Powell River Project Report (2016 – 2017)

Choosing plant species for reclamation to better resist invasion from exotic, invasive plants

Jacob N. Barney and Morgan Franke
Department of Plant Pathology, Physiology, and Weed Science
Virginia Tech

Scope of Work

Introduction:

Post-mining landscapes are currently reclaimed using the Forestry Reclamation Approach (FRA) developed at Virginia Tech that seeks to achieve high hardwood tree canopy cover following establishment of "tree-compatible groundcover". FRA has been successful in advancing development of ecosystem structure (e.g., ground cover, species diversity, stem density). However, as Dr. Burger and colleagues pointed out in 2010, FRA results in more bare ground, which "allows more invasion by plant species from nearby areas." They point out this is often from adjacent native species from natural dispersal or by animals. However, the gaps left by FRA leave much of the ground open to invasion by exotic plants as well, that may have negative impacts to desirable vegetation and ecosystem function. Exotic invasive plants are known to have negative impacts to ecosystem structure and function in a wide range of systems. However, the effect of these exotic plants can be especially problematic on reclaimed mine sites due to the harsh growing environment.

One way in which reclamation practitioners and land managers can combat these unwanted and invasive plants is by being able to pick desired plant species that can more directly compete with the problem species. One selection criteria for identifying species that meet desirable criteria is using plant functional traits, which can be critical for being able to predict invasive species spread and impact (Drenovsky et al. 2012). Plant functional traits are measurements of how a plant interacts with its surrounding environment and other species (Diaz & Cabido 2010). There are numerous functional traits that could be quantified in plants, such as flower shape, fruit size, fiber content, etc. However, we are more concerned with how to better understand a plant's relative competitive and dispersal abilities, which are important for invasion, so we will focus on functional traits that directly relate to competition and dispersal, such as height, biomass, specific leaf area, and seed mass (Wright et al. 2006).

Not only can plant functional traits help with predicting an invasive species' spread, but they can also help with identifying the most effective planting strategies to promote native species and better resist invasion of undesired, exotic plants during reclamation. Invasive species could attribute much of their success to having significantly different functional traits than native species (MacArthur and Levins 1967). Recent evidence suggests that invasive plants most strongly compete functionally similar natives (Case et al. 2016). With more knowledge of the functional traits of plant species on reclaimed sites, whether planted or colonized, managers could ideally be able to establish and manage for plant species that have functional traits that resist unwanted species. Knowledge of functional traits at these sites can also help managers choose desirable non-native species that could inhibit a particularly bad invasive species when there isn't a native species available with the necessary functional traits to combat it available (Drenovsky et al. 2012). For example, if common unplanted exotic species exhibit high specific leaf area (SLA) and uncommon planted native species have low SLA, then future desired planted species could be selected to have high SLA to better resist invasion.

The FRA has done much to improve the success of native hardwood species on reclaimed mine sites in Appalachia over the past few years. However, due to the pressure from exotic, unwanted species continue to invade these areas, and in some cases impede reclamation success. We can improve our selection of desirable species used in the tree-compatible mix through a better understanding of plant functional traits. By quantifying the functional traits of both planted and unplanted species on these sites, and identifying whether these correlate with commonness (i.e. ground cover), we can better choose plant species that will facilitate reclamation goals while better resisting invasion by unwanted invasive species. Additional opportunity for native recolonization, and by extension further invasion depending on the composition, exists in the resident seed bank if the invasive species are removed. Few studies have related the composition of the seed bank to the standing community, and compared their functional trait composition. Understanding the seed bank potential may allow for more passive reclamation by managing invasive species and selecting for natural recruitment of desirable natives in the seed bank. We will make these functional traits comparison of native and invasive plants in the standing community and seed bank in two sites of different age.

Objectives:

1) Quantify common functional traits related to competitiveness and seed dispersal in planted/desired species and unplanted/unwanted species

2) Quantify ground cover of each species to identify cover-functional trait relationships

3) Identify plants in the soil seed bank to see how plant communities at different stages after reclamation directly influence propagule pressure and future native species success

Methods and Progress:

We originally planned to conduct the same survey in two different aged stands that were 6 and 12 years old to compare how functional traits affect plant community development. The 6 yr old plot was usable and was surveyed in the Fall of 2016. However, the 12 yr old stand was so dense with trees and woody vegetation that we could not use this site. Both the planted and volunteer vegetation was much larger than anticipated, precluding making appropriate surveys of the understory vegetation that was surveyed in the younger stand. Thus, we were left to survey only the younger site. Though this site lacked planted woody vegetation. We were unable to get confirmation on site of any additional available sites that may fit our criteria. Thus, we had to modify the objectives of what we could assess given the limitations of available field sites.

Considering the above limitations, we modified our sampling protocol slightly. Within the 6-year-old site we conducted 20 1m^2 vegetation surveys using a stratified random sampling protocol. Within each plot we identified every species present and recorded the percentage ground cover. For each species identified, we harvested up to 20 individuals, no more than 1 per plot, and brought them back to the lab. From each plant, we recorded height and basal diameter, and then removed 3-5 fully mature leaves, recorded their leaf area using a Li-Cor 3100C lead area meter, and then dried in a oven for 3 days to obtain dry biomass.

We also collected soil samples from each plot of roughly 10x10x1 cm. We removed all stones and collected only loose material. Soil samples were collected to evaluate the richness and diversity of the seedbank, as well as to identify how closely the seedbank composition mimics the aboveground community. Due to time and personnel constraints, we have yet to grow these samples out in the greenhouse. We have them stored, and hope to grow them out, and identify the all emerged plants. Once this is done, we will make correlations of standing aboveground cover and relative density of seedlings. This will shed light on which species are driving plant community composition.

<u>Results</u>:

Plant community richness varied little across the reclaimed site. We recorded 5-7 species in all 1m^2 plots, with 15 unique species recorded.

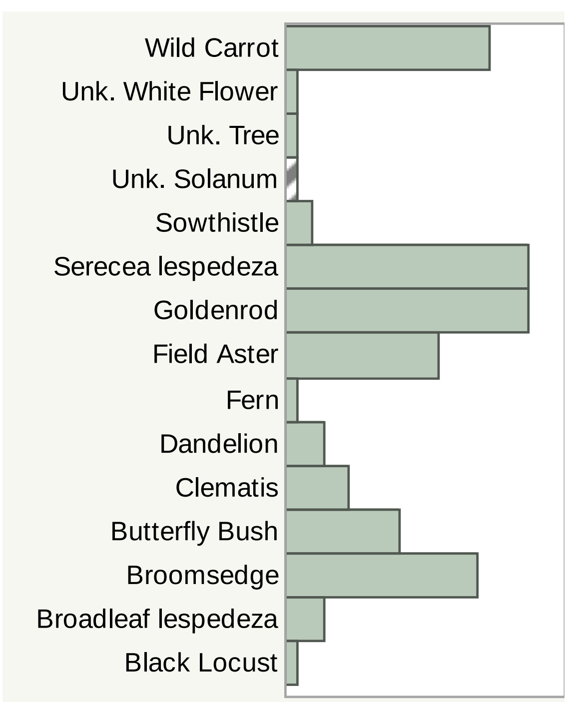

Figure 1. Frequency distribution of recorded plant species.

The species found the most frequently in the surveyed plots were primarily the exotics wild carrot, sericea lespedeza, and butterfly bush, and the natives goldenrod, field aster, and broomsedge.

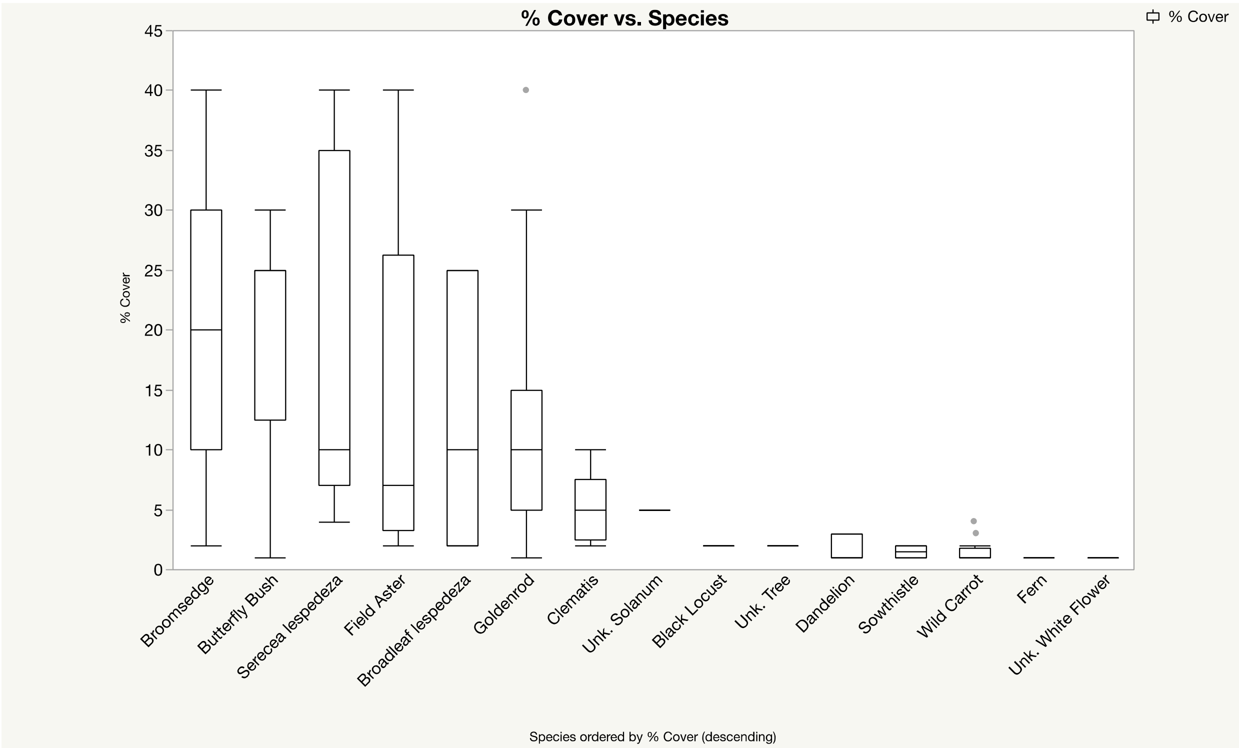

Figure 2. Percent ground cover of all plants identified.

Despite the relatively high plant richness, the majority of the ground cover was composed of six species. The original planting mix was not available to us, but broomsedge and lespedeza are common throughout the Powell River Project. Many of the uncommon species in our plots were unlikely to have been planted, but rather have colonized on their own. Importantly, many of the uncommon species are low growing species, while the common plants are all much taller, and shade the soil.

Is plant abundance related to plant functional traits?

One of our primary interest were whether plant functional traits are related to plant abundance. There is a growing body of literature regarding using knowledge of plant functional traits in restoration and invasive plant mitigation – making communities more resistant to invasion. We collected several plant functional traits for all species identified in our survey, and related those to abundance, in this case ground cover.

We ran linear regressions for plant height, basal diameter, aboveground biomass, and specific leaf area (leaf area per unit leaf mass) against groundcover (Figure 3). In all cases, the functional traits were strong predictors of abundance ($p<0.05$)

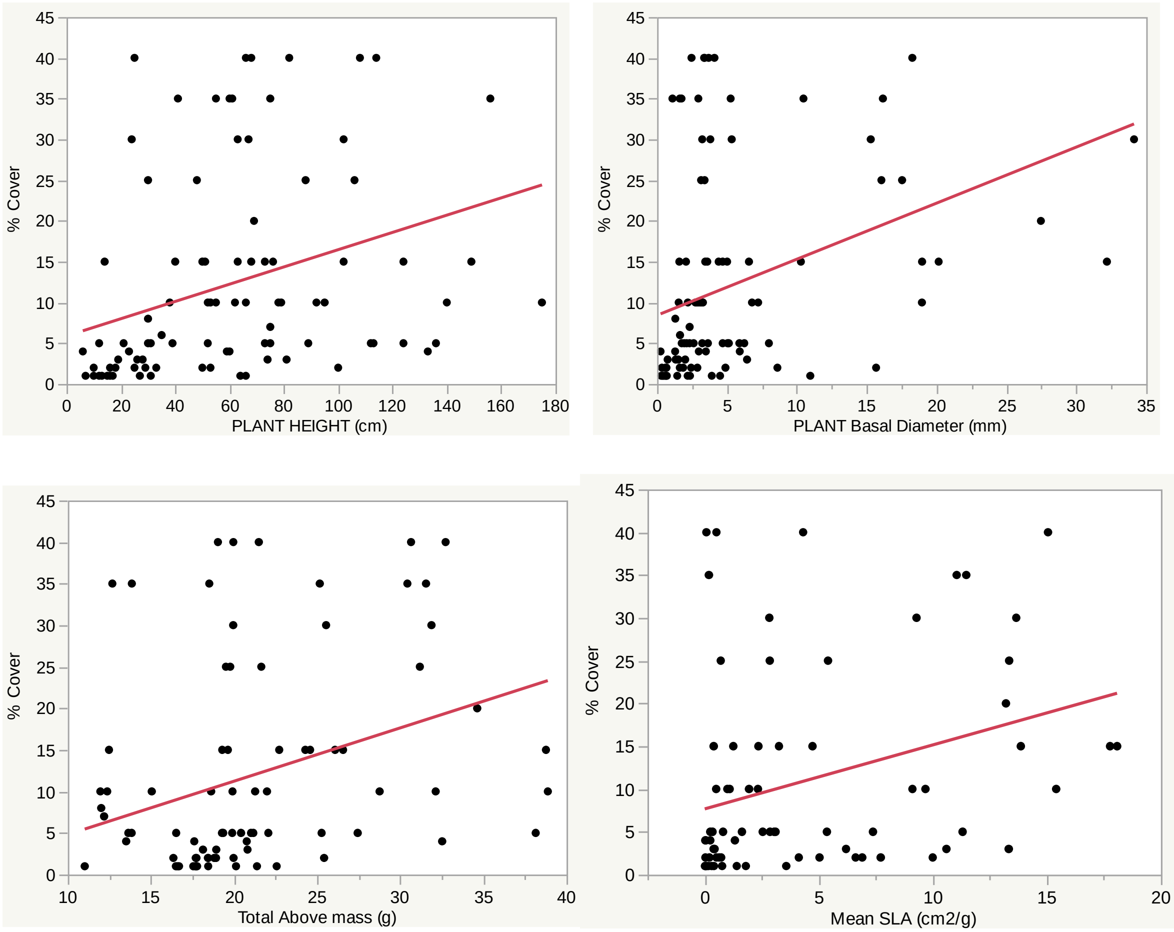

Figure 3. Correlations of the plant functional traits height, basal diameter, aboveground biomass, and specific lead area with abundance (percent ground cover).

This data suggests that plants that are tall, wide, high biomass producing species are also the most dominant. This is somewhat unsurprising, but confirms that these traits can be used in a predictive manner. More importantly, specific leaf area (SLA) was also strongly predictive of abundance. Plants that produced more leaf area per unit biomass, higher SLA, were more common.

SLA is being increasingly recognized as an important plant functional traits that integrates well over other plant performance metrics. SLA is a measure of resource allocation that translates to biomass and reproduction, and in our case abundance.

To further explore the relationship among the plant functional traits, I ran a principal component analysis to identify correlations among the variables (Figure 4). As expected, plant height, basal diameter, and aboveground biomass were strongly correlated with each other. However, SLA is orthogonal to the other functional traits, suggesting it captures variance the other variables do not.

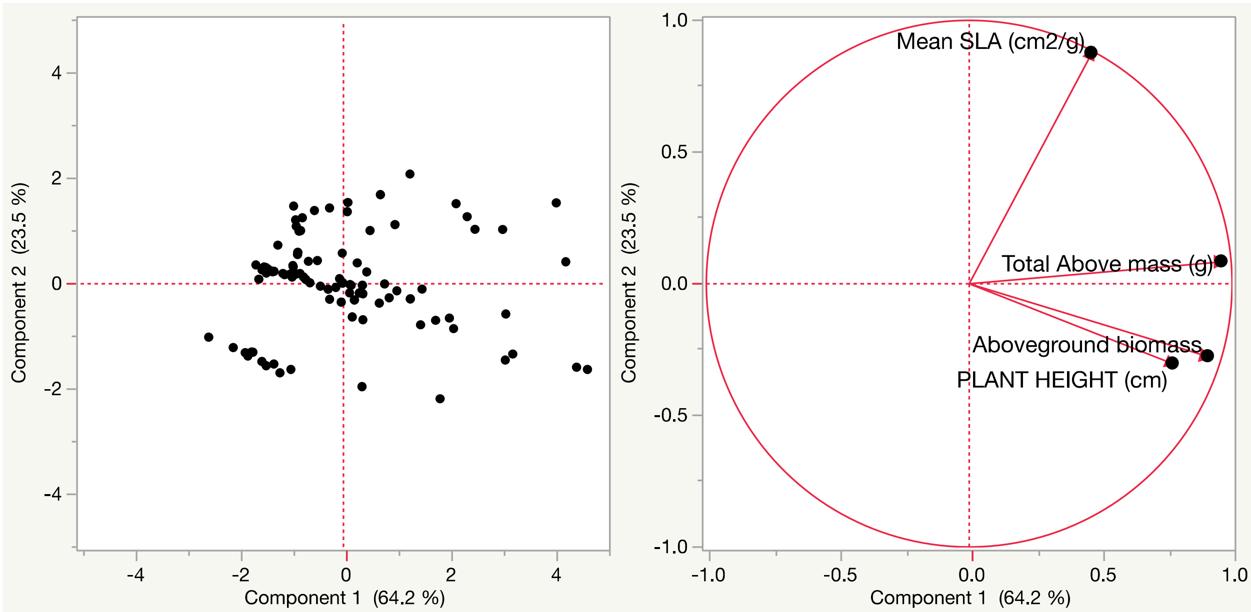

Figure 4. Principal component analysis of plant functional traits.

Plant nativity was not a predictor of plant abundance. This suggests that plant functional traits are stronger predictors of abundance than nativity.

Implications for reclamation

While our study was limited to a single reclamation site, our results suggest that plant functional traits can be used predictively. Easily recorded traits like plant height are strongly predictive of plant abundance. Of course, many of these traits are plastic, they can change depending on their growing environment, and thus should be used with caution.

Though species richness varied little in this 6 year old reclaimed site, the plant community composition did vary within the site. There remained a mix of native and exotic species, many of which appear to have colonized from elsewhere. An interesting next step would be to introduce invasive species such as autumn olive to plots with varying species richness and plant functional traits to see how this relates to invasion resistance. Additionally, taking a functional trait perspective may improve native hardwood establishment, but this also needs to be tested.