

Assateague Island National Seashore Exotic Species Management, 1999-2001

Bianca McIntyre, Biological Technician
Frank Hudson, Biological Technician
Chris Lea, Ecologist
Division of Resource Management

Assateague Island National Seashore
7206 National Seashore
Berlin, MD 21811
(410) 641-1443
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ABSTRACT

A program to manage the exotic invasive species Asiatic sand sedge (*Carex kobomugi*), tree-of-heaven (*Ailanthus altissima*), and purple loosestrife (*Lythrum salicaria*) on Assateague Island National Seashore began in 1999 with the discovery of the first invasion of Asiatic sand sedge. This report is a progress report of the first three years of an exotic invasive species management program. Information regarding plant characteristics, assessment, treatment, and monitoring is presented.

INTRODUCTION

The National Park Service defines an exotic species as any species that occurs outside of its natural range as a result of human actions. Invasive exotic plants can reduce biodiversity by displacing or out-competing native plants, degrading the habitat of wildlife, and often disrupting natural ecosystem processes (Heffernan, 1998). Plant invasions can naturally occur via seed dispersal by wind, water, or wildlife. Additionally, humans may introduce invasive exotic species accidentally or intentionally for aesthetic reasons.

Invasive exotics are often well adapted to survive and prosper in any variety of environments. Due to the ease with which some invasive exotics colonize, they soon become a problem in many National Parks, including Assateague Island National Seashore (ASIS). Legislation specific to ASIS (Public Law 94-578) directs the Secretary of Interior to plan “measures for the full protection and management of the natural resources and natural ecosystems of the seashore.” Certain exotic species have extremely disruptive impacts on native ecosystems (National Park Service, 1991); therefore, management of such species, where feasible, will further fundamental purposes of the National Seashore.

Species of great concern at ASIS are Asiatic sand sedge (*Carex kobomugi*), tree-of-heaven (*Ailanthus altissima*) and purple loosestrife (*Lythrum salicaria*). Found in differing habitats, these highly invasive species pose a threat to native flora and are currently being controlled by resource management personnel. Common reed (*Phragmites australis*) is not currently a target for management, although it may have the greatest ecosystem impact. See section Future Research Needs for further information on this species.

NATURAL HISTORY

Asiatic sand sedge, an invasive plant from East Asia, was introduced into the United States for its sand-stabilizing capabilities. Planted in coastal sands from Massachusetts to Virginia during the 1930s, this clonal plant colonizes in the fore dunes, in a niche naturally filled by native beach grass (*Ammophila breviligulata*) (Small, 1954). National Park Service Ecologist Chris Lea discovered Asiatic sand sedge for the first time on Assateague Island in 1999 at multiple locations on the island. Three colonies were found on Tom's Hook in the Chincoteague National Wildlife Refuge in 2001. See Figure 1. The U.S. Fish and Wildlife Service will be taking responsibility for treatment of these plants. A specimen of this species is vouchered in the ASIS herbarium.

Tree-of-heaven was first introduced to England in 1751 by Pierre d-Incarville who mistook the species for the lacquer tree, found in China (Hoshovsky, 1986). In 1784, a gardener brought the species to the United States, where it quickly became a popular tree for landscaping in cities during the 1800's (Hoshovsky, 1986). Tree-of-heaven became naturalized across the nation because of its popularity and hardiness in poor soils. Today, tree-of-heaven can be found in 42 states, from Florida to Maine, and west to parts of California. At ASIS, two populations of tree-of-heaven have been found, both in disturbance-prone areas (Figure 1). The southern population (AiAl 3 in Figure 1) in the area of Valentine's cabin is close to an administrative road, making it possible for vehicular seed dispersal. The second, smaller population is found at the northern-most part of the island. This area is approximately 50 meters south of the Ocean City inlet. Dr. Steven Hill recorded tree-of-heaven for the first time on Assateague Island in 1984 (Hill, 1986), and a vouchered specimen is also in the ASIS herbarium.

Purple loosestrife was introduced into the northeastern part of the United States and Canada in the early 1800's. A native of Eurasia, it is an invasive species known to form monospecific stands crowding out native wetland species such as cattails, grasses, sedges, and rushes (Virginia Department of Conservation and Recreation and Virginia Native Plant Society, date unknown). Purple loosestrife is widely distributed due to its heavy seed set, producing as many as 300,000 seeds in a single stalk (Hamilton, 2001). This exotic species was found for the first time on Assateague Island at Oceanside Campground in August 2000 by campground office volunteer, Christian Diehm. The occurrence of purple loosestrife consisted of 6 stems, some of which were in flower. This population (LySa in Figure 1) was located in a wet depression under a groundsel tree (*Baccharis halimifolia*) east of the wooden fence along the camper parking lot for the middle of three group camping walk-in areas. In August 2000, the plant was in flower but mature fruit were not seen. A specimen was collected as a voucher and placed in the ASIS herbarium.

ECOLOGICAL THREAT

Asiatic sand sedge is a smaller-stature plant therefore it doesn't have the strong dune-stabilizing capabilities of beach grass. A replacement of native dune grasses by Asiatic sand sedge can create a weakened dune system, which in turn can disrupt the natural process of dune formation and island protection (Small, 1954). Also, dunes dominated by Asiatic sand sedge can be less species rich with native vegetation than dunes where natives dominate (Small, 1954). At ASIS, Asiatic sand sedge poses a competitive threat to a federally listed threatened species, seabeach amaranth (*Amaranthus pumilus*) (Lea and King, 2001). In several cases, these two species were found thriving adjacent to each other in low-lying dunes. The threat of Asiatic sand sedge out-competing seabeach amaranth makes it a high priority for control or eradication at ASIS.

As a pioneer species, tree-of-heaven can be found virtually anywhere with a history of disturbance. Because tree-of-heaven is highly shade intolerant, and grows quickly, it is often considered a "dangerous weed" in forested areas (Hoshovsky, 1986). As a prolific seed producer, it is believed that one tree can produce as many as 350,000 seeds per year that are easily dispersed by wind or water due to its papery winged samara form (Virginia Department of Conservation and Recreation and Virginia Native Plant Society, date unknown). Once established, tree-of-heaven grows quickly, and out-competes native plant species for sunlight and growing space.

Purple loosestrife is also a species that thrives in disturbed areas, and is known to invade natural wetland communities. Due to high seed viability, and the prolific nature of the plant, seed banks are often large and many years of treatment are necessary to deplete the seed supply. These plants have the ability to resprout from cut stems and often regenerate from pieces of root stock. Purple loosestrife is often found in disturbed areas, and thrive in areas subject to drainage, drawdown, ditching, and siltation (Bender, date unknown). These plants are of concern at ASIS due to their ability to shade out native species and quickly form monospecific stands in a very short time due to high seed output capabilities.

CURRENT MANAGEMENT APPROACHES

The three steps necessary to make any exotic species management program successful include: assessment, treatment, and monitoring. Assessment includes the initial field reconnaissance and development of strategic plans for management. In the planning stages, it is important to note that all exotic invasive management should be approached in a species-specific manner. Treatment involves applying a chosen management because the requirements of species differ greatly, aspects of each individual species' biology and ecology must be considered. Exotic species monitoring follows treatment, and is used to assess the success or failure of the control method implemented. The completed monitoring information is then used to reassess management objectives. Table 2 summarizes all treatments for managed species at ASIS for years 1999-2001.

METHODS

Asiatic Sand Sedge

At ASIS, methods of removal of Asiatic sand sedge included using either foliar application, with a pump sprayer, of glyphosate herbicide (2% Roundup™) to destroy large colonies (>5 ramets), or digging to remove small (<5 ramets) colonies. All fourteen known established colonies of Asiatic sand sedge in Maryland were monitored and treated, if necessary, during 2000 and 2001, with an additional two sites found and also treated in 2001. Future monitoring is expected to reveal periodic establishment of small colonies of this plant, since it has been reported in several areas along the mid-Atlantic coast. Since it takes several years for a colony to grow large, annual monitoring should identify populations that may be small enough to be removed by digging. All known Asiatic sand sedge colonies at ASIS were treated in early August. Those sites that were hand-dug during 2000 had less re-growth in 2001. For small colonies, this would be an effective method of Asiatic sand sedge removal. Herbicide use for years 1999-2000 is noted in Table 3.

Herbicide Treatment Research

An experiment was sent up in August of 2000 to determine the most effective foliar herbicide application for Asiatic sand sedge. Three different herbicide treatment regimes were tested for their effectiveness at reducing the number of ramets of Asiatic sand sedge. Three of the larger colonies, which had formed small dunes, were selected for this experiment. These colonies were treated with 2% glyphosate in November 1999, but with little effect on shoot number, perhaps due to ineffective application and/or lateness in the growing season. The colonies treated are the populations of Asiatic sand sedge at CaKo 16, CaKo 20, and CaKo 27 in Figure 1. Each colony was subdivided into three

experimental blocks, each having an approximately equal number of ramets and each block receiving a different treatment regime. Assigned treatments were alternated by block (east, central, or west) between sites to avoid possible confounding effects of dune position. See Figure 2. The three treatments were (1) summer herbicide treatment (2) fall herbicide treatment (3) summer and fall herbicide treatment. Ramets were counted for each treatment group before application of 2% glyphosate, and early in the growing season following treatments. Also, no control (not treated) blocks were employed. It is assumed that glyphosate is the main cause of shoot mortality and that untreated colonies would either remain stable or grow in number of shoots with no treatment.

The results of this experiment show that a summer herbicide application is the most effective measure against controlling Asiatic sand sedge invasions (Table 1). All three treatments were effective; however, the summer treatment proved to be more successful than the fall treatments, and as successful as the summer/fall treatments. The plants killed during summer/fall treatments were killed by the summer treatment alone - thus there is no advantage to two treatments.

Tree-of-heaven

Two populations of tree-of-heaven have been discovered at ASIS. In 2000, a single stem approximately 4 inches in diameter was located just above the bayside beach about 50 meters south of the Ocean City Inlet jetty (see Figure 1). The second population, noted by Dr. Steven Hill in his 1984 survey, was located just west of the Valentine's cabin road, approximately 100 meters south of the cabin. In October 2000 this population consisted of 25 saplings/pole sized stems and 40 seedlings/root sprouts.

Both populations were treated with herbicide in 2000. The North End population was treated on September 29th. This single stem was cut off at about 1 m above the ground and the stump was immediately treated with .7% triclopyr triethylamine (Brush-Be-Gone™). The southern population was treated on September 5th. Larger stems were girdled, by cutting through the cambium layer around the entire circumference of each stem. Saplings were broken off. In both cases the exposed xylem was immediately hand sprayed with triclopyr. Seedlings and root suckers were hand pulled. It was hoped that the shade cast by the residual canopy cover (consisting of other tree species and vine cover) would retard the re-growth of any stems not killed by the herbicide.

On October 22, 2001, both populations were monitored and treated. The treated tree-of-heaven at the North End had root suckers growing from it, despite the treatments from the previous fall, and two more sapling size tree-of-heaven were found 10 meters north of the single tree. The large portion of the stump with root suckers was cut off with a handsaw, and triclopyr was reapplied. This year, to increase success after spraying, Para-film was stretched over the treated stump, and a rubber band was wrapped round it, to ensure that rain would not wash the newly applied herbicide off and into the surrounding vegetation. The two new, smaller trees were treated in the same manner.

At the southern population, chemical control (triclopyr) and physical control (hand-pulling) were employed. The numbers in 2001 totaled 314, with 248 seedlings or sucker sprouts, and 66 saplings. Compared to last year's total of 65, this is a large increase in total numbers. The pole trees that were girdled appeared to have died, because they had a barren canopy and all of the other trees still had all their leaves. However, sucker

sprouts were present in several places at the base of the trunk. A new opening in the forest canopy due to the successful dying off of the girdled trees, allowed the growth of smaller trees and possibly triggered the seed bank to begin invading the area. An additional spring monitoring and treatment may need to be implemented in order to control this population.

Purple Loosestrife

In August of 2000, 6 stems of purple loosestrife were found and immediate action was taken to deter further growth of the species. The flowering heads of the plants were cut and sealed in a plastic bag. The stems were then spot treated with glyphosate. No plants were found in the summer of 2001; however, this area should be checked annually. Depending on the size of the population, methods of removal that could be implemented, , would include hand-pulling and spot application of glyphosate. Hand pulling should be done before flowering has occurred to avoid further dispersal of seeds. Also all pulled plants should be bagged at the site so that fragments are not dropped. This species is capable of reproducing from its stem or root segments, therefore care must be taken when removing the plant from the site. As with all exotics, early detection is the most effective means of controlling a serious invasion.

FUTURE NEEDS

Common reed (*Phragmites australis*), hereafter referred to as *Phragmites*, is debatably native to Assateague Island; however, there is little doubt that the species is invasive. *Phragmites* can alter ecosystem functions and reduce biological diversity. While there are no data to draw firm conclusions, anecdotal observations suggest that *Phragmites* has been and still is increasing in abundance on Assateague, including in relatively undisturbed habitats.

Although *Phragmites* is likely the invasive vascular plant that presently has the greatest ecosystem impact, it is not currently a target for reduction. Its abundance and distribution throughout the island ensure that any general reduction and/or eradication efforts that would restore ecosystem function would require considerable effort, with little guarantee of sustained success. *Phragmites* is well adapted to invade fresh to brackish wet areas. The southern wax myrtle/ hydrocotyle (*Myrica cerifera*/*Hydrocotyle sp.*) community seems to be especially susceptible to *Phragmites* invasion on Assateague Island (Lea, 1997).

Control of *Phragmites* on Assateague Island is not being contemplated with current staff resources because of the magnitude of its frequency and abundance and because patterns, causes, and rates of its establishment and dispersal are poorly known at present.

Yearly monitoring and early detection are the most effective means of controlling the island's population of Asiatic sand sedge. With early efforts in the monitoring and treatment of this species, Asiatic sand sedge can be managed effectively.

With the possibility of further invasions by tree-of-heaven and purple loosestrife, research should be conducted to determine a more effective means of controlling these invasive species. For tree-of-heaven, a long-term management plan may facilitate further removal of the southern population. Time may be a factor in depleting the seed bank in

that area, with continued removal and herbicide spot application. Due to the nature of these species as well as all exotic invasives, avoiding disturbance on the island is the best preventative measure.

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LITERATURE CITED

- Bender, J. Date unknown. Element Stewardship Abstract for *Lythrum salicaria*: Purple loosestrife. The Nature Conservancy, Arlington, Virginia.
- Hamilton, Helen. 2001. Common Plants of Assateague Island. National Park Service, Berlin, MD.
- Heffernan, K. E. 1998. Managing Invasive Alien Plants in Natural Areas, Parks, and Small Woodlands. National Heritage Technical Report 98-25. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia.
- Hill, S. R., 1984. A Botanical Survey of the Maryland portion of Assateague Island. Report to the National Park Service. College Park, MD.
- Hoshavsky, M. 1986. The Nature Conservancy Element Stewardship Abstract: *Ailanthus altissima*. The Nature Conservancy, San Francisco.
- Lea, C. 1997. Vegetation classification of Assateague Island National Seashore, Addendum 1 - July 23, 1997. National Park Service, Assateague Island National Seashore.
- Lea, C. and S. King, 2001. Seabeach Amaranth Restoration Progress Report, 2000. Summary Report. National Park Service, Berlin, MD.
- Lea, C and G. McLaughlin. In prep. Asiatic sand sedge fact sheet. Fact sheet on Weeds Gone Wild web page. The Plant Conservation Alliance Alien Plant Working Group (www.nps.gov/plants/alien).
- McAvoy, W. and K. Bennett, 2001. The Flora of Delaware - An Annotated Checklist. Delaware Department of Natural Resources and Environmental Control. Dover, DE.
- National Park Service, 1991. Natural Resource Management Guideline (NPS-77). National Park Service, Washington, DC.
- Small, J.A. 1954. *Carex kobomugi* at Island Beach, New Jersey. Ecology 35: 289-291.
- Virginia Department of Conservation and Recreation and Virginia Native Plant Society. Date unknown. Invasive alien plants of Virginia: Tree-of-heaven (*Ailanthus Altissima*) Fact sheet.

Table 1. Experimental sites for herbicide removal of *Carex kobomugi*.

Experimental Site at CaKo 16, Figure 1				
		Bayside Plot	Middle Plot	Oceanside Plot
	Date	Summer	Fall	Summer & Fall*
	AUGUST			
Pre-application count	08/03/2000	162	276	170
Application	08/07/2000	3		3
Application	10/04/2000		3	3
Post-application count	06/26/2001	16	50	15
	% Survival	9.9%	18.1%	8.8%

Experimental Site at CaKo 20, Figure 1				
		Oceanside Plot	Bayside Plot	Middle Plot
	Date	Summer	Fall	Summer & Fall*
	AUGUST			
Pre-application count	08/03/2000	1933	752	923
Application	08/07/2000	3		3
Application	10/04/2000		3	3
Post-application count	06/26/2001	31	163	14
	% Survival	1.6%	21.7%	1.5%

Experimental Site at CaKo27, Figure 1				
		Middle Plot	Oceanside Plot	Bayside Plot
	Date	Summer	Fall	Summer & Fall*
	AUGUST			
Pre-application count	08/03/2000	447	522	269
Application	08/07/2000	3		3
Application	10/04/2000		3	3
Post-application count	06/26/2001	0	0	0
	% Survival	0.0%	0.0%	0.0%

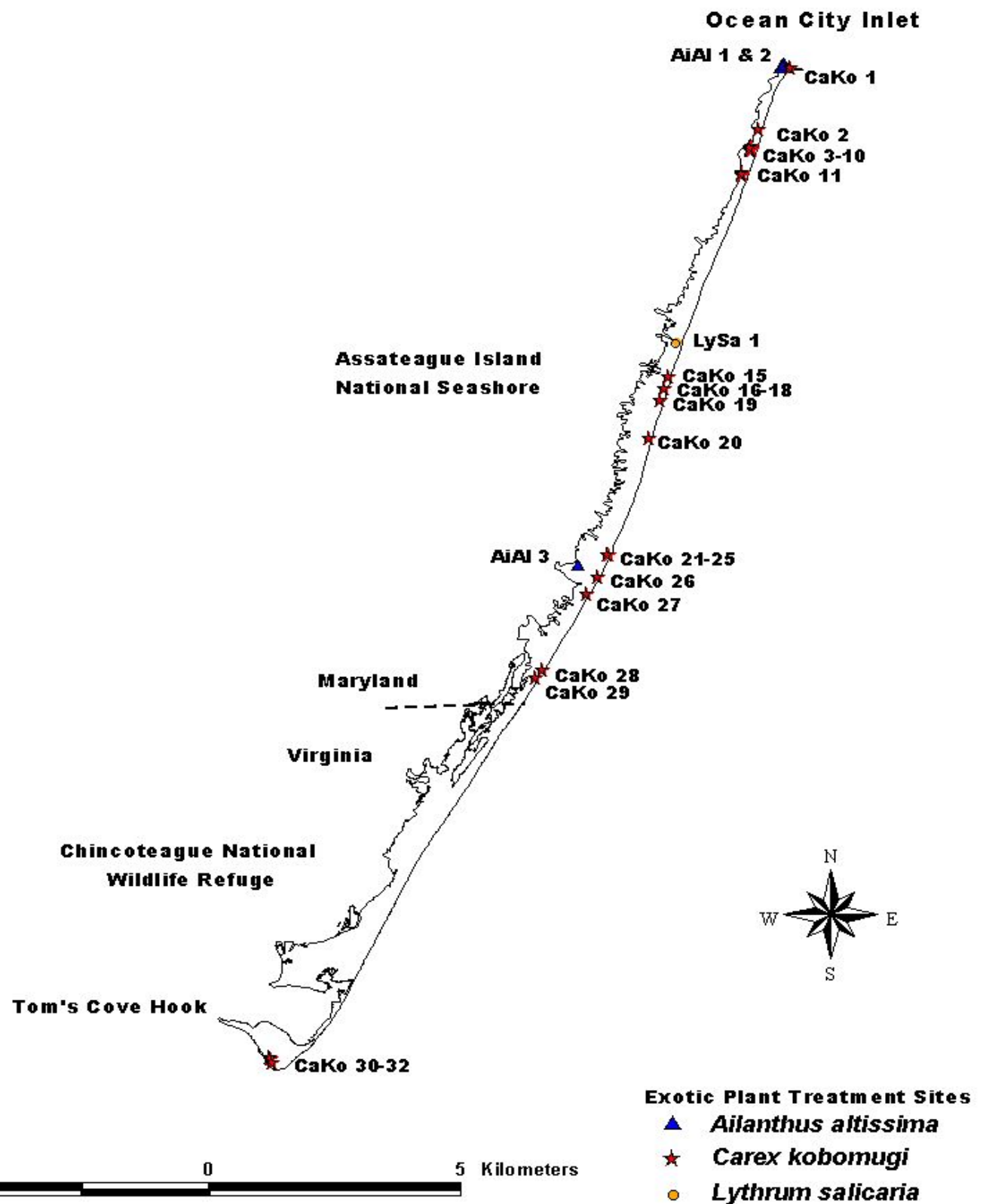
- Pre-application and post-application counts include the number of shoots counted before and after each herbicide treatment.
- Check marks (3) indicate when each of the three experimental blocks was treated.
- *Roundup was applied to live ramets only (not to dead ramets) in the Fall treatment of the Summer & Fall treatment group.
- 84 additional plants in the CaKo 16 site (fall treatment) plants were present but dug up for experimental use by Salisbury State and not included in the 923 total.

Table 2. Treated sites 1999-2001. Site number corresponds to Figure 1.

Site #	Northing	Eastng	Discovered	Ramets 1999	Treatment 1999	Ramets 2000	Treatment 2000	Ramets 2001	Treatment 2001
AIAl 1	4241834.531	491440.705	2001	n/a	n/a	n/a	n/a	2	BBGone 10-22
AIAl 2	4241800.166	491414.4574	2000	n/a	n/a	1	girdled/spray BBG	1	BBGone 10-22
AIAl 3	4215809.743	481379.4073	1994	n/a	n/a	65	girdled/spray bug	314	BBGone 10-22
CaKo 1	4241654.301	491796.849	2000	n/a	n/a	13	dug up	0	none
CaKo 2	4238487.339	490186.9402	2000	n/a	n/a	not checked	dug up	30	2% glyphosate 9-03
CaKo 3	4237589.453	489897.012	2001	n/a	n/a	not checked	dug up	0	none
CaKo 4	4237503.207	489793.6031	2001	n/a	n/a	n/a	n/a	13	2% glyphosate 9-01
CaKo 5	4237424.692	489824.1205	2001	n/a	n/a	n/a	n/a	36	dug up 5-04
CaKo 6	4237420.313	489843.7196	2001	n/a	n/a	n/a	n/a	20	dug up 5-04
CaKo 7	4237418.776	489825.838	2000	n/a	n/a	14	dug up	0	none
CaKo 8	4237404.249	489838.5838	2001	n/a	n/a	n/a	n/a	9	dug up 5-04
CaKo 9	4237402.464	489824.0017	2001	n/a	n/a	n/a	n/a	33	dug up 5-04
CaKo 10	4237393.875	489843.4343	2000	n/a	n/a	n/a	n/a	43	dug up 5-04
CaKo 11	4237038.721	489716.852	2000	n/a	n/a	50	dug up	0	none
CaKo 12	4236193.944	489394.673	2001	n/a	n/a	37	dug up	0	none
CaKo 13	4236172.739	489412.2927	2001	n/a	n/a	n/a	n/a	158	untreated
CaKo 14	4236122.616	489409.3878	2001	n/a	n/a	n/a	n/a	80	untreated
CaKo 15	4225646.83	485760.173	2000	n/a	n/a	374	2% glyphosate 8-29	2	2% glyphosate 8-03
CaKo 16	4225036.717	485594.369	1999	not checked	2% glyphosate Nov	608	Exp. Glyphosate	81	2% glyphosate 8-02
CaKo 17	4222490.577	484802.887	2000	n/a	n/a	not checked	none	5	2% glyphosate 8-01
CaKo 18	4222447.266	484789.414	2000	n/a	n/a	not checked	none	1	2% glyphosate 8-01
CaKo 19	4224429.911	485407.857	2000	n/a	n/a	277	2% glyphosate 8-29	16	2% glyphosate 8-03
CaKo 20	4222426.519	484820.465	1999	not checked	2% glyphosate Nov	3608	Exp. glyphosate	208	2% glyphosate 8-01
CaKo 21	4216381.409	480792.642	1999	not checked	2% glyphosate Nov	not checked	n/a	not checked	2% glyphosate 8-01
CaKo 22	4216369.562	482801.59	1999	not checked	2% glyphosate Nov	not checked	2% glyphosate 8-29	109	2% glyphosate 8-01
CaKo 23	4216366.842	482811.723	1999	not checked	2% glyphosate Nov	not checked	n/a	not checked	2% glyphosate 8-01
CaKo 24	4216360.898	482827.904	1999	not checked	2% glyphosate Nov	not checked	n/a	not checked	2% glyphosate 8-01
CaKo 25	4216355.559	482852.706	1999	not checked	2% glyphosate Nov	not checked	n/a	not checked	2% glyphosate 8-01
CaKo 26	4215252.206	482321.121	2000	n/a	n/a	1	dug up	1	dug up 8-3-01
CaKo 27	4214320.638	481780.718	1999	not checked	2% glyphosate Nov	1238	Exp. glyphosate	7	2% glyphosate 8-01
CaKo 28	4210394.258	479583.625	2000	n/a	n/a	4	dug up 8-25	0	none
CaKo 29	4209967.608	479281.398	2001	n/a	n/a	n/a	n/a	6	dug up 5-2
CaKo 30	4190275.488	466183.2264	2001	n/a	n/a	n/a	n/a	150	untreated
CaKo 31	4190178.282	466247.7212	2001	n/a	n/a	n/a	n/a	250	untreated
CaKo 32	4190024.991	466371.8008	2001	n/a	n/a	n/a	n/a	100	untreated
1-1-1-1	4197700.4	466370.416	2001	n/a	n/a	6	2% glyphosate 8-29	1	untreated

Table 3. Herbicide use for 2000 – 2001. No record of herbicide use found for 1999.

Herbicide Log 2000					
		<u>Date of Use</u>	<u>Purpose</u>	<u>Concentration(%)</u>	<u>Amount Used (oz)</u>
Roundup					
- glyphosate, isoproylamine salt	18.0%	08/07/2000	CaKo	2.00	48.00
- other ingredients	82.0%	08/29/2000	CaKo & LySa	2.00	10.00
		10/04/2000	CaKo	2.00	24.00
				Total oz.	82.00
Herbicide Log 2001					
		<u>Date of Use</u>	<u>Purpose</u>	<u>Concentration(%)</u>	<u>Amount Used (oz)</u>
Brush-B-Gon					
- triclopyr, triethylamine salt	00.70%	09/05/2000	AiAl	100.00	24.00
- other ingredients	99.30%				
				Total oz.	24.00
Herbicide Log 2001					
		<u>Date of Use</u>	<u>Purpose</u>	<u>Concentration(%)</u>	<u>Amount Used (oz)</u>
Roundup					
- glyphosate, isoproylamine salt	18.0%	08/01/2001	CaKo	2.00	1.92
- other ingredients	82.0%	08/02/2001	CaKo	2.00	0.64
		08/03/2001	CaKo	2.00	2.56
		09/03/2001	CaKo	2.00	1.28
		09/04/2001	CaKo	2.00	1.28
				Total oz.	7.68
Herbicide Log 2001					
		<u>Date of Use</u>	<u>Purpose</u>	<u>Concentration(%)</u>	<u>Amount Used (oz)</u>
Brush-B-Gon					
- triclopyr, triethylamine salt	00.70%	10/23/2001	AiAl	100.00	12.00
- other ingredients	99.30%				
				Total oz.	12.00



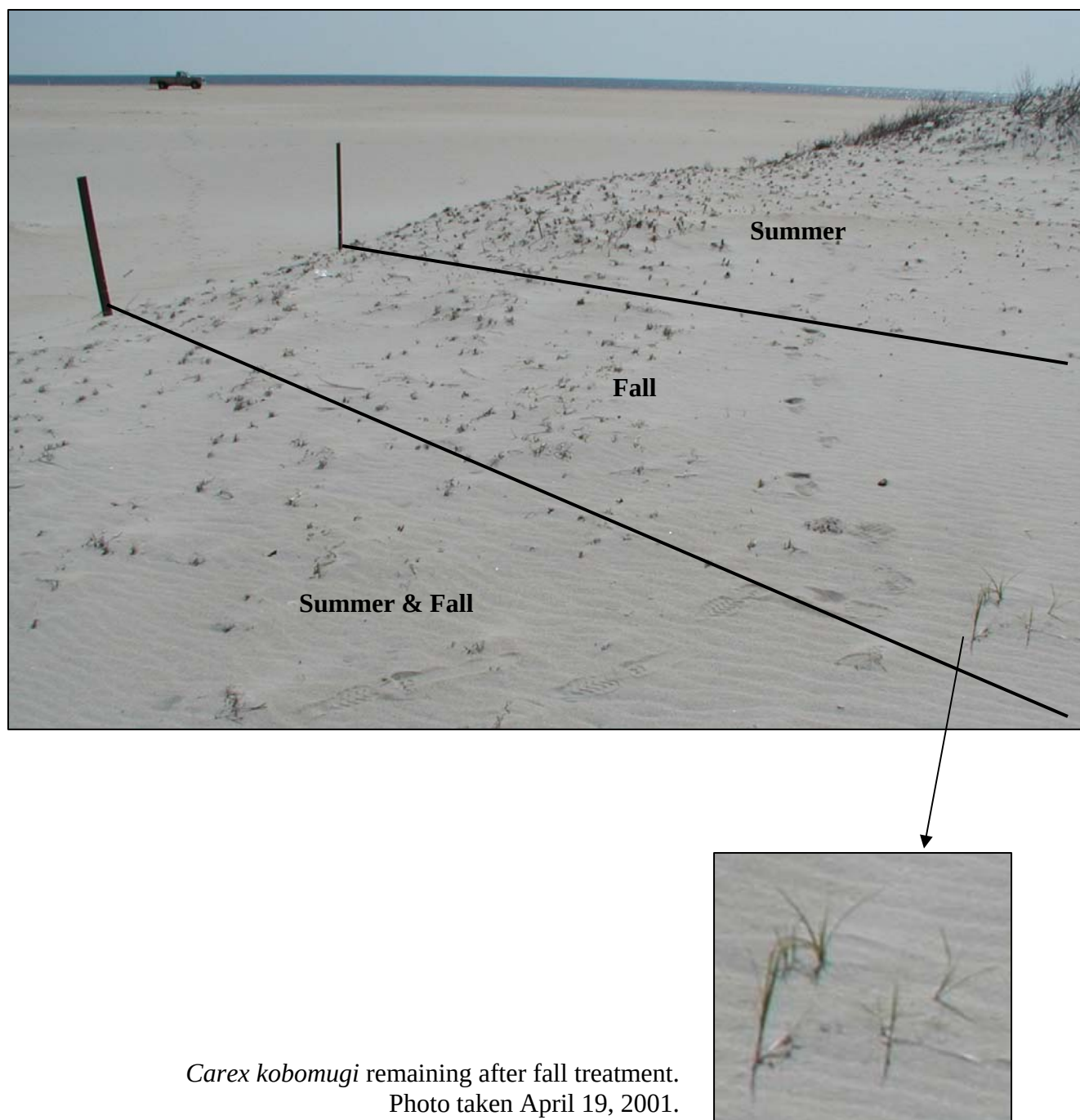


Figure 2. Experimental Site at CaKo 20 (See Figure 1 for location) following application of 2% glyphosate showing seasonal experimental blocks.