Mad River Beach Restoration

Yellow Bush Lupine (*Lupinus arboreus*) Removal and Planting of Native Dune Vegetation

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Problem Statement

The prevalence of the invasive non-native *Lupinus arboreus* (yellow bush lupine) leads to the loss of native dune vegetation species. *L. arboreus* furthers the loss of native dune species by altering the ecosystem and facilitating invasion by other non-native species.

Background

Lupinus arboreus (yellow bush lupine) is a shrub that grows up to 2 meters tall that reproduces by seed, and is pollinated by bumblebees (California Invasive Plant Council). *L. arboreus* usually has bright yellow flowers (can also be blue) that bloom from May to July, and its seed dispersal occurs in the late summer and fall (Cal-IPC). *L. arboreus* can survive up to seven years, but its seed bank can persist for up to 17 years (Pickart 2005).

L. arboreus was introduced to the north spit of Humboldt bay in the 1900's. It was planted with seeds from the Presidio in San Fransisco by the Army Corps of Engineers to stabilize the mobile sand dunes to prevent the railroad from being buried during the construction of the north jetty (Friends of the Dunes). *L. arboreus* is native to areas in southern and central California (Wozniak 2000). *L. arboreus* now dominates 28 percent of the total vegetation cover on Humboldt Bay dunes (Pickart and Sawyer 1998).

The Humboldt bay dune ecosystem extends 34 miles from Little River State Beach going south to Centerville beach. Sand dune environment make up 23% of California's coastal land and most of that has been compromised by development and invasive species (Department of the Interior Recovery Investments). The fragile coastal sand dune communities of the Humboldt Bay-Samoa region of Northern California is constantly drifting its contours. The dune ecosystem is adapted to environments of constantly shifting and well drained sterile sands.

In the coastal dune systems of Northern California *L. arboreus* has become an aggressive invader, and by altering soil chemistry it also facilitates the invasion of the area by other non-native species (Cipra 2006). *L. arboreus* is member of the legume family, Fabaceae. Like many members of the Fabaceae, *L. arboreus* alters soil chemistry by fixing atmospheric nitrogen into plant matter. The plant matter is then broken down by microbes to increase the available nitrogen content of the soil (Cipra 2006). Dune soils are usually quite sterile, and the native plant species have adapted to this. By fixing nitrogen *L. arboreus* allows other non-native

plants are able to tolerate these soils, and their invasion reduces the diversity and cover of native species.

L. arboreus affects the community composition by converting the native open due mat community to a community dominated by dense shrubs and grasses, which further modifies the microclimate by shading and stabilizing the dune soil. This can cause changes in soil moisture patterns, wind and natural sand movement (Cipra 2006).These effects in combination with the increased nutrient content due to nitrogen fixation allows not only for non-native species to colonize, but facilitates a change in the range of native species which are not common to dune ecosystems. For example, native coyote brush (*Baccharis pilularis*) has been steadily moving into dune ecosystems from upland areas since the invasion of lupine, and causes further stabilization of the dunes (HBNWR, 2009). In addition to loss of native plant biodiversity; *L. arboreus* decreases the native diversity of pollinators. Regions dominated by *L. arboreus* supports lower abundance and diversity of bees and wasps than native vegetation (Nyoka 2001).

Efforts to remove the *L. arboreus* and its negative effects on local ecosystems have been an ongoing process in Humboldt county with some success in localized areas around Humboldt Bay. Currently the most effective removal methods are manual and mechanical. Since the plants resprout readily form the base and roots, manual methods typically involve pulling the plants roots up, larger plants are either pulled out with a weed wrench or cut off at the base and the trunk split to prevent resprouting.

Mechanical methods involve ripping *L. arboreus* using a brush rake on heavy equipment then scraping the duff layer off using a plow. Mechanical methods have been an effective technique on large dense stands of *L. arboreus*, but is not appropriate where *L. arboreus* is sparse (Pickart California invasive plant council). Simply removing the plants however is rarely effective; because of the persistent seed bank of *L. arboreus* it takes about four years of management before the seed bank is depleted enough for native plants to become established and the ecosystem is able to sustain itself (Pickart 2005). Methods where *L. arboreus* was removed along with all other non native plants and the litter and duff were the most successful, (Wozniak 2000). The removal of the litter and duff layer disturbs the soil and stimulates the emergence of *L. arboreus* from the seedbank, so removal of *L. arboreus* seedlings must be maintained for at least three years for optimum success. However, the stimulation of the seedbank allows for exhaustion of the reserves of *L. arboreus* seeds faster than without disturbance of the soil. (Pickart 1998).

Cyclical die offs of *L. arboreus* have been observed in the Bodega Bay and Humboldt Bay populations may suggest biological control is present, however, this has not been tested in these regions. Biological control could have the potential to help reduce the seed bank in an experiment conducted in 1997 seed predation by the deer mouse *Peromyscus maniculatus* was found to aid in the exhaustion of seed bank. Granivory by the deer mouse was found to significantly control the seed bank of *L. arboreus* in its native region and this method of control has not been tested on the the populations invading Northern California (Wozniak 2000).

Our research shows that *L. arboreus* has a negative effect on native dune ecosystems by altering the soil chemistry and facilitating the invasion of other non-native species. Due to *L. arboreus*'s impacts on native species diversity and cover, our project aims to reduce these effects at Mad River Beach. This site is local to Northern California that is impacted by *L. arboreus,* but also features natives that could increase their coverage with *L. arboreus* removal. The project will utilize methods that research has shown to be effective in removing *L. arboreus.*

Site Description

The Mad River Beach Restoration project site is located adjacent to the north side of Mad River Beach parking lot in Arcata, Ca. The site is approximately 30 meters by 80 meters and is located in the dune hollows. The percent cover was estimated to be 15% native and 85% exotic. The exotic L. arboreus made up about 20% of the site cover. Plants in the plot include but are not limited to Common Teasel (*Dipsacus fullonum)*, yellow bush lupine (*Lupinus arboreus)*, sand verbena (*Abronia latifolia*), huckleberry (*vaccinium ovatum)*, seaside daisy *(Erigeron glaucus),* dune tansey (*Tanacetum camphoratum*), pacific silverweed (*Potentilla anserina ssp. pacifica)*, beach pea (*Lathyrus japonicus*), european beachgrass (*Ammophylla arnearia)*, beach knotweed (*Polygonum paronychia*), buckwheat (*Eriogonum latifolium*), and rattlesnake grass (*Briza maxima)*.

Aerial Map of Mad River Beach Project Site

Figure 1. Location of project site at the end of Mad River Rd. Northwest of Arcata, CA. Project boundary shown in red and the blue dot shows the location of our photo point at the top of the first large dune.

Goals and Objectives

Goals:

- To reduce the cover of non-native yellow bush lupine (*Lupinus aboreus*) in the area adjacent to the parking lot at Mad River Beach.
- To increase the diversity and cover of native species at the project site.
- Direct the trajectory of the site to a native dune ecosystem in function and structure.

Objectives:

- To remove all yellow bush lupine from the project site.
- To return native species cover to at least 50% at the project site.

Weighing Alternatives for *Lupinus arboreus* Removal

Efforts to remove the *L. arboreus* and its negative effects on local ecosystems have been an ongoing process in Humboldt county with some success in localized areas around Humboldt Bay. After reviewing all relevant removal methods, we decided that for our plot project at Mad River Beach the most effective restoration method is manual removal of L. arboreus combined with removal on non-native litter under removed lupines, and planting of native dune vegetation.

Alternatives that were not selected

Mechanical/ Heavy Machinery

Mechanical methods include manual removal using a variety of tools; hand tools and heavy machinery. However mechanical methods involving heavy machinery typically requires ripping out *L. arboreus* using a brush rake on heavy equipment then scraping the duff layer off using a plow. Mechanical methods utilizing heavy machinery have been an effective technique on large dense stands of *L. arboreus*, but is not appropriate where *L. arboreus* is sparse (Pickart California invasive plant council). Our site has only approximately 20% lupine cover, so mechanical removal is unnecessary. In addition, the impacts of heavy machinery on the sand dune ecosystem contributes to its lack of eligibility as a feasible effort.

Chemical

According to CAL-IPC application of herbicides to treat *L. arboreus* has not been investigated. Attempting to eradicate *L. arboreus* by chemical application without any previous research on the method would not be efficient. The qualifications necessary to apply herbicide is not within the scope of our project. Additionally, the possibility of herbicides getting onto and damaging the other plants surrounding the invasive plant is not an acceptable risk.

Biological Control

Using biological agents as a method of controlling *L. arboreus* have not been approved by the USDA. Cyclical die offs of *L. arboreus* have been observed in the Bodega Bay and Humboldt Bay populations may suggest biological control is present, however, this has not been tested in these regions. These population fluctuations in *L. arboreus* has been linked to herbivory by the subterranean ghost moth *(Hepialus californicus)*. Cyclical die-offs have not been observed in Humboldt bay. Biological control could have the potential to help reduce the

seed bank in an experiment conducted in 1997 seed predation by the deer mouse *Peromyscus maniculatus* was found to aid in the exhaustion of seed bank. Granivory by the deer mouse was found to significantly control the seed bank of *L. arboreus* in its native region but this method of control has not been tested on the the populations invading Northern California (Wozniak 2000). Using the deer mouse in Humboldt County for yellow-bush lupine removal is infeasible because it is not native. Introducing another non-native species to reduce *L. arboreus* is impractical without extensive research because of the potential to further disrupt the natural biological system of the dunes.

Community Volunteers

By having community volunteers assist in our restoration efforts would be effective and help spread awareness of this problem, it is not necessary due to the small size of our plot. The plot is approximately 1658 square meters, and can be treated within a few work days by the four restorationists in the group.

Selected Strategies

Removing Lupine and planting natives

Simply removing the plants is rarely effective; because of the persistent seed bank of *L. arboreus* it takes about four years of management before the seed bank is depleted enough for native plants to become established and the ecosystem is able to sustain itself (Pickart 2005). Allowing time for natives establish naturally would leave the site open longer and may increase the risk of reinvasion by *L. arboreus.* Planting natives will improve the effectiveness of the restoration project on increasing native cover.

Removing Lupine and non-native brush and litter

Methods where *L. arboreus* was removed along with all other non native plants and the litter and duff were the most successful (Wozniak 2000). Removal of the litter and duff layer disturbs the soil and stimulates the emergence of *L. arboreus* from the seedbank, so removal of *L. arboreus* seedlings must be maintained for at least three years for optimum success. However, the stimulation of the seedbank allows for exhaustion of the reserves of *L. arboreus* seeds faster than without disturbance of the soil. (Pickart 1998).

Manual Removal

Currently the most effective removal methods are manual and mechanical.

Since the plants resprout readily form the base and roots, manual methods typically involve pulling the plants roots up, larger plants are either pulled out with a weed wrench or cut off at the base and the trunk split to prevent re-sprouting. The benefit of manual removal especially compared to chemical removal is that it only affects the lupine plant. The native plants growing around the invasive plant will be unharmed, and will be given more space to grow. Additionally, by taking out the root system of yellow bush lupine, we will be able to take out the Nitrogen-fixing nodules. By removing the root system of yellow bush lupine, we are restoring the original chemical composition of the dune ecosystem to encourage native species to grow.

Implementation Methods

Prior to restoration the area of the entire site was measured and total yellow bush lupine (*Lupinus arboreus)* cover was estimated. The percent cover of native species was also estimated, to be compared to future cover estimates in the monitoring stage. Photos were taken of the site from a noted landmark (the top of a large dune). Photos were taken before and after the removal for comparison, as well as after planting of natives at various stages in the recovery process.

All non-native *Lupinus arboreus* were removed using manual methods. These methods included using a weed wrench to pull out woody plants and hand pulling for smaller plants. The majority of the above ground biomass was removed with loppers and pulaskis, to allow access to the trunk for removal with weed wrenches. For plants that were too large to be removed with the weed wrench, their above ground biomass was removed and the stump was split with a polaski. The remaining stump/deep taproot systems that we could not entirely remove was buried. Non-native grasses and shrubs growing in the microclimate under the *L. arboreus* were also removed, using hand pulling or rakes. All duff and nonnative plant material from under the removed lupines was raked up using a rake and trucked out to be disposed of offsite near Moonstone beach by the County of Humboldt.

The growing space cleared by the removal of *L. arboreus* and other non-natives will be planted with native species to enhance the diversity of the site, and to prevent reinvasion by *L. arboreus.* Seeds were collected from local dune habitat at Ma-el'l Dunes South, from dune species including dune tansy (*Tanacetum camphoratum*), seaside daisy *(Erigeron glaucus)*, buckwheat (*Eriogonum latifolium*), sand verbena *(Abronia latifolia)*, and were laid out to dry

before planting. In addition, large potted plants of beach knotweed (*Polygonum paronychia*) were donated by the California Native Plant Society, as well as bare-root pacific silverweed *(Potentilla anserina ssp. pacifica)* which will be planted in the areas where *L. arboreus* and other non-native species were removed. The planting date was at the start of the rainy season to eliminate need for artificial watering.

Project Schedule:

When	What	Who
9/10 to 10/3	Research Lupine characteristics and removal methods	All group members
9/15	Initiate contact with the County of Humboldt	Jenn
9/24	Meet with County official to discuss possibilities	All group members
9/26 to 10/7	Creating feasible goals and objectives	All group members
10/5	Contact Native Plant Society (CNPS) for plant donations-	Kellie
10/10	Create tools list for County	Jenn
10/10	Contact BLM for weed wrenches, pick up and return.	Kellie and Jenn
10/20 to 10/21	Manual pulling of all Lupine at the project site and removal of over invasives and brush under the invasive shrubs.	All group members
10/22	Native Seed Collection	All group Members
11/10 to 11/18	Planting of native dune species acquired from CNPS and collected seeds	All group members

11/26-12/6	Preparation of final report	All group members

Monitoring and Evaluation Plan

The objectives of the restoration project were to remove all yellow bush lupine (*Lupinus arboreus)* from the site and return the native plant composition to at least 50% or the total plant cover. Prior to restoration the area of the entire site was measured and total *L. arboreus* cover was estimated to be 20% of the total plant cover over the entire site. Native plant cover was about 15%. These values can be compared to future cover estimates during the monitoring process. Photos were taken of the site from a noted landmark (the top of a large dune). Photos were taken before and after the removal for comparison, as well as after planting of natives at various stages in the recovery process. These can be used to help visually evaluate the long term success of the project as plant communities change over time.

Post-project monitoring will take place annually for minimum of two years. The Humboldt State Natural Resource Club will implement the monitoring with approximately four members. At least one member of our group will accompany the NR Club for the first monitoring visit late in the spring 2013 semester to take additional photos, point out the site boundaries and begin monitoring. Monitoring will consist of checking the site to see if any new *L. arboreus* plants have sprouted and take necessary action to remove them. The methods of removal of any Lupine will be mechanical, with weed wrenches, and will rake the site post-removal to ensure limited seed-bank is left behind. The dates will be determined by the Natural Resource club but they will take into account not to remove the *L. arboreus* while the seed bank is being released to prevent further spreading. After project completion the native vegetation on site has been increased to 50% of the total plant cover. Ideally, we expect 50% native plants at the project site to be maintained with sufficient monitoring efforts. The project would be considered successful as long as native cover remains above the pre-restoration value of 15% of the total plant cover.

Implications and Conclusion

The removal of *L. arboreus* is an important but small step in the restoration of our native dune ecosystems. However, since L. arboreus has been present at the site for about 100 years,

local wildlife has become adapted to it's presence. It may have become an important habitat species for native wildlife, but we could find little research on its local habitat value. There is potential that our project may have removed habitat for birds that nest in shrubs, eat legume seeds, or pollinate *L. arboreus*, but we have assisted in the conversion of habitat for native birds, small mammals, and pollinators adapted to the regions native dune mat species. In addition, sufficient cover from other plant species still persists in the site, as the site is adjacent to a riparian/dune forest community.. These species include willows (*Salix spp.*), coyote brush (*Baccharis pilularis),* rushes *(Juncus spp.)* and sedges *(Carex spp.),* which may shift to providing habitat for some of the species that utilize *L. arboreus.* The choice for removing invasive species at a site depends on the objectives of the land manager. Our objectives, as well as those of the County of Humboldt who worked with us on this project, was to increase the cover and diversity of native dune mat species at the project site, so lupine removal was necessary. Without removal it likely would have become more prevalent at the site and would have caused further degradation of the native ecosystem. .

Further considerations for our project include that the effects of *L. arboreus* may exist for many years after removal of the existing shrubs. Due to the persistent seed bank *L. arboreus* will quickly attempt to reinvade the site, and seeds will continue to sprout for a number of years. In addition *L. arboreus* is only one of many invasive and nonnative plants that threaten local dune ecosystems. Ideally control of *L. arboreus* and dune restoration would involve ongoing management for at least four years however funding for most projects must be used in a shorter amount of time and volunteers are usually involved for only short periods of time. As seniors, all of us who organized this project will be graduating and may be moving out of the area, we will not be able to continue work on the project. We have arranged for the HSU Natural Resources Club to monitor our project and we are confident that our efforts although far from ideal, will improve the site. Other dune systems around Humboldt Bay have been successfully restored and we are hopeful that continued efforts will help control *L. arboreus* and improve the conditions of Humboldt's dune ecosystems.

References

Cipra, J. (2006). Experimental Assessment of a Gateway Invader: How Yellow Bush Lupine (Lupinus Arboreus) Facilitates the Loss of Native Dune Vegetation. http://humboldt-dspace.calstate.edu/bitstream/handle/2148/127/CIPRA%20THESIS.pdf?sequence=1

Friends of the Dunes. *Restoring the Dunes*. Nature and Science. http://www.friendsofthedunes.org/nature/restore.shtml

Wozniak, Jennifer. (2000). Reversing Invasion of *Lupinus arboreus*, (Yellow Bush Lupine) an Invasive Species of Northern California Sand Dune Communities. Restoration and Reclamation Review. Vol. 6 No. 3.
http://conservancy.umn.edu/bitstream/59733/1/6.3.Wozniak.pdf

Pickart, A.J. California Invasive Plant Council. *Invasive Plants of California's Wildland.* http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=60&surveynumber=182.php

Pickart, A. J., Theiss, K. C., Stauffer, H. B. and Olsen, G. T. (1998). Yellow Bush Lupine Invasion in Northern California Coastal Dunes II. Mechanical Restoration Techniques. Restoration Ecology, 6: 69–74. doi: 10.1046/j.1526-100x.1998.00619.x http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.1998.00619.x/pdf

Pickart, A.J. and J.O. Sawyer. (1998), Ecology and Restoration of Northern California Coastal Dunes. California Native Plant Society, Sacramento, California.

Pickart, A.J. (2005). Introduced Yellow Bush Lupin in Coastal Dunes of Northern California. http://www.cabi.org/cabdirect/FullTextPDF/2005/20053017221.pdf

Department of the Interior Recovery Investments. (2010). *Humboldt Bay Dunes Invasive Plant Eradication*. Arcata Fish and Wildlife Office. http://recovery.doi.gov/press/us-fish-and-wildlife-service/arcata-fish-and-wildlife-office/

Nyoka, S.E. (2001). The Effects of Exotic Plants on the Abundance and Diversity of Native Bees in the Local Dune Ecosystems. Report submitted to U.S. Fish and Wildlife Service, Arcata, Calfornia, USA

Humboldt Bay National Wildlife Refuge (HBNWR). (2009). Yellow Bush Lupine. U.S. Fish and Wildlife Service, Arcata, California, USA.

Appendix A:

Figure 1: Northern photo point before L. arboreus removal

Figure 2: Northern photo point after L. arboreus removal