



**Wormskiold's northern
wormwood (*Artemisia
borealis* var. *wormskioldii*)**

**Miller Island
Conservation Plan**

Prepared for
U.S. Fish and Wildlife Service
Region 1

Prepared by
Joseph Arnett

September 20, 2010



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(*Artemisia borealis* var. *wormskioldii*)

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Prepared
for
The US Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Through Section 6 funding, Region 1
Project 3E2, Segment 51

by
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Introduction

This report documents annual population monitoring of *Artemisia borealis* var. *wormskioldii* on Miller Island, Washington, near the mouth of the Deschutes River, between 2002 and 2010; summarizes all known population information collected between 1983 and 2010; and presents a management plan for this population of the taxon.

Description

Artemisia borealis var. *wormskioldii* is a low-growing (1-4 dm. tall) perennial in the sunflower family (Asteraceae). The inflorescences are typically narrow, and the involucre are generally 3-4 mm high. Flowering occurs in April and May. These traits distinguish the taxon within the genus in Washington, particularly from *Artemisia borealis* var. *scouleriana*, which grows in association with *A. borealis* var. *wormskioldii* on Miller Island.

Artemisia borealis var. *scouleriana* is a common species in Washington and is widespread in western North America. This taxon is several times the height of *A. borealis* var. *wormskioldii* and flowers much later, in mid summer. At the time variety *wormskioldii* is flowering and setting seed, in April and May, the flowering stalks of variety *scouleriana* have not yet developed. We have not observed intermediates between these two taxa.

Taxonomy

The plants that we will refer to here as *Artemisia borealis* Pall. var. *wormskioldii* Besser (ARBOWO) were included in *A. campestris* by Hitchcock et al. (1955), who recognized them under the taxonomic combination of *A. campestris* L. ssp. *borealis* (Pall.) H.M. Hall var. *wormskioldii* (Besser) Cronquist. This is the name used in its designation as a candidate for federal listing (U.S. Fish and Wildlife Service 1999). Since it was first described by Linnaeus in 1753, *A. campestris* has been the subject of many taxonomic revisions. Most recently, in the Flora of North America (FNA) (2006), the subspecies *borealis* was elevated to the rank of species in *Artemisia*. Varieties were not delineated in the FNA, but were treated together under *A. borealis* Pallas. Leila Schultz, the author of the FNA treatment of *Artemisia*, encouraged our recognition of varieties of this species; her treatment of *A. borealis* did not include infraspecific taxa because it was beyond the scope of her review, but not necessarily because infraspecific taxa were not valid (personal communication). To recognize the elevation of *borealis* to the species level, and to retain *wormskioldii* at the varietal level, we refer to the taxonomic combination for these plants in the treatment in Hooker (1833).

Conservation Status

ARBOWO is designated as endangered on the Washington Natural Heritage Program (WNHP) rare plant list (2010), indicating that the taxon is in danger of becoming extinct or extirpated in Washington in the near future if factors contributing to its decline continue. ARBOWO is also a federal candidate for listing under the Endangered Species Act and is listed as sensitive by Region 6 of the U.S. Forest Service. NatureServe has assigned the taxon global and subnational ranks of G5T1 and S1, respectively. These ranks indicate that the taxon is considered to be critically imperiled because of extreme rarity or because it is particularly vulnerable to extinction or extirpation. Typically a taxon given a global or subnational rank of 1 is known from five or fewer occurrences.

Habitat, Distribution, and Abundance

ARBOWO is found on basalt outcrops, compacted river cobbles, and sand along the banks of the Columbia River. While some of the plants at Miller Island are growing in sand, many of the plants appear to be rooted in basalt that protrudes above the sand, or provides stable substrate in that shifting environment. At Beverly, by far the larger population, the plants grow in compacted cobbles, just a few feet above the rivers usual high water level. Certainly both populations would have been inundated by occasional flooding before river levels were more carefully controlled by the dams.

This species was historically collected along the shores of the Columbia River between the John Day and Hood Rivers, but no recent occurrences of the taxon were known until plants were found upstream near Beverly in Grant County in 1975 and on Miller Island in 1983. These are the only two populations known globally. The occurrence in Grant County has declined steadily since 2005, when approximately 1,650 individuals were reported, to 2010, when only approximately 400 individuals remained.

The population on Miller Island was first located in 1983 by Lois Kemp. Population counts were made in 1983, 1999, and annually since 2002. A summary of the population counts is presented below in Table 1.

Miller Island

Miller Island, Washington, encompassing approximately 967 acres, is located near river mile 207 of the Columbia River, approximately 14 miles upstream from The Dalles, Oregon, near the mouth of the Deschutes River, as shown in Figure 1.

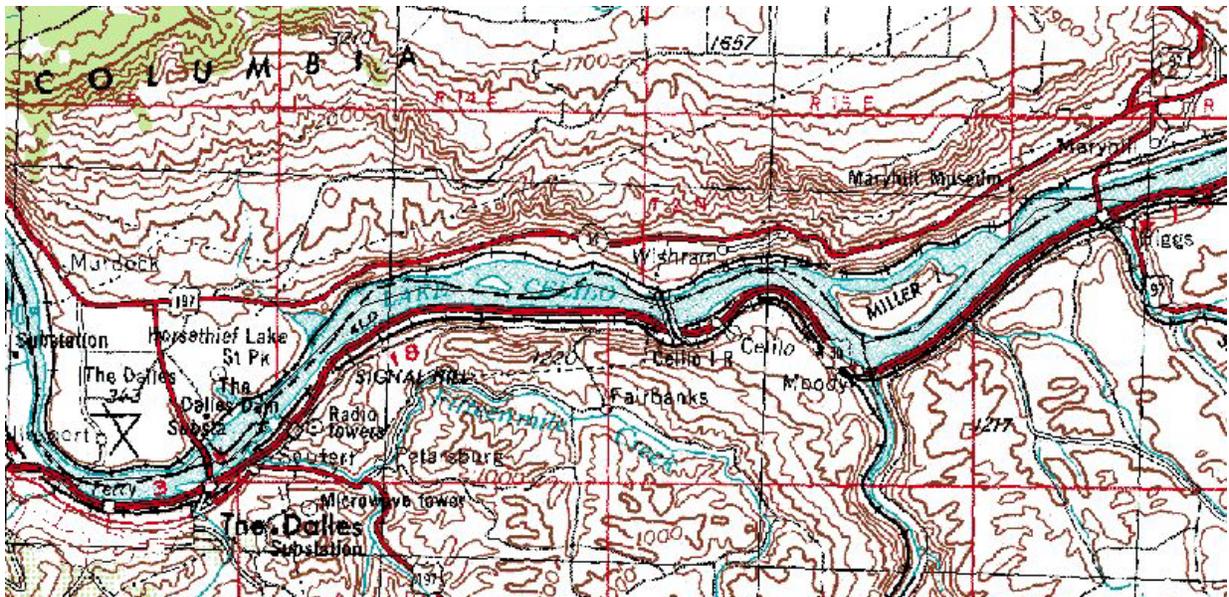


Figure 1. Location of Miller Island at the eastern end of the Columbia Gorge National Scenic Area.

A portion of the island, formerly managed by the Bureau of Land Management, became part of the Columbia River Gorge National Scenic Area in 1986, and the remainder was purchased by the federal government and added to the Scenic Area in 1988.

The island was used for grazing domestic livestock for many years prior to its inclusion in the National Scenic Area; in the more recent part of its grazing history, up to 50 head of cattle were grazed year round, and irrigation was used on the southwest portion of the island to improve pasture. The island has not been grazed since 1988 (Robin Dobson, personal communication). A single-wide trailer formerly sat in the southwest part of the island, and a powerline provided electricity from the Washington mainland to the north. A rock quarry also operated on the south side of the island, where the landing is still evident, and gravel or sand were mined from the far eastern end. The island currently has no facilities but receives recreational use, typically in the form of hunting and camping.

Miller Island lies within the Columbia Plateau ecoregion; the vegetation is mostly herbaceous steppe vegetation with a very minor shrub component. Although the island includes a fairly rich diversity of native grasses and forbes, the long history of grazing is reflected in a high component of non-native species. Occasional small patches of shrubs include *Amelanchier alnifolia*, *Celtis occidentalis*, *Ericameria nauseosa*, and *Chrysothamnus viscidiflorum*. *Artemisia tridentata* and *Purshia tridentata* are present, but uncommon. Small stands of non-native trees including *Morus albus*, *Populus alba*, *Populus nigra* var. *italica*, and *Ailanthus altissima* are present. *Amorpha fruticosa* and *Rubus armeniacus* grow near the edge of the river. A list of all vascular plant species observed is presented in Appendix A.

The landscape of the island is broken up by extensive basalt outcrops and cliffs, and active and stabilized sand dunes are prominent. Lithosols occur on ledges and tops of basalt buttes; between rock outcrops are occasional areas of deep sandy soil. A few small vernal pools are present on rock in the western portion of the island.

Figure 2 shows the location of the ARBOWO population at the east end of the island. The population occurs in an area of drifting sand over cobbles and basalt bedrock. Most of the ARBOWO plants appear to be rooted in the underlying substrate rather than in the sand itself. The site appears to be within about a meter of the reservoir mean high water level.

The threats to the population include trampling by recreational users of the site and sand drifting over the plants. Non-native weeds, including *Centaurea diffusa* and *Bromus tectorum* are present on the site, but they do not appear abundant enough at the present time to compete with ARBOWO.

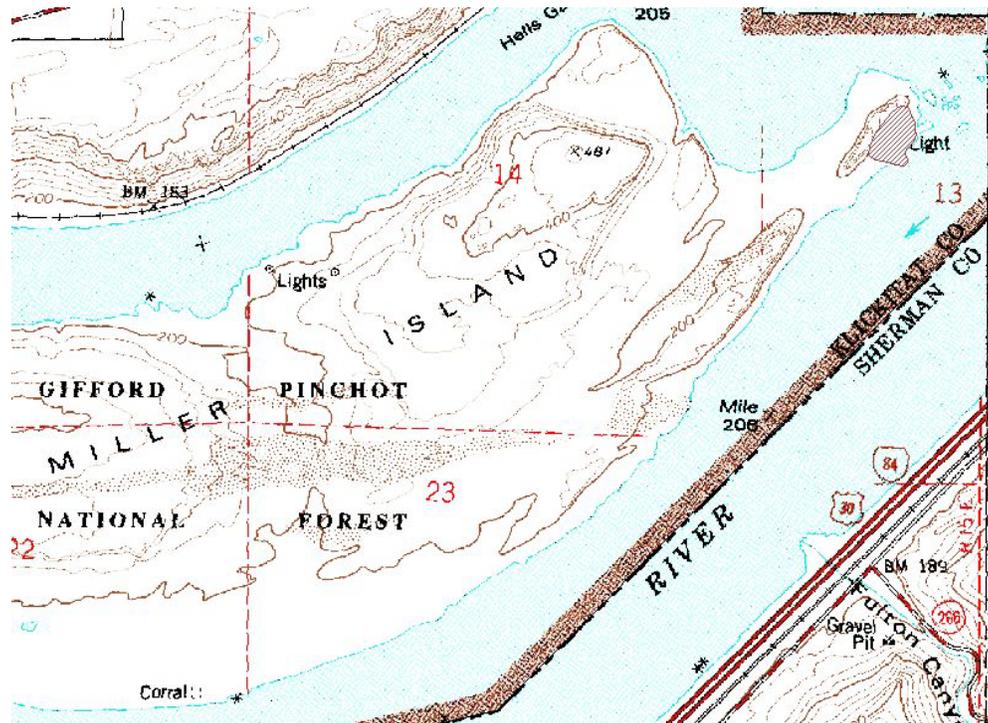


Figure 2. Location of *Artemisia borealis* var. *wormskioldii*, shown in red hatching, at the eastern end of Miller Island.

Population Monitoring

Counts of ARBOWO on Miller Island have been made since it was first documented there in 1983 by Lois Kemp. It is imprecise to compare counts in the first few visits with those done later, because the methods employed varied, particularly with respect to vegetative plants. Later counts were explicit in keeping tallies of vegetative plants separate, because of the difficulty in

distinguishing between var. *wormskioldii* and var. *scouleriana* until flowering stalks develop. Kemp reported counting 88 plants, noting “about 25% seedlings,” and that most of the plants were on steep basalt inaccessible to cattle. Based on the inclusion of seedlings in this early count we calculate that only approximately 65 mature plants were seen in this first observation. In 1995, Kaye (1995) monitored the Miller Island site, noting in contrast to Kemp that most of the plants were in the sandy trough at the base of the cliffs. He reported a total of 319 plants, also including seedlings, and we calculate from the percentage of seedlings included that approximately 110 of these were mature. We assume a degree of error in these early counts because it would not have been possible to distinguish var. *wormskioldii* seedlings from those of var. *scouleriana*. The next count, of 142 flowering plants, was made in 1999 by Tracy Rush (WNHP), who did not include seedlings. WNHP botanists have continued annual monitoring since 2002. These counts are summarized in Table 1.

Table 1. Summary of *Artemisia borealis* population counts, 1983-2010. Numbers are actual counts or estimates of flowering individuals.

| | 1983 | 1995 | 1999 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|
| <i>Artemisia borealis</i> var. <i>wormskioldii</i> (total population including outliers) | | | | | | | | | | | | |
| flowering plants | 65* | 110* | 142 | 100 | 85 | 85 | 71 | 43 | 39 | 35 | 31 | 29 |
| flowering stems | | | | 547 | 452 | 662 | 678 | 182 | 195 | 327 | 276 | 312 |
| flowering stems/ plant | | | | 5.5 | 5.3 | 7.8 | 9.5 | 4.2 | 5.0 | 9.3 | 8.9 | 10.8 |
| <i>Artemisia borealis</i> var. <i>scouleriana</i> (counts since 2007 only within 20x30 meter plot) | | | | | | | | | | | | |
| flowering plants | | | | 11 | 36 | 13 | 136 | 74 | 43 | 82 | 82 | 120 |

*Early counts included seedlings, so these numbers were calculated on the basis of percent seedlings noted in the census reports. Because seedlings of var. *scouleriana* were also presumably present, and indistinguishable vegetatively from var. *wormskioldii*, these counts may be overestimates.

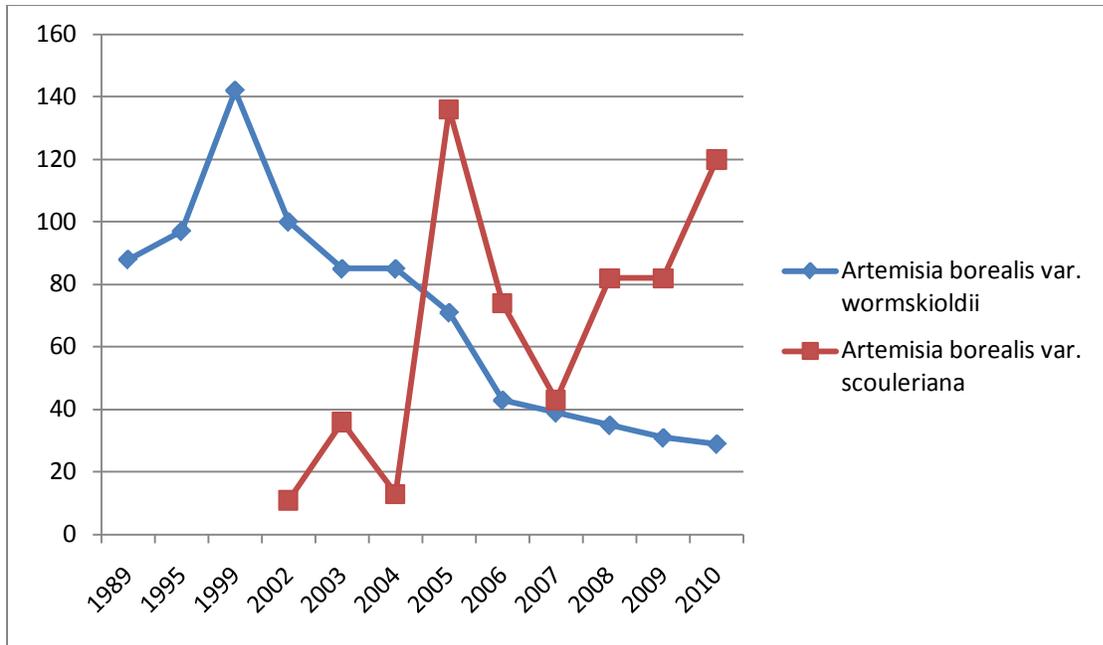


Figure 3. Summary of *Artemisia borealis* census on Miller Island, 1983-2010.

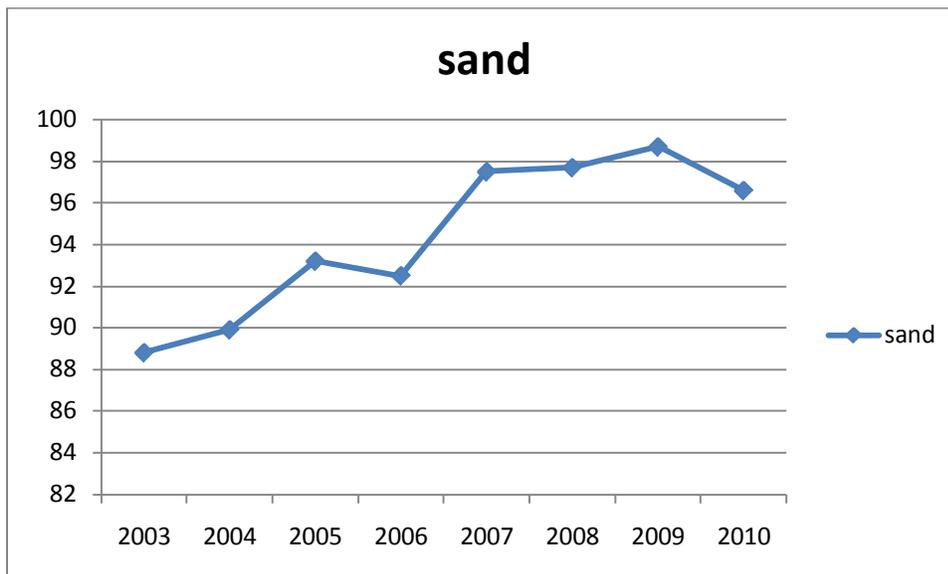


Figure 4. Changes in sand substrate recorded in subplots within the *Artemisia borealis* monitoring plot on Miller Island, 2003-2010.

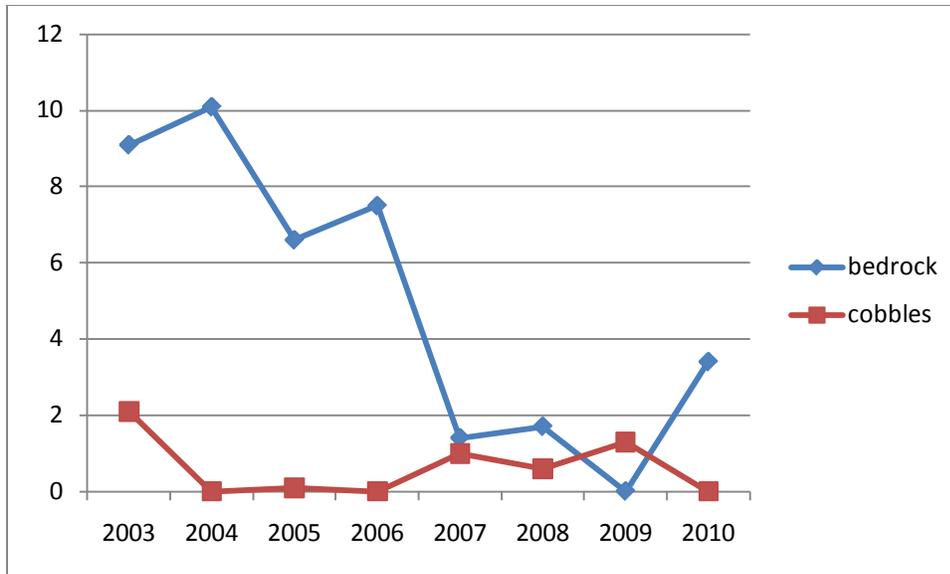


Figure 5. Changes in bedrock and cobble substrates recorded in subplots within the *Artemisia borealis* monitoring plot on Miller Island, 2003-2010.

Demographic Monitoring and Population Viability Analysis

In 1995 a demographic monitoring plan for Miller Island was developed by Kaye (1995), although no monitoring occurred between then and 1999, and data for demographic analysis were not collected until 2002. Data for demographic monitoring were collected between 2002 and 2010.

In the initial methodology two large monitoring plots were established. Plot 1 covered the main group of plants and extended for 20 x 80 meters along a generally level sandy area. Plot 2 covered a basalt outcrop between Plot 1 and the Columbia River to the southeast. Since 2002, detailed monitoring has occurred only within Plot 1, where the bulk of the population remains in the southwest portion. One or two plants have been observed annually in Plot 2; while not measured, these plants have been included in the annual census. After 2008 all ARBOWO plants (except one or two outliers also included in the census total) were found within the southeastern 30 meters of Plot 1. Within this 20 x 30 meter area, *Artemisia borealis* var. *scouleriana* plants have also been recorded. These data provide a comparison of population size changes in the two varieties within a defined area.

The objective of demographic monitoring is to discern population dynamics, and models are created to predict transitions between five life history stages: seedlings, small vegetative plants, large vegetative plants, small reproductive plants, and large reproductive plants (see Figure 6). After collecting population data in 1995, Kaye (1995) recommended that data be collected for four more years in succession and then Population Viability Analysis (PVA) conducted, using a

transition matrix model approach. Based on the population trends, a decision could be made about how often monitoring the site would be warranted. Kaye also recommended that changes in the monitoring protocol be documented in a current monitoring plan.

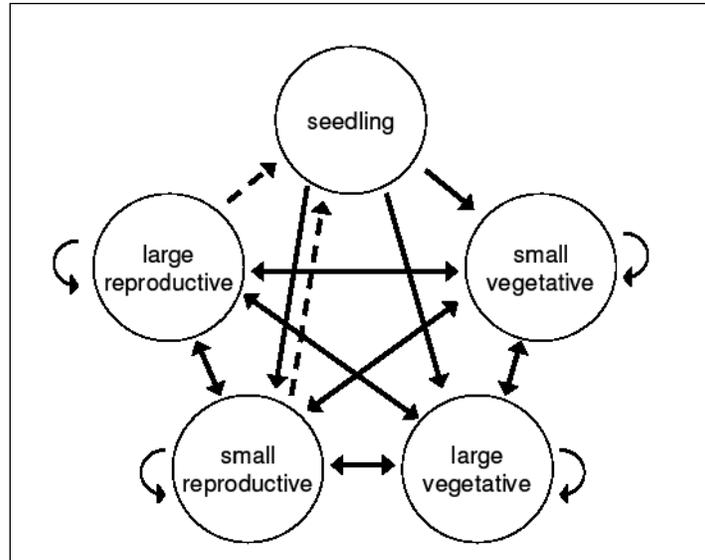


Figure 6. Complex life-history of northern wormwood indicating the possible survival transitions that plants in each stage can make from one year to the next (solid arrows) and processes of seedling recruitment through sexual reproduction (dashed arrows). Curved arrows show that some plants can remain in the same stage.

Unfortunately, a census was not made again until 1999, and demographic data collection was not resumed until 2002. Demographic data were collected in 2002, 2003, and 2004, and preliminary PVA conducted on the two pairs of years, 2002 – 2003 and 2003-2004 (Caplow 2005). This PVA calculated an annual growth rate (\bullet) of 0.759 in 2002-2003 and 0.89 in 2003-2004. Growth rates of less than 1.0 indicate declines.

Demographic data were also collected each year between 2005 and 2010 (presented in Appendix B), but analysis of those data for this report has revealed substantial problems with tracking individual plants from year to year. Difficulties were consistently encountered in interpreting how subplots were named in the monitoring methodology, and how the coordinates of plants within subplots were recorded. Arnett and Birkhauser (2006) revised the methodology to clarify the process, but other difficulties persist.

One complication at this site is that at three of the five life cycle stages shown in Figure 4, it is not possible to distinguish between varieties *wormskioldii* and *scouleriana*, so counts of plants in these size classes must be estimates, based on relative number of adults of varieties *wormskioldii* and *scouleriana*. Another complication is that assumptions are made in the model that seedling

recruitment was the same for each variety, according to the number of flowering stems. A difficulty with this, aside from the gross difference in inflorescence size, is that stems of var. *scouleriana* are usually not developed by the time of monitoring, and so these data cannot be collected.

Other practical difficulties were encountered in striving for precision in demographic monitoring. Field conditions, including high winds and shifting sand substrate at this site, compounded the difficulty in precisely locating subplots and tracking individual plants. A final limitation was financial; PVA modeling is expensive, and the cost to conduct this with the existing data set far exceeded the funding available. In the case of this population, the population trend, a pronounced decline, is not subtle, but is clear even in the simplest census. While we are not able to understand population dynamics with the resolution possible with PVA, in this case, as Table 1 and Figure 3 show, we are clearly able to discern the trend that ARBOWO is declining steadily on Miller Island.

Methodology for Future Monitoring

As a result of the years of experience monitoring *Artemisia borealis* at the Miller Island site, we are proposing here to simplify the methodology to collect the following data:

- For ARBOWO, including plants found outside the plot, if any:
 - Coordinates of each mature plant within each subplot
 - Number of flowering stems on each plant
- For *Artemisia borealis* var. *scouleriana*:
 - Counts of mature plants within each subplot
- For ambiguous *Artemisia borealis* plants:
 - Counts in two size classes, seedlings <5 cm across and vegetative plants \geq 5 cm within each subplot

In this modified methodology, coordinates of seedlings and dimensions of plants (other than the number of flowering stems of ARBOWO) will not be recorded. The proposed modified monitoring protocol is presented in Appendix C. This methodology will allow annual tracking of the number of plants of each species, the number of seedlings and small vegetative plants of both species, and the relative vigor of ARBOWO plants (measured by number of flowering stems). We will also continue to track individual reproductive ARBOWO plants from year to year. Collecting data within subplots will produce a record of the spatial distribution of each of these species and size classes, which will help in interpretation of the dynamics of the site.

Conservation Recommendations

Census Monitoring

In 1999 a conservation strategy was developed for both populations of ARBOWO (Rush 1999). The primary goals identified in that plan were (1) to protect existing populations and habitat and (2) to maintain occupied and potential habitats in a condition that would sustain the taxon. Part of the strategy in that plan to achieve these goals was to continue monitoring at both sites (Beverly and Miller Island). As described above, we are proposing to continue annual census of the Miller Island site, recording spatial distribution of plants as well as the vigor of individuals, though we will discontinue demographic monitoring. The revised monitoring methodology is included in Appendix C.

Site Condition Monitoring and Maintenance

Rush (1994) also recommended annual site condition monitoring, and this has been added to the monitoring methodology to document increases of competing weeds or changes due to drifting sand. Data collection during the census will continue to include recording the substrate on which each plant is growing, as a way of tracking increase in overtopping sand. Weed infestation does not appear to be limiting the population of ARBOWO at the present time, but an annual review at the time of monitoring would be a way to track this carefully.

An inconsistent photographic record has been kept of the site, most frequently including overviews of the whole site taken from the slope above. We recommend continuing the use of photo plots established every three meters along the southeast boundary of the plot, starting at the 2 meter mark, looking northwest along the cross transects. The camera lens should be approximately 55 mm, wide angle enough to capture the appearance of the vegetation within the plot from these vantage points, and the photos taken from 3 to 5 meters back from the plot edge. A whiteboard or paper label indicating the meter mark along the plot edge would relocate each photo plot. The purpose of photographic monitoring is to evaluate gross competing vegetation changes.

As has been the case since 2002, annual monitoring will primarily be the responsibility of the WNHP, as funding allows, with support from the U.S. Forest Service.

An adaptive management strategy seems most appropriate in the case of weeds: if increase of competing vegetation appears to be limiting the vigor of the *Artemisa*, control measures will be recommended by the WNHP to the Forest Service, which has responsibility for management of Miller Island. Likewise, other observed impacts, such as evidence of human trampling or other effects of human use, should be reviewed and reported annually to the Forest Service.

Augmentation and Establishing New Populations

Because of the continuing decrease of both of the known populations of ARBOWO and the lack of success so far in the search for other populations, augmentation and establishing new populations likely offer the best available safeguard against extinction. We expect that initiating a reintroduction program in Washington, drawing on the experience in Oregon by the Native Plant Conservation Program (Amsberry et al. 2007), will have significant beneficial effects to the taxon. However, we advise that this be pursued in a systematic and careful manner, including the development of a reintroduction plan, in accordance with the guidance in Falk et al. (1996).

Potential Pitfalls of Reintroduction

While there are obvious potential benefits of outplanting, there are also potential negative effects, and adequately considering these early in the process should minimize the dangers.

- 1. The increase of planted populations may contribute to reducing the perception of the value of wild populations.**

In the case of ARBOWO, the two known wild populations are already protected on public land and have high priority in the management plans of both areas. Overall, continuing this emphasis on existing populations should prevent the perception that existing populations need not be protected, because new ones can be developed in more convenient places. In practice, the difficulty and failure that may be encountered in efforts to establish new populations emphasizes the value of existing populations and the complexity and specificity of habitat requirements.

- 2. A population that is planted but that unable to reproduce, or that will ultimately decline because of other factors, may give the false impression of recovery.**

Long term monitoring will help our understanding of the viability of outplantings, as will keeping aware that reproduction is essential for viability of a population.

- 3. Bringing plant material onto an isolated site like Miller Island presents the risk of inadvertently introducing weeds or other pathogens from off-site. There are ample examples where propagating material off-site and bringing plants and soil, or even just seed, back to the site of origin have also brought weeds and other unwanted organisms.**

It does not appear that there are absolute safeguards against this form of contamination. However, keeping the risk in mind, conducting careful inspections of material brought onto a site and monitoring specifically for new weed introductions would greatly reduce the potential risk. To reduce the potential for long distance dispersal of pathogens or weeds, one general guideline would be to choose propagation facilities as near as possible to the eventual plantings.

- 4. Outplantings may be misinterpreted as naturally occurring populations. A population planted deliberately has significantly different conservation value than a naturally occurring one.**

This danger should be avoided entirely by including all outplantings in the databases of the respective state Natural Heritage Programs.

- 5. Cross-pollination could occur between a natural population and an outplanted one, if they happen to grow in proximity, resulting in genetic contamination of the wild population.**

Genetic contamination should not be a danger in augmentation plantings, where seed is collected from a population, grown into seedlings off site, and then returned for augmentation planting of the same population.

- 6. Establishing a new population with limited genetic material may result in a genetically depauperate population.**

Establishing a new population from a small number of individuals does present the potential of a population with narrow genetic diversity and may create a genetic bottleneck. Because the natural population at Miller Island is already extremely small, it may be unavoidable that the genetic diversity within any populations established from this stock will be limited. The only likely alternative would be to include plants from the Beverly population. We recommend limiting augmentation of the natural population to plants from seed from Miller Island, but we leave the seed source to be used in establishing other populations to discussion.

- 7. Competing needs may exist for the same resources, or conservation of one species may occasionally be in competition with another. A potential example would be that changes in water levels or water manipulation may affect ARBOWO differently than they affect migrating fish.**

Steps in the Reintroduction Process (not necessarily in strict chronological order)

- Develop an overall reintroduction plan for the taxon, identifying the potential dangers of reintroduction, and proposing safeguards against these.
- Define short and long term success: a great deal of thought and discussion may need to go into defining what would be considered success in these efforts. A stepwise approach to the question may be helpful, defining the simplest and most basic level of success, such as assuring that the species does not become extinct. The ultimate success might be that the taxon is secure in sufficient natural, self sustaining populations in natural plant communities.

- Develop site-specific plans for outplantings, and provide the species recovery group with the opportunity to review these prior to implementation. Follow up with planting and monitoring reports.
- Undertake a systematic evaluation of potential reintroduction sites along the Columbia River in Washington, working in partnership with the parallel effort in Oregon.
- Approach reintroduction in a two step process, first evaluating sites with small experimental plantings and then making decisions about locations that warrant larger scale reintroductions.
- Collect seed from the Miller Island population; likely this would first occur in 2011. In the past seed was successfully collected by bagging inflorescences with fine netting at the time of population monitoring and returning later in the season to retrieve the mature seed. Document seed collection in a central location, such as the WNHP.
- Germinate the seeds off-site and produce plants in pots or plugs for outplanting. Because of the difficulty of access to the natural population, it might be practical to keep a few plants in cultivation as a seed source for ongoing outplanting. The Native Plant Conservation Program had success with this approach.
- Establish experimental outplantings at selected locations on and near Miller Island, starting in Fall of 2012.
- Increase plantings at sites where survival is most promising.
- Expand this effort to other suitable locations in the Washington portion of the Columbia Gorge. While outside the scope of this management plan, sites upstream in the Hanford Reach more closely resemble the gravel and sand bars reports as habitat for this species, and in the long run it may be more productive to focus introduction efforts there.
- Report all outplantings in Washington, including experimental ones, to the WNHP so sites can be included in the program database. Careful documentation will greatly increase the information we can obtain from experimental planting and allow us to make better use of mistakes that might occur.

Potential Miller Island Outplanting Sites

The following locations on and nearby Miller Island, shown in Figure 7, warrant investigation as outplanting sites:

1. The vicinity of the extant ARBOWO population: Locations of extant populations present conditions known to be suitable for the species, and augmentation plantings with other listed species have had high rates of survival (Arnett and Dunwiddie 2010), usually far above other experimental sites.
2. Low land at the north-east end of Miller Island: The mix of cobbles and sand is similar to the extant Miller Island site.
3. Shoreline areas west of the quarry site: *Artemisia borealis* var. *scouleriana* is present at this site, and while the land is generally not as close to the level of the river as either of the extant populations of ARBOWO. Of sites reviewed on Miller Island, this site appears most similar to the location where ARBOWO is growing.
4. The shoreline at the far eastern end of Miller Island warrants a site visit; we were not able to examine this site on the ground, but from the water it looks similar to the sand substrate of the Miller Island ARBOWO site.
5. The small island off the east end of Miller Island, called Miller Lite by Capt. Jack LeFond, has low-lying sandy areas that warrant examination.



Figure 7. Locations to be evaluated for outplanting *Artemisia borealis* var. *wormskioldii* on and adjacent to Miller Island

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Appendix A: Miller Island vascular plant species list, compiled 2010

Nomenclature generally follows the Washington Flora Checklist, available at <http://biology.burke.washington.edu/herbarium/waflora/checklist.php>.

| scientific name | Common name | Origin | Miller Island |
|---|--------------------------------|------------|---------------|
| <i>Amelanchier alnifolia</i> | serviceberry | native | A |
| <i>Abronia mellifera</i> | white sandverbena | native | A, JK |
| <i>Achillea millefolium</i> | yarrow | native | A, JK |
| <i>Achnatherum hymenoides</i> (= <i>Oryzopsis hymenoides</i>) | Indian ricegrass | native | A, GP, JK |
| <i>Agoseris heterophylla</i> | annual agoseris | native | JK |
| <i>Agropyron cristatum</i> | crested wheatgrass | introduced | A, JK |
| <i>Agropyron dasystachyum</i> | thick-spiked wheatgrass | | JK |
| <i>Agropyron intermedium</i> | rhizomatous wheatgrass | introduced | GP |
| <i>Agrostis interrupta</i> | interrupted apera | | JK |
| <i>Ailanthus altissima</i> | tree-of-heaven | introduced | A, JK |
| <i>Allium acuminatum</i> | taper-tip onion | native | A, JK |
| <i>Alnus rhombifolia</i> | white alder | native | A, JK |
| <i>Ambrosia acanthicarpa</i> | bur ragweed | | JK |
| <i>Amorpha fruticosa</i> | false indigo | introduced | A, JK |
| <i>Amsinckia lycopsoides</i> | tarweed fiddleneck | native | A, JK |
| <i>Antennaria dimorpha</i> | low pussy-toes | native | JK |
| <i>Anthemis cotula</i> * | dog fennel | | JK |
| <i>Anthriscus caucaulis</i> (= <i>A. scandicina</i>) | chervil | introduced | A, JK |
| <i>Aphanes occidentalis</i> (= <i>Alchemilla occidentalis</i>) | lady's-mantle | | JK |
| <i>Apocynum cannabinum</i> | Indian hemp | native | A, JK |
| <i>Arabidopsis thaliana</i> | common wall-cress | introduced | JK |
| <i>Artemisia borealis</i> var. <i>scouleriana</i> | Scouler's northern wormwood | native | A, JK |
| <i>Artemisia borealis</i> var. <i>wormskioldii</i> | Wormskiold's northern wormwood | native | A, WB, JK |
| <i>Artemisia dracuncululus</i> | tarragon | native | A, JK |
| <i>Artemisia lindleyana</i> | riverbank sage | native | JK |
| <i>Artemisia ludoviciana</i> | prairie sage | native | A, JK |
| <i>Artemisia tridentata</i> | tall sagebrush | native | A, JK |
| <i>Asclepias fascicularis</i> | narrow-leaf milkweed | native | JK |
| <i>Asparagus officinalis</i> | asparagus | introduced | JK |
| <i>Astragalus purshii</i> | woolly-pod milkvech | native | A, JK |
| <i>Astragalus sclerocarpus</i> | stalked-pod milkvetch | native | GP, JK |
| <i>Athysanus pusillus</i> | sandweed | native | A, JK |

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|--|-------------------------------|------------|--------------|
| <i>Balsamorhiza careyana (deltoidea? JK)</i> | Carey's balsamroot | native | A, JK |
| <i>Berberis aquifolium</i> | tall Oregon-grape | native | JK |
| <i>Bidens frondosa</i> | leafy beggar-ticks | native | JK |
| <i>Bromus - large, carinatus?</i> | brome | native | A |
| <i>Bromus cf. diandrus (Bromus rigidus)</i> | ripgut brome | introduced | A, JK |
| <i>Bromus hordeaceus (B. mollis)</i> | soft chess | introduced | A, JK |
| <i>Bromus tectorum</i> | cheatgrass | introduced | A, GP, JK |
| <i>Calochortus macrocarpus</i> | sagebrush mariposa | native | JK |
| <i>Camissonia contorta</i> | twisted suncup | native | A |
| <i>Cardaria sp.</i> | White-top | introduced | D |
| <i>Carex douglasii</i> | Douglas sedge | native | JK |
| <i>Carex macrocephalum</i> | big-head sedge | native | A |
| <i>Carex praegracilis</i> | clustered field sedge | native | JK |
| <i>Carex-rhizom. Multi heads, thin wing, androgyn.</i> | sedge | native | A |
| <i>Celtis reticulata</i> | hackberry | native | A, JK |
| <i>Centaurea diffusa</i> | diffuse knapweed | introduced | A |
| <i>Centaurea solstitialis</i> | yellow star-thistle | introduced | D |
| <i>Centaureum exaltatum</i> | western centaury | | JK |
| <i>Cerastium glomeratum</i> | sticky mouse-ear chickweed | introduced | A |
| <i>Cerastium vulgatum</i> | mouse-ear chickweed | introduced | JK |
| <i>Chaenactis douglasii</i> | dusty miller | native | A, JK |
| <i>Chenopodium botrys</i> | Jerusalem-oak | | JK |
| <i>Chondrilla juncea</i> | rush skeletonweed | introduced | A |
| <i>Chrysothamnus viscidiflorus</i> | sticky rabbitbrush | native | A, JK |
| <i>Cirsium undulatum</i> | wavy-leaf thistle | native | A, JK |
| <i>Claytonia perfoliata (=Montia perfoliata)</i> | miner's lettuce | native | A, JK |
| <i>Claytonia rubra ssp. depressa</i> | cushion miner's-lettuce | native | A |
| <i>Collinsia parviflora</i> | blue-eyed Mary | native | A, JK |
| <i>Comandra umbellata</i> | bastard toad-flax | native | A, JK |
| <i>Conyza canadensis</i> | horseweed | native | JK |
| <i>Coreopsis atkinsoniana</i> | Columbia coreopsis | native | JK |
| <i>Crataegus douglasii</i> | black hawthorn | native | JK |
| <i>Crepis barbiger</i> | bearded hawksbeard | native | JK |
| <i>Crocidium nudicaule</i> | spring gold | native | A, JK |
| <i>Cryptantha ambigua</i> | obscure cryptantha | native | A |
| <i>Cryptantha flaccida</i> | small white forget-me-not | native | JK |
| <i>Cryptantha pterocarya</i> | wingnut white forget-me-not | native | JK |

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|---|-------------------------|------------|--------------|
| <i>Cynosurus echinatus</i> | bristly dog's-tail | introduced | A |
| <i>Cyperus rivularis</i> | shining flatsedge | native | GP, JK |
| <i>Cyperus squarrosus (C. aristatus)</i> | awned flatsedge | native | JK |
| <i>Cyperus strigosus</i> | straw-colored flatsedge | native | JK |
| <i>Cystopteris fragilis</i> | brittle bladder-fern | native | A |
| <i>Delphinium nuttallianum</i> | upland larkspur | native | A, JK |
| <i>Descurainia incisa (=D. richardsonii)</i> | western tansy-mustard | native | JK |
| <i>Descurainia pinnata</i> | western tansymustard | native | A |
| <i>Digitaria sanguinalis</i> | hairy crabgrass | | JK |
| <i>Dodecatheon conjugens var. conjugens (or hendersonii?)</i> | shooting-star | native | A, JK |
| <i>Dodecatheon cusickii</i> | sticky shooting-star | native | A, JK |
| <i>Draba verna</i> | spring whitlow-grass | native | A, JK |
| <i>Echinochloa crusgalli</i> | barnyard grass | introduced | JK |
| <i>Eleocharis ovata</i> | ovoid spike-rush | native | JK |
| <i>Eleocharis palustris</i> | common spike-rush | native | JK |
| <i>Elymus multisetus (Sitanion jubatum)</i> | big squirreltail | native | JK |
| <i>Epilobium brachycarpum (=E. paniculatum)</i> | tall annual willow-herb | native | JK |
| <i>Epilobium ciliatum ssp. watsonii</i> | Watson's willow-herb | native | JK |
| <i>Epilobium hirsutum</i> | fiddle-grass | introduced | JK |
| <i>Equisetum hymale</i> | common scouring-rush | native | A |
| <i>Eremocarpus setigerus</i> | turkey-mullein | native | JK |
| <i>Ericameria nauseosa</i> | rubber rabbitbrush | native | A, GP, JK |
| <i>Ericameria resinosa (Haplopappus resinosus)</i> | Columbia gumweed | native | A, JK |
| <i>Erigeron divergens</i> | diffuse daisy | native | JK |
| <i>Erigeron filifolius</i> | threadleaf fleabane | native | A, JK |
| <i>Eriogonum compositum</i> | northern buckwheat | native | A, JK |
| <i>Eriogonum- narrow leaves, lanate</i> | buckwheat | native | A |
| <i>Eriogonum niveum</i> | snow desert-buckwheat | native | A |
| <i>Eriogonum strictum</i> | strict buckwheat | native | A |
| <i>Eriogonum umbellatum - yellow</i> | sulfur buckwheat | native | A |
| <i>Eriophyllum lanatum</i> | woolly sunflower | native | JK |
| <i>Erodium cicutarium</i> | crane's-bill | introduced | A, JK |
| <i>Erysimum arenicola</i> | wall-flower | native | A |
| <i>Erysimum occidentale</i> | pale wallflower | native | JK |
| <i>Euphorbia glyptosperma</i> | corrugate-seeded spurge | native | JK |
| <i>Euphorbia maculata (E. supina)</i> | milkspurge | introduced | JK |
| <i>Euthamia occidentalis (Solidago occidentalis)</i> | western goldenrod | native | JK |

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|---|---------------------------|------------|-----------|
| <i>Festuca arundinacea</i> | giant fescue | introduced | GP, JK |
| <i>Festuca cf. rubra</i> | red fescue | native | A |
| <i>Festuca idahoensis</i> | blue bunchgrass | native | JK |
| <i>Festuca pratensis</i> | meadow fescue | introduced | JK |
| <i>Fritillaria pudica</i> | yellowbell | native | A, JK |
| <i>Gaillardia aristata</i> | blanket-flower | native | A, JK |
| <i>Gilia sinuata var. sinuata</i> | cutleaf gilia | native | JK |
| <i>Githopsis specularioides</i> | common blue-cup | native | WB, JK |
| <i>Glycyrrhiza lepidota</i> | licorice | native | A, JK |
| <i>Gnaphalium palustre</i> | lowland cudweed | native | JK |
| <i>Grindelia columbiana</i> | Columbia gumweed | native | JK |
| <i>Gutierrezia sarothrae</i> | matchbrush | native | JK |
| <i>Gypsophila paniculata</i> | baby's-breath | introduced | JK |
| <i>Helenium autumnale</i> | sneezeweed | native | JK |
| <i>Heterostipa comata (=Stipa comata)</i> | needle-and-thread grass | native | A, GP, JK |
| <i>Heterotheca villosa (Chrysopsis villosa)</i> | hairy goldenaster | native | A, JK |
| <i>Holosteum umbellatum</i> | jagged chickweed | introduced | A, JK |
| <i>Hordeum cf. jubatum</i> | foxtail barley | native | A |
| <i>Hordeum marinum ssp. gussonianum</i> | mediterranean barley | introduced | JK |
| <i>Hordeum murinum ssp. leporinum</i> | mouse barley | introduced | JK |
| <i>Hydrophyllum capitatum</i> | waterleaf | native | A, JK |
| <i>Hymenopappus filifolius var. filifolius</i> | Columbia cutleaf | native | A, JK |
| <i>Hypericum perforatum</i> | Klamath weed | introduced | A, JK |
| <i>Hypochaeris glabra</i> | smooth cat's-ear | introduced | A |
| <i>Juncus articulatus</i> | jointed rush | native | JK |
| <i>Juncus balticus</i> | Baltic rush | native | A, JK |
| <i>Juncus bufonius var. bufonius</i> | toad rush | introduced | JK |
| <i>Juncus dudleyi (J. tenuis var. dudleyi)</i> | slender rush | native | JK |
| <i>Juncus torreyi</i> | Torrey's rush | native | JK |
| <i>Juniperus occidentalis</i> | western juniper | native | A, JK |
| <i>Lactuca serriola</i> | prickly lettuce | introduced | JK |
| <i>Layia glandulosa</i> | white tidytips | native | A, JK |
| <i>Lepidium latifolium</i> | broadleaved peppergrass | introduced | A |
| <i>Leymus cinereus (Elymus cinereus)</i> | Great Basin wildrye | native | A, JK |
| <i>Leymus flavescens (Elymus flavescens)</i> | sand wildrye | native | A, JK |
| <i>Lilaeopsis occidentalis</i> | grassleaf-parsley | native | JK |
| <i>Lipocarpa micrantha (Hemicarpha micrantha)</i> | small-flowered hemicarpha | native | JK |
| <i>Lithophragma bulbifera</i> | slender prairie-star | native | A, JK |

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|--|----------------------------------|------------|--------------|
| <i>Lithophragma parviflora</i> | small-flowered prairie-star | native | JK |
| <i>Lithospermum ruderale</i> | Columbia puccoon | native | A, JK |
| <i>Lomatium dissectum</i> | fern-leaf biscuit-root | native | A, JK |
| <i>Lomatium geyeri</i> | Geyer's lomatium | native | A |
| <i>Lomatium gormanii</i> | Gorman's desert-parsley | native | A |
| <i>Lomatium grayi</i> | Gray's desert-parsley | native | A, JK |
| <i>Lomatium laevigatum</i> | smooth lomatium | native | A, WB, JK |
| <i>Lomatium macrocarpum</i> | large-fruited lomatium | native | A, JK |
| <i>Lomatium nudicaule</i> | barestem lomatium | native | A, JK |
| <i>Lomatium piperi</i> | salt-and-pepper | native | JK |
| <i>Lomatium triternatum</i> | Nine-leaf lomatium | native | A, JK |
| <i>Lotus cf. micranthus</i> | short-flower bird's-foot-trefoil | native | A |
| <i>Lotus unifoliolatus (L. purshianus)</i> | Spanish-clover | native | JK |
| <i>Lupinus - annual, bicolor?</i> | lupine | native | A |
| <i>Lupinus bingenensis var. dubius (=L. leucopsis var. shermanensis)</i> | whitish lupine | native | JK |
| <i>Lupinus leucopsis var. mollis (=?)</i> | whitish lupine | native | JK |
| <i>Lupinus sericeus var. fikeranus</i> | silky lupine | native | A, JK |
| <i>Lycopus americanus</i> | cutleaf bugleweed | native | JK |
| <i>Lycopus asper</i> | northern bugleweed | native | JK |
| <i>Machaeranthera canescens</i> | hoary aster | native | JK |
| <i>Medicago lupulina</i> | black medic | introduced | JK |
| <i>Melilotus alba</i> | white sweet-clover | introduced | JK |
| <i>Melilotus officinalis</i> | yellow sweet-clover | introduced | JK |
| <i>Melilotus sp.</i> | sweetclover | introduced | A |
| <i>Mentha arvensis</i> | common field mint | native | JK |
| <i>Micranthes (Saxifraga) integrifolia cf var claytonifolia</i> | swamp saxifrage | native | A |
| <i>Microseris troximoides</i> | false-agoseris | native | JK |
| <i>Mimulus guttatus</i> | seep monkey-flower | native | JK |
| <i>Mimulus moschatus</i> | musk monkeyflower | native | JK |
| <i>Montia fontana</i> | water chickweed | native | A |
| <i>Montia linearis</i> | narrow-leaved montia | native | A |
| <i>Montia spathulata</i> | pale montia | native | JK |
| <i>Morus alba</i> | white mulberry | native | A |
| <i>Muhlenbergia asperifolia</i> | rough-leaved dropseed | native | JK |
| <i>Myosotis stricta (M. micrantha)</i> | blue forget-me-not | introduced | JK, A |
| <i>Myosurus aristatus</i> | bristly mousetail | native | A |

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| <i>Nothocalais troximoides</i> (<i>Microseris troximoides</i>) | false agoseris | native | A |
| <i>Oenothera contorta</i> | slender evening-primrose | native | JK |
| <i>Oenothera pallida</i> var. <i>pallida</i> | pale evening-primrose | native | A, JK |
| <i>Olsynium douglasii</i> (= <i>Sisyrinchium douglasii</i>) | grass-widow | native | JK |
| <i>Olsynium inflatum</i> (= <i>Sisyrinchium inflatum</i>) | purple-eyed grass | native | A |
| <i>Opuntia polyacantha</i> | prickly-pear cactus | native | A, JK |
| <i>Orobanche fasciculata</i> | clustered broomrape | native | A, JK |
| <i>Orobanche ludoviciana</i> | Suksdorf's broomrape | native | A, JK |
| <i>Orobanche uniflora</i> | naked broom-rape | native | A, JK |
| <i>Orthocarpus attenuatus</i> | narrowleaf owlclover | native | A, JK |
| <i>Panicum capillare</i> ssp. <i>capillare</i> | witchgrass, common panic grass | native | A |
| <i>Pascopyrum smithii</i> (<i>Agropyron smithii</i>) | western wheatgrass | native | A, GP |
| <i>Penstemon acuminatus</i> var. <i>acuminatus</i> | sand dune penstemon | native | JK |
| <i>Penstemon richardsonii</i> var. <i>richardsonii</i> | Richardson's penstemon | native | A, JK |
| <i>Perideridia gairdneri</i> | yampah | native | A |
| <i>Persicaria hydropiper</i> (<i>Polygonum hydropiper</i>) | smartweed | native | JK |
| <i>Persicaria maculosa</i> (<i>Polygonum persicaria</i>) | spotted lady's-thumb | introduced | JK |
| <i>Phacelia hastata</i> | arrowleaf phacelia | native | A, JK |
| <i>Phacelia linearis</i> | threadleaf phacelia | native | A, JK |
| <i>Philadelphus lewisii</i> | mock-orange | native | A, JK |
| <i>Phleum pratense</i> * | timothy | introduced | JK |
| <i>Phlox gracilis</i> (= <i>Microsteris gracilis</i>) | annual phlox | native | A, JK |
| <i>Phlox longifolia</i> | long-leaf phlox | native | A, JK |
| <i>Phragmites communis</i> - only 4' tall | reed | native | A |
| <i>Physaria douglasii</i> (= <i>Lesquerella douglasii</i>) | Douglas bladderpod | native | A, JK |
| <i>Pinus ponderosa</i> | Ponderosa pine | native | A, WB |
| <i>Pityrogramma triangularis</i> | gold-back fern | native | JK |
| <i>Plagiobothrys tenellus</i> | slender popcorn flower | native | A, JK |
| <i>Plantago lanceolata</i> | English plantain | introduced | A |
| <i>Plantago patagonica</i> | Indian-wheat | introduced | A, JK |
| <i>Plectritis macrocera</i> | white plectritis | native | A, JK |
| <i>Poa ampla</i> | big bluegrass | introduced | A, GP |
| <i>Poa bulbosa</i> | bulbous bluegrass | introduced | A, JK |
| <i>Poa compressa</i> | flat-stem bluegrass | introduced | JK |
| <i>Poa juncifolius</i> (part of <i>P. secunda</i>) | rush-leaved bluegrass | native | JK |
| <i>Poa leibergii</i> | Leiberg's bluegrass | native | JK |

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| <i>Poa pratensis</i> ssp. <i>pratensis</i> | Kentucky bluegrass | introduced | JK |
| <i>Poa secunda</i> (= <i>Poa sandbergii</i>) | Sandberg's bluegrass | native | A, GP, JK |
| <i>Polemonium micranthum</i> | annual polemonium | native | JK |
| <i>Polygonum aviculare</i> | prostrate knotweed | introduced | JK |
| <i>Polygonum majus</i> | wiry knotweed | native | JK |
| <i>Polypogon monspeliensis</i> | rabbitfoot polypogon | introduced | JK |
| <i>Populus alba</i> | white poplar | introduced | A, WB |
| <i>Populus nigra</i> var. <i>italica</i> | lombardy poplar | introduced | A |
| <i>Potentilla biennis</i> | biennial cinquefoil | native | JK |
| <i>Potentilla rivalis</i> | riverbank cinquefoil | native | JK |
| <i>Prunus</i> - pink flowering, possibly planted | cherry | introduced | A |
| <i>Prunus virginiana</i> | chokecherry | native | JK |
| <i>Pseudognaphalium stramineum</i> (<i>Gnaphalium chilense</i>) | cotton-batting plant | native | JK |
| <i>Pseudoroegneria spicata</i> (= <i>Agropyron spicatum</i>) | blue-bunch wheatgrass | native | A, GP, JK |
| <i>Psoralea lanceolata</i> | scurf-pea | native | A, GP, JK |
| <i>Purshia tridentata</i> | bitterbrush | native | A, JK |
| <i>Ranunculus aquaticus</i> cf. var. <i>porteri</i> | water buttercup | native | A |
| <i>Ranunculus cymbalaria</i> | shore buttercup | native | JK |
| <i>Ranunculus glaberrimus</i> | sagebrush buttercup | native | JK |
| <i>Rorippa curvisiliqua</i> | western yellowcress | native | JK |
| <i>Rosa nutkana</i> | Nootka rose | native | A |
| <i>Rubus armeniacus</i> | Himalayan blackberry | introduced | A |
| <i>Rumex crispus</i> | curly dock | introduced | A |
| <i>Rumex venenosus</i> | sand dock | native | A, GP, JK |
| <i>Salix amygdaloides</i> | peach-leaf willow | native | A, WB |
| <i>Salix exigua</i> | coyote willow | native | A, WB |
| <i>Salsola tragus</i> (= <i>Salsola kali</i>) | Russian thistle | introduced | A, JK |
| <i>Saxiifraga integrifolia</i> | northwest saxifrage | native | JK |
| <i>Secale cereale</i> | cultivated rye | introduced | A |
| <i>Sedum leibergii</i> | Leiberg's stonecrop | native | JK |
| <i>Sedum species</i> | stonecrop | native | A |
| <i>Sisymbrium altissimum</i> | tumblemustard | introduced | JK |
| <i>Solidago</i> | goldenrod | native | A |
| <i>Sporobolus cryptandrus</i> | sand dropseed | native | GP, JK |
| <i>Stellaria nitens</i> | shiny starwort | native | A, JK |

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| <i>Stephanomeria paniculata</i> | stiff-branched skeletonweed | native | JK |
| <i>Symphytotrichum subspicatum</i> | Douglas' aster | native | JK |
| <i>Taeniatherum caput-medusae</i> | medusahead | introduced | A |
| <i>Taraxacum officinale</i> | dandelion | introduced | A |
| <i>Thelypodium laciniatum</i> var. <i>laciniatum</i> | thick-leaved thelypody | native | A, JK |
| <i>Thysanocarpus curvipes</i> | lacepod | native | A, JK |
| <i>Toxicodendron diversiloba</i> | poison-oak | native | JK |
| <i>Tragopogon dubium</i> | oysterplant | introduced | A, JK |
| <i>Tribulus terrestris</i> | puncture-vine | introduced | JK |
| <i>Trifolium fragiferum</i> | strawberry-clover | introduced | JK |
| <i>Trifolium subterraneum</i> | subterranean clover | introduced | A |
| <i>Trileleia grandiflora</i> ssp. <i>howellii</i> (<i>Brodiaea howellii</i>) | Howell's trileleia | native | A, JK |
| <i>Typha latifolia</i> | cat-tails | native | A |
| <i>Ulmus</i> sp. | elm | native | A |
| <i>Verbascum blattaria</i> | moth mullein | introduced | JK |
| <i>Verbascum thapsus</i> | common mullein | introduced | JK |
| <i>Verbena bracteata</i> | bracted verbena | native | JK |
| <i>Veronica americana</i> | American brooklime | native | JK |
| <i>Veronica peregrina</i> var. <i>xalapensis</i> | purslane speedwell | native | A, JK |
| <i>Vulpia bromoides</i> (<i>Festuca bromoides</i>) | six-weeks grass | introduced | A, JK |
| <i>Vulpia megalura</i> (<i>Festuca megalura</i>) | foxtail fescue | introduced | JK |
| <i>Vulpia microstachys</i> (<i>Festuca microstachys</i>) | small fescue | native | JK |
| <i>Vulpia octoflora</i> (<i>Festuca octoflora</i>) | six-weeks grass | native | GP |
| <i>Xanthium strumarium</i> | cocklebur | native | JK |
| <i>Zigadenus venenosus</i> | meadow death camas | native | JK |
| <i>Zygadenus paniculatus</i> | paniculate death-camas | native | A, JK |

Miller Island: J. Arnett, 22May2006, 2May2007, 19 and 20March2008 (with Cathy Flick), 16 and 17April2008. 9May2008, 30April2009 and 1May2009 (with Cathy Flick, Andrew Merritt, Kristin Currin, Krista Thie, Nancy Allen, Carolyn Wright, Robin Beck, Jergen Hess). GP= Interim Management Direction for Miller Island, GPNF 1989; W= WNHP biotics database; JK= list compiled by Russ Jolley and Lois Kemp, 1983; D= communication on weed control from Robin Dobson.

| tag # | row | col | plant # | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | | 2010 | | |
|---------|-----|-----|---------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|
| | | | | X | Y | stems |
| 194 | 6 | 1 | 1 | | | | | | | | | | | | | | | | | | 75 | 84 | 20 | 70 | 90 | 19 | 70 | 90 | 23 | |
| 195 | 6 | 2 | 1 | | | | 88 | 70 | 1 | 98 | 60 | 1 | 100 | 66 | 9 | 88 | 59 | 12 | 88 | 59 | 2 | 84 | 70 | 15 | 70 | 57 | 19 | 90 | 60 | 17 |
| | 6 | 7 | 1 | 62 | 35 | 2 | 70 | 36 | 5 | 70 | 35 | 14 | 80 | 40 | 10 | | | | | | | | | | | | | | | |
| 191 | 6 | 8 | 1 | | | | | | | | | | | | | | | | | | 85 | 15 | 3 | 85 | 3 | 2 | 80 | 2 | 2 | |
| | 6 | 8 | 2 | 54 | 40 | 3 | 55 | 40 | 1 | 63 | 33 | 7 | 70 | 42 | 11 | | | | | | | | | | | | | | | |
| | 6 | 8 | 3 | | | | | | | | | | | | | | | | | | | | | | | | 90 | 45 | 6 | |
| 162 | 6 | 9 | 1 | | | | | | | | | | | | | | | | | | | | | 30 | 30 | 1 | 35 | 30 | 4 | |
| | 6 | 10 | 1 | 48 | 69 | 9 | 50 | 66 | 13 | | | | | | | | | | | | | | | | | | | | | |
| | 7 | 2 | 1 | 11 | 30 | 21 | 7 | 33 | 15 | | | | | | | | | | | | | | | | | | | | | |
| | 7 | 2 | 2 | 20 | 46 | 13 | 15 | 50 | 7 | 28 | 48 | 9 | 34 | 48 | 4 | | | | | | | | | | | | | | | |
| | 7 | 7 | 1 | 70 | 72 | 4 | 63 | 73 | 4 | 75 | 74 | 3 | | | | | | | | | | | | | | | | | | |
| 183 | 7 | 7 | 2 | | | | | | | | | | | | | | | | | | 65 | 60 | 6 | 66 | 45 | 6 | | | | |
| 165 | 7 | 7 | 3 | | | | | | | | | | | | | | | | | | | | 47 | 40 | 14 | | | | | |
| 196 | 7 | 8 | 1 | 25 | 39 | 2 | 20 | 37 | 2 | 26 | 40 | 13 | 27 | 40 | 14 | 27 | 40 | 11 | | | 30 | 35 | 2 | | | | | | | |
| | 7 | 8 | 2 | 45 | 68 | 5 | 42 | 66 | 13 | 48 | 68 | 19 | | | | | | | | | | | | | | | | | | |
| | 7 | 8 | 3 | 67 | 58 | 4 | 63 | 57 | | | | | | | | | | | | | | | | | | | | | | |
| 197/164 | 7 | 8 | 4 | | | | | | | | | | | | | | | | | | 5 | 20 | 1 | 11 | 18 | 3 | | | | |
| | 7 | 8 | 5 | | | | | | | | | | | | | | | | | | | | | | | | 30 | 32 | 13 | |
| | 7 | 10 | 1 | 25 | 5 | 0 | 20 | 5 | 8 | 28 | 7 | 6 | 36 | 9 | 6 | | | | | | | | | | | | | | | |
| | 8 | 4 | 1 | 20 | 22 | 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | 4 | 2 | | | | 11 | 52 | 1 | 25 | 48 | 9 | 26 | 55 | 3 | | | | | | | | | | | | | | | |
| | 8 | 7 | 1 | 40 | 99 | 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | 7 | 2 | | | | | | | 50 | 83 | 5 | 57 | 97 | 4 | | | | | | | | | | | | | | | |
| 163 | 8 | 7 | 3 | | | | | | | | | | | | | | | | | | | | | 91 | 95 | 2 | 10 | 10 | 3 | |
| 188 | 8 | 9 | 1 | 45 | 24 | 8 | | | | | | | | | | | | | | | | | | | | | | | | |

Appendix B-2

| tag # | row | col | plant # | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | | 2010 | | | | | | | | | | | | |
|-------|-----|-----|---------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|--|--|--|--|--|--|--|--|--|--|
| | | | | X | Y | stems | | | | | | | | | | |
| | 8 | 9 | 2 | | | | 67 | 22 | 13 | 78 | 22 | 10 | 86 | 25 | 17 | 86 | 25 | 17 | 86 | 25 | 18 | | | | | | | | | | | | | | | | | | | |
| | 8 | 9 | 3 | | | | | | | | | | | | | | | | | | | 65 | 20 | 24 | 63 | 22 | 2 | 60 | 20 | 26 | | | | | | | | | | |
| 166 | 8 | 9 | 4 | | | | | | | | | | | | | | | | | | | | | | 54 | 25 | 3 | | | | | | | | | | | | | |
| 182 | 9 | 4 | 2 | 68 | 81 | 4 | 62 | 72 | 4 | 70 | 71 | 1 | 80 | 85 | | 78 | 85 | | 78 | 85 | 7 | 60 | 80 | 25 | | | | 65 | 80 | 1 | | | | | | | | | | |
| | 10 | 3 | 2 | 85 | 75 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 198 | 10 | 4 | 1 | 2 | 38 | 4 | 2 | 38 | 4 | 2 | 43 | 5 | 6 | 40 | 5 | 7 | 26 | 4 | 7 | 52 | 8 | 10 | 60 | 32 | 85 | 32 | 56 | 10 | 40 | 45 | | | | | | | | | | |
| | 10 | 4 | 2 | 95 | 63 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | 5 | 1 | 18 | 63 | 12 | 10 | 65 | 2 | 20 | 61 | 8 | 22 | 71 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | 3 | 1 | 0 | 10 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | 3 | 2 | 23 | 66 | 24 | 14 | 60 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | 3 | 3 | | | | | | | 15 | 57 | 19 | 20 | 63 | 25 | 18 | 61 | 13 | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | 3 | 4 | | | | | | | | | | | | | | | | 25 | 78 | 14 | | | | | | | | | | | | | | | | | | | |
| 199 | 11 | 3 | 5 | | | | | | | | | | | | | | | | | | | 15 | 68 | 5 | | | | | | | | | | | | | | | | |
| 186 | 11 | 3 | 6 | | | | | | | | | | | | | | | | | | | 15 | 60 | 20 | 8 | 63 | 20 | 15 | 60 | 30 | | | | | | | | | | |
| 181 | 11 | 4 | 1 | | | | | | | | | | | | | | | | | | | 80 | 80 | 21 | | | | | | | | | | | | | | | | |
| | 11 | 4 | 2 | | | | | | | | | | | | | | | | | | | | | | | 50 | 75 | 11 | | | | | | | | | | | | |
| | 12 | 9 | 1 | 70 | 28 | 6 | 70 | 28 | 9 | 70 | 17 | 14 | 88 | 40 | 12 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 3 | 1 | 84 | 17 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 3 | 2 | 95 | 70 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 3 | 3 | | | | | | | 92 | 6 | 3 | 12 | 26 | 8 | 99 | 2 | 1 | 97 | 10 | 1 | | | | | | | | | | | | | | | | | | | |
| | 13 | 4 | 1 | 3 | 62 | 6 | 10 | 72 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 4 | 2 | 18 | 66 | 3 | 4 | 81 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 8 | 1 | 54 | 57 | 3 | 52 | 60 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | 10 | 1 | 30 | 5 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| tag # | row | col | plant # | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | | 2010 | | | | | | | | | | |
|---------|-----|-----|---------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|--|--|--|----|----|----|----|---|
| | | | | X | Y | stems | | | | | | | | |
| | 16 | 11 | 1 | 21 | 68 | 1 | 20 | 75 | 2 | 20 | 68 | 4 | 32 | 59 | 7 | 30 | 65 | 1 | | | | | | | | | | | | | | | | | | | | |
| | 16 | 11 | 2 | 20 | 94 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 16 | 11 | 3 | 38 | 21 | 0 | 34 | 30 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 16 | 13 | 1 | 37 | 52 | 0 | 30 | 65 | | 39 | 42 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 16 | 13 | 2 | 70 | 68 | 2 | 85 | 60 | 4 | 75 | 62 | 11 | 60 | 38 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| | 16 | 13 | 3 | | | | | | | | | | 91 | 59 | 13 | | | | | | | | | | | | | | | | | | | | | | | |
| 179 | 16 | 13 | 4 | | | | | | | | | | | | | | | 78 | 83 | 15 | 60 | 70 | 17 | | | | | | | | | | | | | | | |
| 178/171 | 16 | 13 | 5 | | | | | | | | | | | | | | | | | | 40 | 12 | 1 | 35 | 18 | 1 | | | | | | | | | | | | |
| 187 | 16 | 13 | 6 | | | | | | | | | | | | | | | | | | 30 | 50 | 5 | 60 | 42 | 25 | 70 | 40 | 10 | | | | | | | | | |
| | 16 | 13 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 65 | 55 | 14 | | |
| | 16 | 13 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 70 | 35 | 6 | |
| | 16 | 14 | 1 | 22 | 82 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 173/172 | 16 | 15 | 1 | 55 | 56 | 4 | 55 | 66 | 2 | 62 | 54 | | 83 | 60 | 11 | 66 | 62 | 4 | 68 | 67 | 11 | 60 | 65 | 8 | 58 | 43 | 5 | | | | | | | | | | | |
| | 17 | 7 | 3 | | | | 92 | 10 | 10 | 98 | 5 | 7 | 100 | 1 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| | 17 | 8 | 1 | 95 | 3 | 29 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 17 | 9 | 1 | 8 | 82 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 17 | 9 | 2 | 28 | 50 | 8 | 25 | 60 | 9 | 31 | 48 | 2 | 28 | 28 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| | 17 | 13 | 1 | 18 | 70 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 173 | 17 | 13 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 17 | 13 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 60 | 90 | 8 |
| | 18 | 4 | 2 | 59 | 63 | 1 | 46 | 55 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 18 | 5 | 1 | 45 | 22 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 18 | 5 | 2 | 42 | 84 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 18 | 5 | 3 | 80 | 0 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 18 | 5 | 4 | | | | 64 | 10 | 4 | 75 | 10 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |

| tag # | row | col | plant # | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | | 2010 | | | | | | | | |
|---------|-----|-----|---------|------|----|-------|------|-----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|------|----|-------|--|--|--|--|--|--|
| | | | | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | | | | | | |
| | 18 | 5 | 5 | | | | | | | | | | | | | | | 95 | 59 | 5 | | | | | | | | | | | | | | | | |
| | 18 | 6 | 1 | 36 | 44 | 0 | 26 | 46 | | 34 | 47 | 2 | 25 | 38 | 14 | | | | | | | | | | | | | | | | | | | | | |
| 172 | 18 | 6 | 2 | | | | | | | | | | | | | | | 6 | 59 | 1 | 10 | 48 | 12 | 22 | 39 | 0 | 38 | 44 | 14 | | | | | | | |
| | 18 | 8 | 1 | 85 | 42 | 9 | 75 | 42 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 19 | 5 | 2 | 27 | 71 | 4 | 20 | 70 | 5 | 20 | 74 | 9 | 29 | 69 | 14 | 35 | 72 | 1 | | | | | | | | | | | | | | | | | | |
| | 19 | 8 | 1 | 3 | 38 | 2 | 4 | 35 | 10 | 0 | 40 | 1 | 8 | 58 | 21 | | | | | | | | | | | | | | | | | | | | | |
| | 19 | 8 | 2 | 23 | 16 | 5 | 20 | 68 | 14 | 15 | 72 | 10 | 17 | 80 | 14 | | | | | | | | | | | | | | | | | | | | | |
| | 19 | 8 | 3 | | | | 88 | 11 | 0 | 95 | 12 | 0 | 100 | 12 | 4 | | | | | | | | | | | | | | | | | | | | | |
| | 19 | 8 | 4 | | | | | | | | | | | | | | | 66 | 25 | 7 | | | | | | | | | | | | | | | | |
| | 19 | 9 | 1 | 93 | 85 | 11 | 92 | 93 | 21 | 90 | 88 | 30 | 100 | 87 | 9 | | | | | | | | | | | | | | | | | | | | | |
| 168/174 | 19 | 9 | 2 | | | | | | | | | | | | | 8 | 10 | 2 | | | | 5 | 5 | 2 | 2 | 6 | 2 | | | | | | | | | |
| 171 | 20 | 5 | 1 | 95 | 66 | 0 | 95 | 66 | 0 | 95 | 66 | 3 | 98 | 85 | 8 | 95 | 72 | 2 | 10 | 90 | 4 | 95 | 70 | 5 | | | | | | | | | | | | |
| | 20 | 6 | 1 | 43 | 63 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 171 | 20 | 6 | 2 | | | | | | | | | | | | | | | | | | | | | | 5 | 45 | 2 | 10 | 60 | 2 | | | | | | |
| | 20 | 7 | 1 | 63 | 26 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 20 | 8 | 1 | 8 | 46 | 7 | 8 | 46 | 8 | 8 | 43 | 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 5 | 1 | 49 | 7 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 167/175 | 21 | 5 | 2 | 45 | 29 | 7 | 50 | 37 | | | | | 33 | 12 | 3 | 26 | 38 | 5 | 26 | 38 | 1 | 34 | 30 | 9 | 48 | 13 | 12 | 60 | 20 | 1 | | | | | | |
| | 21 | 6 | 2 | 77 | 85 | 0 | 80 | 90 | 0 | 70 | 90 | 12 | 67 | 75 | 15 | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 7 | 1 | 25 | 7 | 0 | 25 | 10- | 0 | 19 | 18 | 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 7 | 2 | 51 | 39 | 4 | 51 | 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 8 | 1 | 22 | 79 | 1 | 22 | 79 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 8 | 2 | 48 | 65 | 1 | 47 | 60 | 7 | 40 | 63 | 10 | 34 | 41 | 24 | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 8 | 3 | 39 | 49 | 1 | 40 | 52 | 5 | 32 | 55 | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 8 | 4 | 64 | 47 | 3 | 64 | 49 | 1 | 51 | 49 | 2 | 51 | 32 | 5 | | | | | | | | | | | | | | | | | | | | | |
| | | | | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | | 2010 | | | | | | | | |

Appendix B-6

| tag # | row | col | plant # | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems | X | Y | stems |
|-------|-----|-----|---------|----|----|-------|----|----|-------|----|----|-------|-----|----|-------|----|----|-------|----|----|-------|---|---|-------|---|---|-------|
| | 32 | 6 | 2 | | | | 90 | 47 | 2 | 90 | 51 | 2 | | | | | | | | | | | | | | | |
| | 32 | 8 | 1 | 35 | 2 | 2 | 35 | 1 | 3 | 38 | 3 | 5 | | | | | | | | | | | | | | | |
| | 33 | 6 | 1 | 43 | 32 | 3 | 45 | 30 | | | | | | | | | | | | | | | | | | | |
| | 33 | 8 | 1 | | | | 90 | 20 | 5 | 92 | 22 | 9 | 100 | 25 | 9 | | | | | | | | | | | | |
| | 34 | -1 | 1 | 97 | 70 | 1 | | | | | | | | | | | | | | | | | | | | | |
| | 34 | 6 | 1 | | | | 52 | 55 | 2 | 52 | 42 | 5 | 56 | 35 | 5 | 98 | 66 | 3 | 98 | 66 | 7 | | | | | | |
| | 34 | 7 | 1 | | | | | | | | | | 12 | 59 | 1 | | | | | | | | | | | | |
| | 35 | 1 | 1 | | | | | | | 95 | 76 | 0 | 96 | 78 | 0 | 92 | 76 | 1 | 92 | 65 | 2 | | | | | | |
| | 35 | 12 | 1 | 35 | 16 | 9 | 45 | 10 | 5 | 43 | 5 | 0 | | | | | | | | | | | | | | | |
| | 35 | 15 | 1 | | | | 11 | 54 | 0 | 5 | 44 | 0 | 5 | 40 | 1 | | | | | | | | | | | | |
| | 39 | 8 | 1 | | | | 10 | 91 | 0 | 12 | 84 | 2 | 90 | 66 | 7 | 5 | 95 | 2 | 90 | 95 | 8 | | | | | | |
| | 42 | 7 | 1 | 63 | 10 | 0 | | | | 75 | 15 | 17 | 65 | 5 | 13 | 65 | 5 | 2 | | | | | | | | | |
| | 43 | 9 | 1 | 40 | 5 | 12 | 40 | 7 | 9 | 48 | 5 | 13 | 55 | 5 | 0 | | | | | | | | | | | | |
| | 63 | 17 | 1 | | | | | | | 68 | 80 | 10 | 73 | 90 | 10 | | | | | | | | | | | | |
| | 68 | 16 | 1 | | | | | | | 98 | 1 | 2 | | | | | | | | | | | | | | | |
| | 74 | -1 | 1 | | | | 90 | 30 | 3 | 78 | 25 | 6 | 75 | 25 | 8 | | | | | | | | | | | | |
| | 74 | -1 | 2 | | | | 59 | 48 | | 42 | 42 | 1 | | | | | | | | | | | | | | | |
| | 74 | 1 | 1 | 95 | 14 | 1 | 90 | 14 | 1 | | | | | | | | | | | | | | | | | | |
| | 74 | 1 | 2 | | | | 25 | 93 | 2 | | | | | | | | | | | | | | | | | | |
| | 74 | 2 | 1 | 7 | 73 | 2 | 7 | 73 | 0 | | | | | | | | | | | | | | | | | | |
| | 74 | 3 | 1 | 75 | 72 | 4 | 75 | 72 | 7 | 70 | 78 | 7 | 60 | 80 | 10 | | | | | | | | | | | | |
| | 75 | -1 | 1 | 92 | 53 | 0 | 92 | 53 | 0 | 79 | 45 | 1 | | | | | | | | | | | | | | | |
| | 76 | 2 | 1 | 40 | 94 | 1 | | | | | | | | | | | | | | | | | | | | | |
| | 79 | 1 | 1 | 25 | 33 | 1 | | | | | | | | | | | | | | | | | | | | | |
| | 79 | 1 | 2 | | | | 25 | 73 | 1 | 12 | 68 | 2 | 20 | 75 | 11 | | | | | | | | | | | | |

Table B-2. Summary of stem counts at Miller Island for 2002-2010. Plants in highlighted rows had ambiguous coordinates or irregular data and may include data from more than one plant.

| | | | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---------|-----|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| tag # | row | col | plant # | stems |
| | 2 | 4 | 1 | 34 | 33 | 56 | | | | | | |
| | 3 | 1 | 1 | | | | | 7 | | | | |
| | 3 | 3 | 1 | 13 | 5 | 22 | 32 | | | | | |
| 189 | 3 | 9 | 1 | | | | | 10 | 9 | 9 | | |
| | 4 | 1 | 1 | 22 | 1 | 38 | 35 | 2 | | | | |
| | 4 | 7 | 1 | 5 | 2 | 10 | 15 | | | | | |
| | 4 | 7 | 2 | 0 | 4 | 3 | 4 | 2 | | | | |
| | 4 | 7 | 3 | | | | | | 5 | | | |
| 193 | 4 | 7 | 4 | | | | | | | 12 | 4 | |
| | 4 | 8 | 1 | 7 | 2 | 8 | 7 | | | | | |
| 192 | 4 | 9 | 1 | 5 | 8 | 2 | | | | | | |
| | 4 | 9 | 2 | | | | 6 | 2 | 1 | 1 | | |
| | 4 | 10 | 1 | 8 | 5 | 10 | | | | | | |
| | 4 | 10 | 2 | | | | 13 | 5 | | | | |
| | 4 | 10 | 3 | | | | | | 6 | | | |
| | 5 | 3 | 1 | 5 | 2 | 5 | 5 | 7 | | | | |
| | 5 | 3 | 2 | 9 | | | | | | | | |
| | 5 | 8 | 1 | 2 | 3 | 4 | 6 | | | | | |
| | 5 | 8 | 2 | 6 | 3 | 2 | 4 | | | | | |
| 190 | 5 | 9 | 1 | | | | | | 1 | 1 | | |
| | 5 | 10 | 1 | | | 1 | 8 | 13 | 7 | | | |
| 194 | 6 | 1 | 1 | | | | | | | 20 | 19 | 23 |
| 195 | 6 | 2 | 1 | | 1 | 1 | 9 | 12 | 2 | 15 | 19 | 17 |
| | 6 | 7 | 1 | 2 | 5 | 14 | 10 | | | | | |
| 191 | 6 | 8 | 1 | | | | | | | 3 | 2 | 2 |
| | 6 | 8 | 2 | 3 | 1 | 7 | 11 | | | | | |
| | 6 | 8 | 3 | | | | | | | | | 6 |
| 162 | 6 | 9 | 1 | | | | | | | | 1 | 4 |
| | 6 | 10 | 1 | 9 | 13 | | | | | | | |
| | 7 | 2 | 1 | 21 | 15 | | | | | | | |
| | 7 | 2 | 2 | 13 | 7 | 9 | 4 | | | | | |
| | 7 | 7 | 1 | 4 | 4 | 3 | | | | | | |
| 183 | 7 | 7 | 2 | | | | | | | 6 | 6 | |
| 165 | 7 | 7 | 3 | | | | | | | | 14 | |
| 196 | 7 | 8 | 1 | 2 | 2 | 13 | 14 | 11 | | 2 | | |
| | 7 | 8 | 2 | 5 | 13 | 19 | | | | | | |
| | 7 | 8 | 3 | 4 | | | | | | | | |
| 197/164 | 7 | 8 | 4 | | | | | | | 1 | 3 | |

| | | | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|-------|-----|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| tag # | row | col | plant # | stems |
| | 7 | 8 | 5 | | | | | | | | | 13 |
| | 7 | 10 | 1 | 0 | 8 | 6 | 6 | | | | | |
| | 8 | 4 | 1 | 7 | | | | | | | | |
| | 8 | 4 | 2 | | 1 | 9 | 3 | | | | | |
| | 8 | 7 | 1 | 2 | | | | | | | | |
| | 8 | 7 | 2 | | | 5 | 4 | | | | | |
| 163 | 8 | 7 | 3 | | | | | | | | 2 | 3 |
| 188 | 8 | 9 | 1 | 8 | | | | | | | | |
| | 8 | 9 | 2 | | 13 | 10 | 17 | 17 | 18 | | | |
| | 8 | 9 | 3 | | | | | | | 24 | 2 | 26 |
| 166 | 8 | 9 | 4 | | | | | | | | 3 | |
| 182 | 9 | 4 | 2 | 4 | 4 | 1 | | | 7 | 25 | | 1 |
| | 10 | 3 | 2 | 1 | | | | | | | | |
| 198 | 10 | 4 | 1 | 4 | 4 | 5 | 5 | 4 | 8 | 32 | 56 | 45 |
| | 10 | 4 | 2 | 4 | | | | | | | | |
| | 10 | 5 | 1 | 12 | 2 | 8 | 0 | | | | | |
| | 11 | 3 | 1 | 1 | | | | | | | | |
| | 11 | 3 | 2 | 24 | 10 | | | | | | | |
| | 11 | 3 | 3 | | | 19 | 25 | 13 | | | | |
| | 11 | 3 | 4 | | | | | | 14 | | | |
| 199 | 11 | 3 | 5 | | | | | | | 5 | | |
| 186 | 11 | 3 | 6 | | | | | | | 20 | 20 | 30 |
| 181 | 11 | 4 | 1 | | | | | | 4 | 21 | | |
| | 11 | 4 | 2 | | | | | | | | 11 | |
| | 12 | 9 | 1 | 6 | 9 | 14 | 12 | | | | | |
| | 13 | 3 | 1 | 6 | | | | | | | | |
| | 13 | 3 | 2 | 1 | | | | | | | | |
| | 13 | 3 | 3 | | | 3 | 8 | 1 | 1 | | | |
| | 13 | 4 | 1 | 6 | 3 | | | | | | | |
| | 13 | 4 | 2 | 3 | 1 | | | | | | | |
| | 13 | 8 | 1 | 3 | 1 | | | | | | | |
| | 13 | 10 | 1 | 3 | | | | | | | | |
| | 14 | 2 | 1 | | | 1 | 7 | 4 | | | | |
| | 14 | 3 | 1 | 1 | | | | | | | | |
| | 14 | 3 | 2 | | 2 | | | | | | | |
| 184 | 14 | 3 | 3 | | | | | | | 1 | 3 | |
| 185 | 14 | 8 | 1 | 7 | 6 | 13 | 21 | 6 | 13 | 31 | 10 | 31 |
| | 14 | 8 | 2 | 6 | 1 | 10 | 8 | 6 | | | | |
| | 14 | 10 | 1 | 5 | | | | | | | | |
| | 14 | 10 | 2 | 1 | 2 | 10 | | | | | | |
| 175 | 14 | 13 | 1 | 32 | 51 | 35 | 35 | 1 | 3 | 2 | | |

| | | | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---------|-----|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| tag # | row | col | plant # | stems |
| | 14 | 13 | 2 | | | | | | 2 | | | |
| 176 | 14 | 13 | 3 | | | | | | | 5 | | |
| 180 | 15 | 4 | 1 | 3 | 1 | 4 | 9 | 4 | 6 | 13 | 3 | 3 |
| | 15 | 4 | 2 | | | | | 5 | 1 | | | |
| | 15 | 10 | 1 | 8 | 6 | 6 | | | | | | |
| | 15 | 10 | 2 | 3 | 7 | 7 | | | | | | |
| | 15 | 13 | 1 | 6 | 14 | 11 | 25 | | | | | |
| 174 | 15 | 13 | 2 | | | | | 2 | 3 | 6 | | 6 |
| | 15 | 13 | 3 | | | | | 2 | | | | |
| | 15 | 13 | 4 | | | | | 4 | | | | |
| 177/168 | 15 | 13 | 5 | | | | | | | 8 | 27 | 7 |
| | 15 | 13 | 6 | | | | | | | | | 3 |
| | 16 | 9 | 1 | 4 | 1 | | | | | | | |
| | 16 | 10 | 1 | 2 | 4 | 2 | 2 | 1 | 9 | | | |
| | 16 | 10 | 2 | | | | | | | | 5 | 18 |
| | 16 | 11 | 1 | 1 | 2 | 4 | 7 | 1 | | | | |
| | 16 | 11 | 2 | 5 | | | | | | | | |
| | 16 | 11 | 3 | 0 | 2 | | | | | | | |
| | 16 | 13 | 1 | 0 | | 2 | | | | | | |
| | 16 | 13 | 2 | 2 | 4 | 11 | 4 | | | | | |
| | 16 | 13 | 3 | | | | 13 | | | | | |
| 179 | 16 | 13 | 4 | | | | | | 15 | 17 | | |
| 178/171 | 16 | 13 | 5 | | | | | | | 1 | 1 | |
| 187 | 16 | 13 | 6 | | | | | | | 5 | 25 | 10 |
| | 16 | 13 | 7 | | | | | | | | | 14 |
| | 16 | 13 | 8 | | | | | | | | | 6 |
| | 16 | 14 | 1 | 1 | | | | | | | | |
| 173/172 | 16 | 15 | 1 | 4 | 2 | | 11 | 4 | 11 | 8 | 5 | |
| | 17 | 7 | 3 | | 10 | 7 | 12 | | | | | |
| | 17 | 8 | 1 | 29 | | | | | | | | |
| | 17 | 9 | 1 | 2 | | | | | | | | |
| | 17 | 9 | 2 | 8 | 9 | 2 | 6 | | | | | |
| | 17 | 13 | 1 | 2 | | | | | | | | |
| 173 | 17 | 13 | 2 | | | | | | | | 2 | |
| | 17 | 13 | 3 | | | | | | | | | 8 |
| | 18 | 4 | 2 | 1 | 1 | | | | | | | |
| | 18 | 5 | 1 | 2 | | | | | | | | |
| | 18 | 5 | 2 | 1 | | | | | | | | |
| | 18 | 5 | 3 | 1 | | | | | | | | |
| | 18 | 5 | 4 | | 4 | 2 | | | | | | |
| | 18 | 5 | 5 | | | | | | 5 | | | |
| | 18 | 6 | 1 | 0 | | 2 | 14 | | | | | |

| | | | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---------|-----|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| tag # | row | col | plant # | stems |
| 172 | 18 | 6 | 2 | | | | | | 1 | 12 | 0 | 14 |
| | 18 | 8 | 1 | 9 | 2 | | | | | | | |
| | 19 | 5 | 2 | 4 | 5 | 9 | 14 | 1 | | | | |
| | 19 | 8 | 1 | 2 | 10 | 1 | 21 | | | | | |
| | 19 | 8 | 2 | 5 | 14 | 10 | 14 | | | | | |
| | 19 | 8 | 3 | | 0 | 0 | 4 | | | | | |
| | 19 | 8 | 4 | | | | | | 7 | | | |
| | 19 | 9 | 1 | 11 | 21 | 30 | 9 | | | | | |
| 168/174 | 19 | 9 | 2 | | | | | 2 | | 2 | 2 | |
| 171 | 20 | 5 | 1 | 0 | 0 | 3 | 8 | 2 | 4 | 5 | | |
| | 20 | 6 | 1 | 3 | | | | | | | | |
| 171 | 20 | 6 | 2 | | | | | | | | 2 | 2 |
| | 20 | 7 | 1 | 1 | | | | | | | | |
| | 20 | 8 | 1 | 7 | 8 | 11 | | | | | | |
| | 21 | 5 | 1 | 8 | | | | | | | | |
| 167/175 | 21 | 5 | 2 | 7 | | | 3 | 5 | 1 | 9 | 12 | 1 |
| | 21 | 6 | 2 | 0 | 0 | 12 | 15 | | | | | |
| | 21 | 7 | 1 | 0 | 0 | 2 | | | | | | |
| | 21 | 7 | 2 | 4 | | | | | | | | |
| | 21 | 8 | 1 | 1 | | | | | | | | |
| | 21 | 8 | 2 | 1 | 7 | 10 | 24 | | | | | |
| | 21 | 8 | 3 | 1 | 5 | 5 | | | | | | |
| | 21 | 8 | 4 | 3 | 1 | 2 | 5 | | | | | |
| | 21 | 8 | 5 | 1 | | | | | | | | |
| | 22 | 6 | 1 | 3 | 2 | 5 | 5 | 5 | | | | |
| | 22 | 6 | 2 | | | | 2 | | | | | |
| | 22 | 7 | 1 | 0 | | | | 1 | | | | |
| | 22 | 7 | 2 | 1 | | | | | | | | |
| | 22 | 8 | 1 | 1 | | | | | | | | |
| | 22 | 8 | 2 | 0 | | 1 | 5 | 1 | | | | |
| | 22 | 8 | 3 | 5 | | | | | | | | |
| 169/176 | 22 | 13 | 1 | | | | | | | 3 | 10 | 2 |
| 177 | 23 | 6 | 1 | | | | | | | | 1 | 7 |
| | 23 | 7 | 1 | 0 | | | | | | | | |
| | 23 | 7 | 2 | 0 | 1 | 1 | 5 | 2 | 2 | | | |
| | 23 | 8 | 1 | 4 | | | | | | | | |
| | 23 | 9 | 1 | 1 | 6 | 1 | 1 | | | | | |
| | 24 | 8 | 1 | 0 | 1 | 2 | 1 | | | | | |
| | 24 | 8 | 2 | 1 | | | | | | | | |

| | | | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|-------|-----|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| tag # | row | col | plant # | stems |
| | 24 | 8 | 3 | | | 1 | 1 | | | | | |
| | 24 | 9 | 1 | 6 | 6 | 12 | 14 | 7 | 4 | | | |
| 178 | 26 | 6 | 1 | | | | | | | | 6 | |
| | 26 | 7 | 1 | 3 | 5 | 7 | 8 | 2 | 3 | | | |
| 166 | 26 | 7 | 2 | | | | | | | 2 | | |
| | 26 | 7 | 3 | | | | | | | | | 6 |
| | 27 | 8 | 1 | 4 | 0 | | | | | | | |
| | 31 | 3 | 1 | 3 | 1 | 10 | | | | | | |
| | 32 | 6 | 1 | | 3 | 9 | 7 | | 5 | | | |
| | 32 | 6 | 2 | | 2 | 2 | | | | | | |
| | 32 | 8 | 1 | 2 | 3 | 5 | | | | | | |
| | 33 | 6 | 1 | 3 | | | | | | | | |
| | 33 | 8 | 1 | | 5 | 9 | 9 | | | | | |
| | 34 | -1 | 1 | 1 | | | | | | | | |
| | 34 | 6 | 1 | | 2 | 5 | 5 | 3 | 7 | | | |
| | 34 | 7 | 1 | | | | 1 | | | | | |
| | 35 | 1 | 1 | | | 0 | 0 | 1 | 2 | | | |
| | 35 | 12 | 1 | 9 | 5 | 0 | | | | | | |
| | 35 | 15 | 1 | | 0 | 0 | 1 | | | | | |
| | 39 | 8 | 1 | | 0 | 2 | 7 | 2 | 8 | | | |
| | 42 | 7 | 1 | 0 | | 17 | 13 | 2 | | | | |
| | 43 | 9 | 1 | 12 | 9 | 13 | 0 | | | | | |
| | 63 | 17 | 1 | | | 10 | 10 | | | | | |
| | 68 | 16 | 1 | | | 2 | | | | | | |
| | 74 | -1 | 1 | | 3 | 6 | 8 | | | | | |
| | 74 | -1 | 2 | | | 1 | | | | | | |
| | 74 | 1 | 1 | 1 | 1 | | | | | | | |
| | 74 | 1 | 2 | | 2 | | | | | | | |
| | 74 | 2 | 1 | 2 | 0 | | | | | | | |
| | 74 | 3 | 1 | 4 | 7 | 7 | 10 | | | | | |
| | 75 | -1 | 1 | 0 | 0 | 1 | | | | | | |
| | 76 | 2 | 1 | 1 | | | | | | | | |
| | 79 | 1 | 1 | 1 | | | | | | | | |
| | 79 | 1 | 2 | | 1 | 2 | 11 | | | | | |

**Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii*
monitoring methodology**

Artemisia borealis var. *wormskioldii*

Miller Island Monitoring Methodology

Revised 2010

Joseph Arnett
Washington Department of Natural Resources
Natural Heritage Program

**Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii*
monitoring methodology**

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

Monitoring Methodology

Background

A methodology for demographic monitoring of *Artemisia borealis* var. *wormskioldii* (ARBOWO) at Miller Island was first developed and described in Caplow (2005) and Kaye (1995), and data were collected between 2002 and 2010. Collecting data appropriate for demographic modeling at this site has been problematical. Vegetative plants of ARBOWO, including seedlings, cannot be distinguished in the field from those of *Artemisia borealis* var. *scouleriana* (ARBOSC), which is abundant and mixed in with ARBOWO at the site. Difficulty was also encountered in trying to record precise locations of individual plants. The frequent high winds encountered during monitoring and the shifting sand substrate contributed to a data set that was inconsistent, with the locations of plants one year often difficult to reconcile with positions in other years. Finally, the steady decline of ARBOWO at the site has been unmistakable, and the cost of demographic modeling did not appear warranted, since it did not seem likely to enable us to perceive a trend that was not already obvious.

Consequently, we have decided to discontinue collecting data for demographic modeling and to simplify the monitoring methodology, while still collecting sufficient data to achieve two primary objectives: a precise annual population census of ARBOWO (including a census of ARBOSC within the plot), and a record of the spatial distribution of the species at the site. The latter information will be collected in hopes that it may contribute to understanding the site dynamics that are leading to the decline of the species.

The following data will be collected for ARBOWO, including any plants found outside the plot:

- Coordinates of each mature plant within each subplot (except for the few outliers)
- Number of flowering stems on each plant

In addition to the data on ARBOWO, the following counts will be made within each subplot:

- Number of seedlings (<5 cm across)
- Number of ambiguous vegetative plants (≥ 5 cm)
- Number of ARBOSC plants

The best time for monitoring is mid-May, as it is easier to differentiate between ARBOWO and ARBOSC individuals. Data are not collected on *Artemisia ludoviciana*, which is also present at the site but which is discernable by its wider leaf segments and rhizomatous habit.

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

Plot Location and Layout

The location of Miller Island, near river mile 207 of the Columbia River, approximately 14 miles upstream from The Dalles, Oregon, near the mouth of the Deschutes River, is shown in Figure 1. Figure 2 shows the location of the ARBOWO population at the east end of the island.

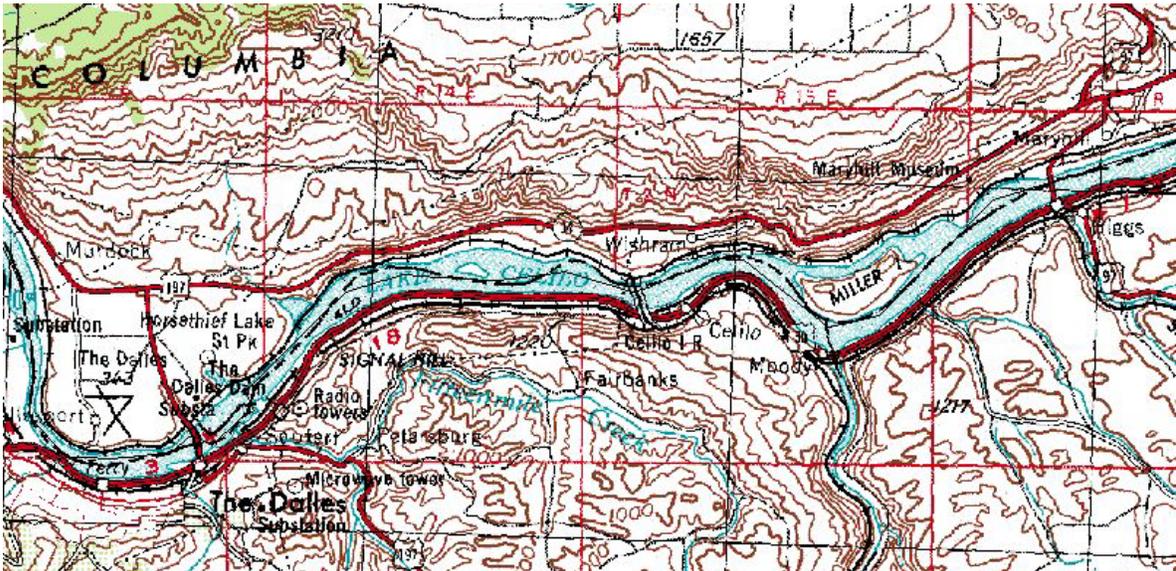


Figure 1. Location of Miller Island at the eastern end of the Columbia Gorge National Scenic Area.

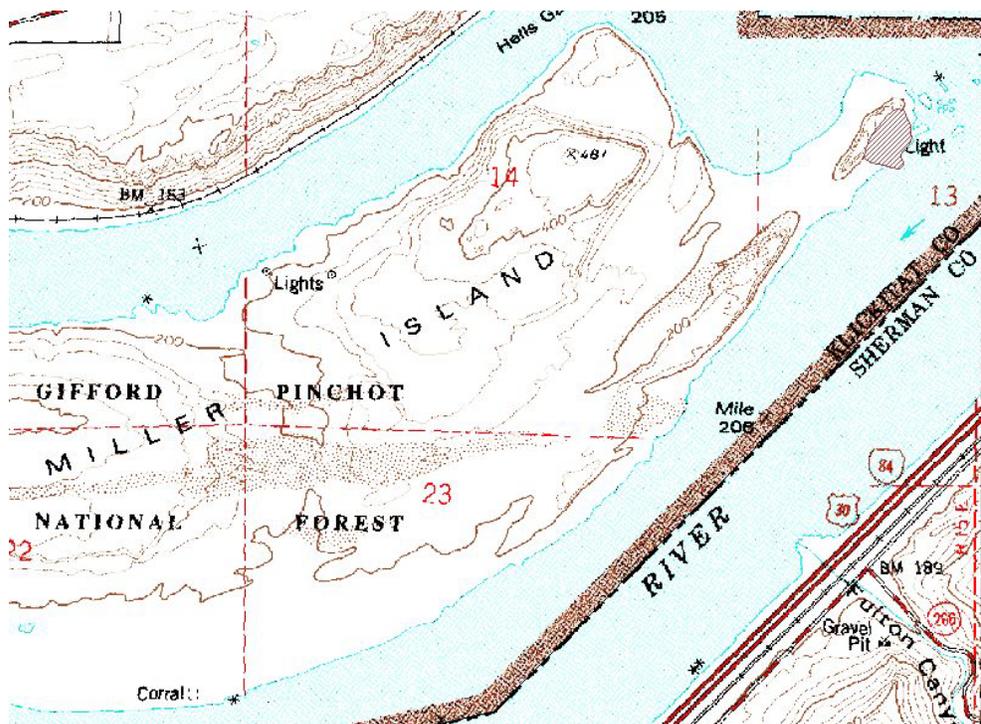


Figure 2. *Artemisia borealis* var. *wormskioldii* at the eastern end of Miller Island

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

Almost all of the population of ARBOWO currently present on Miller Island occurs within a 30 by 20 meter plot that is oriented long-ways from southwest to northeast on a flat area at the eastern end of the island, shown in Figures 3. Only the southwest 30 meters of the plot is now included in the monitoring, which in the past extended for 80 meters to the northeast. This plot is subdivided into square meter subplots. The orientation of the plot and all subplots is with the southwest at the top and northeast at the bottom. Subplots are named on the basis of the row and column in which they occur, as illustrated in Figure 4.

Side tapes (the x-axis) are laid along the long sides of the plots starting at the southwest end, and cross tapes (the y-axis) are laid perpendicular to these, forming rows, starting along the southeast edge, reaching from meter marks on the southeast side to the corresponding meter marks on the northwest side. These tapes effectively divide the entire plot into one meter square subplots.

Each subplot is named on the basis of the row and column in which it occurs. Note that row 1 is between 0 and 1 on the side tapes, and column 1 is between 0 and 1 on the cross tapes. Data are collected in subplots along one row at a time, and the tapes are moved down the plot, row by row, as the monitoring progresses. Prior to collecting data it is advisable to walk the rows and flag seedlings and plants to avoid trampling them.

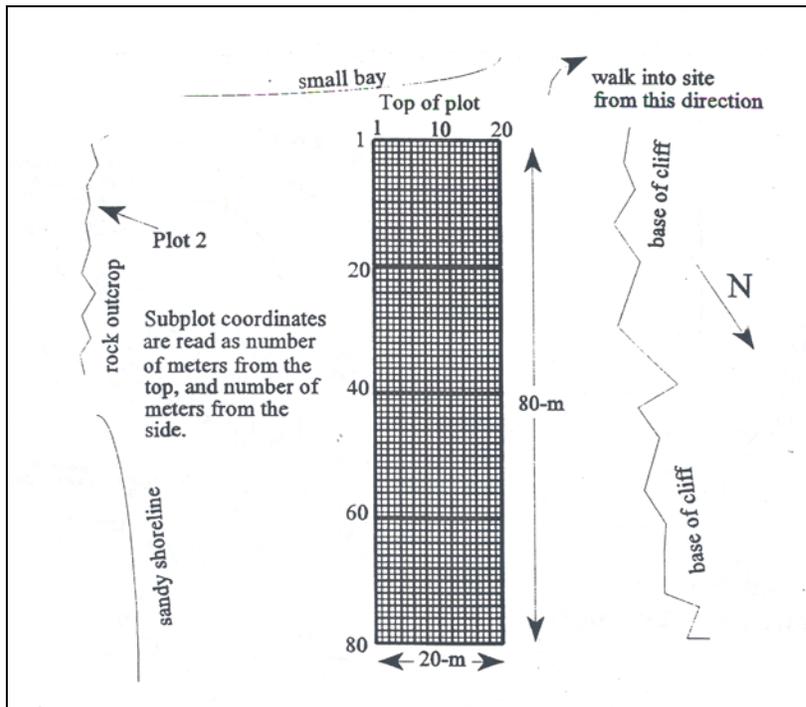


Figure 3. Overview of the *Artemisia wormskioldii* var. *wormskioldii* plot on Miller Island. Note that the plot has been reduced to the southwestern 30 meters of this larger plot.

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

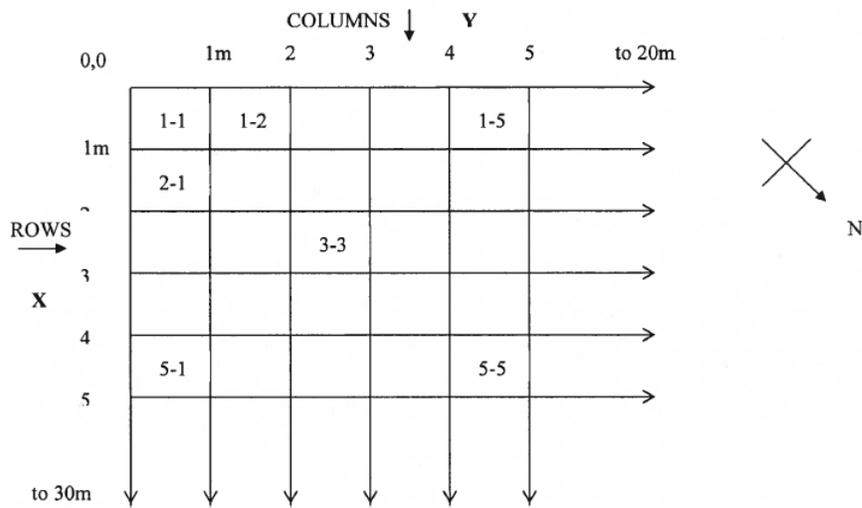


Figure 4. Method of naming subplots within the *Artemisia borealis* var. *wormskioldii* plot at Miller Island.

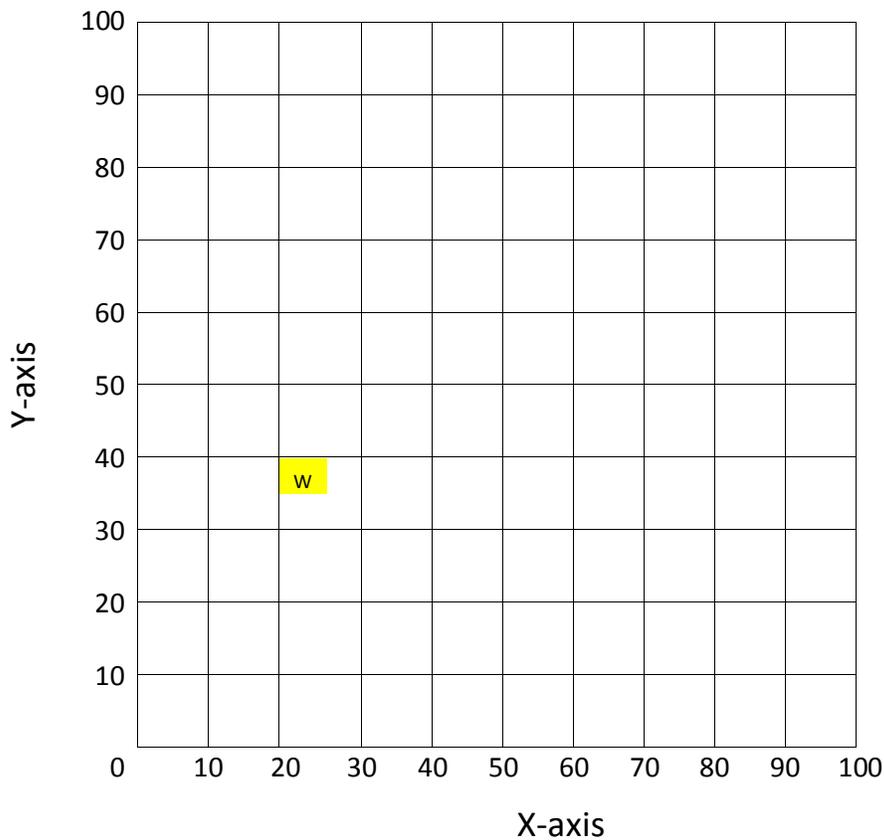


Figure 5. Method of recording coordinates of plants within subplots at the *Artemisia borealis* var. *wormskioldii* plot at Miller Island. The “W” would be recorded at 22, 38.

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

Subplot Data Collection

The following information is recorded on data sheets for each subplot in the large Miller Island plot. If no *Artemisia borealis* plants, of any size class, are present in a subplot, list that subplot in the right column of the data sheet, in sequence, so that all subplots are accounted for.

Name and date: Please give your full name and the date on at least the first data sheet; on subsequent sheets first names are adequate.

Substrate Data

Within each subplot, the substrate – sand, bedrock, or cobble – is recorded by percent, totaling 100%. Whether or not blowout, or sand being blown away from the plants' bases, is also recorded.

Subplot map: Diagram the approximate location and size of live ARBOWO, ARBOSC, and ambiguous plants, identifying them with a “W”, “S” or “A”. Seedlings need not be mapped. Dead plants may be noted on the diagram but are not included in the table of ARBOWO data nor included in the other counts described below. Note that the top of the subplot corresponds with the top of the overall plot.

ARBOWO plant data: A table is provided for data on reproductive ARBOWO plants within the subplot. Record tag number (if present), the X and Y coordinates of each ARBOWO plant, and the number of live flowering stems. Stems that branch above the base are counted as a single stem. Plants with branching rosettes are still recorded as one single plant.

See Figure 5 to understand the coordinate system of the subplots. Keeping the top of the subplot aligned with the top of the large plot, as shown in Figure 4, will simplify keeping track of this.

We are attempting to track individual plant from year to year, which is relatively straightforward when the tags can be found. However, tags often disappear, and the tapes for locating subplots are hard to position precisely, especially in high wind. Try to relate each plant with the previous year's datasheets, and note on the datasheets if the plants appear to have been recorded in a different subplot in previous years.

Other plant Data

In addition to information on mature ARBOWO, the following counts are made within each subplot; the numbers are recorded in the place provided: ARBOSC, seedlings (<5 cm across), and ambiguous vegetative plants (≥ 5 cm across).

Photographic Record

Every year, take a photo down every third row, starting at row 2. Set up a dry erase blackboard at base of row with row number and take the photo 10-15 feet back from the

Appendix C: Miller Island *Artemisia borealis* var. *wormskioldii* monitoring methodology

south-east tape along the long side of the plot using a 55mm lens (not a wide angle). The purpose of this photographic record is to evaluate gross competing vegetation changes.

Data Entry

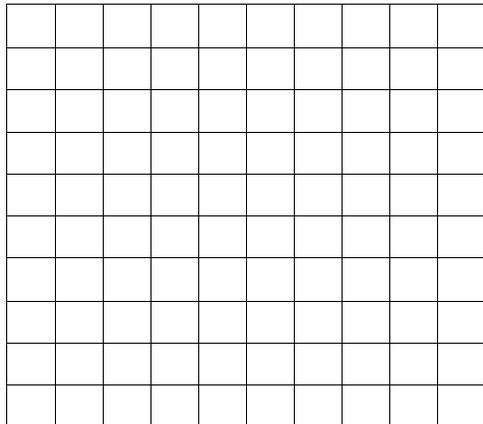
The electronic database is found in the Department of Natural Resources in Olympia on a drive identified as 'snarf\am\div_lm\nat_her_cons (Z:)'. The data file, titled "ARBOWO Miller data to 2010" is located at Z:\botany\Species\Artemisia\ARBOWO\ARBOWO Miller Island. The file name should be updated to reflect the most current year of monitoring.

Essential Monitoring Materials

- Photocopies of data sheets from the previous years monitoring. These are helpful for tracking plants that have been previously recorded in previous years.
- Previous years monitoring report
- Printout of spreadsheet of data from all years
- Approximately 100 datasheets, half on write in the rain paper
- Clipboards, pencils
- Three tapes at least 30 meters long, marked in meters
- At least one 20 meter tape marked in meters for each monitoring team of 2
- Pin flags for marking seedlings and plants to avoid trampling them
- Rebar (2 ft. sections) and a 2-lb. Hammer for replacing any missing plot markers
- Tags and stakes (20d galvanized nails may be adequate) for marking plants
- Rubber bands for holding data sheets to clipboards in the wind
- Large wire staples for holding tapes in place in the wind
- Clips to hold tapes to rebar
- Small dry erase board
- Camera

Artemisia borealis var. *wormskioldii* Miller Island Name _____ Date _____

Subplot: Row _____ Column _____ Substrate: % sand _____ % bedrock _____ % cobble _____



10 20 30 40 50 60 70 80 90

ARBOWO Plant data:

| Plant # | Tag # | X | Y | Flr.stems |
|---------|-------|---|---|-----------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

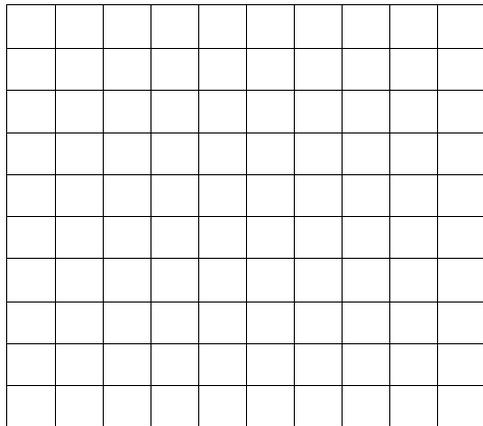
List of subplots in which no *Artemisia borealis* was seen:

Number of ARBOSC plants _____

Number of seedlings (<5cm) _____

Number of vegetative plants (5cm+) _____

Subplot: Row _____ Column _____ Substrate % sand _____ % bedrock _____ % cobble _____



10 20 30 40 50 60 70 80 90

ARBOWO Plant data:

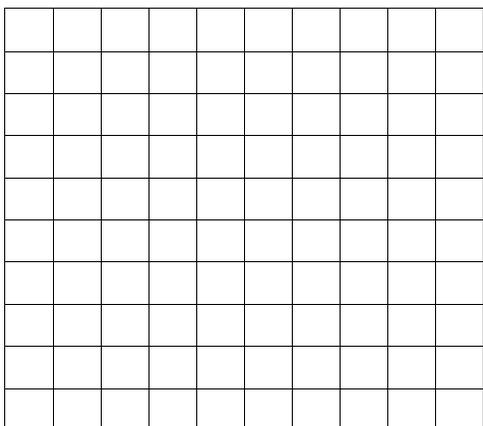
| Plant # | Tag # | X | Y | Flr.stems |
|---------|-------|---|---|-----------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

Number of ARBOSC plants _____

Number of seedlings (<5cm) _____

Number of vegetative plants (5cm+) _____

Subplot: Row _____ Column _____ Substrate: % sand _____ % bedrock _____ % cobble _____



10 20 30 40 50 60 70 80 90

ARBOWO Plant data:

| Plant # | Tag # | X | Y | Flr.stems |
|---------|-------|---|---|-----------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

Number of ARBOSC plants _____

Number of seedlings (<5cm) _____

Number of vegetative plants (5cm+) _____

W= *Artemisia borealis* var. *wormskioldii*
 S= *Artemisia borealis* var. *scouleriana*
 A= Ambiguous *Artemisia borealis*