

Cedarburg Bog:
A Case study of Invasive Control in a High Quality Wetland

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A Case Study of Long-term Buckthorn Control in the Cedarburg Bog State Natural Area, Wisconsin

Overview

The 2,190-acre Cedarburg Bog in Southeastern Wisconsin contains the southernmost, high-quality, intact examples of the wetland communities once common to the region, and is a key reference wetland for the southern Lake Michigan Watershed. Still an excellent example of a healthy pre-settlement wetland system for the region, the Bog is threatened by a growing population of invasive glossy buckthorn (GB).

The Cedarburg Bog property is mostly owned by the State of Wisconsin: The Department of Natural Resources (DNR) and the University of Wisconsin – Milwaukee (UWM), which has an academic research Field Station on its portion of the Bog. A third actor”, the Friends of the Cedarburg Bog (FOCB) among other things, is comprised of volunteers who are chartered by the state to permit stewardship activities on the state-owned properties.

This case study considers the efforts of all three entities to understand and control the spread of invasive buckthorn during the period from 1991 to 2019. It is one of several required outputs for a grant issued by the US Environmental Protection Agency (USEPA) to the FOCB.

This case study is divided into the following sections:

- A description of the extent of buckthorn in the study area
- Strategy and Planning
- A summary of historical efforts through the current day
 - Methodology
 - Herbicides and Equipment
- A description of specific control projects, including a section showing project progression
- Current situation

Buckthorn in the Cedarburg Bog

Of the 407 plant species that have been recorded in the undisturbed portions of Cedarburg Bog, only 19 species are exotic, and of these exotics, only one species, *Frangula alnus*, currently exhibits invasive behavior throughout much of the Cedarburg Bog. This Eurasian shrub produces bird-dispersed seed in fleshy fruits and was first reported in Wisconsin in 1943 (Pohl 1943). Based on maximum stem ages estimated from annual growth rings (Reinartz and Kline 1988), it had arrived in the Cedarburg Bog by circa 1955.

[Reinartz, J.A. and J. Kline. 1988. Glossy buckthorn (*Rhamnus frangula*), a threat to the vegetation of the Cedarburg Bog. Field Station Bulletin 21(2): 20-35.]

By 1962, *R. frangula* was present at low densities throughout much of the string bog. Birds distribute the fruits of buckthorn widely. However populations, first introduced by long-distance bird dispersal, do not begin to grow logarithmically until they begin to produce fruit within the wetland. In the Cedarburg Bog string bog habitat studied by Reinartz and Kline (1988) glossy buckthorn begins to produce fruit when the plants are 11 to 12 years old.

Two quantitative descriptions of the vegetation of the Cedarburg Bog, completed in 1991 and 2006, used identical methods. 165 sampling units were established at regular intervals of 100 m along 10 east-west transects across the wetland. Transects were located at each quarter section line that crosses the wetland. At each sample unit, cover of herbaceous plants was estimated in two, 1m² quadrats, trees were measured

and recorded in a 100m² quadrat, and the cover of all shrub species, including buckthorn, was measured on a 10m line intercept. The complete vegetation surveys allowed both a quantification of the invasion by glossy buckthorn and its change in abundance over a 15-year period, and the response of co-occurring native plants to the change in buckthorn abundance.

Frangula alnus occurred in 45% of the 165 sample units in 1991, and that frequency increased to 73% by 2006 (Figure 1). In those sample units where it was present, mean glossy buckthorn cover increased by 46% (Figure 2). In 2006, the total number of *F. alnus* seedlings exceeded by an order of magnitude the number of seedlings of all other tree and shrub species combined. Despite the dramatic increases in the abundance of *F. alnus*, the invasion elicited little apparent response by the resident plant community. Species richness and plant cover in the herbaceous plant stratum showed no apparent relationship with change in *F. alnus* cover. Richness of shrub species other than *F. alnus* also showed no relationship with change in *F. alnus* cover, but the cover of other shrubs decreased as *F. alnus* cover increased. In the 15 years between samples, species composition changed independently of changes in *F. alnus* cover.

Figure 1: Frequency of Glossy Buckthorn in 165 sample units in the Cedarburg Bog (1991 and 2006 surveys).

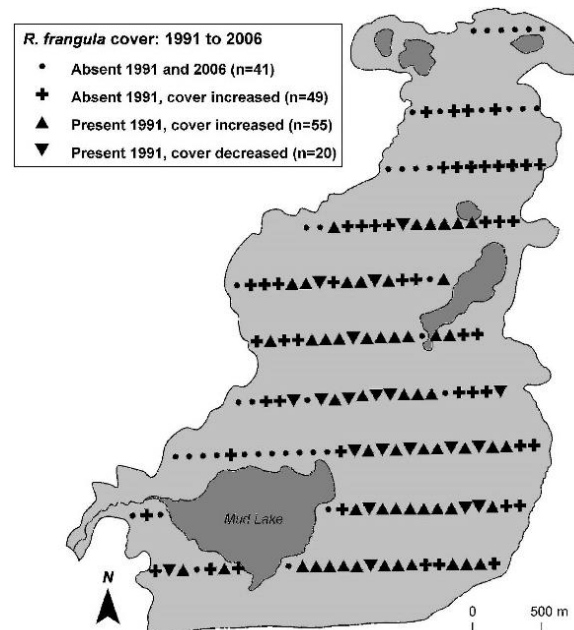
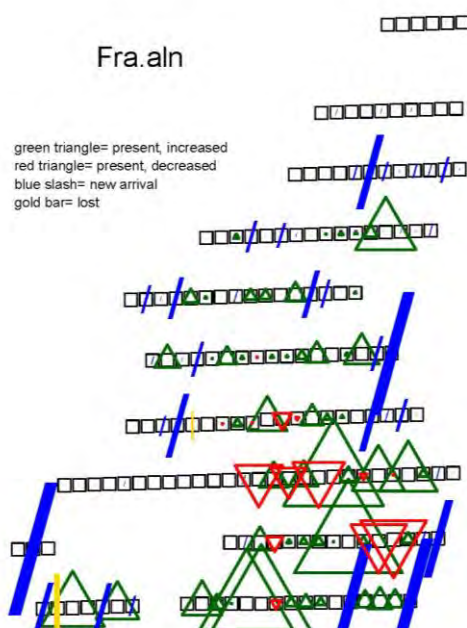


Figure 2: Change of cover of *Frangula alnus* in 165 sample units in the Cedarburg Bog from 1991 to 2006. The size of the symbol is proportional to the magnitude of the change in cover over that 15 year period.



These results showed that the tremendous increase in glossy buckthorn distribution and cover in the Bog over that 15-year period had not yet had a major impact on the composition of the Bog's native plant communities, but should not lead to an assumption that it will have no impact in the future. The resistance of the native communities to change resulting from the increase of buckthorn attests to the diversity, resilience, and health of those communities. However, the sheer impressive and growing cover and accumulated biomass of glossy buckthorn in the Bog argue that over time the invasive is bound to have a negative effect on the system. It would be very difficult for any ecologist to look at the buckthorn in the Bog system and believe that it will not have an impact over the long term.

Glossy buckthorn appears to have invaded the Bog from the south to the north, so that the northern portions of the Bog had lowest frequencies and cover of buckthorn in both sample periods (Figures 1 & 2). The earliest efforts to control buckthorn in the Bog were concentrated on preserving large areas of representative native communities in the northern portion of the Bog where the infestation was at its lowest levels.

General Control Strategy and Planning

The vast majority of invasive buckthorn in the Cedarburg Bog (the Bog) is glossy (*Frangula alnus*). However, common buckthorn (*Rhamnus cathartica*) also occurs in the Bog, and in some places is at a higher density than glossy. High densities of common buckthorn are found primarily in areas near the wetland margin in the northern and western parts of the Bog. Both invasive species of buckthorn were killed when encountered. The native, alder-leaf buckthorn (*Rhamnus alnifolia*) also grows in the Bog, and is both relatively rare and easily distinguished from the invasive species.

Most work to-date has focused on buckthorn that is at, or near, fruiting size (>1.5m tall, and >1.0cm diameter at the base). In most parts of the Bog small buckthorn occur at a high density and it is not feasible to treat all of the small buckthorn plants present. Even if time allowed treatment of smaller individuals, there would be too much risk of damage associated with the higher level of herbicide application required. One situation in which it may be worthwhile to treat smaller size classes is where buckthorn is at a very low density and killing some smaller individuals will nearly eliminate buckthorn from the area.

The strategic goal has been to eliminate fruiting of buckthorn within the treated areas. This approach recognizes that the same areas will need to be treated repeatedly. Treatments must continue until the small plants have grown to the size where they are controlled, and the population is eventually exhausted because the lack of local fruit production nearly eliminates new recruitment of seedlings. As the small, high-density, plants grow, their density is reduced through a self-thinning process. Tens, or even hundreds, of plants per square meter are reduced to a much lower density as they grow. This approach requires that control efforts be repeated every 4 to 6 years to prevent fruit production as the small plants in the population grow.

Thorough surveys of the vegetation of the Bog conducted by the UWM Field Station in 1991 and again in 2006 showed that glossy buckthorn was at a much lower density in the north (north of Donut Lake) and in the open string bog area west of Long Lake than it was in any other parts of the Bog. For that reason control work was first concentrated on those two areas with the lowest density in an effort to keep buckthorn from becoming uncontrollable there (Map 1). One other, much smaller, area that had a very high density of buckthorn was targeted in the string bog area at the east end of the UWM boardwalk. This area was chosen to remove buckthorn from a representative example of string bog where the strings are closer together than in the area west of Long Lake, and because of the ease of access and high public and research use of the UWM boardwalk (Map 4).

After initial control was completed in the parts of the Bog with the lowest buckthorn densities, areas were chosen for control in order to remove and exclude buckthorn from representative examples of all of the plant communities that are found in the Bog (Map 1).

Summary of buckthorn control in the Cedarburg Bog – 1991 to 2019

A total of 576 acres of the Bog have had fruiting-sized buckthorn removed at least once between 1991 and 2019 (Maps 1 through 5; Excel file: Buckthorn control summary-2019.xlsx). The buckthorn control projects that have been conducted over that time have totaled 843 acres, with many areas having been treated more than once. There are currently about 300 acres that have been controlled only once. FOCB has developed a plan to maintain control on the 576 acres that have received control treatments. That on-going control will be dependent on the availability of future funding.

Record of 28 Years of Buckthorn Control Projects in the Cedarburg Bog 1991 - 2019

Year	Dates	Project Area	Acres	New Acres	Cost	
1991	Feb.	Dense string bog @ end of boardwalk	1.0	1.0	DNR	
1992	Jan. & Feb.	Dense string bog @ end of boardwalk	3.0	3.0	DNR	
1992	Feb.	Open string bog W of Long Lake			DNR	Began work on 250m x 250m (15.4 acre) area
1996	Feb.	Dense string bog @ end of boardwalk	4.0	0.0	DNR	Second clearing of 4 acres above
1996	Feb.	Dense string bog @ end of boardwalk	2.0	2.0	DNR	Area expanded to 6 acres (157m x 157m)
2001	Feb.	Open string bog W of Long Lake	15.4	15.4	DNR	Complete work on 250m x 250m (15.4 acre) area
2001	Feb.	Dense string bog @ end of boardwalk	1.0	0.0	DNR	Second clearing of original 1991 area
2002-05		Open string bog W of Long Lake	38.0	34.6	DNR	Area expanded to open sting bog boundaries
2002-05		North end around Watt's Lake	108.0	108.0	DNR	
2006-08		North end between Watt's and Donut Lakes	117.0	117.0	DNR	
2011&12		Dense string bog @ end of boardwalk & along UWM Boardwalk	15.0	9.0	FOCB	6 acres at end previously treated; 9 acres along boardwalk new
2012	Nov.	Area southeast of Beimbom Lake	10.4	0.0	FOCB	
2013	Jan.	North end around Watt's Lake	91.0	0.0	DNR	Previously treated 2002-2005
2013	Jan.	Open string bog W of Long Lake	20.0	0.0	DNR	Previously treated 2002-2005
2014	Jan.	Open string bog W of Long Lake	30.6	5.0	DNR	First treatment of northern edge of the open string bog
2013-14	Dec. - Mar.	North end southeast of Beimbom Lake	67.0	0.0	FOCB	
2013-14	Dec. & Jan.	UWM Boardwalk and trail to Mud Lake from Cedar Sauk Rd.	2.0	2.0	FOCB	Volunteers
2015-19		Various areas in Bog	318.0	279.0	FOCB	EPA/GLRI Grant project
		Total acreages	843.4	576.0		

Since 1991 project acreages have totaled approximately 843 acres. Approximately 576 acres in the Cedarburg Bog have had fruiting-sized buckthorn cut and treated with herbicide at least once.

Timing

Most (>80%) of the buckthorn control work was done during the winter season when the Bog has been frozen (December through February or into March). Less acreage has been treated from September through November, and a very small amount of treatment has been conducted from late April through August. No treatment work has been done in the “ice-out” period in early spring when the ice will no longer support a worker’s weight. When the ice is breaking up is a particularly difficult time to move around in the Bog, and in early spring, when the sap is flowing up, we have observed the sap seeming to push or flush the herbicide off the stumps. Work in the deep interior of the Bog, especially in the string bog, is only practical when the Bog is frozen.

Methods Employed

All buckthorn control work in the Bog to-date has employed the method of control wherein stems are cut and herbicide is applied to the cut stump to prevent resprouting. Reinartz experimented with basal bark treatment, but was convinced that it was not much more efficient since the herbicide in oil must be applied to completely encircle the stem, and that the method is considerably less selective, using much more herbicide than the cut-stump method. Plants were generally cut at 6” or lower, and herbicide was applied within minutes to the cut stumps. Deep snow during a few control periods prevented cutting stems lower than 12”. One volunteer group in 1996 (noted below) ignored directions and cut stems higher, which caused poor control, with a high level of resprouting.

Most cutting has been done with hand pull-saws or loppers. In areas where large buckthorn was common, a chain saw was used to cut the large stems. A substantial number of large buckthorn (> 2.0” diameter) must be present to make hauling a chain saw into the wetland (and listening to it run) worth the effort. Where a high density of desirable vegetation is growing near the base of the buckthorn stems, selective cutting with a chain saw is very difficult. A girdling cut can also be made around very large stems and herbicide applied to the girdle incision to kill the plant, in order to eliminate the need for a chain saw.

A DNR crew used a gas-powered brush-cutter in one area. That area had clumps of buckthorn stems and was dominated by cattails. In general, brush cutters are not useful for this work since there are very few locations where native species such as bog birch, winterberry, willows, or dogwoods are not also interlaced with the buckthorn clumps. Our practice has always been to expend considerable effort to protect any native shrubs that might compete with the invasives.

Herbicides Used for Control

Work prior to 2011 used glyphosate as the herbicide applied to cut stumps (12% – 15% active ingredient, i.e. a 25% solution of concentrate with 50% to 60% active ingredient). Winter control with glyphosate was good (>90% kill) when the stems were cut at 6" or lower. Kill rate with glyphosate was observed to be lower when stems were cut higher than 6".

Control work done in 2011 and all following seasons, used triclopyr herbicide, either the "4" (Ester) formulation or the "3A" (Amine) formulation of triclopyr. Triclopyr has proven to provide a higher, and more consistent, kill rate (lower rate of resprouting) than glyphosate.

From 2011 to 2016 Garlon 4® (or triclopyr equivalent) was used exclusively. Garlon 4® was mixed in agricultural oil (Bark Oil Blue®) as a 20% solution (1 part herbicide to 4 parts oil) of the concentrate. The triclopyr concentrate was ~60% active ingredient, so the herbicide as applied was 15% active ingredient.

From 2017 to 2019 Garlon 4® in Bark Oil Blue® (as described above) was used whenever air temperature was well below freezing. When air temperature was near or above 32°F, or when any liquid water was present in the work area, Garlon 3A® (or triclopyr equivalent) mixed in water was used. Garlon 3A® was mixed 1:1 (50% solution of the concentrate) in water, and blue marker dye was added. The Garlon 3A® concentrate was ~44% active ingredient, so the herbicide as applied was 22% active ingredient.

Our cut-stump application methods were very selective, resulting in very little herbicide coming in contact with water in the Bog. But the "3A" (Amine) formulation of triclopyr is safer to use if there is any chance of having herbicide come in contact with water. There is a possibility that the "4" (Ester) formulation of triclopyr could be mobile and taken up by non-target plants in water. The Garlon 4® in Bark Oil Blue® must be used at temperatures well below freezing because it does not freeze as the water (3A) herbicide mixture does.

Herbicide Application Equipment

The herbicide applicators used have been varied and changed over the years as different equipment has been thought to be more efficient or selective. In general the progression of equipment used has been:

1. Common trigger-pump garden spray bottles of a wide variety of manufacturers. We have never found an applicator of this style that would last for long, and the trigger-pump invariably leaked herbicide onto the workers' gloves. We no longer use these applicators.
2. 8 oz./250mL Nalgene™ Wide-Mouth Unitary™ Wash Bottles with 24mm Cap (www.usplastic.com). Excellent for very selective application to buckthorn growing in dense desirable vegetation. We still use these as one of our most-favored applicators. Drawbacks of these bottles include: a) The squirt tip is a separate part that tends to get lost, and cannot be purchased separately, b) Workers can expect to get herbicide on their gloves from the bottles, c) Herbicide should not be stored, even over-night, in the bottles because changes in temperature will cause continual pumping of herbicide out of the nozzle and make a mess.

3. Buckthorn Blasters™ (<https://landscape-restoration.com/product/buckthorn-blaster/>), a small sponge-tipped applicator with a spring-loaded valve between the reservoir and sponge. An excellent, efficient, and selective applicator that we still use. Drawbacks of the Buckthorn Blasters are: a) They do not easily apply enough of the more viscous oil-based herbicide and are therefore only used for the Garlon 3A in water herbicide, b) The bottles are thin and can easily be punctured by the sharp hand saws, c) The sponge tips wear out and need to be replaced frequently.
4. High quality (i.e. expensive), 2 Quart Heavy Duty Pump-Up Sprayer with Adjustable Brass Tip Nozzle. Available from “4-Control” (<http://4-control.com/model-942-pump-up-sprayer/>). We still use these applicators. Over the years we have tried many less-expensive pump-up sprayers from the garden centers and have never found one that would last more than a day or two. The advantage of a pump-up sprayer is that with just a couple pressurizing pumps the nozzle will produce many gentle squirts of herbicide. The disadvantages of these sprayers include: a) They are somewhat large and cumbersome for selective control work in dense vegetation. Their bulk renders them less selective, i.e. there is more over-spray and off-target spray, b) They need to be kept nearly full of herbicide to work with the nozzle pointed down toward the stump. If they are not full, the take-up tube will not contact the herbicide in the reservoir.
5. Some use has been made of sponge applicators home-made of PVC parts and valves. These sponge applicators can seem quite efficient, but have been found to be a mess, prone to spills and leaks. They are of very limited use.

Records of Control Projects

Control work between 1991 and 2001

Control work in the dense string bog area at the end of the UWM boardwalk (Maps 1 & 4) began in February 1991. Control in this area has been done in a series of three nested squares (2-acres, 90m x 90m; 4-acres, 127m x 127m; 6-acres, 157m x 157m) as the area was expanded over time. The three square areas were laid out N-S/E-W by Reinartz with a compass and sting distance measurer. Glyphosate herbicide was used for all cut-and-treat control work through 2001 as described above.

2/6 to 2/8, 1991 – A DNR State Natural Areas crew cut and treated all “finger-diameter” buckthorn from about 1/3 of the 2-acre square contained within (and nearest) the end of the boardwalk loop.

1/20 to 1/23, and 2/24 to 2/25, 1992 – Reinartz expanded the buckthorn control area at the end of the Boardwalk from a 2-acre to a 4-acre square. The DNR crew finished cutting and treating buckthorn in the remainder (from 1991) of the 2-acre square, and completed removal in the additional 2-acres of the 4-acre square. Removal of all “finger-diameter” buckthorn from the 4-acre square was completed at this time (Map 4).

2/26 to 2/28, 1992 – Reinartz established and flagged a 250m x 250m (15.4-acre) square area in the center of the open sting bog area west of Long Lake (Maps 1 & 3). The DNR crew began, but did not complete, cut-and-treat of “finger-diameter” buckthorn in this area. (Maps 1 & 3)

2/10, 1996 – A Sierra Club volunteer group re-cleared (cut-and-treat) “finger-diameter” buckthorn from the western half of the 4-acre square at the end of the boardwalk. They did a poor job. They cut stems much higher than they were instructed, and in the following years many of the cut stems resprouted. This effort led to very poor control; the cut plants became multiple-stemmed in growth form.

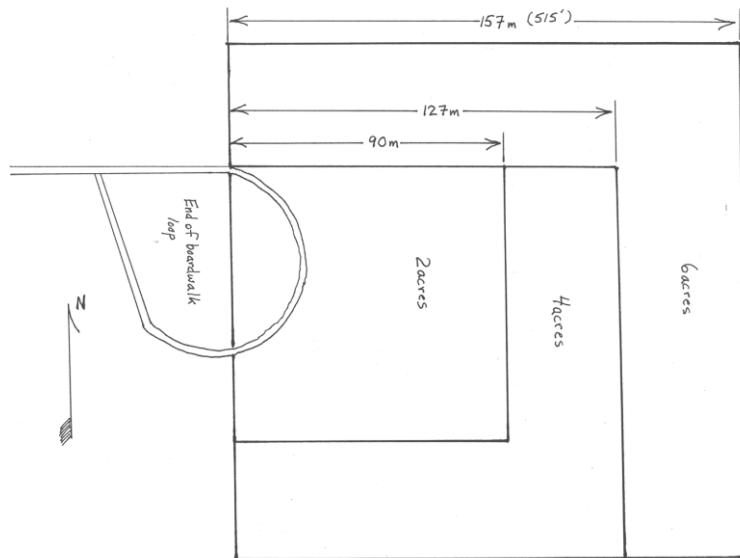


Figure 3: Figure showing detail of control areas at the end of the boardwalk loop.

2/26 to 2/29, 1996 – The DNR crew finished a second clearing (cut-and-treat) of buckthorn from the remainder of the 4-acre square not cleared by the Sierra Club group, and completed a first removal of finger-diameter buckthorn from the last 2-acres of the 6-acre square. The entire 6-acre square had now been cleared for the first time. (Map 4)

2/13 to 2/15, 2001 – A DNR State Natural Areas crew completed removal of all finger-diameter buckthorn from the 250m x 250m (15.4-acre) square area in the center of the open string bog west of Long Lake. (Map 3)

2/15, 2001 – A DNR crew re-cleared approximately the west ½ of the

original 2-acre square at the end of the boardwalk. This was the area where the Sierra Club work led to poor control in 1996. (Map 4)

Control work between 2002 and 2005

Open string bog

The control area in the open string bog west of Long Lake was expanded beyond the 250m x 250m (15.4-acre) square area to the outer border of the entire open string bog area (~50 acres, see Map 3). This larger open string bog area was cleared of finger-diameter buckthorn by a DNR State Natural Areas crew sometime between the 2002 and 2005 winter seasons. The UWM Field Station records do not include dates for this work, and we have not been able to obtain DNR-SNA records of when this work was done.

North end of the Bog

Between 2002 and 2005 contractors for the Wisconsin DNR, and FOCB volunteers, killed fruiting-sized buckthorn in an area of the far north end of the Bog around Watt's Lake (~108 acres, see Maps 1 & 2). The UWM Field Station records do not include dates for this work, and we have not been able to obtain DNR-SNA records of when this work was done. Most of this work was contracted by the DNR using grant funds.

Control work from 2006 to 2008

The Wisconsin Department of Natural Resources contracted for the removal of common buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*Frangula alnus*) from eight Work Units, each approximately 20 acres in area during the winter of 2006 – 2007. The contractor (Applied Ecological Services, Inc.) completed removal of buckthorn from five of the Work Units and parts of two other Work Units, for a total cleared area of approximately 117 acres (Map 2). The main target of the work crews was to cut buckthorn that was approaching the size at which they begin to fruit in the Bog, although they also cut and treated some smaller stems.

In 2007 Reinartz conducted a detailed survey of the results of that contract work:

Buckthorn Density – The average density of buckthorn stems throughout the area in which crews worked in 2006-07 was 135 stems/acre. Buckthorn density increased from north to south through the work area, from 40 stems per acre in the north, to 399 stems per acre in the southernmost area where the crew cut buckthorn. It was estimated that there were approximately 14,000 buckthorn stems > 1.5 cm diameter at the base in the area that was treated

Percent of Buckthorn Cut – Over the entire area in which the crew worked, 89% of buckthorn over 1.5 cm diameter at the base were cut. There was a positive relationship between the density of buckthorn stems and the percent of buckthorn that were cut and treated. Over 90% of the buckthorn was cut from every sample unit that had a density of over 270 stems / acre. An explanation for this relationship is that when buckthorn is widely scattered at low density it is easier for a worker to miss some stems, than when the buckthorn is present at a higher density. An alternative explanation for this trend is that the crew worked from north (lower density buckthorn) to south (higher density) over the winter and gained effectiveness at finding buckthorn with experience. The work done by the crew was considered to be very high quality. However, despite the high percentage of buckthorn killed (almost 90%), after their work there were undoubtedly well over 1,000 fruiting-sized buckthorn that remained in the area because of the initial high density of the stems.

2011 and 2012 buckthorn control work by the Friends of Cedarburg Bog

Work on buckthorn control in the Cedarburg Bog SNA was done in January 2011 by a WDNR crew (12 person-days), and between 1/3/12 and 2/22/12 (84 person-days, contract work by Environmental Design, Inc.; and additional work by a WDNR crew).

There were two main goals of this project: 1) clear all buckthorn approaching fruiting-size from the 6-acre exclusion plot off the east end of the boardwalk that had been previously cleared of buckthorn (see Map 4 and description of previous work above), and 2) clear all buckthorn approaching fruiting-size from the large open string bog area west of Long Lake. Both of these areas are buckthorn exclusion zones that had been established in the past and were in need of follow-up control work.

The January 2011 work by the DNR crew was in the 6-acre exclusion plot at the end of the Field Station boardwalk loop. The Environmental Design crew (contract work) started 1/3/2012. Winter work was performed by Environmental Design and a small crew of local WDNR part-time workers. FOCB was planning to have a crew of WDNR workers from around the state to work as a large crew for a few days. Reinartz decided that the work in the open string bog west of Long Lake should be performed by the large WDNR crew, because he felt that that was the only project on which he could effectively manage the large crew. Unfortunately, the WDNR crew could not be organized to come here to work until 2/20/12, right after the thaw started and the ice was no longer safe. The large crew was cancelled and the control work in the open string bog was not completed.

All buckthorn approaching fruiting-size was cut and treated in the 6-acre exclusion plot (Map 4). All buckthorn approaching fruiting-size was also cut and treated within 20' to 30' on either side of the UWM Field Station boardwalk from the stream bridge to the sting bog loop, and a little way north along the stream, an area totaling approximately 9 acres (Map 4). This work was done after the 6-acre exclusion plot was completed and after the ice was no longer safe to travel to the open string bog. Clearing buckthorn from the area adjacent to the boardwalk was added as a priority control area because this is where most of the general public is educated about the Bog and its diversity of plant communities.

In total buckthorn was cleared from 15 acres, the majority of time being spent on the 6-acre exclusion plot, where all buckthorn with diameter larger than about 1cm at the base was cut and treated. All work in the Bog was halted on about 2/22/12 because the thaw was too extensive by that time and it is not safe to apply the herbicide when there is water over the ice. Work in the open string bog west of Long Lake was not completed.

November 2012 FOCB Control Project

A crew of 4 to 5 worked from 11/26/2012 through 11/30/2012. The northern and eastern boundaries of the work area were surveyed and flagged by Jim Reinartz prior to the crew beginning work. Buckthorn was cut and the stumps were treated with 20% Triclopyr (Element 4) in agricultural oil. All buckthorn with a basal diameter greater than 1.0 cm and greater than 5 ft. tall were cut and treated.

From 11/26/2012 through 11/30/2012 the Environmental Design crew worked 170 person hours at \$33/hr (\$5610) and charged \$190 for herbicide materials, for a total invoice of \$5,800. This project exhausted the funds from a previous WE Energies foundation grant administered through the Natural Resources Foundation. The work was conducted in an area of the Bog that has been worked on with NAWCA funding in the past, where additional NAWCA funding could not be used.

A total of 10.4 acres was treated (Maps 1 & 2). Rates of work can be expressed as 0.061 acres/person hour, or as a cost of \$558/acre at the rate charged. **In 170 worker-hours they cleared 10.4 acres; 16.3 person-hours/acre.** General observations made concerning this project:

- A considerable majority of the buckthorn found in this area was common buckthorn (*Rhamnus cathartica*), a much lesser amount of glossy buckthorn (*Frangula alnus*) was present.
- A high density of common buckthorn was found along the central portions of the northern boundary of the area.
- A very high density of glossy buckthorn was found right along the lake margin on the western boundary of the work area. This was the only area with a high glossy buckthorn density. It appeared that this area may not have been controlled during the previous control work.
- Throughout the area there was the cut-stump evidence of the previous control project conducted in 2006-2008. However there were large shrubs that had obviously been missed in that previous work scattered throughout the area.
- The acreage-productivity of this work (0.061 acres/hour) seemed low to me. However, this may have been caused by:
 - Shrubs were treated down to a smaller size class (1cm diameter at the base and eye-level tall) than much of the previous work. This probably added considerably to the work time required.
 - Some of the dense areas probably required more time than was estimated.
 - Observing the crew while they were working gave me the impression that a little more time may have been spent orienteering in the work area to achieve good coverage than would have been required by someone more expert at that task. This time could be reduced if someone who can orient easily would flag out strips of reasonable width to guide work progress.
- The location and control of invasives in the area appears to be very good (i.e. nearly all plants were found and treated).
- There was what seemed like a relatively high incidence of native shrubs also cut. These were primarily nannyberries (*Viburnum lentago*). This was not a problem that caused any major damage to the wetland community or any major loss of work effort; however, it is an issue that should be addressed more effectively during future projects.

January 2013 Control Work – DNR

In January 2013 the DNR completed buckthorn control work in two areas, 91 acres at the north end of the Bog, and 20 acres in the open string bog west of Long Lake (Maps 1, 2, & 3). Both of these areas had fruiting-sized buckthorn cut and killed once previously between 2002 and 2005 (see above). The northern area was treated with a large DNR crew during the week ending 1/7/2013, and the string bog area was treated by a DNR crew during the week ending 1/23/2013.

January 2014 Control Work – DNR

In January 2014 a DNR crew killed fruiting-sized buckthorn in the open string bog area west of Long Lake (Map 3). The DNR crew controlled buckthorn in 31 acres as part of this project. The DNR crew in the string bog was 6 workers who worked for 40 hours. **In 240 worker-hours they cleared 30.6 acres; 7.8 person-hours/acre.**

The southern portion of that control area had been treated previously between 2002 and 2005. The 2014 work extended the control area to the north to the limits of the open area of the string bog (Map 3). The control zone stopped at a stand of thick white cedar at the northern limits of the open string bog area.

2013 – 2014 Control Work – FOCB

FOCB obtained grants from We Energies Foundation, the Natural Resources Foundation, and the Knowles-Nelson Stewardship Program and spent \$21,262.79 on labor and materials to cut and treat 67 acres at the north end of the Bog (Map 2). The work was done between mid-December 2013 and 8 March 2014. The workers hired for this work were treated as independent contractors, and were managed by Jamie Beaupre, hired as an independent contractor acting as FOCB's foreman. A crew from Environmental Design, Inc. was also hired to work on the project; \$9,126 of the budget was spent on the Environmental Design crew.

All of this 67-acre area had been treated once previously between 2002 and 2008 (Map 2). **The combined labor of all the contractors was 882.5 hours to treat 67.0 acres; 13.2 person-hours/acre.**

FOCB volunteers also controlled buckthorn in two areas totaling approximately 2 acres (along the UWM boardwalk and along the access trail to Mud Lake from Cedar Sauk Road, Maps 4 & 5). This work was done over two days of work parties.

2015 – 2019 EPA-GLRI Grant – FOCB

A detailed daily work record was kept in the form of a GIS for this project. Polygons defining control areas completed on a daily basis were recorded in the field with a GPS and recoded in the GIS system (Maps 1 through 5). The GIS attribute table includes the acreage cleared, the size of the crew and the number of person-hours worked that day, an index of the relative buckthorn density, the herbicide used on the cut stumps, and notes. In total, this project controlled fruiting-sized glossy and common buckthorn plants (cut and treated with herbicide) in a total of 318 acres of the Cedarburg Bog (Map 1). 8,589 worker hours were devoted to the project over the four-year period.

The total budget for this project was \$246,675 (\$197,119, EPA; \$49,557, FOCB, WI Knowles-Nelson Grant, and Natural Resources Foundation Grant). The total labor budget for field workers controlling buckthorn was approximately \$193,300. The work was originally proposed to be completed over two fall-winter seasons (2015 – 2017). Difficult weather and ice conditions over those seasons caused the

Quality control sampling, described in the project QAPP, was used to estimate the percentage of fruiting-sized buckthorn stems that were located, cut, and treated in the control areas. That sampling also provided the best estimate of the total number of buckthorn stems cut on the 318 acres treated (calculated by multiplying the average stem density by the total number of acres). An estimated 410,000 buckthorn stems were cut and treated, and 98.0% of the fruiting-sized buckthorn in the work areas was killed.

For the first two years of the project (the originally planned duration) Jamie Beaupre was hired as the Project Manager, which included being the crew chief and foreman for all of the field activities. We hired three to four additional field workers over the first two years. The crew worked any days when the

weather was acceptable (Bog frozen; temperature above ~ 10°F; no precipitation). In each of the four years of the project we also contracted with the Wisconsin DNR Natural Areas Crew for at least one week of work on the project. For the third season of the project, 2017-18, Jamie Beaupre worked half-time as the Project Manager/crew chief, she had other work commitments that prevented her from working full-time. For the fourth season, 2018-19, Jamie was not available to hire for this project, but we were able to hire her company, Native Niche, Inc., as a contractor on the project. Jamie still helped considerably with management of the project and direction of the field crews, although Jim Reinartz had to be much more involved with direction of the two employees FOCB was able to hire for that last season. There was a substantial change in the availability and ability for FOCB to hire workers who do this kind of work over the course of these four years. In the final year of the project all of the workers that we had hired in previous years had full-time jobs that employed them over the winter. The hourly labor cost roughly doubles when the work must be contracted (\$40/hour) as opposed to hiring employees (\$20/hour). Half as much work (at best) is accomplished per dollar spent.

In total, this project controlled fruiting-sized glossy and common buckthorn plants (cut and treated with herbicide) in a total of 318 acres of the Cedarburg Bog (Map 1). The original acreage estimate for control with the project budget was unrealistic. It was proposed that FOCB would be able to control buckthorn on 680 acres with the project budget. That acreage goal was based on an estimate of 13 labor-hours per acre treated derived from records of previous projects. In retrospect, that proposed acreage was based on an estimate of the time required to clear an acre of buckthorn which was derived from areas that had lower buckthorn density than the averages we encountered over the entire project area.

- During the first year of this project 2015 – March 2016 we cleared 196 acres at a labor rate of 15.9 man-hours/acre, which was close to, but higher than, the labor requirement that the original proposal was based on. After those initial 196 acres, the buckthorn densities we encountered, and the hours per acre treated, grew higher and higher.
- Fall 2016 – March 2017, 72 acres, required 33.7 hours/acre.
- Fall 2017 – March 2018, 37 acres, required 45.3 hours/acre.
- Fall 2018 – March 2019, 14 acres, required 100.1 hours/acre!

Over the entire four-year project, we cleared 318 acres with 8,589 hours of labor, or an average of 27 hours per acre cleared. The marginal cost per acre cleared was clearly growing higher over time.

A few factors contributed to the exceptionally high labor requirement for the 14 acres controlled in the final year of the project. It is worth reviewing these to learn to better estimate labor requirements:

- Work in areas with higher buckthorn density. Representative examples of the plant communities in the Bog with lower initial buckthorn density had already been treated at least once.
- Work in areas where the buckthorn had a growth form with multiple smaller stems growing in clumps, as opposed to larger single-stemmed plants. Native shrubs (bog birch, winterberry, willows, dogwoods, etc.) were often also growing in the clumps, greatly increasing the time required for selective buckthorn control.
- A high incidence of dead buckthorn stems mixed in the clumps of small-stemmed buckthorn. Dead buckthorn stems make rapid differentiation between stems of buckthorn and native species more difficult, and the dead stems are harder to cut. Search, identification, and handling times are increased by the presence of dead buckthorn stems.
- In general, because of the multiple, small-stemmed, growth form, workers were cutting and treating much smaller stems (smaller than fruiting-sized) than in areas that had more single-stemmed growth form. The goal to cut and treat only stems approaching fruiting size was almost impossible to apply when the buckthorn was growing as a dense clump.
- The variables of crew size and buckthorn density are confounded in the daily records of man-hours per acre cleared. However, there is some suggestion that the larger the crew working, the lower the productivity per worker hour. My personal observation also suggests that productivity

over the course of the project ranked from highest to lowest is: 1) Jamie working alone; 2) Jamie leading a small crew of FOCB employees; 3) DNR Natural Areas Crew (although these were variable); 4) Large crews of contractor workers. In the final year of the project FOCB had no alternative but to hire contractors to complete the project. There were some days when with the two FOCB employees, the DNR crew, Marek Landscaping Inc., and Native Niche Inc., there were as many as 15 workers. It is clear that a combined crew that large is not a formula for the highest productivity.

Current situation

FOCB has developed a Sustainment Plan to continue control of buckthorn on the 576 acres that have been treated at least once in the Bog. Sustainment of buckthorn control will remain a high priority of the Friends of Cedarburg Bog. There are no current plans to expand the control area in the Bog, other than to provide a control area on 26 acres of privately-owned land in the southeastern part of the Bog that has the only open-bog, and black spruce-tamarack plant communities in the wetland (see the Sustainment Plan). Work in that area would bring the total buckthorn control areas in the wetland to 600 acres.

FOCB will continue to work with the Wisconsin DNR State Natural Areas Program to control buckthorn regrowth in those areas that have been treated previously. To sustain control of 576 acres into the future with an ideal treatment recurrence interval of 6 years will require treating almost 100 acres per year. At a cost of \$500/acre (20 hours x \$25/hr.) this work will potentially require an average \$50,000 per year over the next 6-year cycle of control. Cost will decline after that, since there will be less and less buckthorn present in the treatment areas over time.

There are currently 50 acres that are overdue for follow-up treatment, having been last treated over six years ago, and another 93 acres that will be due for treatment in 2020. FOCB will continue to apply for grant funding for this work. Potential sources include: Great Lakes Restoration Initiative grants, National Fish and Wildlife Foundation's Sustain Our Great Lakes Program grants, and Wisconsin DNR Stewardship grants. FOCB can devote some funding to control work in the Bog, however, as a small non-profit, FOCB will not be able to fund a substantial part of the \$50,000 required without grant funding.

The control work in the Cedarburg Bog has been almost entirely on state-owned Wisconsin DNR State Natural Area. In order to sustain the control that has already been achieved into the future, the Wisconsin DNR will have to make the Bog a funding priority.

