Evaluating the seed bank of a disturbed site to determine potential ecological restoration strategies

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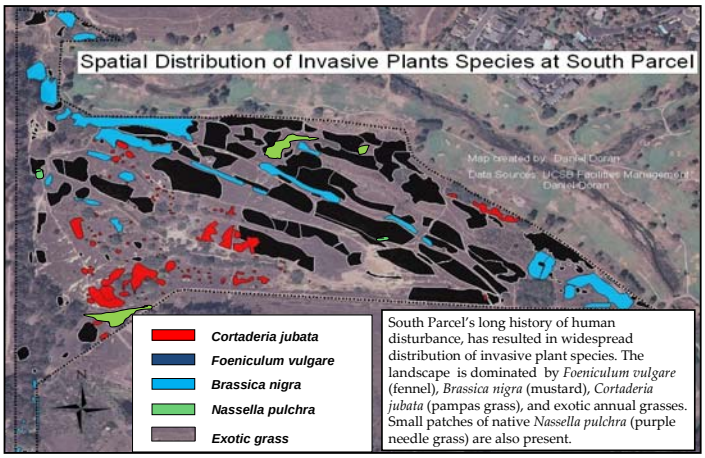
Introduction

South parcel is a 69 acre area that will receive University funding for restoration by the Cheadle Center for Biodiverstiy and Ecological Restoration (CCBER). Due to intense anthropogenic disturbances, the native plant communities have been greatly reduced and replaced by exotic species. Existing plant communities are dominated by mustard (*Brassica nigra*), fennel (*Foeniculum vulgare*), pampas grass (*Cortaderia jubata*), exotic grasses, or native purple needlegrass (*Nassella pulchra*). In addition to what is growing above ground, the soil is full of dormant seeds (seed bank) which play a role in community composition particularly early in a restoration project. Yet the composition of the seed bank at South Parcel is unknown. If the seed bank is dominated by exotic species, then restoration strategies must be devised to anticipate and reduce regeneration of these exotic species from the seed bank. Removing the top 3 inches of soil could reduce exotic seed abundance, thereby aiding efforts to restore native communities. By reducing the exotic seed bank, restoration efforts are more likely to be successful due to decreased competition between native and exotic species, increased resource availability, and increased establishment of native vegetation. In this study we evaluated the composition of the seed bank in areas of South Parcel dominated by different species including several exotics. We hypothesized that the plant communities would show differences in soil properties, the seed bank of most sites would be dominated by non-native species, and seed bank density would be reduced in deeper soil.



Methods

Two soil samples were collected in October 2008 from twelve locations within each of the five communities (from the surface to 3 inches and 3-6 in. depth). Samples were spread on plastic trays in a green house and watered daily to allow seed germination. Seedlings were monitored frequently, counted, and removed following identification from November 2008 to April 2009.

Eight additional soil samples were collected from each community and analyzed for conductivity, texture, pH, available nitrogen, phosphorus, potassium, total carbon, and total nitrogen. These tests of soil characteristics sought to determine if there were inherent abiotic differences in the soil which may be influencing community composition.


Brassica nigra seedling


Centaurium muehlenbergii seedlings

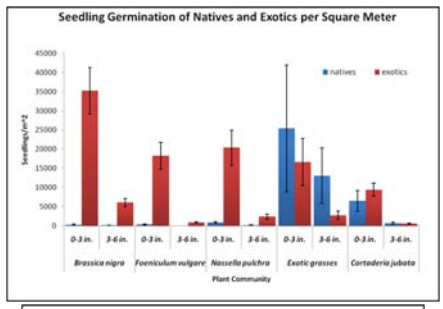

Setting up seed bank trays in the greenhouse.

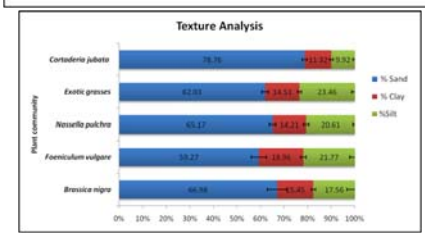
Results

❖ The seed bank is dominated by exotics. *Brassica nigra* is the dominant species in the *B. nigra* seed bank while exotic grasses dominate the seed bank in all other communities. The non-native seed bank is reduced in the samples taken at 3-6 inches compared to surface samples. This reduction is significant in *B. nigra*, *F. vulgare, N. pulchra*, and *C. jubata* communities (P<0.0001, 0.0001, 0.002, and 0.0001 respectively), and marginally significant in exotic grass (P<0.058). Natives are significantly reduced in only *N. pulchra* and *C. jubata* communities (P<0.009, 0.046 respectively). Native germination appears greatest in exotic grass sites due to high germination of a native annual wildflower, *Centaurium muehlenbergii* in two of the samples.

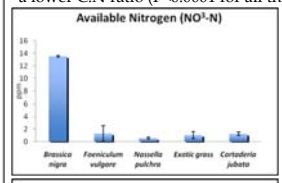
❖ Soil texture is similar across *Brassica nigra, F. vulgare, N. pulchra* and exotic grass sites. *Cortaderia jubata* sites has the greatest sand (P<0.0001) and lowest silt percentage (P<0.0001) than soil in other sites.

❖ There is no significant difference in soil conductivity or pH among the communities.

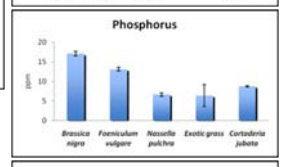




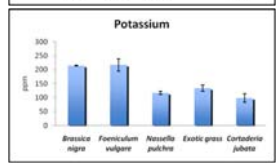
❖ Total carbon and nitrogen levels are similar among all sites except in *C. jubata* communities, which have significantly lower carbon and nitrogen levels as well as a lower C:N ratio (P<0.0001 for all three).



❖ *Brassica nigra* communities have the highest levels of available nitrogen (P<0.0001). There is no significant difference in available nitrogen among the other sites.



❖ Phosphorus levels are highest in *B. nigra* and *F. vulgare* communities. *Brassica nigra* soils have higher phosphorus levels than *N. pulchra*, exotic grass, and *C. jubata* (P<0.0001); while *F. vulgare* soils have marginally higher phosphorus than *N. pulchra* (P<0.060) but not exotic grass or *C. jubata.*



❖ *Brassica nigra* and *F. vulgare* have significantly higher levels of potassium than the other communities (P<0.0001). There is no significant difference in potassium among the other sites.

Discussion/ Recommendations

If exotic species seeds are dominant in the upper three inches of soil, then removal of that soil should aid restoration. Our results support this idea: we found that exotic seeds were concentrated in the surface soils. This finding may benefit restoration at South Parcel because restoration strategies that include topsoil removal may increase success of native plant establishment by reducing competition with exotics. While disturbance is often seen as a negative influence in restoration, negative impacts caused by removing topsoil at specific sites in South Parcel would be outweighed by benefits for reestablishing native communities.

❖ *Brassica nigra* sites had the highest nutrient levels, contained almost no natives, and showed a significant decrease in the exotic seed bank with topsoil removal. Thus, ***B. nigra* sites are ideal for utilizing soil removal in restoration allowing native species to establish in an environment with reduced competition from exotics**.

❖*Foeniculum vulgare* sites also contained few native individuals and the exotic seed bank was highly reduced with topsoil removal; thus, similar to the *B. nigra* sites, **restoration efforts in *F. vulgare* communities could benefit by incorporating topsoil removal to aid in the establishment of native species.**

❖The native annual wildflower *Centaurium muehlenbergii* was distributed in patches within the exotic grasslands, and found in high abundance in two of the samples. **Due to the variable and patchy nature of the exotic grass communities, they should be dealt with at a local scale, where some areas may benefit from topsoil removal and others may require hand pulling of exotics or other methods to avoid disturbing native individuals.**

❖The *C. jubata* sites had the lowest nutrient levels and sandiest soil, but also contained the greatest species diversity. The harsh abiotic conditions of the *C. jubata* sites allow for greater species diversity because poor growing conditions inhibit competition by one or two dominant competitors. **Therefore, soil removal would be less efficient in reducing exotics, and removal of *C. jubata* followed by planting of natives to restore a coastal dune, back-dune, or coastal sage scrub community would be more effective.**

❖Topsoil removal would not benefit the native *N. pulchra* communities because this perennial grass does not build up an extensive seed bank. Exotic species could be removed effectively by hand pulling to avoid disturbing *N. pulchra* individuals. Low germination of *N. pulchra* suggests that it is seed limited. *Nassella pulchra* communities had low nutrient levels, probably due to the perennial nature of *N. pulchra* contributing little biomass to the soil annually, and being able to efficiently use available nutrients. **Thus, transplanting *N. pluchra* individuals into South Parcel sites or seeding *N. pulchra* after removal of exotics in other habitats (e.g. *B. nigra* or *F. vulgare* sites) would be most effective in increasing *N. pulchra*.**


Cortaderia jubata


Foeniculum vulgare


Brassica nigra


Nassella pulchra


Bromus diandrus
(an exotic grass)

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