Garry Oak Ecosystems Recovery Team

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Author Contacts

Hannah E. Anderson
The Nature Conservancy of Washington, Olympia, WA 98502
handerson@tnc.org

Karin Bodkter
Parks Canada, Western and Northern Service Centre, Vancouver, BC
604-666-2368
Karin.Bodtker@pc.gc.ca

Warren Devine
USDA Forest Service, PNW Research Station, Forestry Sciences Laboratory, 3625 93rd Ave SW, Olympia, WA 98512 US
wdevine@fs.fed.us

Christian Engelstoft
Alula Biological Consulting, 1967 Nicholas Road, Saanichton, BC V8M 1X8
alula.bc@telus.net

Wayne Erickson
BC Ministry of Forests and Range, PO BOX 9513 STN PROV GOVT Victoria, BC V9C 5Y3
Wayne.Erickson@gov.bc.ca

Emily Gonzales
Centre for Applied Conservation Research, 3041-2424 Main Mall, Forest Sciences, University of British Columbia, Vancouver, BC V6T 1Z4
604-822-1256
emilyg@interchange.ubc.ca

Peter Gould
USDA Forest Service PNW Research Station, Forestry Sciences Laboratory, 3625 93rd Ave SW, Olympia, WA 98512 US
pgould@fs.fed.us

Constance Harrington
USDA Forest Service, PNW Research Station, Forestry Sciences Laboratory, 3625 93rd Ave SW, Olympia, WA 98512 US
charrington@fs.fed.us

Travis D. Marsico
Department of Biological Sciences, Galvin Life Sciences 107, University of Notre Dame, Notre Dame, IN 46556 US 574-631-0296
tmarsico@nd.edu

David A. Jordan
Department of Geographic Studies, Trinity Western University, Langley, BC V2Y1Y1
davidj@twu.ca

Patrick Lilley
M.Sc. candidate, Department of Botany, University of British Columbia, Vancouver, BC lab: 604-827-3250, cell: 604-812-2578
plilley@interchange.ubc.ca

Carolyn MacDonald
Environmental Education Officer, Planning Department, District of Saanich, 770 Vernon Ave, Victoria, BC V8X 2W7 250-475-5475
macdonac@saanich.ca

Madrona Murphy and Russel Barsh
Kwiáht: Center for the Historical Ecology of the Salish Sea P.O. Box 415 Lopez Island, WA 98261 US
madrona@graffiti.net, RLBarsh@gmail.com

David H. Peter
USDA Forest Service PNW Research Station, Forestry Sciences Laboratory, 3625 93rd Ave SW, Olympia, WA 98512-9193 US
dpeter@fs.fed.us

Shyanne Smith
GOERT Recovery Group Coordinator and Ecological Consultant
314 Becher Bay Road, Sooke, BC V0S 1N0
Office 383-5449 Cell: 250-896-4179
shyanne.smith@goert.ca or shyanne.smith@gmail.com

Carson Beebe Sprenger
carson@rainshadowconsulting.com

Conan Webb
Eco-system Scientist, Parks Canada, 2-711 Broughton St., Victoria, BC V8W 1E2 Office: 250-363-6910, Cell: 250-812-8133
conan.webb@pc.gc.ca

STATUS OF CANDIDATE SPECIES CONSERVATION ON PRAIRIE AND OAK WOODLANDS

Hannah E. Anderson
The Nature Conservancy of Washington

Four species that are candidates for listing as endangered or threatened under the United States Endangered Species Act occur on prairies and oak woodlands of the Georgia Basin, Puget Trough, and Willamette Valley - Taylor's checkerspot *(Euphydryas editha taylori)*, mardon skipper *(Polites mardon)*, Mazama pocket gopher *(Thomomys Mazama)*, and streaked horned lark *(Eremophila alpestris strigata)*. All four species are in decline and have been extirpated from many historically occupied sites, including those in the northern and southern extents of their ranges. Integrated, cooperative conservation actions are necessary to both ensure the viability of existing populations and secure potential sites for reintroduction throughout the species' present and historic range. To ensure all partners working toward conservation of these species are in accord, we have compiled information both from the scientific literature and in cooperation with experts regarding the population status, research needs, and conservation/restoration actions necessary to promote recovery of these rare species. A generalized structure for recovery and conservation actions has been generated. Building on that structure, specific information regarding the status and conservation actions needed for each species is presented in a visual format. This work is funded by the Legacy Resource Management Program of the Department of Defense through the Rare Species Recovery Project. Information for the conservation status and actions needed was generated in cooperation with Washington state and US federal agency biologists and conservation organizations.

HOW MIGHT CLIMATE CHANGE IMPACT THE CONSERVATION OF GARRY OAK (*QUERCUS GARRYANA*) ECOSYSTEMS?

Karin Bodtker[1], Alex Cannon[2], and Marlow Pellatt[1]
[1]Western and Northern Service Center, Parks Canada
[2] Environment Canada

Global climate models warn us of a generally warmer future and since Garry oak ecosystems exist in a near-Mediterranean climate, we might assume climate change will assist Garry oak conservation efforts. However, recent bioclimatic modeling efforts predict that geographic ranges for many ecosystems will shift over time coupled with their zones of climatic suitability. To assess whether the climate in currently protected locations of Garry oak ecosystems will remain suitable for Garry oak into the future, we developed a spatial model of climatic suitability for Garry oak ecosystems in the Pacific Northwest and forecasted the distribution of suitable climate regions into the future based on predictions from four Global Climate Models (GCM). To build the model we used location data for current Garry oak sites and environmental predictors including 33 climate variables (baseline conditions from 1961-1990) and four geographic variables derived from a digital elevation model (DEM). We tested the performance of four types of statistical models (classification tree, multivariate regression, Bayesian classification, and minimum-distance classification) and chose the best model (classification tree) to forecast future distributions. In general, results suggest that the climate in the British Columbia portion of the current Garry oak range will be less suitable for Garry oak in the future. These results are subject to many caveats from both modeling and ecological perspectives. Therefore, interpreting these research findings in a broader ecological context is both challenging and mandatory to inform protected areas management.

WHY IS GARRY OAK FAILING TO ESTABLISH IN COASTAL BRITISH COLUMBIA?

Lesley Davy, Shyanne Smith, and Ze'ev Gedalof
Climate and Ecosystem Dynamics Research Laboratory, Department of Geography, University of Guelph

In coastal British Columbia most Garry oak (*Quercus garryana*) savannahs have been built over, or are threatened by conifer encroachment. Thus, identifying the processes needed for restoration and maintenance of these ecosystems is critical. Paleoecological research undertaken since 2003 has revealed a disturbing lack of recruitment by Garry oak since ca. 1950 at many locations in British Columbia, despite large masting years and generally high seedling abundances. Fire exclusion alone is inadequate to explain this trend. In this presentation we review the research undertaken to date that has revealed this pattern, and discuss several potential explanations. We also present preliminary results from an experiment undertaken at Rocky Point to test two of the candidate explanations. Deer exclosures and landscaping cloth were used to evaluate the roles of herbivory, above-ground competition, and interaction effects on seedling survival. Mortality was not significantly reduced among any treatment type after one year, and was increased in the landscaping cloth treatment. We conclude by describing growth-chamber and field studies being initiated in 2007 to test for below-ground competitive effects, and the role that exotic vegetation might play in limiting oak seedling survival. The growth-chamber study will be used to determine the seasonal phenology and soil moisture usage of exotic grasses, native grasses, and Garry oak seedlings. The field study will consist of comparing soil moisture using a split paired plot experiment with native only and native and exotic vegetation assemblages. Overall, these two studies will aid in the understanding of soil moisture competition between Garry oak seedlings and native and exotic vegetation.

IMPACT OF BROOM REMOVAL ON GRAZING PRESSURE OF WHITE-TOP ASTER ON MILL HILL, VICTORIA, BRITISH COLUMBIA.

Christian Engelstoft
Alula Biological Consulting

This study assessed the grazing pressure of the threatened white-top aster (*Aster curtus* or *Sericocarpus rigidus*) in Mill Hill Regional Park as Scotch broom (*Cytisus scoparius*) was removed. Black-tailed Deer (*Odocoileus hemionus columbianus*) and Eastern Cottontail (*Sylvilagus floridanus*) grazing pressure was separated by constructing grazing exclosures around white-top aster shoots that provided access to one or the other species. The cottontail and deer populations were estimated by using pellet or pellet group counts, respectively, and we initiated a pilot pellet deterioration study during the last year of the study. The results of this project suggest that white-top aster is relatively heavily grazed upon by both cottontail and deer and that broom removal causes a decrease in the cottontail population. The only exclosure type with a decline in white-top aster shoot numbers over the three years was the exclosure where both species had access. This suggests that other white-top aster sub-populations on Mill Hill are likely declining due to grazing pressure. By contrast, we found that there was almost a doubling in the white-top aster biomass index (height of shoot) over the three years in the protected exclosures. We found no fecal pellet deterioration over the summer. Cottontail pellets, however, disappeared in other ways which raised questions about the interpretation of the pellet count data. We found a summer density equivalent of 40-49 deer / km^2 and 3-5.7 rabbit pellets / m^2, whereas during the winter of 2005-06 the densities were 15 deer / km^2 and 1.1 rabbit pellets / m^2.

GARRY OAK (*QUERCUS GARRYANA*) PLANT COMMUNITIES IN BRITISH COLUMBIA: A GUIDE TO IDENTIFICATION

Wayne R. Erickson and Del Meidinger
BC Ministry of Forests and Range

This field guide covers the native plant communities with a component of Garry oak (*Quercus garryana*) in British Columbia. It is to be released in March 2007 as BC Ministry of Forests and Range Technical Report 040. The purpose of this guide is to standardize the use of plant communities in conservation and recovery of the Garry oak habitat, and thus to move toward an ecosystem approach. Standardized communities can provide a basis for mapping and inventory. The guide is also intended to provide targets for Garry oak habitat restoration, and could help identify reference communities, which are then monitored to detect long-term ecological trends.

Compared with previous work, this guide introduces the plant association as a new, simplified level. The seven plant associations (see below) are subdivided into 16 plant community types and 6 sub communities. Most are similar to those in Erickson (1996, 1998), with changes mainly in the level of classification. Categories are maintained for bedrock outcrop and colluvial, early and late season (phenological), grassy, and shrub thicket communities. Native communities from each of these categories are included in one-page descriptions. Sections include a general description of sites, soils, stands, and vegetative composition; a chart with geographic area against site moisture regime; comments including equivalent communities and succession to native or invasive alien communities; a chart with the relative importance value of the major understorey plant species; and a chart with management rankings. It is hoped that this guide will be updated and refined over time through use and testing, together with the incorporation of local knowledge on plant communities.

List of Garry Oak Plant Associations
Garry oak - Grey rock-moss - Wallace's selaginella plant association
Garry oak - Broom-moss plant association
Garry oak - Hairy honeysuckle plant association

Garry oak - Roemer's fescue plant association
Garry oak - Common camas - Blue wildrye plant association
Garry oak - Great camas - Blue wildrye plant association
Garry oak - Oceanspray - Common snowberry plant association

Production of the guide culminates quite a few years of effort and the authors wish to thank GOERT and other interested parties for their encouragement.

Citations:
Erickson, W.R. 1996. Classification and interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. M.Sc. thesis. Univ. Victoria, Dept. Geography, Victoria, B.C.
_____. 1998. Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. Available from: http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/garryoak/index.html.

BLACK-TAILED DEER AS SEED DISPERSERS VIA ENDOZOOCHORY IN COASTAL MEADOWS

Emily Gonzales[1] Ph.D. Candidate and Travis D. Marsico[2]

[1]Centre for Applied Conservation Research, University of British Columbia Ph.D. Candidate

[2]Department of Biological Sciences, University of Notre Dame

Although most species dispersal is relatively local, long distance dispersal events account for substantial effects on species distributions. For example, short distance seed dispersal events fail to explain rapid rates of invasion and migration for many plant species, particularly those on isolated locations such as islands. Long-distance dispersal events, particularly passive events via animal vectors, are likely critical for range expansion and persistence. We investigated endozoochory in abundant Columbian black-tailed deer, the dominant large herbivore in western North America. Fresh pellets were collected from 12 islands in the Southern Gulf Islands and germinated in growth chambers at UBC. More non-native species germinated than native species; however the overall abundance of native species was greater. Thus, black-tailed deer not only reduce native growth and fitness through direct browse damage of established plants, but also likely play a complex role in the distribution of both native and non-native seeds.

DENDROCHRONOLOGICAL INVESTIGATION OF GARRY OAK (*QUERCUS GARRYANA*) IN CROW'S NEST ECOLOGICAL RESEARCH AREA (CNERA) SALTSPRING ISLAND, BRITISH COLUMBIA

David A. Jordan
Department of Geographical studies, Trinity Western University

Garry Oak (*Quercus garryana* Dougl. ex. Hook) are the only native oak trees in British Columbia and are a vital component of one of the most endangered ecosystems in Canada. This research report documents the first dendrochronological investigation of Garry oak trees at woodland sites on Saltspring Island. Mature trees were selected for study in two 25 m. plots at approximately 180 m. a.s.l. A total of 46 cores from 40 trees were extracted for age determination and development of a site specific master ring-width chronology. High quality cores were prepared, carefully measured and cross-dated using standard dendrochronological techniques. Trees on the site cross-dated well (mean interseries correlation r = 0.700) and proved ideally suited for age structure analysis and chronology development. A preliminary age structure analysis reveals a bimodal distribution of age classes with two distinct cohorts; one >105 years and the other < 65 years. The best replicated segment of the tree-ring chronology (1898-2005 A.D.) shows common intervals of reduced radial growth in the 1900s, early 1920s, mid 1930s to mid 1940s and 1980s. A significant sustained growth release begins in 1948 and lasts until approximately 1960. A second significant, albeit shorter, growth release begins in 1989 and lasts until 1995. The results suggest that further dendrochronological studies using this species are warranted and can contribute to establishing historical Garry oak ecosystem conditions.

MAKING SENSE OF THE MEADOWS: UNDERSTANDING REGIONAL PATTERNS OF PLANT DIVERSITY IN THE ENDANGERED GARRY OAK ECOSYSTEM

Patrick Lilley and Mark Vellend
Department of Botany and Biodiversity Research Centre
University of British Columbia

Throughout the Georgia Basin Puget Sound region, human land use patterns are converting natural ecosystems to fragmented networks of habitat patches. On southeastern Vancouver Island, the endangered Garry oak (*Quercus garryana*) ecosystem has been fragmented by urban development, agriculture and forestry such that less than 1-5% of the ecosystem remains in a near-natural state. Many of the remaining patches of Garry oak ecosystem exist as 'habitat islands' in parks and protected areas. These habitat patches are crucial reservoirs for the high native plant diversity characteristic of this ecosystem. However, patches vary substantially in their local environmental conditions (climate, topography, soils, etc.) as well as their size and position within the surrounding landscape. Native species also face an additional threat of invasion by exotic plant species. While natives and exotics could respond to similar variables, high native species diversity may confer resistance to invasion by exotic species. Designing effective policies to conserve species can benefit from a thorough understanding of how environmental characteristics and landscape context influence species distributions and diversity.

We surveyed plant community composition and diversity in 43 Garry oak habitat patches around Greater Victoria and the Saanich Peninsula that vary in their area, connectivity, environmental conditions, and surrounding land use to assess the relative importance of these factors in influencing native and exotic plant diversity patterns. Initial results show positive relationships between patch area and all measures of species richness: total, native, and exotic. Using a stepwise regression approach, in addition to patch area, precipitation and surrounding road density explain significant variation in native species richness. Native species richness correlates

positively with mean annual precipitation and negatively with road density, used as a proxy for the degree of urbanization in the surrounding landscape. Exotics show significant but opposite relationships with these same variables. Therefore, although there is a weak negative correlation between native and exotic species richness, it appears that natives and exotics are responding to the same drivers but in opposite ways.

CHALLENGES AND SUCCESSES RESTORING GARRY OAK ECOSYSTEMS IN MUNICIPAL PARKS: SAANICH'S GARRY OAK RESTORATION PROJECT (GORP)

Carolyn MacDonald
Environmental Education Officer and GORP Chair
Saanich Environmental Services

The Garry Oak Restoration Project (GORP), an initiative of Saanich, was started in late 1999. The program is supported through a steering committee with representatives from Saanich Environmental Services, Saanich Parks, Environment Canada, the Garry Oak Meadow Preservation Society and UVic's Restoration of Natural Systems Program. GORP is focused on nine unique restoration demonstrate sites on Saanich parklands. Our volunteer program is an important aspect of our work and one of our key educational tools. We currently maintain about 45 volunteers year-round who contributed over 1200 hours to GORP sites during 2005-2006.

GORP sites range in size from 0.2 to 0.8 hectares (1/2 to 2 acres). Initial work on the sites included inventories of plants, wildlife, soils and land use/ history. There is an overall Restoration Management Plan and individual Site Action Plans, though they are due for updating at this time.

A key challenge for our restoration program is the fact that we are trying to restore small, public sites. Human impacts to the sites are varied and constant. Other management challenges at this time include trying to find practical monitoring tools beyond the photopoint monitoring we started initially and our ongoing volunteer monitoring and inventories. Invasive grasses are a difficult issue, as with any Garry oak ecosystem restoration, and are an issue we are beginning to seriously plan for this year. GORP is also hoping to attract and conduct more research on our sites in the future.

Some key successes of GORP include, besides improved ecological conditions on all the sites, some success with rare species protection. Our volunteer and education programs have been growing and make a big difference to the success of our program. GORP has provided support and modeling for other jurisdictions to

take on their own restoration projects including other municipalities, private landowners and community restoration projects. The program also provides a model for land stewardship for on our own municipal lands.

If we have learned anything in the last 7 years, it is to expect the unexpected! Our program is a constant learning and developing process.

Related Links:
GORP website: www.gorpsaanich.ca
Saanich website: www.saanich.ca

GARRY OAKS IN AN ARCHIPELAGO WITH DIVERSE ECOSYSTEM HISTORIES

Madrona Murphy and Russel Barsh
Center for the Historical Ecology of the Salish Sea

The distribution and recruitment success of Garry oaks vary significantly between islands in the San Juan Archipelago. One factor is the uneven distribution of acorn caching animals including northern flying squirrels (*Glaucomys sabrinus*), Douglas squirrels, Steller's jays and non-native squirrels. The distribution of non-caching acorn consumers (band-tailed pigeons, rabbits, rats and deer, and insect parasites such as filbert worms and weevils) also varies between islands. Differences in pre- and post-contact land use history are less susceptible to quantitative comparisons, but also appear to have played an important role in the patchiness of Garry oak distribution.

DENDROECOLOGY OF GARRY OAK SAVANNAHS IN COASTAL BRITISH COLUMBIA

Shyanne Smith
Climate and Ecosystem Dynamics Research Laboratory, Department of Geography, University of Guelph

Garry oak (*Quercus garryana*) ecosystems in British Columbia have largely disappeared, with only approximately 5% of their historical range remaining. These remnants have been altered over the last two centuries by a number of factors including agricultural development and livestock grazing, establishment of exotic plant species, increased deer browsing, and fire suppression. Identifying the historical stand structure and ecosystem processes is therefore critical for effective restoration and management of these ecosystems. In this study, tree-ring analysis was used to reconstruct the stand history at eight Garry oak sites within and adjacent to the Gulf Islands National Park Reserve. At most study sites, encroachment by conifers has been progressing over recent decades. Additionally, few Garry oak trees have become established since ca. 1950, although large numbers of seedlings are typically present at most sites. At several sites, it appears that establishment of Garry oak occurred after stand-replacing fires that were followed by multiyear wet intervals. After the initial colonization by Garry oak, Douglas-fir (*Pseudotsuga menziesii*) also began establishing at these sites, and recruitment of Douglas-fir has continued until present. Results from the smaller island sites suggest that local environmental conditions, weather events, and competitive interactions are likely important controls on Garry oak ecosystem dynamics. Smaller island sites were found be less disturbed, and to have less exotic species and conifer encroachment, and more ongoing oak recruitment than larger island sites.

GARRY OAK ECOSYSTEM RESTORATION AT FORT RODD HILL NATIONAL HISTORIC SITE OF CANADA

Conan Webb
Eco-system Scientist, Parks Canada

Fifty four hectares of land is protected within Fort Rodd Hill and Fisgard Lighthouse National Historic Sites. Fort Rodd Hill National Historic Site (FRHNHS) contains significant examples of remnant Garry Oak and associated ecosystems. Ecosystem restoration has been ongoing at FRHNHS for the last five years.

Invasive species removal and research is the primary restoration activity at FRHNHS. In particular research on Spurge Laurel (*Daphne laureola*) has been successful at discovering effective control techniques. Adult plants must be cut below ground (at or below the root collar) as they do not sprout from roots, but will sprout prolifically form any remnant aerial stem. This is easily done with bypass loppers.

Extensive Spurge Laurel seedling germination is often seen after the removal of adult plants. Pulling, hoeing, and weed-eating methods were tried to kill these seedlings. All three treatments showed high success rates; seedlings do not seem to have the same ability as adults to sprout from aerial shoots. In terms of effort and time required for effective results, weed-eating is the method of choice. However, solutions for reducing exposure to toxic aerosols would need to be employed. Also, the overall effect on the duff layer would need to be considered carefully. A hand tool that causes similar top-cutting damage to Spurge Laurel seedlings without the need for a motor would be ideal. The most efficient and safe method for the removal of these seedlings appears to involve top cutting three-year-old plants with a hand-powered blade; plants of this age are taller, and easier to cut. Furthermore, fourth and subsequent year removal may be preferable since a natural “thinning” process, which may reduce the required effort, appears to begin between the third and fourth years. Unfortunately, the ability of four year and older plants to survive top cutting was not tested in these trials.

The number of new Spurge Laurel seedlings emerging each year is inversely correlated with years since initial removal of mature

Spurge Laurel cover. Two years after mature plant removal, an average of approximately 76 new seedlings emerged. This number dropped to an average of 23 new seedlings emerging after three years. The average number of new seedlings 4 years after Spurge Laurel cover removal was approximately 15. It would be best to target treatments after the second or third year because further germination from the seed bank is expected to be minimal. It should be noted that no reproductive Spurge Laurel individuals were observed, even in the oldest plots where the maximum age of plants was four years. This is important since control treatments should be initiated prior to reproductive age.

Deer have a significant impact on the flora of FRHNHS. Installation of a deer fence resulted in the return of large numbers of blooming Camas (*Camassia* spp.), Spring gold (*Lomatium utriculatum*), and other species.

Conversion of a small Orchard grass (*Dactylis glomerata*) field to native grass appears to be possible with a reasonable effort. Orchard grass can be removed by cutting the root crown out of the soil using a hooked knife or other suitable tool. Local native grass seed can be collected in the summer and grown as plugs within a short time (11 weeks or less) for planting in the fall. This method appears to work well for revegetating areas with native grass quickly after the removal of Orchard grass.

REGENERATING OREGON WHITE OAK IN THE PUGET SOUND REGION

Warren Devine and Constance Harrington
USDA Forest Service, Pacific Northwest Research Station

Oregon white oak has been extirpated from many of its original locations in the Puget Sound region, and thus, planting of oak seedlings is often the best way to re-establish the species.
The Silviculture and Forest Models Team of the USDA Forest Service PNW Research Station has investigated techniques for propagating Oregon white oak and improving the survival and early growth of planted seedlings. Whether seedlings are grown in nursery beds and planted bare-root, or grown in containers, it is important to promote a vigorous root system that will allow seedlings to establish quickly after planting. Oregon white oak is a taprooted species, but for a seedling that will be transplanted, taproot length is restricted by container depth, nursery equipment, and depth of the planting hole. However, techniques such as air-pruning in pots and undercutting of nursery seedlings can increase growth of a seedling's lateral roots and ultimately provide a more branched root system that will have increased soil contact after outplanting.

Research on planting techniques has shown that early growth is strongly affected by initial seedling size and post-planting treatments such as weed control and tree shelters. Plastic mulch (i.e., weed mats) increases seedling growth by reducing vegetative competition for soil water. Solid-walled plastic tree shelters reduce browse and increase early height growth, although seedlings will temporarily be more slender until they grow above the height of the shelter for several years. Unless mesh-walled shelters are very wide, they can be problematic for Oregon white oak, as branches grow through the mesh and may become browsed or entangled. Planting seedlings early (i.e., by February) allows their roots to become established before soils begin to dry. With proper root management, and control of competing vegetation and animal damage, seedling survival rates have been high in the early years of our studies.

Publications:

Devine, W.D., C.A. Harrington, and L.P. Leonard. 2007. Post-planting treatments increase growth of *Quercus garryana* Dougl. ex Hook. (Oregon white oak) seedlings. Restoration Ecology 15(2). [*In press*]

Devine, W.D., and C.A. Harrington. 2004. Garry oak woodland restoration in the Puget Sound Region: releasing oaks from overtopping conifers and establishing oak seedlings. *In* Proc. Society for Ecological Restoration, 16th Int'l Conference, Victoria, Canada. 24-26 Aug. 2004.

AN IMPROVED MODEL FOR PREDICTING THE DEVELOPMENT OF GARRY OAK

Peter Gould and Constance Harrington
USDA Forest Service, Pacific Northwest Research Station

Forest managers can promote Garry oak (also called Oregon white oak) through management activities such as conifer removal or thinning in young oak stands. In the past, there was little information to quantify and predict the effects of forest management on oak. We developed new equations for ORGANON, a publicly available forest-growth model for the Pacific Northwest, to help predict the effects of management on oak. The equations predict oak diameter growth and survival over time and under different stand conditions. The diameter-growth equation was developed from measurements of 665 oaks and the mortality equation was developed from measurements of 1043 oaks, all located in western Oregon and Washington. Compared with past equations, which were based on much less information, the new equations predict faster diameter growth for more open-grown oaks, but also lower survival for those growing under heavy competition, such as in stands where oaks are overtopped by conifers. This new information indicates that the window of opportunity is small to restore oak stands that have been invaded by conifers before many of the oaks are lost. ORGANON Edition 8.2 can be downloaded at http://www.cof.orst.edu/cof/fr/research/organon/downld.htm.

RELEASING OAKS FROM OVERTOPPING CONIFERS

Constance Harrington and Warren Devine
USDA Forest Service, Pacific Northwest Research Station

In many areas along the Pacific Coast, the cessation of burning by Native Americans or First Peoples in the mid 1800's resulted in the invasion of oak savannas and oak woodlands by conifers. Many of these stands still exist and restoration opportunities may exist to remove the conifers to reduce mortality and increase the growth and vigor of the remaining oaks. Research begun in 2001 has resulted in several publications which provide both scientific results from a replicated study and practical guidelines for implementing release activities. The study showed that even oaks suppressed for many years can respond to release with increased growth, increased acorn production, and rapid formation of epicormic branches (trees are rebuilding their crowns). Growth after release was best in trees with the largest crowns. Tree damage was minimal if the loggers understood the purpose of the conifer removal. Additional information indicated that removing the conifers not only increased light to the oak crowns, it also increased soil water content. Other measurements taken and not yet published include response of understory plants (including tree seedlings) and other microclimatic variables. Many people have speculated that suppressed oak trees could not be effectively released after suppression or that a partial release would be more desirable. Our results show that even trees suppressed for many decades could respond to release and that a full release was the most beneficial for the oak trees.

Recent publications:

Devine, Warren; Harrington Constance. 2007. Release of Oregon white oak from overtopping Douglas-fir: effects on soil water and microclimate. Northwest Science. 81(2) (in press)

Devine, Warren; Harrington, Constance. 2006. Changes in Oregon white oak (*Quercus garryana* Dougl. ex Hook.) following release from overtopping conifers. Trees. 20:747-756.

Harrington, Constance A.; Devine, Warren D. 2006. A practical guide to oak release. Gen. Tech. Rep. PNW-GTR-666. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Center. 28 p.

EFFECTS OF UNDERBURNING ON OREGON WHITE OAK REPRODUCTIVE CAPACITY

David H. Peter
USDA Forest Service, Pacific Northwest Research Station

Effects of heat treatments and prescribed underburning on Oregon white oak (*Quercus garryana*) reproductive capacity were examined at Fort Lewis, Washington, USA. Microscopic examination of heat treated buds (60s at 133°C) showed more damage to staminate and scale scar primordia, and bud scales (outer bud organs) than to inner bud organs (leaf, pistillate, vegetative and apical meristems). Damage included cellular suberization and death, but no difference was detected in numbers of staminate, pistillate and leaf organs emerging from similarly treated buds in spring, suggesting that this treatment is near a threshold in terms of damage to production. Bud mortality sharply increased with hotter treatments (60s at 201°C killed 50% of buds). Three low intensity underburns were monitored with thermocouples in 16 trees. Foliage died when temperatures peaked above 75°C even for a few seconds, but temperatures that high were infrequent. Spring flowering was related to peak temperature and amount of exposure over 40°C or 50°C. Flower and acorn production, but not leafing was reduced at exposures below those that caused damage in the heat treatment experiment which suggests factors other than heat were also important. Smoke (possibly ethylene) is a suspected contributing factor. However in a retrospective study, annual acorn production (data from the *Quercus garryana* Acorn Production Study: http://www.fs.fed.us/pnw/olympia/silv/oak-studies/acorn_survey) and surveys of staminate inflorescence production suggest that reproductive effort increased for 2-8 years after burning (Figure 1). Thus, acorn crops in periodically underburned trees can be maintained at levels similar to unburned trees over time.

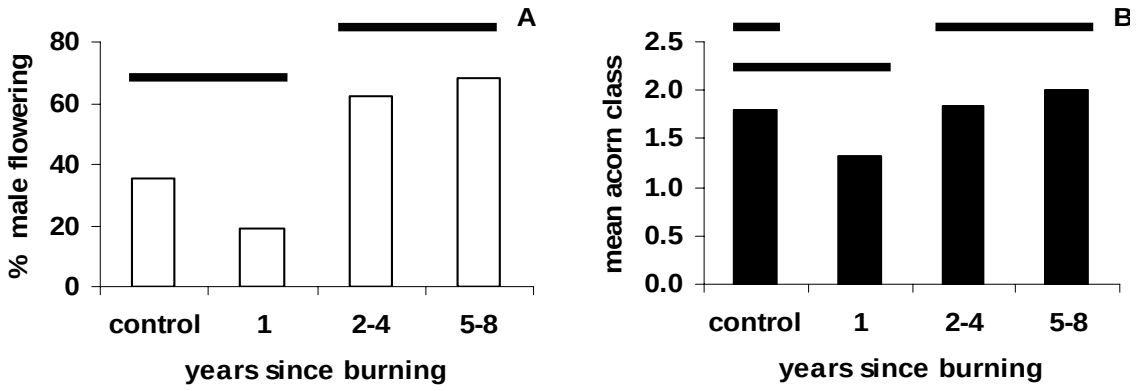

Figure 1. Two indices of reproductive effort following prescribed burning. A) Percent male flowering is the percent of branch tips bearing male inflorescences in the spring. B) Acorn class is a 1-4 scale of acorn production where "1" is no acorn production and "4" is heavy acorn production. Statistical significance is indicated by bars at different levels over the columns.

FIRE HISTORY OF A DOUGLAS-FIR—OREGON WHITE OAK WOODLAND, WALDRON ISLAND, WASHINGTON

Carson Beebe Sprenger
Rainshadow Consulting

A fire scar chronology was constructed from a *Pseudotsuga menziesii—Quercus garryana* community within a 155 ha study site on southeast Waldron Island, Washington. 62 scars were identified on 15 cross-dated samples dating from 1530 to 1908. A single sample recorded six scars prior to 1700. A master chronology was created for the period 1685 to 2004. Composite fire intervals for the entire study site, individual-tree fire intervals, and two methods of natural fire rotation (NFR) were used to characterize the fire history. For the historic period (1700-1879) the composite mean fire return interval (FRI) (Weibull Median Probability Interval) was 7.4 yrs. The historic period mean individual-tree FRI was 18.4 yrs. In contrast, only three fires were recorded during the settlement/modern period (1880-2004), resulting in a mean individual-tree FRI of 103.8 yrs. NFR for the two methods ranged from 49 to 72 yrs for all years analyzed (1700-2004), 32 to 49 yrs for the historic period, and 210 to 213 yrs for the settlement/modern period. Seasonality of past fires indicates that most fires occurred during late summer and fall. No evidence of spring or early summer burning was detected.