Ecology of Black Lily (*Fritillaria camschatcensis*): A Washington State Sensitive Species

by Holly Zox, Central Puget Sound Chapter, Warren Gold, Associate Professor, University of Washington, Bothell

Black lily (*Fritillaria camschatcensis* (L.) Ker-Gawl.) is a bulbous perennial herb in the Liliaceae distributed along the northern Pacific Rim from Japan to northwestern North America. Though globally secure, black lily is a state-listed sensitive species in Washington, where it is considered imperiled (S2), and Oregon, where it is critically imperiled (S1). Washington and Oregon represent the southern extent of its range in North America (Hultén 1968; NatureServe 2008). Information on black lily in the Pacific Northwest is largely ethnobotanical. Also known as northern rice root, the rice-like bulblets were eaten by many Northwest Coast Peoples (Turner, 1975; Pojar and MacKinnon, 1994; Kari, 1995). The only detailed ecological research reported in the peer reviewed literature examined the dynamics of large subalpine populations in northern Japan (Shimizu et al., 1998; Yonezawa et al., 2000). In Washington State, black lily is found in the northwest portion of the state across two disparate ecological habitat types: coastal high salt marsh and montane to subalpine wetlands. An understanding of the biology and local distribution of black lily would aid in conservation and restoration efforts for a species of cultural and ecological concern (see Fig. 1).

In 2004, a study was begun on the basic biology, ecology, and population dynamics of black lily in two Snohomish County, Washington sites: (1) a high salt marsh population in the Quilceda Estuary, part of the Snohomish River estuary of Puget Sound, and (2) a subalpine population in a sphagnum fen in the Morning Star Natural Resources Conservation Area (NRCA) in the Cascades Mountains. Though only 38 km apart, these two locations contrast in climatic and ecological characteristics. Plants at both populations have been censused on an annual basis (through 2008), for their presence, life stage, and reproductive characteristics. The phenological stage of plants has been recorded at periodic intervals through the growing seasons, from growth initiation to senescence. This information will aid in understanding of basic population dynamics, reproduction, and life stage transitions. In addition to population data, a limited subset of data was gathered on growth and reproduction (e.g., plant height, capsule, and seed production). Physical and chemical features of the environments at these two sites were also sampled. Chemical analyses of soil samples from areas with and without black lily were conducted at both sites for soil moisture, organic matter, pH, conductivity (to assess salinity), and available nitrogen. Air and soil temperatures were also measured throughout the growing seasons at both sites, and tidal inundation–the exact location and tidal height of black lily patches–was measured at the estuary. In addition, a vegetation community survey was conducted in 2005 for plots with and without black lily at both sites.

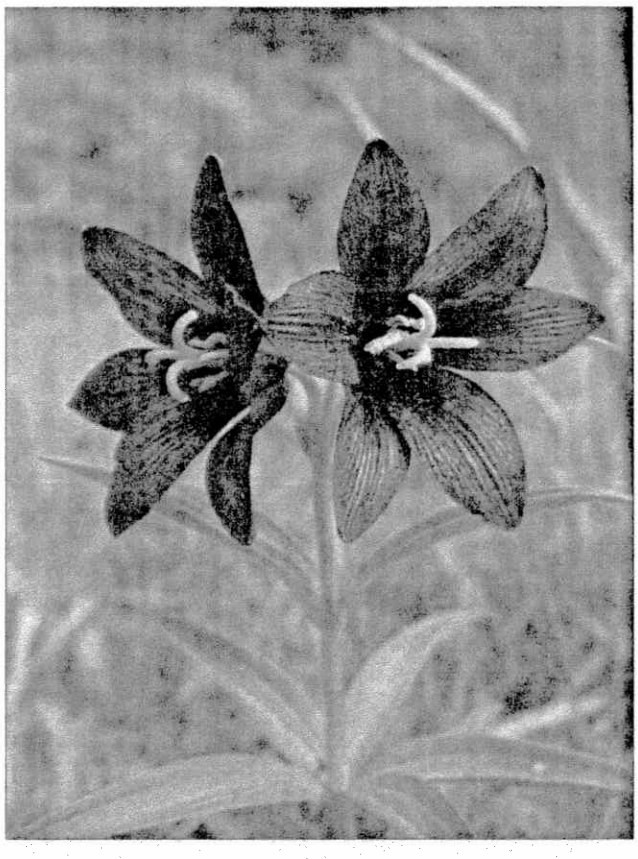

Figure 1. Black lily with perfect (bisexual) flowers. PHOTO: HOLLY ZOX

The Black Lily

Black lily grows from a scaly bulb covered with rice-like bulblets (Pojar and MacKinnon, 1994) (see Fig. 2). The species exhibits a complex life history including three stages distinguished by leaf type and reproductive state: (1) single-leaf / non-flowering (SL), (2) multi-leaf / non-flowering (ML), and (3) multi-leaf / flowering (MLF)

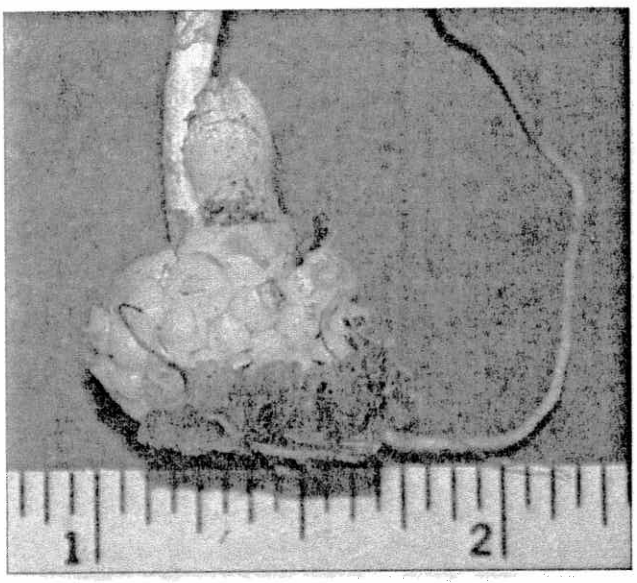

Figure 2. Black lily bulb composed of individual bulblets. Scale is in inches. PHOTO: WARREN GOLD

Figure 3. Different life stages of black lily: multi-leaf flowering ramet with flower buds in the lower right; multi-leaf ramet in lower center and left side; and single-leaf ramets in upper middle of the photograph. PHOTO: HOLLY ZOX

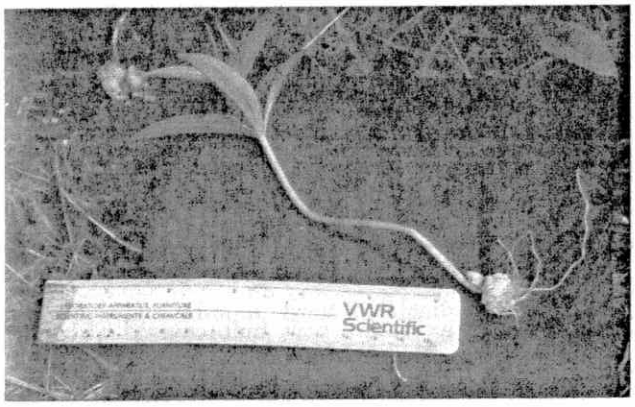

Figure 4. Multi-leaf ramet with bulb attached. Note disintegrating bulb in upper left of photograph with detached individual bulblets. PHOTO: WARREN GOLD

(Shimizu et al., 1998; Yonezawa et al., 2000). Leaves are arranged in whorls in both multi-leaf stages (see Fig. 3). Flowers may be either male or perfect (bisexual) and exist on a plant in any combination. Plants live for many years and move back and forth between life history stages, with death thought to occur only in the single-leaf stage. All three stages (single-leaf non-flowering, multi-leaf non-flowering, and multi-leaf flowering) reproduce clonally as bulblets detach and sprout new ramets (individual members of a clone) (see Fig. 4). In the Japanese studies, seedlings were rarely encountered, leading the researchers to conclude that populations appear to be maintained by clonal reproduction (Shimizu et al., 1998; Yonezawa et al., 2000). Flowering plants can have anywhere from one to seven (the most we have observed) flowers, and grow about 10 to 60 cm tall. Flowers are pollinated by flies of the family Calliphoridae (which includes blow flies), no doubt attracted by the aroma of rotting flesh (personal observation). The aroma is responsible for some of black lily's more interesting names, such as outhouse lily and lady-on-the-pot.

The Study Sites

The Quilceda Creek estuary is located on the Tulalip Indian Reservation near Marysville, Washington. The coastal maritime climate is moderate year-round. Daily maximum and minimum air temperatures averaged over a year were 15 °C and 6 °C in nearby Everett, Washington from 1971 – 2000. Average annual precipitation (predominantly rainfall) during the same period was 95 cm (University of Washington 2008). The Quilceda Estuary is one of the least impacted portions of the lower Snohomish River delta and has high ecological and cultural value. The study site includes a gradient from low tidal elevations at the creek edge to upper tidal elevations at the forest edge over a distance of approximately 152 meters. This gradient encompasses high emergent, woody debris wrack line, and backshore habitat types. Tidal vegetation communities include those dominated by Lyngby's sedge (*Carex lyngbyei*) at lower elevations, hardstem bulrush (*Schoenoplectus acutus* subsp. *occidentalis*, syn. *Scirpus acutus*), or salt grass and spike bent grass (*Distichlis spicata* and *Agrostis exarata*) at middle elevations, and vegetated decomposing logs and shrub island communities at upper elevations.

Black lily is restricted to upper tidal elevations, known as the backshore habitat from the forest edge to the open marsh behind the woody debris wrack line. The habitat is a mosaic of tidal channels, sedge and rush sediment plateaus, woody debris, and shrub/tree islands. In addition

to black lily, our early surveys have identified populations of Henderson's checker-mallow (*Sidalcea hendersonii*), uncommon in Puget Sound estuarine sites and springbank clover (*Trifolium wormskjoldii*), another species of cultural use and concern for native tribes. Most black lily patches occur within a 30 cm tidal band from 3.2 to 3.5 meters above Mean Low Low Water. This elevation is found primarily on rotting logs and at the edges of shrub/tree clumps and is above most ordinary high tides (and the tops of most hip waders, as we found when conducting a night-time high tide survey).

The Morning Star NRCA is part of a larger high precipitation zone bordered on the north by the North Fork Stillaguamish River, on the south by the Middle Fork Snoqualmie River, and extends from the western Cascades front to near the crest. This area is characterized by steep topography which intercepts the full brunt of prevailing winter storms from north and south of the Olympic Mountains, leading to the unusually high precipitation, which otherwise occurs only on the Olympic Peninsula. Annual precipitation in the NRCA ranges from 254-508 cm, most of which falls as snow. Snow accumulations above 750 meters elevation average greater than 300 cm (Henderson et al. 1992, Washington Department of Natural Resources 2003). The cool, unusually wet climate of this zone results in vegetation zones nearly 500 meters lower than expected for this latitude (Washington Department of Natural Resources 2003).

The black lily study site within the NRCA is a sphagnum fen at 872 meters elevation. This is a cold, high snow accumulation site, as evidenced by the subalpine plant association of mountain hemlock (*Tsuga mertensiana*) and copperbush (*Elliottia pyroliflora*, syn. *Cladothamnus pyroliflorus*) within a montane Pacific silver fir (*Abies amabilis*) forest matrix. The snow persists well into June or July, leaving a short growing season. Black lily at this site grows in lakeside sphagnum communities containing a mosaic of shrub islands and herbaceous meadows.

What We Found: Biology of Black Lily

1. What you see is not what you get.

Populations of black lily are dominated by the less conspicuous single-leaf life stage (> 80%), which is not mentioned in species descriptions (Hitchcock and Cronquist, 1973; Pojar and Mackinnon, 1994) and may be overlooked during surveys. Rapid assessments using large, flowering individuals often do not reveal the extent and abundance of black lily (and most SLs senesce before the larger individuals bloom). However, life stage proportions remained stable across populations and years, with about 3 – 4% of black lily ramets producing flowers (similar to Japanese populations; Shimizu et al., 1998). Consequently, it may be possible to estimate ramet population size by counting all MLF and figuring they represent about 4% of a population.

2. They grow up fast

In both locations, black lily is one of the first species to become active in the spring (March-April in the estuary and June-July in the mountains). This appears to allow black lily to accomplish much of its growth and reproduction before surrounding herbaceous competitors have grown taller and deciduous shrubs have established a mature shade canopy.

3. Is the importance of children overrated?

While only 3 – 4% of our populations produced flowers, an even smaller proportion produced ripe seed (1.4% and 0.6% in the estuary and mountains respectively). The lower seed production in the mountains appears tied to a loss of seed capsules during ripening, which takes about twice as long in the mountains (~9 weeks) compared to the estuary (~ 4.5 weeks). Most of the flowering individuals produced from 1-3 flowers, though rare individuals produced as many as 5-7 flowers. Much of the seed at both sites was contributed by these few robust plants.

However, the proximate maintenance of black lily populations may not be strongly linked to seed production. Since all three life-history stages (SL, ML, and MLF) reproduce clonally and seed production is so low (as in the Japanese studies) our populations appear to be largely maintained by clonal reproduction.

The maintenance of genetic diversity associated with even occasional sexual reproduction, however, could be vital to black lily's survival at the southern extent of its range in a warming climate. Care should be taken when collecting seed. Consideration should be given to how much seed collection populations can sustain, how to distribute collection among individuals, and whether protocol should differ among populations. Mountain populations need to be larger to sustain seed collection due to lower seed production and expected habitat changes from climate change.

4. Change happens

Both populations, though apparently secure in 2004, have suffered declines as of 2007 related to biotic disturbances. Beavers flooded the mountain site, and small mammals (probably voles) created an extensive system of tunnels under the largest black lily patch in the estuary. Patches contain one to hundreds of ramets and are scattered throughout the study sites. The largest

Quilceda patch declined 69% from 2006 – 2007, leading to a decline of 24% in the overall Quilceda population for 2007. The large patch has not rebounded, and population size remains low in 2008. The mountain population declined considerably from 2004 – 2005. Most of the black lily patches were flooded, making an accurate census difficult. Only 42% as many plants produced flowers in 2005 as in 2004, and only 24% of the flowering plants ripened capsules. Only a few black lilies have been seen in the mountain site in 2006 - 2008.

An additional (and worrisome) agent of change in the estuary is the presence of perennial pepperweed (*Lepidium latifolium*), an exotic invasive herb that also is one of the first plants to emerge. Pepperweed typically forms dense monocultures (Renz, 2000; Zouhar, 2004). Pepperweed is encroaching on black lily habitat in the estuary and has already displaced some patches. A pepperweed control program is under way (Zox, 2008).

Populations of black lily in Washington and Oregon, where it is a sensitive species, exist as islands (Sommargren 2008), with little chance for recruitment among sites. Distribution of black lily at both Quilceda and Morning Star is scattered and patchy, in essence tiny islands of suitable microhabitat in the midst of larger rare islands where this habitat might be encountered, making lilies at these sites possibly even more vulnerable to disturbance.

Ecology of Black Lily

1. Higher ground

Black lily grows in a variety of very different ecological settings. However, the habitats of the two populations studied (mountain fen and estuarine salt marsh) share some structural similarities. In both, black lily was found growing on locally raised elevations such as decaying wood and the margins of woody mosaics. The higher elevations may result in shorter, less frequent inundation and earlier snow melt. Frequency and duration of tidal inundation in salt marshes and timing of snow melt in subalpine habitats have been shown to exert major influence on vegetation patterns (Evans, 1976; Woodward et al., 1995; Mitsch and Gosselink, 2000). The somewhat less-stressful conditions of the black lily patches relative to the surrounding habitat is further reflected in some of the vegetation community and environmental features tested. The dominance of hardhack (*Spiraea douglasii*), a facultative wetland shrub found in nitrogen-medium soils, on Morning Star plots with black lilies as opposed to marsh cinquefoil (*Potentilla palustris*), an obligate wetland herb, in Morning Star plots without black lilies suggests black lily might be growing on ground subject to less flooding (Cook, 1997; McCoy, 2006). In the estuary, soil ammonium and organic matter content were higher in black lily plots than in plots without black lily. The higher ammonium and organic matter of black lily plots might create less stressful conditions than found in the surrounding marsh. Higher organic matter is often associated with less tidal flushing of raised locations (Mitsch and Gosselink, 2000). The presence of Pacific crabapple (*Malus fusca*, syn. *Pyrus fusca*), a shrub characteristic of nutrient-rich sites, in estuary plots with black lily might reflect the higher ammonium (Klinka et al., 1989). Though the average salinity at estuary plots with and without black lily was not significantly different, black lily plots were less variable, and avoided the highest salinity readings. Variability of salinity is even more stressful to many plant species than high salinity (Mitsch and Gosselink, 2000). Plots with black lilies at both study sites had higher species richness and diversity (Shannon-Weiner index) than plots without black lilies, and plots with black lilies at both sites had more variability in nearly all the soil characteristics tested, perhaps resulting in more niches for different plant species.

2. Related or not?

The soil environment at both the mountain and estuarine habitats presents challenges to plant function. The specific challenges, however, are quite different. Soils in the subalpine fen are cool and acidic, leading to slow decomposition and low nutrient availability. Soils in the salt marsh are warm and saline, and could lead to drought stress (Mitsch and Gosselink, 2000).

Vegetation analysis of species cover clearly differentiated between the plant associations containing black lily in saltmarsh versus mountain fen communities (Kovach Computing Services, 2005). The differences in plant communities and in soil challenges and the adaptations necessary to survive such challenges in two such disparate settings, suggest the possibility of different ecotypes (something we would like to explore in future research). The presence of different ecotypes would have major implications for conservation and restoration approaches.

The Future

The long term persistence of black lily in Washington faces a number of challenges. Our region lies at the southern extent of this species' range and a warming climate may jeopardize regional populations. Mountain populations linked to high precipitation zones may be impacted by predicted changes in the timing, form and amount of precipitation associated with climate change. Successful management will require continued study.

In five field seasons we have barely scratched the surface

of the black lily story in Washington. Genetic testing of mountain and estuarine populations would be essential in discovering whether we have different ecotypes. Different karyo-ecotypes were found in Japan. Lowland populations were found to be triploid (36 chromosomes), larger, with more and larger leaves, more flowers, and apparently sterile, while mountain populations were found to be diploid (24 chromosomes), smaller, and fertile (Matsuura, 1935). Germination studies need to be done on seeds from both sites, and from plants with different numbers of flowers. Furthermore, the role of humans in dispersal and maintenance of Washington's black lily populations would be important to understand for this culturally important species.

In addition, biological and ecological features that might make some populations more vulnerable to disturbance and extirpation need to be identified. Scattered, patchy distribution, small populations, and early emerging invasive species would be some factors to consider. Populations more at risk will need more frequent monitoring. Control to ameliorate some risks (such as with invasive species) should be considered. Enhanced understanding of the basic biology of black lily will facilitate the management of this species for use in cultural purposes. The emerging understanding of black lily should be applied to the enhancement of impacted populations and the introduction of black lily to restoration efforts with appropriate habitats. For instance, the introduction of woody debris at appropriate tidal heights in local estuarine restoration projects could facilitate black lily restoration on site or the maintenance of nearby populations.

Acknowledgements

The Washington Native Plant Society provided funding for this project. The Washington Department of Natural Resources and Tulalip Tribes provided permission and access to the study sites. Many thanks go to Julia Gold for leading us to the estuary lilies, many hours in the field, and so much more. Carie McCoy helped with the vegetation survey and soil analysis and was a cheerful companion on some very wet field days. Anna Heckman and John Hawthorne provided valuable assistance with laboratory soil analysis. Lin Kyan was an intrepid bush whacker and helped survey the most difficult to access black lilies. Crackerjack, our canine research assistant, helped relocate study plots, found the best routes through deep water, and made every trip a joy. She will be sorely missed.

References

Cooke, S.S., Editor. 1997. *A Field Guide to the Common Wetland Plants of Western Washington and Northwestern Oregon.* Seattle Audubon Society, Seattle, WA, USA.

Daubenmire, R.F. 1959. A canopy-coverage method. *Northwest Science* 33:43-64.

Evans, R. D., 1986. The relationship between snowmelt and subalpine meadow community pattern, Excelsior Ridge, Western North Cascades. Bellingham, WA: Western Washington University. 44p. M.S. thesis.

Henderson, J.A., R.D. Lesher, D.H. Peter, and D.C. Shaw. 1992. Field guide to the forested plant associations of the Mt. Baker-Snoqualmie National Forest. USDA Forest Service Technical Paper R6-ECOL-TP-028-91.

Hitchcock, C.L. and A. Cronquist. 1973. *Flora of the Pacific Northwest.* University of Washington Press, Seattle, WA, USA.

Hultén, E. 1968. *Flora of Alaska and Neighboring Territories.* Stanford University Press, Stanford, CA, USA.

Kari, P.R. 1995. Tanaina Plantlore, Dena'ina K'et' una; An Ethnobotany of the Dena'ina Indians of Southcentral Alaska, 4th Edition. Alaska Native Language Center, Alaska Natural History Association, National Park Service, U.S. Department of the Interior, USA.

Klinka, K., V.J. Krajina, A. Ceska, and A.M. Scagel. 1989. *Indicator Plants of Coastal British Columbia.* UBC Press, Vancouver, Canada.

Kovach Computing Services. 2005. MVSP Version 3.13n. Multi-Variate Statistical Package. Cluster Analysis.

Matsuura, H. 1935. On karyo-ecotypes of *Fritillaria camschatcensis* (L) Ker – Gawler. *Journal of the Faculty of Science Hokkaido Imperial University Series V Botany* Vol. III No. 5. The Hokkaido Imperial University Sapporo, Japan. Pages 219 – 234.

McCoy, C. 2006. *Fritillaria camschatcensis.* Bothell, WA: University of Washington, Bothell, Undergraduate senior research project; Interdisciplinary Arts & Sciences Program.

Mitsch, W.J. and J. G. Gosselink. 1993. *Wetlands,* 2nd Edition. John Wiley & Sons, Inc. New York, USA.

NatureServe Explorer. 2008. www.natureserve.org/explorer/servlet/NatureServe?searchName=Fritillaria+camschatcensis. Retrieved 20 June, 2008.

Pojar, J. and A. MacKinnon, editors. 1994. *Plants of the Pacific Northwest Coast; Washington, Oregon, British Columbia, and Alaska.* Lone Pine Publishing, Canada.

Renz, M.J. 2000. Element Stewardship Abstract for *Lepidium latifolium*. TNC library 04 April 2000. http://tncweeds.ucdavis.edu/esadocs/documents/lepilat.pdf Retrieved 25 January 2008.

Shimizu, T., Y. Hatanaka, H. Zentoh, T. Yashima, E. Kinoshita, Y. Watano, and T. Shimizu. 1998. The role of sexual and clonal reproduction in maintaining population in *Fritillaria camschatcensis* (L.) Ker-Gawl. (Liliaceae). *Ecological Research* 13:27-39.

Sommargren, A. 2008. *Fritillaria camschatcensis*: Introduction to the autecology of a Pacific Northwest lily. MS Thesis, College of Forest Resources, University of Washington, Seattle, Washington.

Turner, N.J. 1975. Food Plants of British Columbia Indians; Part 1/Coastal Peoples. British Columbia Provincial Museum Handbook ISSN 0068-1268; no. 34, Victoria, Canada.

University of Washington DAS. 2008. http:/www.atmos.washington.edu/marka/wa.normals.html. Retrieved 21 June, 2008.

Washington Department of Natural Resources. 2003. Ecological assessment: Upper Sultan Basin Natural Resources Conservation Area, Mount Pilchuck, Greider Ridge, Morning Star. Natural Areas Program, Northwest Region.

Woodward, A., E.G.Schreiner, and D. G. Silsbee. 1995. Climate, geography, and tree establishment in subalpine meadows of the Olympic Mountains, Washington, USA. *Artic and Alpine Research* Vol. 27, No. 3: 217 – 225.

Yonezawa, K., E. Kinoshita, Y. Watano, and H. Zentoh. 2000. Formulation and estimation of the effective size of stage-structured populations in *Ftitillaria camschatcensis*, a perennial herb with a complex life history. *Evolution* 54(6):2007-2013.

Zouhar, Kris. 2004. Lepidium latifolium. In:Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Retrieved 22 January 2008. http://www.fs.fed.us/database/feis/ [2008, undefined232008, undefined 22].

Zox, H.A. 2008. Quilceda Estuary perennial pepperweed management protocol. Tulalip Natural Resources Division, The Tulalip Tribes of Washington, Tulalip, WA, USA.

WNPS Member Donations at Work

This research was supported in part by a grant from the Washington Native Plant Society.

Conservation Grant Funds Available

The WNPS Conservation Committee is soliciting proposals for Conservation Grants of up to $500 that further the goals of conservation of Washington native plants. Through its grant process, the committee's goal is to support or enhance on-the-ground conservation or restoration projects.

Deadline for submissions is January 15, 2009.

For more guidelines, format and where to send see: http://www.wnps.org/conservation/conservation_grant.html

For more information or to discuss your proposal contact:
John Browne, Co-Chair
Conservation Committee
206-463-9641
jbrowne001@centurytel.net

League of Conservation Voters Report

http://www.lcv.org/

The independent political voice for the environment.

Vote Scorecard: 110th, 1st session Search Results

Sen. Maria Cantwell, DEM	87%
Sen. Patty Murray, DEM	87%
Rep. Jay Inslee, DEM, WA-1	95%
Rep. Rick Larsen, DEM, WA-2	80%
Rep. Brian Baird, DEM, WA 3	95%
Rep. Doc Hastings, REP, WA 4	5%
Rep. Cathy McMorris Rodgers, REP, WA-5	5%
Rep. Norman Dicks, DEM, WA 6)	95%
Rep. Jim McDermott, DEM, WA-7	95%
Rep. Dave Reichert, REP. WA-8	85%
Rep. Adam Smith, DEM. WA-9	90%

Date: September 1, 2008

Obama, Illinois, 67%
Biden, Delaware, 67%
McCain, Arizona, 0%
State Leadership Averages, 80-90% includes WA, OR,