Disposal Methods of European Beachgrass at the Friends of the Dunes

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1 Introduction

Ammophila arenaria (European beach-grass) is one of two species of the genus Ammophila in the family Poaceae native to the sandy beach dune coastlines of Europe and North Africa. This plant was imported into the United States to stabilize shifting coastal sand dunes from blowing onto roads, dwellings and railroad tracks. Over time, this grass has invaded and displaced native dune habitats, significantly altered dune morphology and is the primary threat to several endangered plant and animal species. *Ammophila arenaria* with its extensive underground rhizome network is extremely tenacious and its eradication has proven to be an ongoing challenge with no one proven method of success. Friends of the Dunes are a nonprofit organization in Humboldt County, California that manages a coastal dune property known as the Humboldt Coastal Nature Center (HCNC) that is located on the Samoa Peninsula. The purpose of this capstone project is to offer recommendations to the Friends of the Dunes on disposal methods for the European Beach Grass removed periodically from the coastal dunes on their property. The criteria selected was to convert the European Beach Grass into a commodity that could be sold, fulfill an existing need or select a disposal method that was local and inexpensive thereby ensuring the sustainability of these disposal methods.

2 Purpose and need

The invasion of European Beach Grass along the west coast is disrupting the balance of many coastal dunes ecosystem by crowding out important native species. The Friends of the Dunes is seeking sustainable solutions for the proper disposal of removed beach grass. They hope the removal of these invasive species will allow native plant and wildlife communities to become reestablished along these important coastal sand-dune communities. We are conducting this research to offer them sustainable options for managing their bio-waste disposal over time. Currently the waste is being burnt or shipped off to a dump, so we feel that a sustainable option would be to repair the existing Grass Baler and offer ideas where the beach grass meets an existing need.

2.1 Objectives

The objectives were to quantify the amount and distribution of European beach grass biomass on the property at Friends of the Dunes and suggest disposal methods that would be sustainable over time by creating or fulfilling a need that the grass could justify. These disposal methods would be evaluated for success based on the criteria of converting the harvested beach grass into a commodity that could potentially be sold on the market place, or be desired by commercial operators who would readily make use of it.

2.2 Constraints

The constraints were recognized to be funding due to Friends of the Dunes being a not-for-profit organization, and a lack of technical manpower to operate and maintain sophisticated technologies. The available maps and data regarding the area and density of Beach Grass infestation at the dunes were from 2010 and needed updating. The timeline available for this project was only a semester long, and the hay baler was from a previous project and we were picking up where the other team left off.

2.3 Evaluation

The disposal methods selected would be evaluated for feasibility as to whether they actually meet and fulfill a commercial or end user need in the community. Efficiency and convenience of disposal are important as Friends of the Dunes relies on volunteers for the grass removal and so these methods should be simple. And the most important benchmark for evaluation would be cost effectiveness in that it should not be a monetary drain on the Friends of the Dunes for the grass disposal. If these criteria are met, then we feel that the proposed disposal methods would meet our evaluation criteria for long term sustainability.

2.4 Monitoring

The proposed disposal methods would be checked to make sure that it does not contribute to the spread of this invasive grass to new locations as this would merely compound the problem. The disposal methods we propose will be quantified and compared to other similar methods so as to confirm their feasibility and effectiveness over time. The grass baler would be improved to maximize efficiency by increasing the density of beach grass, wrapped and tied tight enough to withstand transport to end-user locations without spillage or breaking.

2 European Beach grass

European Beach grass (*Ammophila arenaria)* is a monocot, perennial grass species growing in tufts connected by deep, creeping rhizomes. The flower-heads are dense, cylindrical spike-like panicles up to 12 inches long, with spikelet's containing a single floret. The leaves are thick, coated in a white waxy cuticle, up to 1 meter long and sharply pointed. According to the CAL- IPC database, it prefers an annual precipitation between 13 – 75 inches, at least 175 frost free days, soil pH between 6 – 8.5 and medium to coarse soil textures. Natural establishment takes place through seedlings and vegetative from pieces of rhizome washed ashore at high tide. Rhizomes can be carried by seawater for 7 days and still have more than 50% of buds capable of producing new shoots (Aptekar, 1999). Even after 13 days of immersion in seawater, European beach-grass rhizomes retain a mean bud viability of 8.5%. This grass grows vigorously in substrates with free drainage, low organic matter on mobile and semi-stable dunes (Buell et al, 1995). Being highly adapted to sand accretion, it can withstand sand burial up to 1meter in depth. Ammophila's nutrient and productivity capabilities are superior to those of the Native American dune grass Leymus mollis, and evidence for the presence of nitrogen- fixing bacteria in the rhizosphere of these grasses and significant rates of nitrogen- fixation have been confirmed (Wahab and Waring, 1980). This nitrogen fixing capability allows this grass to thrive in coastal sand dunes that are low in nutrient content, giving it a competitive advantage over native dune vegetation thus creating large monospecific stands and changes in the sand dune morphology.

3 History of the Grass

European Beach Grass was introduced to the west coast of North America when it was first planted at Golden Gate Park in San Francisco in the late 1800's. It was imported to Humboldt County from San Francisco in 1901 to stabilize dunes adjacent to a timber mill in the town of Samoa (Buell et.al, 1995). The next earliest documented planting of Ammophila on the Pacific coast was around 1910 at Coos Bay, Oregon. Over time, this grass spread exponentially through the coastal fore-dunes of the Pacific North West, to San Luis Obispo and to British Columbia. According to Buell et al, this rapid spread was due to multiple introductions along the coast, the fore-dunes being optimal habitat, proximity to the ocean for rhizome fragments to wash ashore and the competitive edge of the grass over the native dune vegetation. European beach-grass invasion is known to transform coastal dune morphology from irregular and hummocky to continuous, densely vegetated and massive fore-dunes where none previously existed. Development of fore-dunes up to 10 meters in height along the Oregon coast has been associated with European beach-grass invasion.

4 **Removal methods**

Dunes depend on constant change and natural sand movement, while the presence of invasive plants disrupts this balance by inhibiting sand movement leading to the crowding out of important native plants. The invasion of European beach-grass has jeopardized several sensitive dune communities including the nesting grounds for the Western Snowy Plover. The Western Snowy Plover (*Charadrius alexandrines*) is a small shorebird federally listed as threatened under the Endangered Species Act (ESA), and whose survival depends on the health of these coastal sand dunes. By removing the invasive European beach-grass from these dunes, native plants are able to regenerate and increase in numbers and re-claim areas once invaded, which helps restore native biodiversity and will return native ecosystem process to the dune ecosystem.

Efforts for the disposal of *Ammophila* have required much research and experimental trials to develop an effective technique, when applied on a large scale these methods show variable success (Pickart and Sawyer, in press). The collection of known restoration techniques includes manual, mechanical, and chemical alternatives; however modifications and other methods are still being sought after. Below are some of the removal and disposal methods that have proven successful in the attempt to reduce and control the spread of *Ammophila*.

4.1 Manual Removal and Disposal

A successful restoration using hand removal methods took place at the Humboldt Nature Conservancy’s Lanphere and Ma-le’l Dunes area which consists of 444 acres of public land managed by the BLM and USFWS. Here, a combination of coastal dune, wetland, and estuarine ecosystems provide habitat for eleven different native plant communities, including the federally endangered Humboldt Bay wallflower (*Erysimum menziesii*) and Beach layia (*Layia carnosa*). This preserve has undergone restoration efforts at great expense by the California

Conservation Corp (CCC) to remove this non-native grass. Between 1992 and 1997, a ten acre plot of *Ammophila* was subjected to repeat manual digging with the help from the CCC (Miller 1994). Shovels where used to dig up the active rhizomes at a depth of about 8 inches, where the rhizomes were collected and piled for buring. Resprouts soon followed, and the crews returned to pull and dig the resprouts for a total of eight times the first season, and seven times during the second season. By the end of the third season, *Ammophila* had been pretty much eradicated with burning as the disposal method of choice. The Lanphere Dunes and other areas along the Ma-le'l Cooperative management plan have done a good job in protecting and maintaining these coastal dune systems to a pristine environment, thus setting the model for dune restoration.

4.2 Mechanical Removal and Disposal

The North Coast Redwood District took the initiative on an experimental pilot study at Little River State Beach (LRSB) where European beach-grass has steadily displaced native plant communities and contributed to the degradation of near shore dunes. During the 1960's these impacts were exacerbated by the construction of Highway 101. The restoration goals included the removal of non-native plant species and the rehabilitation of natural dune topography using heavy equipment and a combination of manual and chemical control. A further goal was the re-introduction of native plant species on the dunes for the breeding and sheltering of the western snowy plover. Eight treatment plots of about 1.5 acres each were treated four times consisting of three mechanical removal methods and one control (no treatment). The pilot study results indicated that mechanical grading was the most effective at reducing beach grass cover and resulted in the least amount of resprouting of invasive plants after treatment. Disposal methods consisted of using a D8 Dozer to bury the beach grass at depths up to 2 meters, pile burning and the use of green and black flaming, where green flaming caused wilting to the plant and black flaming would cause incineration.

4.3 Chemical Control and Disposal

The Santa Cruz County Department of Parks and Recreations (DPR) have demonstrated success using chemical, mechanical and manual techniques to control the spread of *Ammophila*. In their attempt to seek a cost effective management option, the Sunset State Beach, located in Watsonville CA, has relied on prescribed burning and glyphosate (Roundup and Rodeo) applications as their method of choice to control and to substantially reduce Ammophila. The DPR has conducted prescribed burning during the fall to allow native annuals to grow and set seed and later treat the resprouts with glyphosate several times throughout the season, one year after the burn. This integrated approach has proven effective to substantially reduce the per acre cost of European beachgrass to as low as $4,000/hectare (Hyland and Hollaran). The applications of herbicides have been widely accepted within this county,due to the leading role played by agriculture.The Sunset State Beach has been successful in controling *Ammphila,* because of their easy site access, in-house expertise with prescribed burns and herbicide use, and remnant native plant communities to facilitate regeneration of natives. Disposal Methods for the Sunset Beach consist of chemical applications (glyphosate), which cause plant death, followed by prescribed burning on site. Manually removed grass was subject to burn piles.

A wide range of treatments have been experimentally tested (Apteka 2000, Pickart and Sawyer 1998), but most large-scale efforts in California tend to rely on either repeated manual digging (Pickart and Sawyer 1998) or mechanical burial (Peterson 2004, Pickart and Sawyer 1998). Such methods remain costly on a per-hectare basis. Manual removal costs range from

$36,600/hectare to $69,000/hectare in Marin County (Peterson 2004) and up to $86,703/hectare in Humboldt County (Pickart and Sawyer 1998). Mechanical burial can be substantially cheaper, but not always. At one demonstration project, it cost $13,246/hectare (Peterson 2004) but another effort at the same site cost $38,769/ha (Jane Rodgers, pers. comm.).

5 Friends of the Dunes

Friends of the Dunes (FOD) are a non-profit involved in the conservation of coastal environments, ecosystem restoration and education programs since 1982. They manage the 113 acre coastal dune habitat on the Samoa Peninsula that has been impacted by the European Beach Grass. Their goal of conserving strategically located coastal properties through conservation that is consistent with the ecological values of native coastal dune systems is being compromised by the ongoing beach grass invasion on their dunes. Much time and effort is dedicated to clearing this grass with volunteer clean up days and help from the California Conservation Corp. Currently, European Beach grass is being composted and or burned at this site, but neither one of these methods have proven to be successful in the long run. The burning is limited to specified burn days, takes up valuable volunteer time and effort and does not generate any income. Also, this activity has led to complaints from the neighbors due to the smoke generated. The onsite composting of the harvested grass has been less than successful due to design issues with the composter and the lack of a trained operator to oversee the composting process.

7 Disposal Options

The most common disposal method is burning the beach grass biomass in large piles, but this leads to a large amount of smoke,soot and airborne ash. The next method is hauling the removed biomass off to a dump or large scale composting site, which can be costly and un-sustainable. Another use of this grass would be for structural support in earthen buildings like adobe structures or for insulation and farm animal bedding. The last and most progressive use of this grass would be to use it as a fuel for energy generation. The beach grass could be fuel for electricity generation through combustion in a biomass power plant or it could also be mixed in with bio-digester slurry to create methane or "natural gas" through anaerobic digestion.

The first option of burning the biomass is out of the picture because, friends of the dunes is located in the heart of Manila and Eureka is directly across the bay, so the management at friends of the dunes is worried about the disrupting the air quality for the residents of both of these communities. The next option is shipping their bio-waste over 20 miles to a local dump outside of Blue Lake, burning at least a gallon of fuel each way, for this biomass to just be trashed in a landfill. This is the basis of the problem because this is what Friends of the Dunes have been doing with all their waste in the past.

We talked to Humboldt Waste Management Authority in Eureka and they offered to bio-digest or compost this grass at a small charge for collection. This is problematic because Friends of the dunes have limited funds, being a nonprofit they do not want to pay for more trash collection. We talked to the University and they seem like the most practical potential users of this biomass because they will take it for free. There are earthen building projects going on at CCAT and the engineering department could use this grass for building earthen structures, insulating buildings or it could be thrown into the campus wide compost mix to keep good fiber levels for degradation. This is a great option but the school is not ready to take 4 acres worth of European beach grass. So what else can be done with this surplus of removed invasive beach grass?

The last and most intriguing idea to us was to find the imbedded energy of this grass, to see if it were comparable to other fuels currently being used for biomass power generation, and see if any power plants would be interested in collecting this grass for their own combustion.

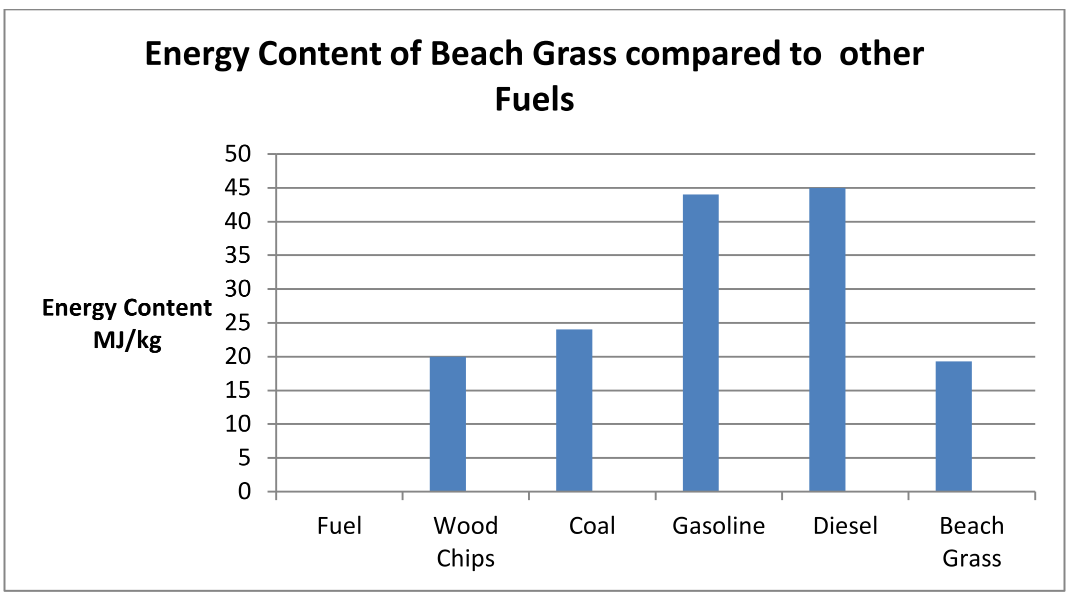
8 <u>Bomb Calorimeter</u>

In another class of mine we were lucky enough to find and calculate the energy content of the European beach grass through the use of a Bomb Calorimeter in the engineering lab. How does this Bomb Calorimeter work? We create a pellet with a known mass, then this mass was enclosed in a capsule, suspended in water, then the substance was combusted completely with oxygen, and we measure the change in water temperature to determine the amount of energy released. We used the change in temperature times a calibration constant to get (Q). After this I reweighed the mass of what was left in the capsule to find the change in mass (M) or the amount fuel consumed. Then we plugged it into the equation E=Q/M to find the energy content of the fuel (E). What we came to find is that the European Beach grass has an energy content of 19.27 MJ/ KG of beach grass. This is close in comparison to other more popular fuels currently being used for biomass power generation like wood chips with energy content of 20 MJ/Kg. Table 1 and Graph 1 below show a comparison of the energy content of various fuels compared to European Beach Grass.

Table 1. Energy Contents of Various Fuels including Beach Grass (MJ/kg)

Fuel	Energy Content (MJ/kg)
Wood Chips	20
Coal	24
Gasoline	44
Diesel	45
Beach Grass	19.3

Graph1. Energy Content of Beach Grass Compared to other Fuels



Once we knew that this beach grass had potential we had to figure out how much potential was available on site at Friends of the Dune. The first step toward quantifying the amount of embedded energy in European beach grass was to determine the range of the species and its average density. The density was found by our group conducting two transect studies.

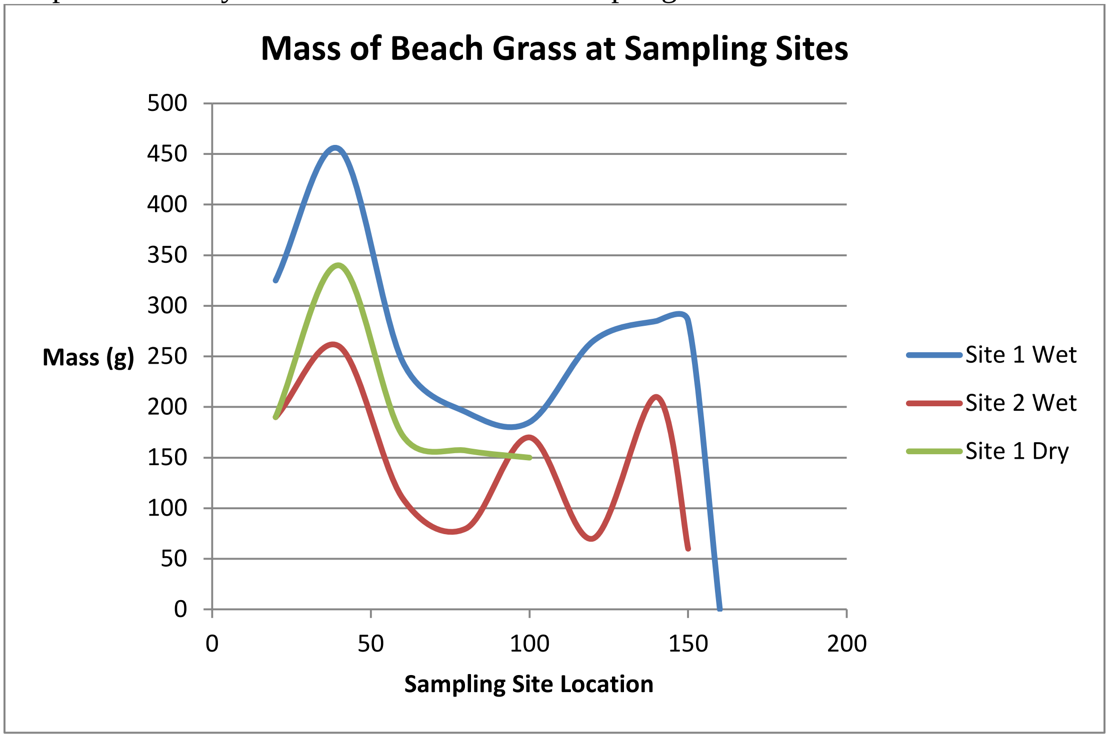
9 Transect Studies

What we did was stretch a transect tape from the beginning of the fore dune by the ocean to the end of the European Beach Grass vegetation line and this distance was measured to be 160 feet. This distance was marked off every 20 feet as a sampling location, the vegetation density was estimated visually and ranked (1-5) with 5 being the densest, then the vegetation was randomly inserted into the 12 inch diameter hoop, cut off at ground level and the biomass weighed in the field. The wet biomass was obtained by using a pre-weighed collection bag and subtracting this weight from the total bag and biomass weight. Table 2 and Graph 2 below shows the wet and dry biomass collected from two sampling sites at Friends of the Dunes.

Table 2. Beach Grass Wet/Dry Mass and Density Estimations for Each Site

		Site 1	Site 1	Site 2
Feet	Density Rating	Final Wet Mass (g)	Dry Mass (g)	Final Wet Mass (g)
20	3	325	190	190
40	5	455	340	260
60	4	245	172	110
80	4	195	157	80
100	3	185	215	170
120	2	265		70
140	2	285		210
150	1	285		60
160	0	0		0

Graph 2. Wet/Dry Mass of Beach Grass at Sampling Locations



We then calculated the density of Beach Grass biomass available at the dunes from our line transects study data as follows;

<u>Calculations</u>
Area of Sand Dunes impacted by beach grass = 4.15 Acres (43,560 Sq. feet)
Area of Transect Hoop= 115 sq. inches
Average of Wet Biomass in a hoop area = 212 grams

$$= [4.15 \text{ acres}] \times \left[\frac{43{,}560 \text{ sq.feet}}{1 \text{ Acre}}\right] \times \left[\frac{144 \text{ sq. inches}}{1 \text{ sq. ft}}\right] \times \left[\frac{1 \text{ hoop area}}{115 \text{ sq. inches}}\right] = 226{,}361 \text{ hoop}$$

$$= [226,\ 361 \text{ hoops on dune}] \times \left[\frac{212 \text{ g av. wet biomass}}{\text{Hoop}}\right] = 47{,}988{,}423.23 \text{ g wet mass}$$

$$= [226{,}361 \text{ hoops}] \times \left[\frac{215\text{g av. Dry biomass}}{\text{Hoop}}\right] = 48{,}667{,}615 \text{ g dry mass}$$

= 47,988 Kg of wet European Beach Grass on Dunes

After these transect studies were conducted we could make a rough estimation of the average wet mass per 12 in. diameter hoop or 115 sq. in. hoop , thus giving us a density(211.9 g) to quantify the total amount of energy content embedded in beach grass at Friends of the Dunes. The next piece of key information these transect studies supplied us with was the average ratio of dry mass per wet mass (.73g dry/g wet), because the biomass needs to be dry in order to be burned for electric generation, this is a more accurate number for the amount of beach grass that can be used for fuel. This was found by dividing the dry masses by the wet masses and averaging these numbers together for our drying ratio. Lastly we needed the energy content found earlier with the Bomb Calorimeter (19.27MJ/KG) and the acreage of the dunes that is currently infested with European beach grass; this was given to us by Emily Walters of Friends of the Dunes.

10 Amount of Energy On Site/Analysis

(Avg. wet mass/π r^2)(Avg. dry mass/wet mass)(1KG/1000G)(19.27MJ/KG) x

(144Ft/Ft^2)(43560Ft^2/Acre)(4.15Acre beach grass/Friends of the dunes) =

Math:

(211.9g wet/113.1in^2)(.73g dry g/wet g)(1Kg dry/1000g dry)(19.27Mj/dry KG) x

(144 in^2/Ft^2)(43560Ft^2/Acre)(4.15Acres of beach grass/@Friends of the dunes) = 686.1Gj

686.1Gj@friends of the dunes

We determined that there was 686.1GJ of embedded energy in beach grass currently at friends of the dunes. Six gigajoules is about the amount of potential chemical energy when combusting a barrel of oil. So the amount of energy held in beach grass is equal to roughly the chemical energy of combusting 114 barrels of oil.

It seemed like a fair amount of energy, so we took it the next step and got in contact with the Fairhaven biomass power plant manager to see if their company would be interested in consuming an invasive beach grass for power generation. But this specific power plant was only set up for consuming wood chips and bark products, because they recycled their ashy byproduct and distributed it locally as a fertilizer. This power plant manager gave us suggestions on other local power plants that could be interested in this waste product, and what types of power plants could burn this fuel. We passed all this knowledge along to Friends of the dunes and we can only hope that this information will influence them to further pursue this idea and that the bales will motivate collection efforts.

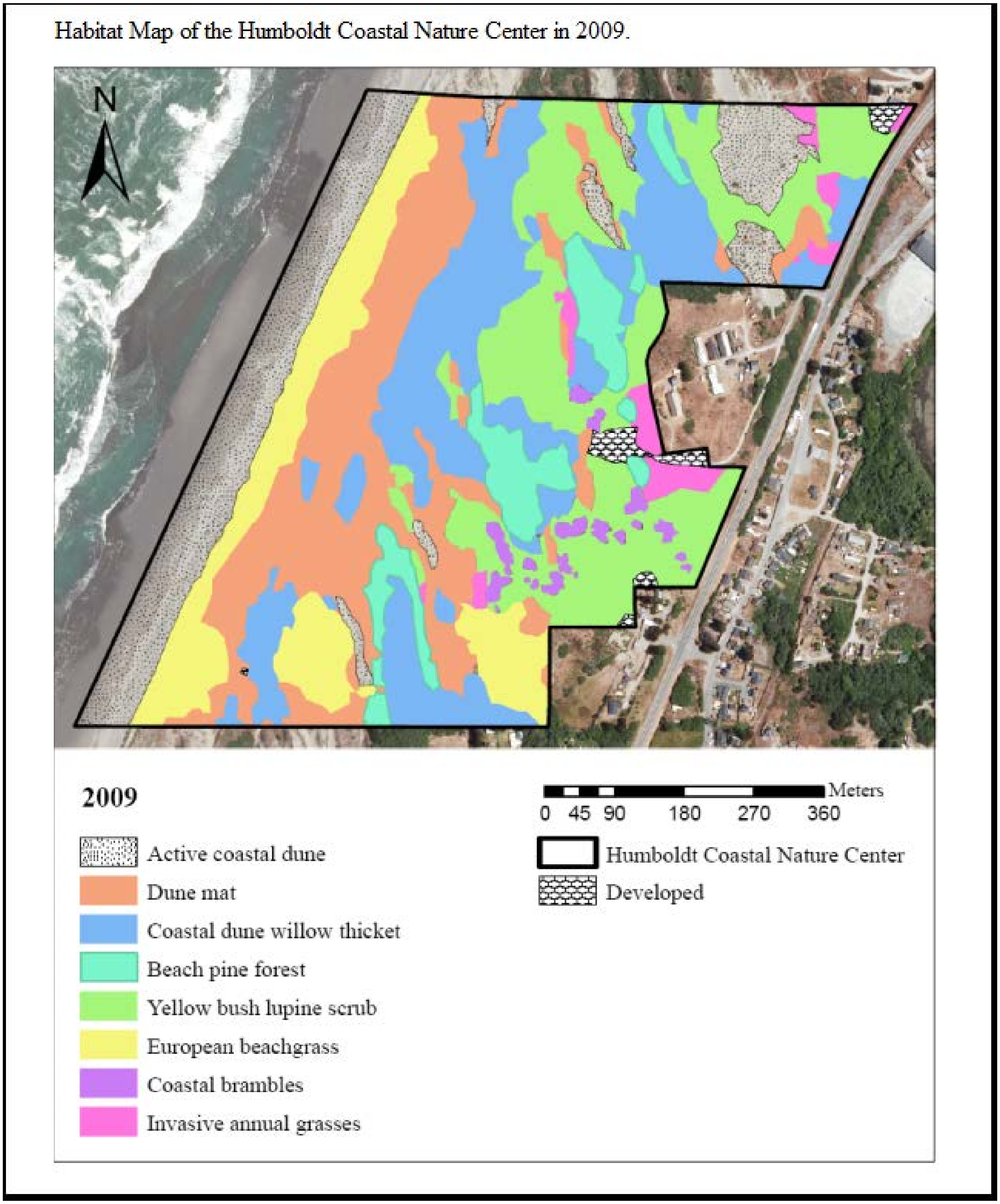
11 <u>Hay Bailer</u>

European beach grass is removed with hands and shovels at the Friends of the Dunes. Community volunteers and the CCC, participate in this labor intensive removal which has proven most effective since it requires the direct removal of the attached root system that grows deep in the sand. Because this grass is continually re-sprouting and will require 4-8 follow up treatments before it can be starved from its nutrients, *Ammophila* is usually piled up and left to dry before being burned and transported. One of our options for efficiently collecting and disposing of *Ammophila* includes a mechanical system otherwise known as a “Hay Baler”, this piece of farm equipment which made up of plywood and two by fours can be used to compress the grass into compact bales that can be easy to handle, transport, and store for other purposes. With the working hay bailer which we have modified and tweaked, *Ammophila* can be collected more efficiently and be converted into compressed rectangular bales, which can later be transported off-site where they can be used for other multi-use functions such as green building, composting, fuel etc. For improvements and recommendations on the hay bailer, we suggested new tires be purchased allowing easier access to the foredune, where bales can be prepared on site and staked. Also, stronger rope will be needed to tie the compressed *Ammophila* bales. We believe that the hay baler will be an effective resource for compacting and transporting Ammophila, without running the risk of further propagation and seed germination, given proper management of disposal.

12 Conclusion and Recommendations

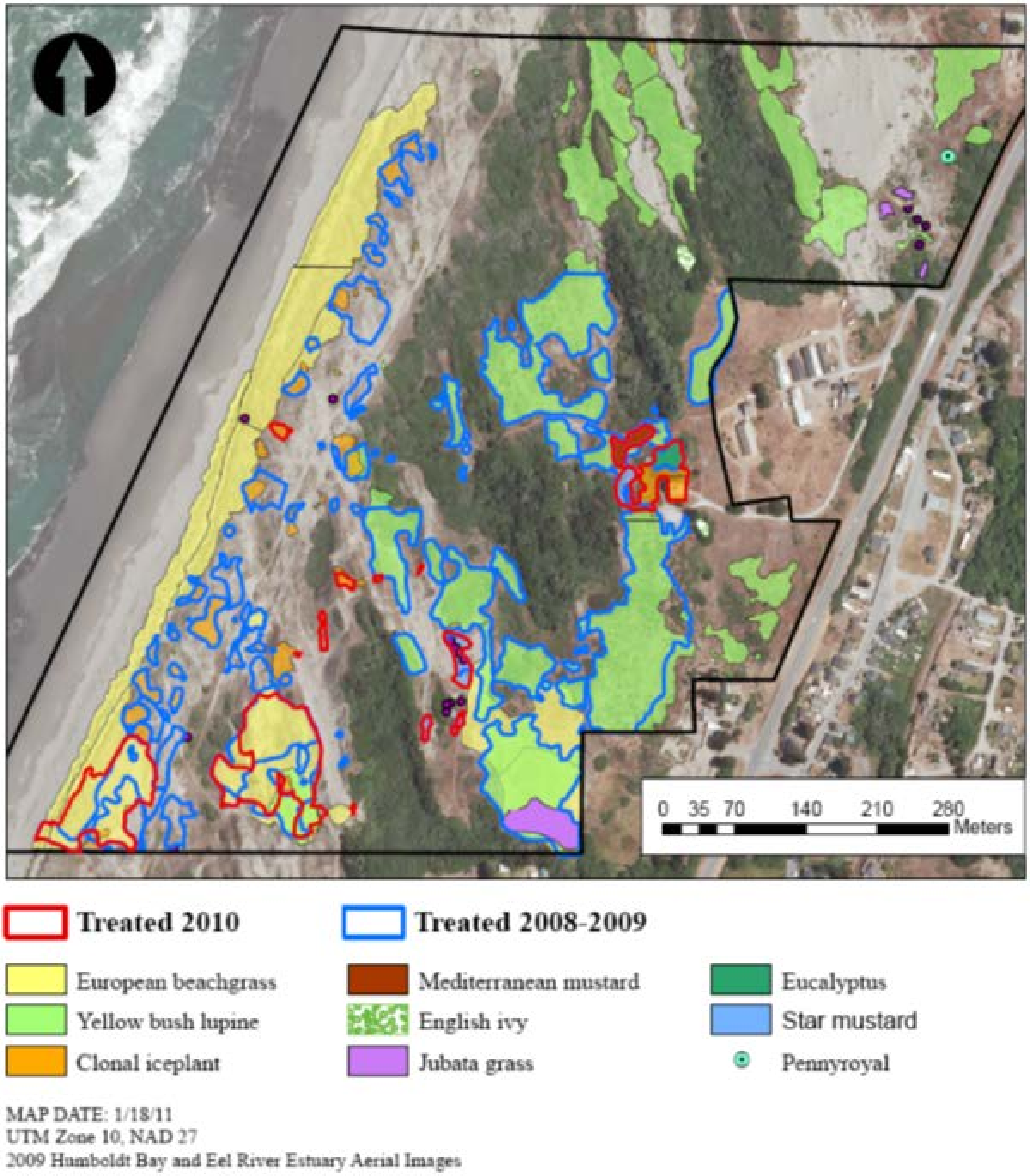
Our preferred method for sustainable disposal includes a handmade hay bailer which will compact the grass into hay bales, so the beach grass is easier to transport to the many uses and end points or graves we spoke about earlier. These uses include the generation of energy from burning the Beach Grass in bio-mass power plants, use of beach-grass bales in alternative earthen building structures and enhancing local composting. This will make a positive difference in the local coastal environment because they will display a sustainable way to recycle invasive species by filling the needs that exist in the local community. The grass should be treated to prevent further germination during transportation and we have decided on this disposal method based on feasibility, cost effectiveness for friends of the dunes, and sustainability for the environment. Our recommendations are for a dialogue with the Biomass Powerplant in Blue Lake to pursue the use of Beach grass as a biofuel, soliciting the assistance of Lonni Grafman at HSU and CCAT to explore the use of this grass as a building material and following up with the offer of the Humboldt Waste Management Authority to compost the grass. The almost 50,000 kg of beach grass available on the dunes translates to 686 GJ of energy that is just waiting to be exploited!

Friends of the Dunes



GIS map from Emily Walters at friends of the dunes

Figure 1. Treated areas at the Humboldt Coastal Nature Center in 2010



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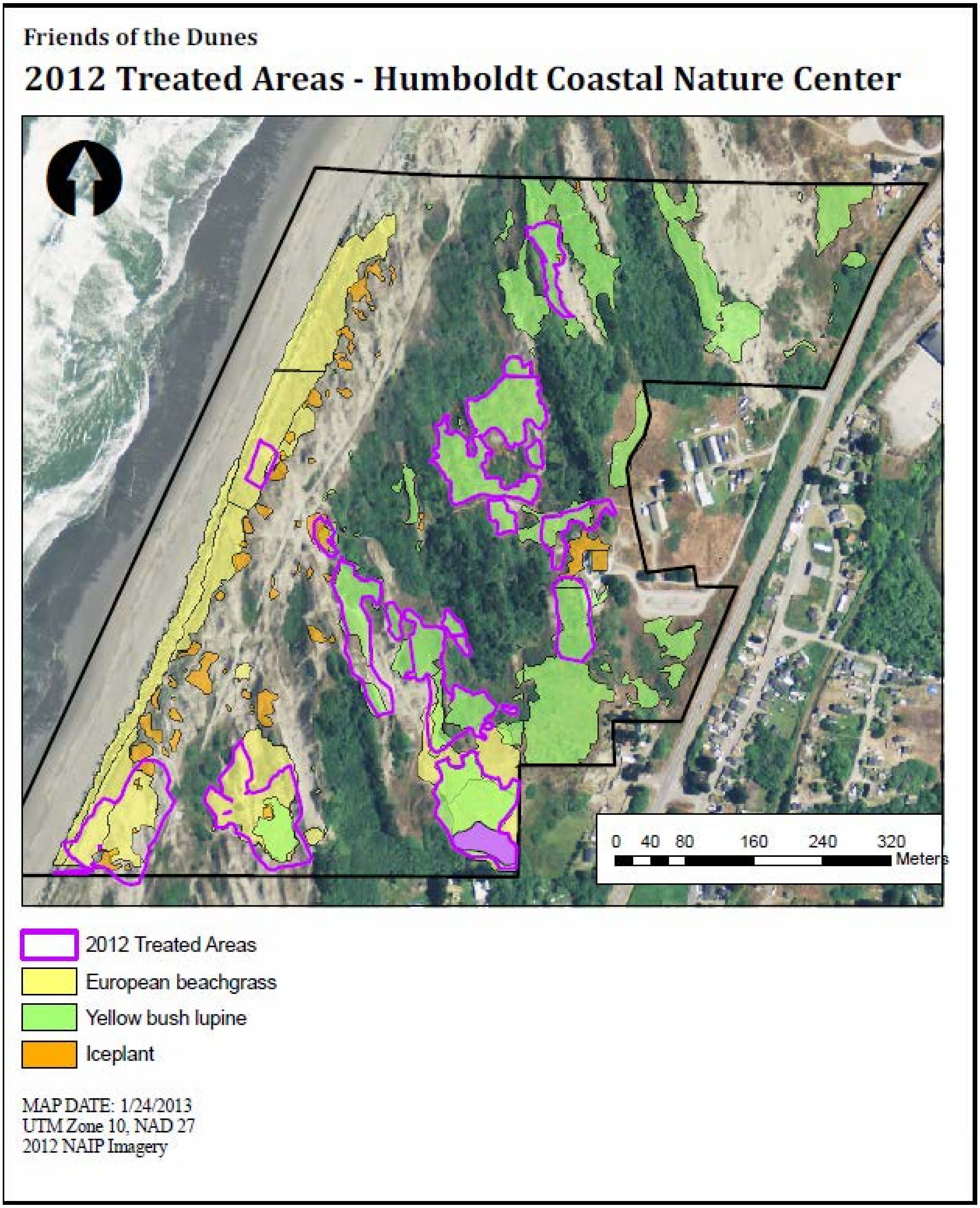

GIS from Emily Walters at Friends of the Dunes

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Redwood National and State Park is employing heavy equipment to root out about 15 acres of European beachgrass, an invasive plant, from the dunes of Gold Bluffs Beach in Prairie Creek Redwoods State Park.

The Nature Conservancy Lanphere-Christensen Dunes Preserve
Arcata, CA 95521

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This page is all about the baler that was built by HSU students last year.
http://documents.coastal.ca.gov/reports/2013/1/W8a-1-2013.pdf

http://essmextension.tamu.edu/pinestraw/baling.html Hand baler plans.

http://www.oregon.gov/OPRD/RULES/docs/BA-644-08_USFS_SiltcoosEstuaryFindings.pdf
European Beach grass disposal by scooping out the top layer of sand in Oregon.

Western Snowy Plover Tools and Resources for Recovery
http://www.westernsnowyplover.org/about_plovers.html

http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/arcata/malel_plan.Par.24848.File.tmp/Malel_Dunes_CMA_Access_Plan.pdf

Thesis from the Humboldt Coast Nature Center by Emily Walker

dspace.calstate.edu/bitstream/handle/2148/716/Emily_Walter_Thesis_FINAL.pdf?sequence=1