

North Cascades Field Research to Study Eradication Methodologies for Japanese Knotweed

Final Report to the M. J. Murdock Charitable Trust

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Introduction and Background

In 2002, Jay Vestal of the National Park Foundation worked with North Cascades National Park to develop a proposal to study the ecological consequences of knotweed (*Polygonum cuspidatum*) on riparian systems and to work with local partners to develop a strategic approach to control of this species. In August 2002, the M. J. Murdock Charitable Trust awarded a grant of \$97,000 based on the proposal developed by North Cascades National Park, The Nature Conservancy, and the University of Washington. Initially, our proposal had six objectives:

- Complete the Inventory and Mapping of existing Japanese Knotweed Populations along the Skagit River
- Conduct research on the ecological effects of knotweed, pathways of dispersal, and control methods
- Develop a strategic plan for control of knotweed within the Skagit and Stehekin River Corridors
- Evaluation of Research and the Strategic Plan
- Develop a research-based outreach program focusing on exotic plants, control of exotic species and protection of riparian ecosystems. We will develop brochures to be used in environmental education programs and with the general public.
- Publish all results in technical and/or peer review journals such as the *Natural Areas Journal* or *Conservation Biology*.

Upon the grant award by the M. J. Murdock Charitable Trust, Dr. Sarah Reichard, University of Washington, initiated a process to recruit one or two students to conduct the proposed research. During the recruitment process, Drs Peter Dunwiddie (The Nature Conservancy) and Regina Rochefort (North Cascades National Park) assisted Dr. Reichard with the selection of Lauren Urgenson as the graduate student to conduct this project. When the project was first developed, we had thought we might select two graduate students—one to work with partners on the strategic plan and one to conduct the ecological research. However, the Skagit Knotweed Working Group (TNC, NPS, USFS, and WA State) had completed mapping and treating knotweed on most of the Skagit River and felt it was more important to concentrate our efforts on the research and outreach components of this project. This change was discussed with the Murdock Charitable Trust, and we then decided that one graduate student could best address the applied research questions raised in this proposal: 1) What is the ecological effect on riparian ecosystems? and 2) How can we implement effective restoration of knotweed infested areas? This change meant that objective 1 (inventory and mapping of knotweed) and objective 3 (development of a strategic plan) had been completed, and Lauren would concentrate on objectives 2 (conduct research on the ecological effects of knotweed and control methods) 4 (scientific evaluation of the research and recommendations), 5 (outreach of information), and 6 (publication of results). Lauren's work has been conducted in the format of a Master's degree (completed June 2006) and a Ph.D. (scheduled for June 2010). In addition, we requested (March 2007 progress report) to work with the PNW IPC (Pacific Northwest Invasive Plant Council) to conduct outreach and education through their website and outreach program since a knotweed brochure had already been developed by state groups. This change was approved, and we went ahead with this collaboration.

The summary of our accomplishments has organized in two parts: Lauren Urgenson wrote the first section detailing her research, outreach, and schedule for completion of her degree. Upon completion of her degree, we will provide a copy of her Ph.D. to the M. J. Murdock Charitable Trust. The second part is a summary of the PNW IPC written by Lizbeth Seebacher, the Coordinator of the PNW Invasive Plant Council.

Ecological Consequences of Knotweed Invasion on Riparian Forests and Applications toward Restoration

This report is based on the timeframe between fall 2003 and June 2010. In fall 2003, I began my graduate research investigating the ecological effects and control of Japanese knotweed (*Polygonum cuspidatum*, *P. bohemicum*, *P. sachalinense*) invasion in Pacific Northwest riparian forests. In 2005 and 2006, the National Park Service obtained an additional \$64,000 in matching funds through the Natural Resource Program. In 2006, I was granted an

international fellowship through the National Science Foundation's IGERT (Integrated Graduate Education and Research Training) Program, which supplied an additional \$70,000 (plus 2 years or 8 quarters graduate tuition) (Table 1). The IGERT provides two years funding as well as the opportunity to travel abroad to work with other researchers on exotic plant invasion research and community education programs. Together, these funds were used to support both Master's and PhD research at the University of Washington's College of Forest Resources. I am currently a PhD candidate with an anticipated graduation date of spring 2010.

In June 2006, I completed a Master's thesis entitled, "The Ecological Consequences of Knotweed Invasion into Riparian Forests." This study investigated the effects of knotweed invasion on riparian understory vegetation and autumnal litter-fall along Grandy Creek, a tributary of the Skagit River, WA. My thesis was subsequently adapted into a journal article, *Community and ecosystem consequences of giant knotweed (Polygonum sachalinense) invasion into riparian forests of western Washington, USA* and submitted to the journal *Biological Conservation* for peer review. This journal accepted the article for publication in January 2009 and it is currently in press. I have included the abstract below and will send the Murdock Charitable Trust a copy of the manuscript upon publication.

"Abstract: The invasive, non-native herb, giant knotweed (*Polygonum sachalinense*) is becoming increasingly common in riparian corridors throughout North America and Europe. Despite its prevalence, there has been limited study of its ecological impacts. We investigated the effects of knotweed invasion on the abundance and diversity of forest understory plants, and the quantity and nutrient quality of leaf-litter inputs, in riparian forests in western Washington, USA. Among 39 sampling locations, knotweed stem density ranged from 0 to 8.8/m². Richness and abundance (cover or density) of native herbs, shrubs, and juvenile trees (≤ 3 m tall) were negatively correlated with knotweed density. Where knotweed was present (> 5.3 stems/m²), litter mass of native species was reduced by 70%. Carbon:nitrogen ratio of knotweed litter was 52:1, a value 38-58% higher than that of native woody species (red alder [*Alnus rubra*] and willow [*Salix* spp.]). Resorption of foliar N prior to leaf drop was 76% in knotweed but only 5-33% among native woody species. By displacing native species and reducing nutrient quality of litter inputs, knotweed invasion has the potential to cause long-term changes in the structure and functioning of riparian forests and adjacent aquatic habitats."

These Master's data were also presented at a number of regional and national meetings and conferences between 2004 and 2007. I've included a summary list of presentations and awards received in association with the Master's research:

November 2004: Pacific Northwest Japanese Knotweed Symposium
February 2005: College of Forest Resources Graduate Student Symposium
April 2005: Society of Ecological Restoration NW Annual Conference
September 2005: Stehekin and NPS Community Meeting
November 2005: Olympic Peninsula Working Group Meeting
November 2005: UW Water Center Annual Research Review (poster)
November 2005: PNW-Integrated Vegetation Management Association Conference
December 2005: Skagit Knotweed Working Group Meeting
March 2006: Stillaguamish Cooperative Weed Management Area Annual Meeting
April 2006: National Forest Service Washington Aquatic Biologists Meeting
April 2006: Research in North Cascades National Park (UW class)
May 2006: National Forest Service PNW Aquatic Biologist regional meeting
May 2006: Interlake High School's Horticulture Class
June 2006: North Cascades National Park Science Days
September 2006: Meeting the Challenge: Invasive Plants in Pacific Northwest Ecosystems (poster)
November 2006: Olympic peninsula knotweed working group meeting
November 2006: Lecture on plant invasions in riparian systems for UW course "preserving wildlands"
December 2006: invited guest in Mount Vernon Christian environmental science class
Feb 10, 2007: Fall Forestry seminar, "Don't let invasive plants limit your choices" CFR/WSU Extension
March 16, 2007: Western Weed Society Annual Conference
August 2007: ESA/SER joint meeting

Associated Awards:

2005: 2nd place presentation Society of Ecological Restoration NW Annual Conference
2005: 1st place poster UW Water Center Annual Research Review (Poster)
2005: Skagit Working Group Partner of the Year

In summer 2006, I began PhD field work on the Dickey River, Olympic Peninsula, WA. The Dickey field site is situated within a Quileute tribe knotweed restoration area and located directly upstream from Olympic National Park. This research uses an experimental removal approach to evaluate the ecological impacts and restoration of Japanese knotweed (*Polygonum x bohemicum*) invasion. Two specific research objectives are being addressed. First, quantify the response of riparian understory vegetation to knotweed removal. This objective will determine whether knotweed removal alone is an adequate restoration approach to support native species recovery and examine relationships between vegetation community response and local environmental factors. Second, identify the mechanisms governing knotweeds effects on riparian tree recruitment. This objective will determine tree seedling-species responses to measured changes in light, soil litter, nutrient availability, and mycorrhizal colonization associated with knotweed invasion to determine the underlying cause of invasion impacts. I completed the third and final field data collection period for this project in October 2008 and am currently analyzing results. Preliminary data from my first two field seasons illustrate increases in the abundance of resident herbs, shrubs, and tree seedlings within one growing season following knotweed removal; setting the stage for more in-depth of analyses of community structure and suggesting knotweed control can be an effective restoration approach. Results also demonstrate reduced growth and survival of tree seedlings in knotweed-invaded treatments with the magnitude knotweed of effects varying across species. Thus, suggesting native species traits may influence the extent and/or processes underlying invasion impacts. I have presented preliminary findings at a few meetings and conferences, including:

November 2007: Olympic Peninsula Knotweed Working Group Annual Meeting (2007)
March 2008: Washington Weed Board Annual Coordinator's Meeting
May 2008: University of Victoria Restoration Institute Annual Conference (2008)



Figures 1 and 2. Between June-September 2006, we established 25, 21 x 10 m plots within highly invaded knotweed patches along the Dickey River study site. A knotweed removal treatment was randomly assigned to one half of each plot, and knotweed was left in-tact within the other half. Understory community composition and environmental factors known to influence riparian community structure and composition were measured prior to knotweed removal. These variables were then re-measured one and two years post-knotweed removal. The removal treatment was conducted by a Quileute Natural Resources crew. Following standard restoration protocols, the crew sprayed knotweed foliage with a glyphosphate-based herbicide two to three times throughout the field season (June-September).



Figure 3. The effects of knotweed invasion on the growth and survival of *Alnus rubra*, *Picea sitchensis*, and *Tsuga heterophylla* seedlings was measured by planting 10 seedlings of each species into knotweed removed and knotweed present treatment units in nine of the twenty-five vegetation study plots (10 seedlings \times 3 species \times 2 experimental units \times 9 plots = 540 total seedlings). These experimental treatments were used to examine the response of seedlings to knotweed induced changes in light (photosynthetically active radiation; $\mu\text{mol m}^{-2} \text{s}^{-1}$), soil nutrient availability, and ectomycorrhizal colonization of root tips. At the end of my final field season (September 2008) surviving *A. rubra*, *P. sitchensis*, and *T. heterophylla* seedlings were harvested and transported back to the lab for measurements of above and below ground biomass.

In January 2009, I began the international portion of my dissertation. I am currently conducting research as an affiliate post-graduate at the University of Stellenbosch, South Africa. The goal of this project is to evaluate conservation perceptions and behaviors of private landowners in the Western Cape, South Africa in association with the national program, Working for Water (WfW). Recognized globally for combining ecological conservation with socio-economic development, WfW hires historically disenfranchised groups to remove invasive, nonnative plants from along waterways and other ecologically sensitive habitats. Landowner involvement has been identified as a limiting factor in the long-term success of this program. Through landowner interviews, I will assess the strengths and limitations of WfW's education and economic policies in promoting public awareness and control of invasive plants. This study will provide important insight into linkages and barriers between conservation attitude and behavior, and can be used to guide development of future outreach and policy initiatives. This portion of my field data collection and analysis will be completed by November 2009. Upon completion, I will return to the University of Washington, finish my PhD, publish in scientific peer reviewed journals, and apply the investigative skills developed in graduate school to a career conducting research in the fields of ecological restoration and invasive species.

Education and Public Outreach: A Collaboration with the Pacific Northwest Invasive Plant Council

The PNW IPC initially formed in 1993 as the PNW EPPC (Exotic Pest Plant Council) with the overall goal of providing a forum for the exchange of information and best practices for the management of invasive plant species in natural area settings. In its early years, it created an initial "List of Concerns" detailing those problematic invasive plant species (that may or may not be regulated as state noxious weeds) of wildlands. Unfortunately, membership and strong leadership waned in PNW EPPC by mid 1990's. By the mid-2000's, however, the interest and awareness of invasive species as a top ecological threat grew anew, the PNW EPPC was revived (now as PNW IPC) at a conference titled "Meeting the Challenge," where over 200 participants shared information on invasive plant biology, research, and management. With grants from the National Forest Service, National Park Service, the M.J.

Murdock Charitable Trust, and the University of Washington, work began on a survey of over 1,500 interested parties in the summer of 2007. From this point to the present, the PNW IPC has provided the following:

- An up-to-date innovative website, which includes valuable information and data such as: general information on the invasives and specific invasive plants; a collective noxious weed list for Oregon, Washington, British Columbia and Alaska; links to numerous resources; up-to-date research and control methods for invasive plants from researchers and land managers from around the region; a calendar link for upcoming events; EDRR general and program information for the region; and a resources link.
- A ListServe with over 1,400 members thus far. The members of this ListServe share information that they have gathered on invasives, conferences, workshops, as well as invasive plant biology and management information.
- Joined forces with the Washington State Nursery and Landscape Association (WSNLA) Invasive Species Task Force to begin a program of indentifying nurseries that commit to not selling known or suspected invasive plants.
- Education and outreach materials for: the Seattle Flower and Garden show; several University of Washington guest lectures; a workshop with elementary school children; and the Natural Areas Conference (Oct. 14-17, Nashville, TN).
- Participation in the Washington and Oregon State Invasive Species Councils and other Invasive Plant Councils, such as Cal-IPC.
- Investigation of Early Detection Rapid Response programs worldwide through contacts of the steering committee and board members as well as published information.

The Invasive/Exotic Plant Councils nationwide are linked together by the National Association of EPPC's (<http://www.naepcc.org/>). This partnership is the first step to provide a large network of individuals on the ground, looking for and reporting the location and spread of new invasive species. We are small non-profit organizations and are able to not only connect interested parties within the invasive plant arena equally and effectively, but can afford rapid adaptive management techniques for all of our programs. We are able to work with small local organizations to bring people together, educate them and get them out on the ground quickly. Several federal and state agencies have researched and written about EDRR programs, but few have teams of monitors on the ground. The PNW Invasive Plant Council also has access to many of the most respected invasive plant experts in the country, from which many are on the PNW IPC board and steering committee.

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Table 1. Budget Summary Table

Project Components	Murdock Trust Funds	National Park Service Funds	Partner Funds	Project Total Cost
Personnel				
<i>Graduate Student</i>	\$55,000	\$60,000	\$70,000 ¹	\$185,000
<i>Field Assistants</i>	\$21,000			\$21,000
<i>Exotic Plant Control Crew</i>			\$50,000 ²	\$50,000
Office Costs			\$8,000 ¹	\$8,000
Travel and Lodging	\$6,080	\$4,000	\$15,000 ¹	\$25,080
Field Equipment			\$500 ³	\$500
Equipment and Laboratory Costs	\$1,800		\$5,700 ¹	\$7,500
Miscellaneous	\$13,120		\$30,000 ⁴	\$43,120
Totals	\$97,000.00	\$64,000	\$179,200	\$340,200

¹University of Washington + two years or eight quarters graduate tuition

²Quileute Tribe licensed herbicide applicator crew

³Rayonier Co. and Silvaseed Co, tree seedlings for regeneration

⁴ US Forest Service, partner for exotic plant education and outreach