outreach materials.

4. Projected timetable to complete the portions(s) of the project for which the extension is being required.

We will complete the field testing and outreach portions for which the extension is requested as follows:

Project Action	Time Frame	Milestone
Compilation of initial field testing and tool verification With EQIP eligible producers	27 Aug-Oct. 2009	Data set of field stream condition measurements and analysis of tool accuracy
Grower outreach and feedback meeting	Nov. 2009	Tool final revision plan: **Nov. 2009**
Final revisions to tool based on grower input	Nov. 2009- Mar. 2010	Final version of tool: **March 2010**
Development of outreach materials (website, extension publications).	March-July 2010	Final tool documentation: **July 2010**
Evaluation of project	July-August 2010	Final report: **July 2009**

5. Signature of the grantee and the project director.

____

John Lambrinos

6. Status of cost-sharing to date.

We have met and documented our cash cost-sharing obligations totaling $90,556. Our cooperators have also provided in-kind cost sharing totaling $81,650.

APPENDIX IV

User Guide and Instructions

Shade Tool Calculator

1. Coverage Area

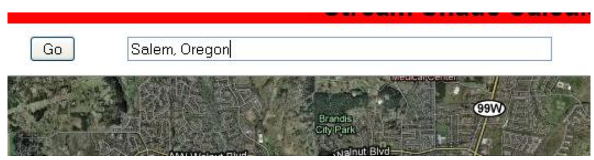
1.1 The calculator is designed to provide results for the riparian zones in the Willamette Valley basin (See Map 1). The working area for calculating the potential vegetation and shading consists of 120 foot buffers around all the streams in the basin. The calculator does not work outside of these buffers.

1.2. We use Lidar data provided by the Oregon Department of Geology and Mineral Industries (DOGAMI) to provide estimates of current vegetation height along streams. Map 1 shows the current extent of this coverage in our tool. Outside of this coverage area the calculator does not report current vegetation characteristics. Users, however, can supply field estimates for vegetation parameters.

2. Navigation

The calculator is based on a Google Maps interface, so if you are familiar with that you should have no problem.

2.1 You can navigate to a place name, a street address, or lat long coordinates by typing it into the dialog box at the upper right of the screen and pressing enter or the “go button”

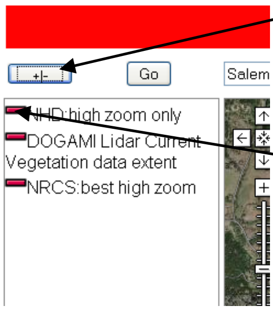


2.2 You can zoom and pan using the controller on the left hand side of the screen, or using mouse controls.

2.3 Just like in Google maps, you can toggle between different map views

One good navigation strategy is to use the navigation box to get near your site of interest and then to pan and zoom to reach your target.

3. Data Layers and extent



2.1 The +/- toggle button in the top left corner exposes and hides the data layer panel.

You can turn each data layer on and off by clicking on their own toggle buttons

3.2 The NHD ("National Hydrologic Dataset") layer displays the stream courses. This is useful for finding your stream of interest. **Note:** that the stream courses only become visible at the highest zoom levels.

3.3 The DOGAMI Lidar displays the current extent of our vegetation data. **Note:** currently the tool provides current vegetation data for the majority of streams in the Willamette Valley, but we have not operationalized the Portland Metro Area and other parts of the northern valley. In these areas a warning appears in the output box indicating that you our outside of the current vegetation coverage area.

3.4 The NRCS displays the USDA soil survey codes.

4. Digitizing Streams and Calculating Results

Once you navigate to your stream of interest, the next step is to digitize it.

4.1 You begin digitizing but clicking one of the two digitizer pencil icons on the upper right side of the screen. The single dot pencil digitizes points and is useful for getting a quick reading from a single spot. The double dot pencil digitizes line segments, and is what you need to digitize a stream reach.

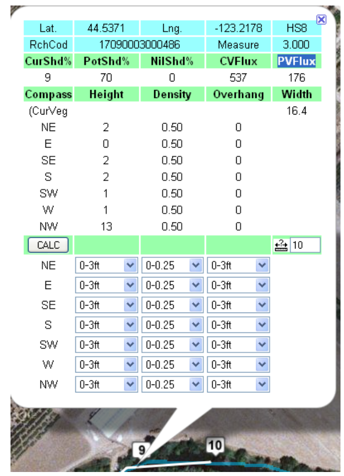
4.2 To start digitizing click (and release) at the beginning of your stream reach. This will create a point. Continue outlining the stream with your curser. To negotiate bends and curves use mouse clicks to place another point and create a new line segment. When you reach the end of your stream click to place an end point and click again on the point to finish digitizing. Your curser icon should then return to normal.

4.3 Once you have digitized your stream line or point click the 

button to calculate output.

4.4 Depending on the length of your stream, calculation time may take up to a few minutes. When complete, the icons will display numbers that indicate the % shade at that point in the stream.

4.5 You can click on each of the points to display an information window that provides the lat long coordinates, the NHD reach code and measure, and the following calculated values:



CurShd% : current % shade
PotShd%: estimated potential % shade following restoration
NilShd%: % topographic shading
CVFlux: current solar flux (kcal/ft^2/day)
PVFlux: estimated potential solar flux (kcal/ft^2/day)

4.6 The info window also displays the current vegetation characteristics for the riparian zone closest to the stream bank along each of seven cardinal directions relative to the stream bank: Height (ft), canopy density (%), bank overhang (ft) and stream width (ft).

5. <u>Getting results for a full stream reach</u>

The initial calculation provides results for points spaced every 100m along your digitized stream reach. To get integrated summary results for your entire length of stream you will need to generate a report (see section 7).

NOTE: You can digitize multiple stream reaches or points at the same time. When you generate a report the results will be summarized for each stream reach and point separately.

6. <u>Changing the Current Vegetation and Stream Width</u>

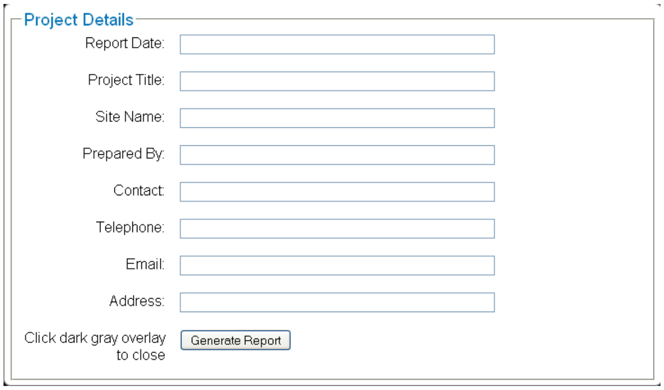
You may need to add field collected current vegetation characteristics because your stream is outside of the Calculator's lidar coverage area. You might also want to adjust the current vegetation characteristics that we report from the lidar data (for instance if trees were recently removed). Also, currently the tool does not automatically calculate the stream's wetted width. Instead we assume an average value of 16 ft. This is typical for many small and medium sized streams in our region at the end of summer. However, variation in wetted width has an influence on shade, particularly at the extremes. You can override the default wetted width.

6.1 To change current vegetation characteristics and wetted width use the input panels on the bottom half of the info window. You can change each of the reported vegetation characteristics along each of the seven cardinal directions relative to the stream. See Appendix VII for a brief protocol for measuring vegetation and width characteristics of your stream in the field.

7. Generate a Report

To print a summary report of your results click the printer icon.

7.1 After pressing the printer icon an input window will appear where you can add details about your project to your report. You can enter as much or as little information as you want (including none at all). When you are done press the "generate report" button or click on the dark gray overlay to close the dialog box and return to the map view



7.2 After pressing the generate report button, the Calculator will generate a PDF report in a separate browser window that you can save to your local computer or print. The report contains five sections:

i. user added project details
ii. summary of the methods used to calculate the results
iii. summary of current stream shading thermal load from solar radiation
iv. summary of potential stream shading and thermal load from solar radiation
v. summary of the potential benefit from restoration in terms of shading and thermal load.

9. Privacy

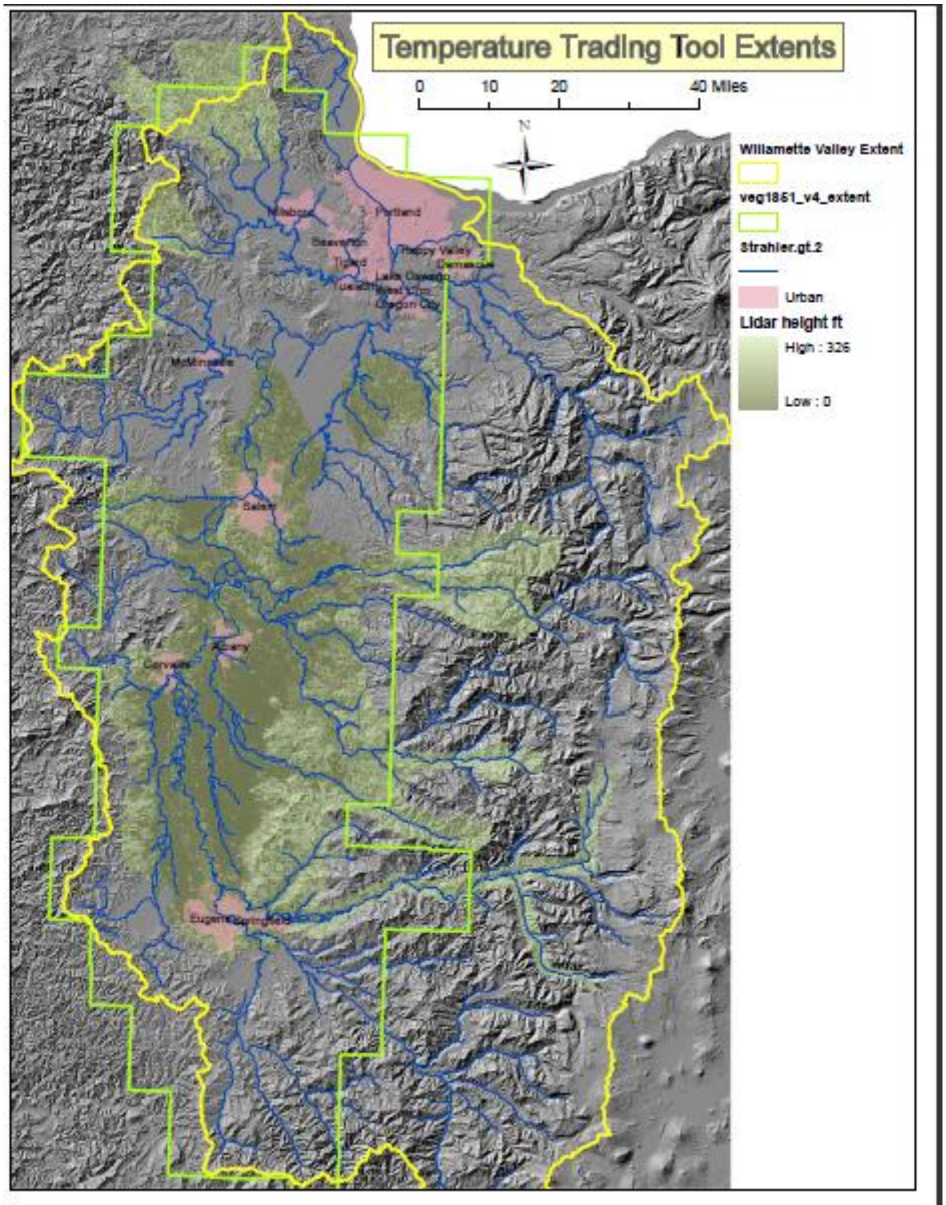
We do not collect or store any personal information or the calculated results of any user session. While you can print or save the summary report of the results for your own use we do not keep or share any of this information.

10. Caveats, Limitations, and Disclaimers

Unfortunately, fully quantifying the habitat quality of your stream is not as simple as measuring shade. Habitat quality involves a number of different parameters beyond shade like in stream refugia and water levels. It also varies for the specific species you are interested in and depends somewhat on the conditions beyond your stream in the greater watershed. Still, shade is a significant component of overall habitat quality, and it is relatively straightforward to measure and compare.

The calculator is meant only to help you get a sense of your stream's current shade conditions and potential for improvement. This calculator does not provide an official estimate of restoration potential or ecosystem service credits. Use the calculator at your own risk. No claims are given regarding the accuracy and precision of this calculator.

Map 1
Extents of the data layers used by the Stream Shade Calculator



APPENDIX V

Site and shade characteristics of 173 data points used for field validation of the Shade tool. ACD is Angular Canopy Density measured in the field, ShdCurVeg is current shade estimate for the site calculated from the Web Shade Tool; ShdPotVeg is the potential shade estimate for the site calculated from the Web Shade Tool.

ID	Long	Lat	NHD	Reach	Stream	Land Use	Rest.	ACD	ShdCurVeg	ShdPotVeg
1	-123.288	44.559	1.71E+13	AnimalSci	Oak	AG	No	16.25	45.84	68.80
2	-123.287	44.559	1.71E+13	AnimalSci	Oak	AG	No	87.50	68.94	69.20
3	-123.287	44.559	1.71E+13	AnimalSci	Oak	AG	No	66.25	69.58	68.80
4	-123.287	44.558	1.71E+13	AnimalSci	Oak	AG	No	62.50	74.17	68.80
5	-123.286	44.558	1.71E+13	AnimalSci	Oak	AG	No	76.25	67.41	69.03
6	-123.286	44.558	1.71E+13	AnimalSci	Oak	AG	No	26.25	60.66	68.96
7	-123.286	44.558	1.71E+13	AnimalSci	Oak	AG	No	65.00	66.37	69.31
8	-123.285	44.558	1.71E+13	AnimalSci	Oak	AG	No	76.25	65.27	68.82
9	-123.285	44.559	1.71E+13	AnimalSci	Oak	AG	No	71.25	65.59	68.93
10	-123.285	44.559	1.71E+13	AnimalSci	Oak	AG	No	71.25	72.27	68.97
11	-123.327	44.569	1.71E+13	BHMeadow	BaldHill	AG	No	3.75	0.53	77.01
12	-123.327	44.569	1.71E+13	BHMeadow	Bald Hill	AG	No	0.00	0.53	77.00
13	-123.328	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	0.57	77.03
14	-123.328	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	1.47	77.24
15	-123.328	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	1.24	77.36
16	-123.329	44.569	1.71E+13	BHMeadow	BaldHill	AG	No	0.00	2.03	77.52
17	-123.329	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	3.29	77.67
18	-123.329	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	48.75	5.49	77.28
19	-123.330	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	23.56	80.03

20	-123.330	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	0.00	2.48	77.11
21	-123.330	44.569	1.71E+13	BHMeadow	Baldhill	AG	No	2.50	11.04	77.35
22	-123.301	44.567	1.71E+13	cb-east1	Oak	AG	Yes	47.50	45.11	71.32
23	-123.301	44.567	1.71E+13	cb-east1	Oak	AG	Yes	33.75	53.52	68.81
24	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	72.50	70.56	67.26
25	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	60.00	68.13	67.36
26	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	77.50	75.40	67.83
27	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	65.00	76.46	67.44
28	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	50.00	71.91	67.22
29	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	75.00	74.95	67.26
30	-123.300	44.566	1.71E+13	cb-east1	Oak	AG	Yes	72.50	62.78	67.63
31	-123.299	44.565	1.71E+13	cb-east1	Oak	AG	Yes	70.00	65.51	67.47
32	-123.299	44.565	1.71E+13	cb-east2	Oak	AG	Yes	58.75	67.58	67.66
33	-123.299	44.565	1.71E+13	cb-east2	Oak	AG	Yes	60.00	71.06	67.55
34	-123.299	44.565	1.71E+13	cb-east2	Oak	AG	Yes	55.00	70.58	67.62
35	-123.299	44.565	1.71E+13	cb-east2	Oak	AG	Yes	52.50	70.32	67.54
36	-123.298	44.565	1.71E+13	cb-east2	Oak	AG	Yes	63.75	69.60	67.79
37	-123.298	44.564	1.71E+13	cb-east2	Oak	AG	Yes	62.50	69.86	67.35
38	-123.298	44.564	1.71E+13	cb-east2	Oak	AG	Yes	52.50	74.75	67.37
39	-123.298	44.564	1.71E+13	cb-east2	Oak	AG	Yes	46.25	77.55	67.68
40	-123.297	44.564	1.71E+13	cb-east2	Oak	AG	Yes	53.75	74.54	67.38
41	-123.297	44.564	1.71E+13	cb-east2	Oak	AG	Yes	70.00	75.85	68.36
42	-123.297	44.565	1.71E+13	cb-east3	Oak	AG	Yes	47.50	73.15	73.03
43	-123.296	44.565	1.71E+13	cb-east3	Oak	AG	Yes	77.50	72.68	73.09

44	-123.296	44.564	1.71E+13	cb-east3	Oak	AG	Yes	72.50	71.95	68.70
45	-123.296	44.564	1.71E+13	cb-east3	Oak	AG	Yes	71.25	73.74	67.33
46	-123.295	44.564	1.71E+13	cb-east3	Oak	AG	Yes	63.75	57.52	67.28
47	-123.295	44.564	1.71E+13	cb-east3	Oak	AG	Yes	78.75	70.08	67.21
48	-123.295	44.564	1.71E+13	cb-east3	Oak	AG	Yes	67.50	57.82	67.22
49	-123.295	44.563	1.71E+13	cb-east3	Oak	AG	Yes	72.50	74.70	67.37
50	-123.294	44.563	1.71E+13	cb-east3	Oak	AG	Yes	68.75	63.41	67.28
51	-123.301	44.567	1.71E+13	cb-west1	Oak	AG	Yes	65.00	51.40	73.45
52	-123.302	44.567	1.71E+13	cb-west1	Oak	AG	Yes	37.50	64.53	73.75
53	-123.302	44.567	1.71E+13	cb-west1	Oak	AG	Yes	46.25	71.99	73.25
54	-123.302	44.567	1.71E+13	cb-west1	oak	AG	Yes	67.50	62.77	72.12
55	-123.302	44.567	1.71E+13	cb-west1	Oak	AG	Yes	27.50	58.09	68.19
56	-123.303	44.567	1.71E+13	cb-west1	Oak	AG	Yes	68.75	66.33	67.68
57	-123.303	44.567	1.71E+13	cb-west1	Oak	AG	Yes	57.50	43.68	67.16
58	-123.303	44.567	1.71E+13	cb-west1	oak	AG	Yes	60.00	60.84	67.70
59	-123.303	44.567	1.71E+13	cb-west1	Oak	AG	Yes	31.25	47.23	68.34
60	-123.304	44.567	1.71E+13	cb-west1	Oak	AG	Yes	80.00	43.52	67.87
61	-123.304	44.567	1.71E+13	cb-west1	Oak	AG	Yes	6.25	39.54	68.15
62	-123.304	44.567	1.71E+13	cb-west2	Oak	AG	Yes	41.25	39.58	67.58
63	-123.304	44.567	1.71E+13	cb-west2	Oak	AG	Yes	88.75	60.95	68.01
64	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	75.00	54.54	67.50
65	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	26.25	43.62	67.75
66	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	72.50	58.81	67.75
67	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	46.25	37.06	68.10

68	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	51.25	38.42	68.20
69	-123.304	44.568	1.71E+13	cb-west2	Oak	AG	Yes	26.25	50.60	68.78
70	-123.305	44.568	1.71E+13	cb-west2	Oak	AG	Yes	70.00	50.62	68.89
71	-123.305	44.568	1.71E+13	cb-west2	Oak	AG	Yes	23.00	37.95	68.23
72	-123.305	44.568	1.71E+13	cb-west2	Oak	AG	Yes	83.75	60.71	68.33
73	-123.305	44.568	1.71E+13	cb-west3	Oak	AG	Yes	20.00	55.62	68.09
74	-123.306	44.569	1.71E+13	cb-west3	Oak	AG	Yes	73.75	63.28	67.90
75	-123.306	44.569	1.71E+13	cb-west3	Oak	AG	Yes	75.00	57.05	68.55
76	-123.306	44.569	1.71E+13	cb-west3	Oak	AG	Yes	41.25	69.37	68.62
77	-123.307	44.569	1.71E+13	cb-west3	Oak	AG	Yes	51.25	70.61	69.54
78	-123.307	44.569	1.71E+13	cb-west3	Oak	AG	Yes	13.75	60.13	68.29
79	-123.307	44.569	1.71E+13	Cb-west3	Oak	AG	Yes	61.25	73.15	69.34
80	-123.307	44.569	1.71E+13	Cb-west3	Oak	AG	Yes	68.75	71.36	67.98
81	-123.308	44.570	1.71E+13	cb-west3	Oak	AG	Yes	71.25	68.79	67.48
82	-123.307	44.570	1.71E+13	cb-west4	Oak	AG	Yes	35.00	65.79	67.96
83	-123.308	44.570	1.71E+13	cb-west4	Oak	AG	Yes	60.00	69.76	67.62
84	-123.308	44.570	1.71E+13	cb-west4	Oak	AG	Yes	48.75	58.91	67.61
85	-123.308	44.570	1.71E+13	cb-west4	Oak	AG	Yes	65.00	77.05	68.28
86	-123.308	44.570	1.71E+13	cb-west4	Oak	AG	Yes	80.00	65.16	72.02
87	-123.309	44.570	1.71E+13	cb-west4	Oak	AG	Yes	23.75	48.76	73.46
88	-123.309	44.570	1.71E+13	cb-west4	Oak	AG	Yes	57.50	52.88	73.74
89	-123.309	44.571	1.71E+13	cb-west4	Oak	AG	Yes	28.75	54.79	73.35
90	-123.309	44.571	1.71E+13	cb-west4	Oak	AG	Yes	62.50	48.68	73.66
91	-123.309	44.571	1.71E+13	cb-west4	Oak	AG	Yes	76.25	59.16	73.55

92	-123.265	44.575	1.71E+13	CHS	Dixon	Urban	No	30.00	30.91	69.28
93	-123.266	44.575	1.71E+13	CHS	Dixon	Urban	No	50.50	53.37	70.47
94	-123.266	44.575	1.71E+13	CHS	Dixon	Urban	No	68.75	65.19	69.98
95	-123.266	44.576	1.71E+13	CHS	Dixon	Urban	No	62.50	35.58	69.49
96	-123.266	44.576	1.71E+13	CHS	Dixon	Urban	No	57.50	31.60	69.00
97	-123.267	44.576	1.71E+13	CHS	Dixon	Urban	No	13.75	17.23	69.42
98	-123.267	44.576	1.71E+13	CHS	Dixon	Urban	No	17.50	26.86	69.37
99	-123.267	44.576	1.71E+13	CHS	Dixon	Urban	No	72.50	52.76	69.63
100	-123.268	44.576	1.71E+13	CHS	Dixon	Urban	No	82.50	66.83	69.72
101	-123.282	44.557	1.71E+13	Hilton	Oak	Urban	No	67.50	65.39	68.77
102	-123.282	44.557	1.71E+13	Hilton	Oak	Urban	No	60.00	63.53	68.78
103	-123.282	44.556	1.71E+13	Hilton	Oak	Urban	No	72.50	61.70	68.79
104	-123.281	44.556	1.71E+13	Hilton	Oak	Urban	No	61.25	69.16	68.77
105	-123.281	44.556	1.71E+13	Hilton	Oak	Urban	No	71.25	64.02	68.77
106	-123.281	44.556	1.71E+13	Hilton	Oak	Urban	No	28.00	66.61	68.77
107	-123.280	44.556	1.71E+13	Hilton	Oak	Urban	No	80.00	72.28	68.77
108	-123.280	44.556	1.71E+13	Hilton	Oak	Urban	No	90.00	60.17	68.76
109	-123.280	44.556	1.71E+13	Hilton	Oak	Urban	No	55.00	41.15	68.76
110	-123.280	44.556	1.71E+13	Hilton	Oak	Urban	No	16.25	38.85	68.77
111	-123.289	44.560	1.71E+13	OCCUH	Oak	Urban	No	23.75	44.45	69.06
112	-123.289	44.560	1.71E+13	OCCUH	Oak	Urban	No	70.00	47.31	69.12
113	-123.289	44.560	1.71E+13	OCCUH	Oak	Urban	No	85.00	67.03	68.86
114	-123.289	44.560	1.71E+13	OCCUH	Oak	Urban	No	72.50	68.78	68.78
115	-123.289	44.560	1.71E+13	OCCUH	Oak	Urban	No	61.25	60.29	68.80

116	-123.289	44.559	1.71E+13	OCCUH	Oak	Urban	No	65.00	71.90	68.78
117	-123.289	44.559	1.71E+13	OCCUH	Oak	Urban	No	51.25	59.62	68.86
118	-123.289	44.559	1.71E+13	OCCUH	Oak	Urban	No	72.50	52.47	68.88
119	-123.288	44.559	1.71E+13	OCCUH	Oak	Urban	No	90.00	59.30	68.78
120	-123.288	44.559	1.71E+13	OCCUH	Oak	Urban	No	50.00	56.71	68.82
121	-123.289	44.559	1.71E+13	OCCUH	Oak	Urban	No	48.75	55.75	68.85
122	-123.284	44.559	1.71E+13	Reser	Oak	Urban	No	90.00	69.31	69.62
123	-123.284	44.558	1.71E+13	Reser	Oak	Urban	No	62.50	72.04	69.32
125	-123.284	44.558	1.71E+13	Reser	Oak	Urban	No	76.25	73.98	69.20
126	-123.284	44.559	1.71E+13	Reser	Oak	Urban	No	70.00	74.09	68.80
127	-123.283	44.559	1.71E+13	Reser	Oak	Urban	No	71.25	63.49	73.01
128	-123.283	44.558	1.71E+13	Reser	Oak	Urban	No	67.50	70.88	69.90
129	-123.283	44.558	1.71E+13	Reser	Oak	Urban	No	52.50	68.11	70.09
130	-123.283	44.558	1.71E+13	Reser	Oak	Urban	No	52.50	57.65	69.01
131	-123.283	44.558	1.71E+13	Reser	Oak	Urban	No	83.75	64.16	68.79
132	-123.282	44.558	1.71E+13	Reser	Oak	Urban	No	78.75	64.86	68.80
133	-123.282	44.558	1.71E+13	Reser	Oak	Urban	No	45.00	65.58	68.78
134	-123.282	44.557	1.71E+13	Reser	Oak	Urban	No	53.75	39.44	68.79
135	-123.308	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	67.50	16.83	67.54
136	-123.308	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	1.75	10.90	67.16
137	-123.308	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	6.25	7.12	67.10
138	-123.308	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	68.75	31.61	66.31
139	-123.309	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	8.00	20.68	66.19
140	-123.309	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	28.75	48.61	66.42

141	-123.309	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	78.75	48.98	66.51
142	-123.310	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	65.00	43.30	66.64
143	-123.310	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	56.25	44.08	67.30
144	-123.310	44.550	1.71E+13	Safeway	Dunawi	Urban	Yes	41.25	29.26	67.36
145	-123.260	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	42.50	17.58	70.28
146	-123.260	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	68.75	40.28	69.70
147	-123.260	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	67.50	19.28	70.39
148	-123.261	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	36.25	21.29	68.92
149	-123.261	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	86.25	32.64	68.95
150	-123.261	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	68.75	29.77	70.66
151	-123.261	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	8.75	23.57	68.94
152	-123.262	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	67.50	14.38	70.12
153	-123.262	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	1.00	9.32	70.88
154	-123.262	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	0.50	10.24	69.08
155	-123.263	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	37.50	20.49	70.03
156	-123.263	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	7.50	17.79	69.38
157	-123.263	44.573	1.71E+13	Sunflower	Dixon	Urban	Yes	32.50	19.90	69.94
158	-123.301	44.548	1.71E+13	Sunset	Dunawi	Urban	Yes	3.75	14.20	67.15
159	-123.301	44.548	1.71E+13	Sunset	Dunawi	Urban	Yes	70.00	53.58	67.15
160	-123.302	44.548	1.71E+13	Sunset	Dunawi	Urban	Yes	28.75	60.65	67.15
161	-123.302	44.548	1.71E+13	Sunset	Dunawi	Urban	Yes	65.00	60.64	67.15
162	-123.303	44.548	1.71E+13	Sunset	Dunawi	Urban	Yes	6.25	49.45	67.17
163	-123.303	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	11.25	32.50	66.05
164	-123.303	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	31.25	50.40	66.07

165	-123.304	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	43.75	59.41	66.31
166	-123.304	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	17.50	29.36	66.33
167	-123.304	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	46.25	17.77	66.29
168	-123.305	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	17.50	26.71	66.40
169	-123.305	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	1.25	3.92	66.51
170	-123.306	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	0.00	1.43	66.59
171	-123.306	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	1.25	5.86	66.63
172	-123.306	44.549	1.71E+13	Sunset	Dunawi	Urban	Yes	8.75	21.45	66.49
173	-123.307	44.550	1.71E+13	Sunset	Dunawi	Urban	Yes	8.75	8.52	67.38

APPENDIX VI

Ecosystem Credit Worksheet (following pages)

Quantifying Ecosystem Services
Your land provides a number of goods and services. Some of these, like agricultural commodities, are straightforward to measure and value. Others, like the fish habitat or water quality benefits provided by riparian vegetation, are harder to quantify. New web-based tools can help you get a quick measure of some of these ecosystem services, as well as demonstrate how changing management practices could help enhance these services on your property. This worksheet introduces you to these tools, and allows you to compile an unofficial portfolio of some of the existing and potential ecosystem services on your land. The back of the worksheet provides links to supporting organizations and agencies that can help you actually do restoration.

Shade
One simple way to improve stream conditions for fish is to plant trees that restore water cooling shade. The OSU Stream Shade Calculator provides you with a quick and reliable estimate of your stream's current shade condition and its potential for restoration. Use the calculator to estimate you stream's current and potential heat loading. The difference is the potential thermal benefit you could see from doing a restoration.

Current heat load (kcal/day/ft): __________________

Heat load after restoration (kcal/day/ft): __________________

Potential heat load reduction (Kcal/day/ft): __________________

Nutrient and Sediment Retention
The loss of nutrients and sediment from land can be a major source of water pollution. Conservation practices such as expert nutrient management, reduced tillage, and the presence of riparian buffers can greatly improve the retention potential of your land. The USDA **Nutrient Trading Tool (NTT)** allows you to enter a baseline management system, an alternative conservation management system and produce a report showing the nitrogen, phosphorous, and sediment loss potential difference between the two systems. Test a current and alternate management strategy using the tool and report the results:

Loss From Field	Baseline	Alternative	Difference
Total N (lb./ac.)			
Total P (lb./ac.)			
Runoff (in.)			
Sediment (t/ac.)			

Getting Help for Restoration
The webtools on the opposite page give you a picture of the potential for ecosystem improvements on your land. So how do you go about making changes? A number of programs exist to help you preserve or enhance ecosystem services on your property. The Natural Resources Conservation Service, your Soil and Water Conservation District, and your Watershed Council can provide a wealth of technical assistance for planning and implementing a restoration project. In addition they can help you access a number of incentive and cost share programs to help offset the costs of improving ecosystem services on your land. One of the best ways to learn about these resources, as well as the emerging resources described below, is to contact your local USDA Service Center.

Emerging Tools
There are exciting new programs currently being piloted that promise to help make doing restoration on your land easier and potentially profitable.

The Freshwater Trust is developing an innovative program to help ease and simplify the often complex process of doing restoration. StreamBank is a web based tool that enables landowners and restoration professionals to efficiently fund, permit and implement a restoration project.

Improving the ecosystem services provided by your land is a benefit to society as a whole. There are developing efforts to help compensate you for providing this greater good. The idea is to treat ecosystem services just like any other commodity produced by a farm, and then to match willing sellers with buyers in a market. The Willamette Partnership has been working to develop just such a market in the Willamette Valley, and they have started several pilot projects demonstrating how such a market could work to increase the pace, scope, and effectiveness of conservation.

List of Weblinks:
Stream Shade Calculator: http://groups.hort.oregonstate.edu/content/stream-shade-tool
Nutrient Trading Tool: http://ntt.tarleton.edu/nttwebars/%28S%28g4ia3445meblxciivpiw0m45%29%29/Default.aspx
Natural Resources Conservation Service: http://www.or.nrcs.usda.gov/
Soil and Water Conservation Districts: http://www.oacd.org/districts.shtml
Watershed Councils: http://oregonwatersheds.org/oregoncouncils
Freshwater Trust: http://www.thefreshwatertrust.org/
StreamBank: http://www.thefreshwatertrust.org/conservation/streambank/streambank-solution
Willamette Partnership: http://willamettepartnership.org/

DISCLAIMER: The worksheet and the associated webtools are for informational purposes only. They do not provide an official estimate of restoration potential or ecosystem service credits.

APPENDIX VII

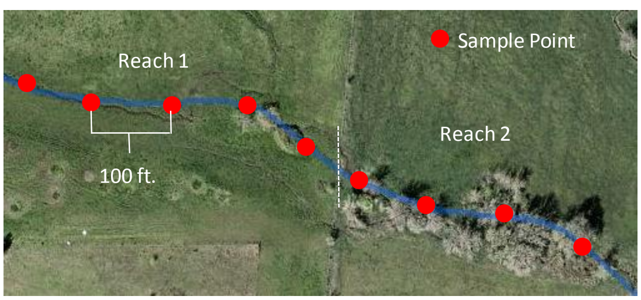
Protocols for Measuring Stream Characteristics in the Field

You may need or want to provide the shade calculator with field collected estimates of your stream's current conditions. The shade calculator uses the following stream characteristics to estimate the shade of your stream: tree height along the stream, canopy density of the vegetation, vegetation overhang, and wetted width. This protocol describes some simple ways you can measure these values in the field.

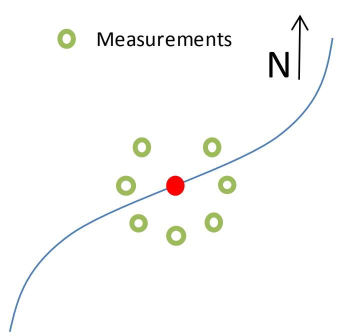
1. Sampling Design

1.1. The stream reach you are interested in is undoubtedly not uniform. There will probably be bits with dense canopy, bits with sparse canopy, and bits that are in-between. The goal is to measure several points along your stream reach and then take an average to get an overall estimate that is a good representation of the reach as a whole. If your stream has sections with very sharp and distinct characteristics (like a heavily wooded section and a section with little or no trees) it is a good idea to measure and analyze those sections separately as distinct reaches.

1.2 Once you have your reach sections defined the next step is to plan out a sampling pattern. A good design is to measure vegetation characteristics every 100 ft. along your stream. This is the sample spacing that the Stream Shade Calculator uses. It's perfectly fine to adjust the sample spacing slightly to avoid obstacles like intense blackberry thickets or poison oak. You may also need to reduce the spacing if your stream reach is short. You want to take an average of at least three points for each reach. Here is a diagram of a typical stream sample design, with the stream section of interest divided into two reaches:



1.3 At each sample point you will need to measure the near stream vegetation characteristics in each of seven cardinal directions relative to the stream (NE, E, SE, S, SW, W, and NW). This allows the shade calculator to get a good estimate of the effective shade. You can imagine that a stream with lots of trees on its northern banks but little on its southern banks will not have very much shade. To sample this pattern you don't necessarily have to get your feet wet, although depending on stream conditions it may be convenient to walk down the center of the stream at least part of the time.



1.4 Also at each sample point you should measure the vegetation overhang and the wetted width. You only need one measure of each of these for each point.

2. Measuring Canopy Height

2.1 You can get a pretty accurate estimate of canopy height just by using a stick. You just need a stick that is the same length as the distance between your eyes and your thumb holding your arm straight out in front of you. Next hold your stick vertically out at arm's length and then position yourself so that the length of stick and the tree that you are trying to measure line up. The horizontal distance from where you are standing when this happens and the base of your tree is the height of the tree. You can measure out this distance with a tape measure, or you can pace it out if you know the length of your paces. Here is a brief video demonstrating this method: http://www.youtube.com/watch?v=PQyETUg2_I0

2.2 A slightly more accurate method is to use a clinometer to measure the angle between you and the top of a tree at a known distance away. You can then use trigonometry to work out the tree height). Here is a brief tutorial on this method:
http://en.wikipedia.org/wiki/Clinometer_%28forestry%29
If you have one, a laser rangefinder will do the angle measuring and the math for you!

2.3 Whatever method you use, after some practice you will probably get pretty good at estimating tree height just by visual approximation (i.e. not actually measuring out the angles or horizontal distances). After practicing a while you can compare your visual approximations with the other measures of tree height to see how accurate you are. Canopy heights often tend to be fairly uniform over reaches. One good approach is to combine visual approximations with the more precise methods. For instance you can group the canopy along your reach into height classes (e.g. zero, short, medium, tall). Instead of recording the actual height at each sample point you record its height class. You can then convert these height classes into an estimate of actual heights by measuring the actual height of a representative section of vegetation for each height class. This approach allows you to quickly survey a stream reach without having to measure angles or horizontal distances at each sample point. It also often gets very difficult to measure distances and angles in dense or overgrown vegetation.

3. Measuring Vegetation Density

3.1 This is a measure of how thick or sparse the tree canopy is measured in percent. A value of 100% indicates that the canopy cover is complete, and no open sky is visible. One simple and accurate way to measure canopy density is to use a spherical densiometer. This is just a small concave (or sometimes convex) mirror etched with a grid consisting of 24, 1/8" x 1/8" squares. You estimate canopy cover by adding up the total number of grid squares that are open sky (i.e. not covered by vegetation). A given square may only be partially open, and so you add this fraction (e.g. ¼ square). The uncovered area is the total number of open squares multiplied by 4.17. Subtract this number from 100% to get overstory density in % (e.g. 100% - (10 unfilled squares x 4.17) = 58.3%. The biggest drawback to this method is that you have to borrow or purchase a densiometer. You can get one for about $100 at outdoor supply stores such as Ben Meadows

3.2 You can also just visually estimate canopy closure. Simply look up and estimate what proportion of the sky is blocked by vegetation. For this method it is best to simplify things by using broad categories such as: <25%, 25-50%, 50-75%, >75%. You should also practice a few times until you get consistent.

4. Measuring Vegetation Overhang

4.1 This is a measure of how far the vegetation extends out over the stream surface from the bank. This can come from angled trees, or more typically from low vegetation like shrubs that extend out. This can be a tricky thing to measure accurately, but thankfully in most cases it does not have a large influence on the Shade Calculator results. Using a length of measured pole is one handy way to estimate how far growing vegetation like shrubs extend out from the stream bank.

5. Measuring Stream Wetted Width

5.1 Wetted width is simply a measure of how wide the actual water surface of the stream is. This can be considerably less than the full bank width of the stream during low flow periods. The Stream Shade Calculator is geared toward estimating stream shading during late summer when conditions are warm and sunny and stream volumes are typically low. You can easily estimate wetted width by pacing, a tape measure, or a measured length of pole.

6. Entering Data into the Stream Shade Calculator

6.1 After you have collected your data you will have sets of data for a series of sample points. You will need to average these data across you sample points to get representative values for your stream reach that you can enter into the override panel in the calculator (see #6 in the user guide).

7. General Considerations

7.1 A data sheet makes recording and compiling your data easier. An example data sheet is provided below. It's ideal to have two people helping with your estimates (one to take the data, and another to record the data in the data sheet).

7.2 Like with anything you get better and more efficient with practice.

7.3 These protocols are meant to provide you with simple methods to input your own vegetation characteristics into the Stream Shade Calculator.   Agencies and programs that you work with to implement a restoration will have their own monitoring and verification protocols and requirements.

Example Data sheet

Site:

Date:

Start Time: **End Time:**

Recorder:

Reach	**Direction**	**Tree Ht. (ft.)**	**Canopy Density (%)**	**Overhang (ft.)**	**Wetted width (ft)**	**Notes**
	NE					
	E					
	SE					
	SE					
	SW					
	W					
	NW					
	NE					
	E					
	SE					
	SE					
	SW					
	W					
	NW					
	NE					
	E					
	SE					
	SE					
	SW					
	W					
	NW					
	NE					
	E					
	SE					
	SE					
	SW					
	W					
	NW					

APPENDIX VIII
Workshop Handout (next pages)

Stream Shade Calculator

HOW TO QUANTIFY THE SHADE VALUE OF YOUR POTENTIAL CONSERVATION BUFFER

Over the years many streams have lost their shady tree canopy, contributing to the decline of cool, clean water for drinking, fish, and irrigation. This user-friendly, on-line tool quantifies the amount of shade created by current riparian buffers and potential thermal load reduction created through restoration activities. Global markets are beginning to recognize the value of riparian lands in protecting environmental services and are developing ways to pay landowners to maximize these benefits.

THE IMPORTANCE OF ECOSYSTEM SERVICES AND RIPARIAN BUFFERS

Ecosystem Services (ES) are defined as the benefits that human communities receive (and depend on) as a result of natural processes and ecological diversity. Water filtration; protection against flooding; protection against drought; abundant biodiversity (including food sources); clean air; healthy soil; and protection against soil loss are examples of ES that affect community health. Mechanical methods of providing ES generally require more capital infrastructure, more on-going energy inputs, and more frequent maintenance/replacement. Ecological strategies seek to achieve balance and integration between all uses of an ecosystem by carefully evaluating the trade-offs with every management action.

Riparian areas are a critical interface between land management activities and our natural water resources. Vegetated riparian lands act as water quality filter strips, water temperature regulators, habitat corridors, and protectors against soil erosion, and have high ES value when managed for these goals.

OREGON ES MARKET DEVELOPMENT

To place a market value on ES, a landscape action must first be quantified into the water quality, soil health, air quality, or habitat benefit it generates. Second, people must be willing / regulated to pay for those benefits. Globally, carbon (emissions and sequestration) dominates the ES markets, but Oregon is developing other pathways.

Clean Water Services with DEQ pioneered a water quality credit trading permit that results in strategic ES benefit and reduced cost to CWS- $6 million to restore 35 miles of streams versus projected capital and operational costs of $60+ million.

Senate Bill 513, in July 2009, recognized the statewide importance of sustainable rural landscapes that provide ES with public value. A Workgroup under the Oregon Sustainability Board will provide policy recommendations to the 2011 legislature.

The Ecosystem Credit Accounting System is a work-product of the Willamette Partnership, but represents agreement among federal, state, and local agencies, conservation organizations, and the buyers and sellers likely to use an ES market. Their current two-year pilot focuses on standards and tools for assessing benefits and impacts of land management activities affecting 4 major currencies: water quality, wetlands, upland prairie, and salmonid habitat. In contrast to some of the existing markets for ES (such as wetland mitigation banking) that split the environment into constituent parts (water, soil, air, etc), the Willamette Partnership has developed an integrated approach where multiple ES can be credited in the same market.

ADDITIONAL RESOURCES

WILLAMETTE PARTNERSHIP — www.willamettepartnership.org
Ecosystem Credit Accounting System and Counting on the Environment programs.

SUSTAINABLE PLANT RESEARCH AND OUTREACH CENTER, SPROut — www.SPROutOregon.org
Phytotechnology projects, resources, events, and trainings.

OREGON STATE UNIVERSITY, HORTICULTURE DEPARTMENT — www.hort.oregonstate.edu
Includes themes on "Ecological Landscapes" and "Resilient Farm and Food Systems".

NATURAL RESOURCES CONSERVATION SERVICE, OREGON DIVISION — www.or.nrcs.usda.gov
Oregon funding options and BMP's for managing riparian lands as conservation buffers.

KATOOMBA GROUP — www.katoombagroup.org & www.ecosystemmarketplace.com
Portal for information and mobilization of markets that implement payments for ES.

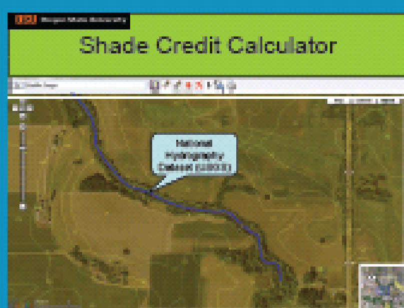
STREAM SHADE CALCULATOR ONLINE: HTTP://DELPHI.BIOE.ORST.EDU/CIG/

HOW THE STREAM SHADE CALCULATOR WORKS

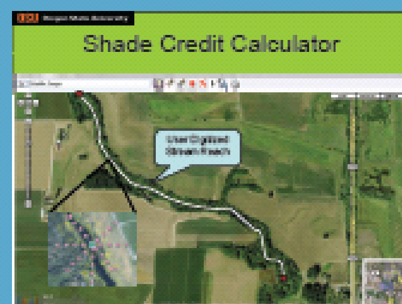
This calculation tool makes use of the increasing amount of remotely sensed environmental data that is available for Oregon. The calculator is able to get estimates of traits like tree height and canopy density at a fine spatial scale without going into the field to measure them. The ideal vegetation conditions for your stretch of stream are estimated, based on historical records and soil conditions. The calculator inputs the current and potential vegetation conditions into the Heat Source model that converts these into stream shading. Heat Source was developed at OSU and is used by the Oregon Department of Environmental Quality to simulate stream thermodynamics and hydrology.

USING THE CALCULATOR IS EASY!

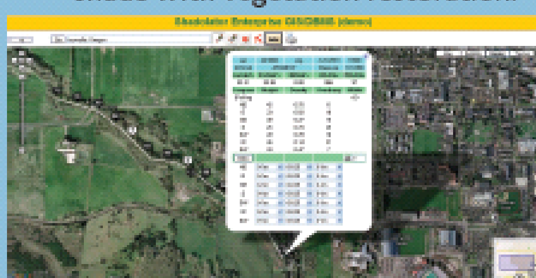
1 Find your stream on the Google Maps interface.



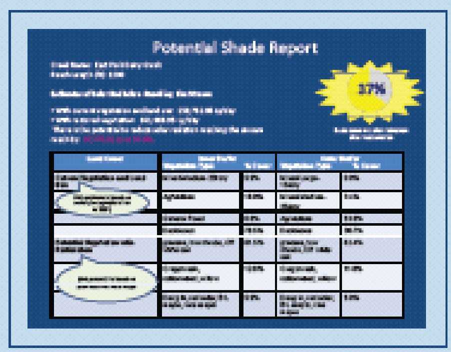
2 Using the digitizer tool, highlight the exact stream reach you want information for.



3 Press the calculate button to see the current shade conditions for your stream as well as potential shade with vegetation restoration.



4 Print your results as a simple summary report.



For more information, contact Renee Stoops, SPROut Director: renee.stoops@chemeketa.edu | 503-584-7252

STREAM SHADE CALCULATOR ONLINE: HTTP://DELPHI.BIOE.ORST.EDU/CIG/

CREDITS AND AUTHORS

This is a joint project of Oregon State University (OSU) and the Sustainable Plant Research and Outreach Center (SPROut). Funding is by USDA—Natural Resources Conservation Service as a competitively awarded Conservation Innovation Grant (CIG). The Principle Investigator for the project is John Lambrinos, Horticulture, OSU.

APPENDIX IX

Published Abstracts

We gave technical talks about the webtool design at three scientific meetings:

Lambrinos, J.G. and Guzy, M. 2009. Linking landowners to ecosystem service markets using web-based quantification tools. Annual Meeting American Fisheries Society. Nashville, TN.

Lambrinos, J.G. and Guzy, M. 2009. Linking landowners to ecosystem service markets using web-based quantification tools. Annual Meeting Ecological Society of America. Albuquerque, NM.

Lambrinos, J.G., M. Guzy, H. Cover, H. Lal. 2008. A framework for calculating ecosystem service credits using distributed geodatabases. Annual Meeting American Association of Agricultural and Biological Engineers.