Decomposition rates and impacts on biodiversity of living *Phragmites australis* and litter in two sites along Sturgeon Bay, Michigan

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ABSTRACT

The purpose of this study was to examine the effects of *Phragmites australis (P. australis)* on native flora along Sturgeon Bay in Northern lower Michigan. We examined plant species composition amongst both native patches of species (without *P. australis*) and patches where *P. australis* was present. Using the Shannon-Weiner index, we found *P. australis* to have no direct effect on biodiversity on shoreline species. We also quantified decay rates of both *P. australis* litter and native litter in order to relate *P. australis* presence to soil characteristics. *P. australis* lost an average 3.57% of its mass due to decomposition, and native litter lost an average of 7.31% of mass due to decomposition, indicating that native litter decomposes more rapidly than *P. australis* litter. This suggests *P. australis* litter could have a greater impact on the plant community than native litter, as it decomposes significantly more slowly. We also examined soil moisture and organic matter content in the native and *P. australis* patches. The moisture to mass proportion present in the soil for “*P. australis* patch1” was 0.243, “*P. australis* patch2” was 0.036, “native patch1” was 0.28 and “native patch2” was 0.154. This data suggests that soil where *P. australis* is present is less capable of retaining moisture than native patches of dune flora. Data for organic matter content did not show a significant difference between native and *P. australis* patches but instead a greater variation between the two native patches alone. By cross-examining our three studies, we can conclude that *P. australis* will not change the species composition and diversity. However, it has an effect on soil moisture, organic content, and decomposition rates on Great Lakes shore communities.

INTRODUCTION

Invasive species are a growing problem worldwide and have numerous negative impacts on native biodiversity. For instance, invasives may compete directly with native species for resources, out-compete them, expose them to disease, or change ecosystem functions (Antonio & Meyerson, 2002). It is theorized that because of invasive species’ adaptability, aggressiveness, and high reproductive capacity, they are able to thrive and spread at remarkable rates (Ricciardi et al. 2000). *Phragmites australis* (reed canary grass), was introduced into North America in the late 1700’s or early 1800’s, and the dispersal and abundance of this invasive has increased considerably over the past 150 years. Today, it exists throughout the United States and southern Canada and often serves as an indicator of wetland disturbance (Saltonstall 2002). Species/communities of *Typha* spp., marsh meadow, and sedge/grass hummock are frequently out-competed by *P. australis.* (Wilcox 2003). In addition, *P. australis* disrupts ecosystem functioning by altering the food web and/or physical environment (Ricciardi et al. 2000). Changes in the physical habitat may then reduce numbers of insects, birds, and other organisms in the surrounding area, as well as indirectly increase local CO_2 emission levels, creating another CO_2 source and additional concern about the progression of Global Warming (Chambers et al. 1999, Kuehn et al. 2004).

Several characteristics contribute to the relative success of *P. australis* in Great Lakes coastal areas, including the plant's ability to change the "hydrological regime" in the area it inhabits (Saltonstall 2002). A part of this ability stems from the accumulation of concentrated litter. Organic matter accumulates readily because of high shoot fiber content, tough, woody outer support tissues, and a waxy cuticle (Armstrong et al. 1996b). In a comparison study of older and younger *P. australis* conducted by Rooth (2003), amounts of litter across *P. australis* invaded areas was found to be twice as large in regions containing the older, 20-yr-old invasive. With few native insects feeding on *P. australis,* or its litter, accumulation of *Phragmites australis* detritus is additionally heightened (Tewksbury et al. 2001). Our experiment further looks at environmental changes caused by litter buildup. In addition, asexual reproduction and the transfer of nutrients to each plant along rhizome conduits add to its success as an invasive organism (Saltonstall 2002, Amsberry et al. 2000).

Past literature suggests that when *P. australis* is present, noticeable and measurable differences will occur in the environment. We attempted to answer the following three questions on the impacts of *P. australis* on native plant composition and density in two patches found at our study site. First, does the presence of *P. australis* alter the proportion of the native flora along Sturgeon Bay? We believed that a reduction in species diversity would occur in the presence of *P. australis*. Secondly, does litter of *P. australis* decompose at a different rate than the litter of native plant species? We expected *P. australis* litter to decompose at a slower rate than native litter for reasons previously mentioned. Lastly, does the presence of *P. australis* alter the percentage of organic material present in the soil and soil moisture content? Assuming *P. australis* litter decomposes at a slower rate than native litter, then both organic material present and soil moisture should decrease. This is because the aboveground accumulation of *P. australis* detritus would require more time to degrade, therefore entering the soil and replenishing stores of organic material less frequently. Because organic material does a better job at trapping moisture, smaller amounts of it in the soil may also result in lowered soil moisture content.

METHODS

Our study site is located on Sturgeon Bay along the shores of Lake Michigan, North of Cross Village, Michigan, where sand-building dynamics dominate the landscape. The beach is controlled by shifting sand and dune formation. At the site, we sampled two patches (18.4m x 19.4m and 27.7m x 15.3m, respectively) of *P. australis* along the shore of Lake Michigan and called these patches “*P. australis*1” and “*P. australis*2”. We then sampled two equally sized native patches (undisturbed by *P. australis*) adjacent to the *P. australis* patches at an equal distance from the water in an attempt to maintain approximately equal soil and plant moisture conditions. We called these patches “Native1” and “Native2”. In both *P. australis* plots and native plots, we laid a transect tape, measuring 16m, across the densest portion. At increments of 2m, we laid our quadrat (measuring ½ m x ½ m) with the bottom right corner at the measuring point. Using visual aerial analysis, we measured species richness and relative species abundance (percent cover per quadrat). To take into account future growth, because the study was done in early spring, the stalks of larger species were estimated to represent five percent of cover while nearly full-grown plants were estimated using their current size.

Assuming the quadrats represent a random sample of all four patches, we then calculated the average frequency of individual species in each patch. We also graphed the Shannon-Weiner index to determine the difference in biodiversity amongst sites. By comparing the species frequencies of the native patches to the invasive patches, we were able to determine the average percent change of species composition due to growth of the invasive *P. australis*.

In order to study the decomposition rates of *P. australis* litter when compared to native litter, we collected random samples of litter found on the ground from "*P. australis1*" and "Native1" patches. The plant litter was dried at 60 degrees Celsius for 24 hours and put into leaf packs made of mesh with 4mm-wide hexagon-shaped holes. Each individual pack was weighed, tagged for identification, and then submerged in pairs (one "*P*. australis" bag and one "Native" bag) for 11 days in a naturally occurring pool of water, located roughly 30.5m from the shoreline and near the first site. We chose this area to ensure that each leaf pack was exposed to the same environmental conditions, and we submerged the bags in pairs to account for any varying conditions within different regions of the pool. After 11 days, the samples were re-collected, dried for 24 hours, and weighed to determine the amount of matter lost. We ran an Independent Samples T-test using an alpha value of 0.05.

In order to study the percentage of organic matter present in the soil and moisture content of our specific patches, we collected soil cores 5cm deep from within each quadrat. The soil was weighed, dried at 60 degrees Celsius for 24 hours, and then weighed again to measure moisture content. We ran an Independent Samples T-test using an alpha value of 0.05. After this, the soil was burned at 500 degrees Celsius for 4 hours and then weighed. The mass lost indicated amount of organic matter in soil, allowing us to find differences in soil composition between patches. We ran an Independent Samples T-test using an alpha value of 0.05.

RESULTS

Species diversity

The difference in species diversity was not significant between the *P. australis* patches and the native patches, but we did find a change in species density. For instance, our data shows that the proportion of silverweed, *Potentilla anserina*, incresed from 2% in the *P. australis* patches to 13% in the native patches. Also, in one patch, the proportion of Dune grass, *Ammophila beviligulata sp.*, increased from 0% in native patches to 10% in P. *australis.* The Shannon Weiner index shows that species composition changes for *P. australis*2 (Phrag2) and native2, but biodiversity remains consistent amongst these two patches (Figure 1). Site1 (consisting of *P. australis1* (phrag1) and native1) had a biodiversity index of between 0.6 and 1.4. Site2 (consisting of *P. australis*2 (phrag2) and nativ2) ranged in biodiversity indices of 0.2 to 1.0.

Litter Decomposition

Our data shows that the proportion of litter degradation was significantly higher for native packs than for *P. australis* packs (P=0.00, df=14, t=-8.275) (Figure 2).

Organic Matter

We found no significant variance between the *P. australis* patches and the native patches. (P=0.237, df=30, t=-1.208). However, when we compared the two native patches using the same test (figure 3), organic matter varied significantly (P = 0.001, df = 14, t = 4.461). Also, we found a significant difference in organic matter between "*P. australis*1" and "Native1" (P=0.011, df = 14, t = -2.927) (Figure 3).

Soil Moisture

We found a significant difference between the *P. australis* patches and the native patches (Figure 4). In addition, when we compared the two *P. australis* patches, we found soil moisture varied significantly (P = 0.00, df = 14, t = 14.011). Moisture also varied significantly between the two native patches (P=0.00, df = 14, t = 5.511) and between *P. australis*2 and Native2 (P = 0.00, df =14, t = -9.870) (Figure 4).

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Figure 1

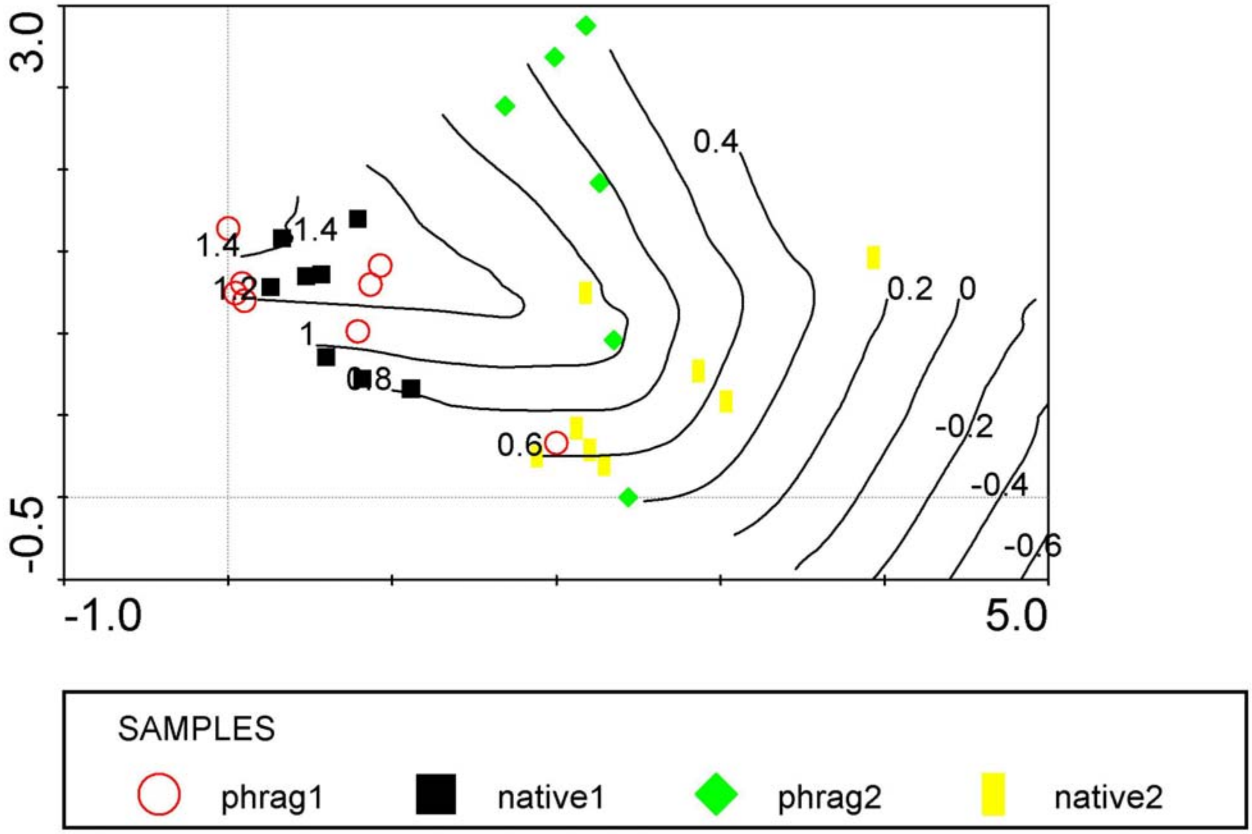


Figure1. Shannon-Weiner diversity indices for shoreline species, showing patch phrag1 (*P. australis1*) and native1 to have relatively the same level of biodiversity. Species composition changes for phrag2 and native2 but biodiversity remains consistent amongst these two patches. Site1 (consisting of phrag1 and native1) had a biodiversity index of between 0.6 and 1.4. Site2 (consisting of phrag2 and nativ2) ranged in biodiversity indices of 0.2 to 1.0.

Figure 2

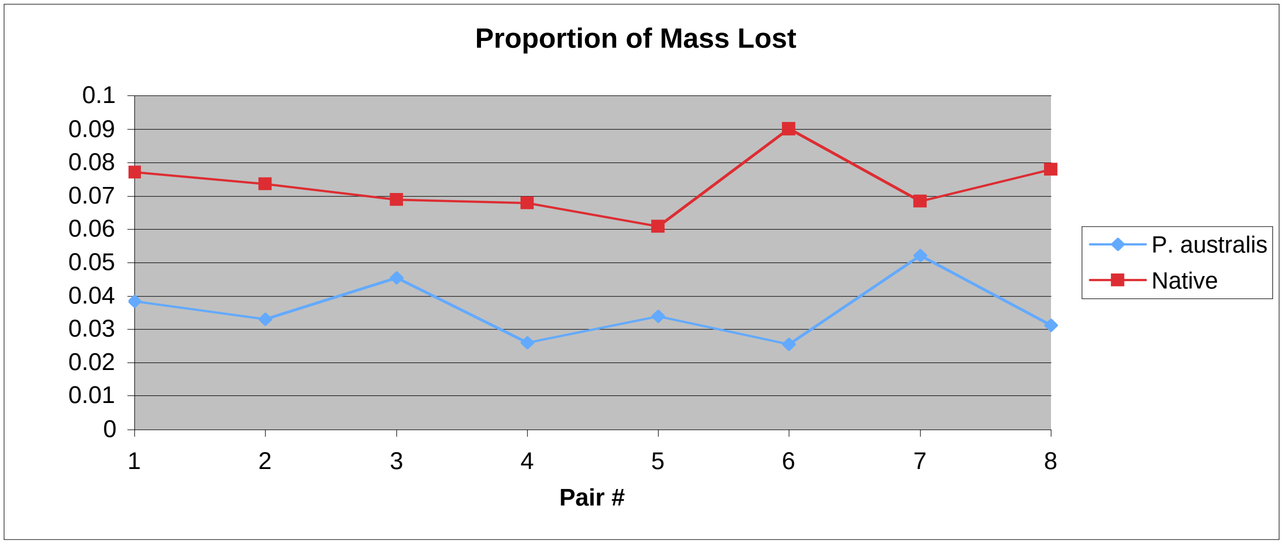
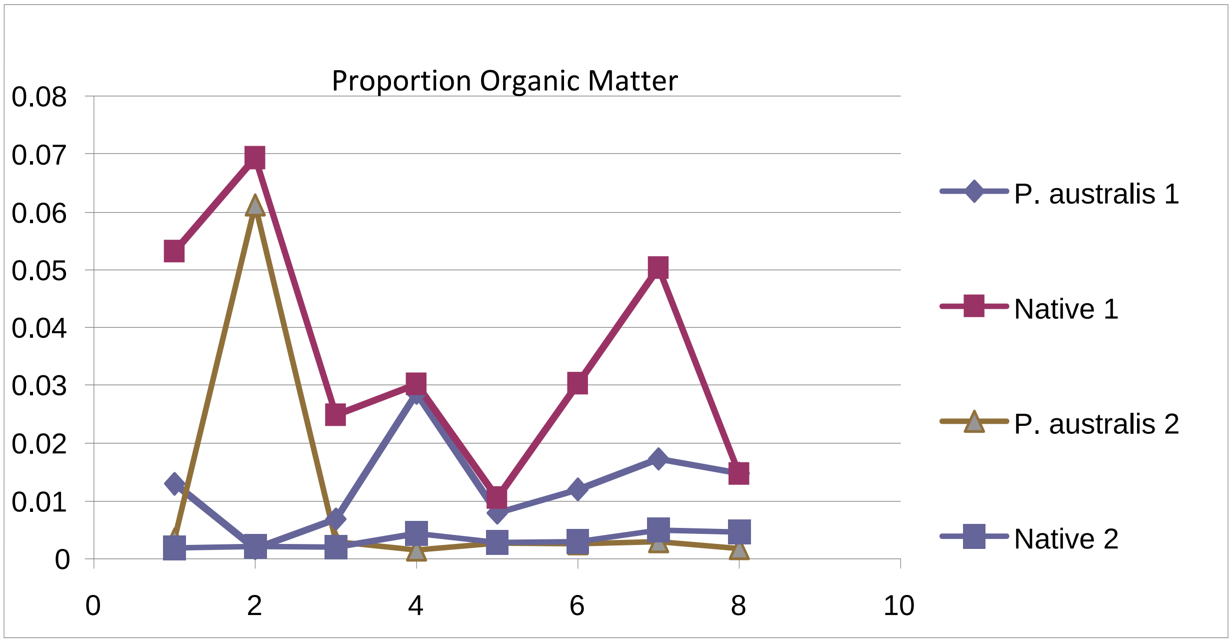


Figure2. This graph shows each litter packet's decomposition rate and compares *P. australis* litter to native litter packets that were paired in experiment location. There were 16 packets submerged in the same water 8 comprised of native litter and 8 comprised of *P. australis*. of The *P. australis* litter was consistently lower than 0.05 in proportion of mass lost while native litter was consistently above 0.06 for each value.

Figure 3



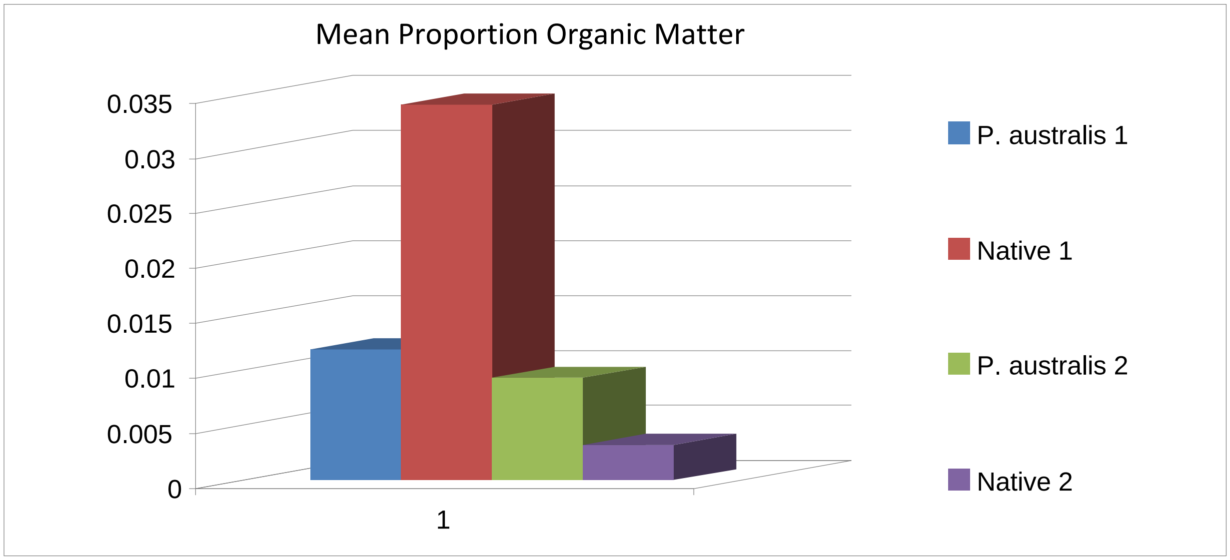
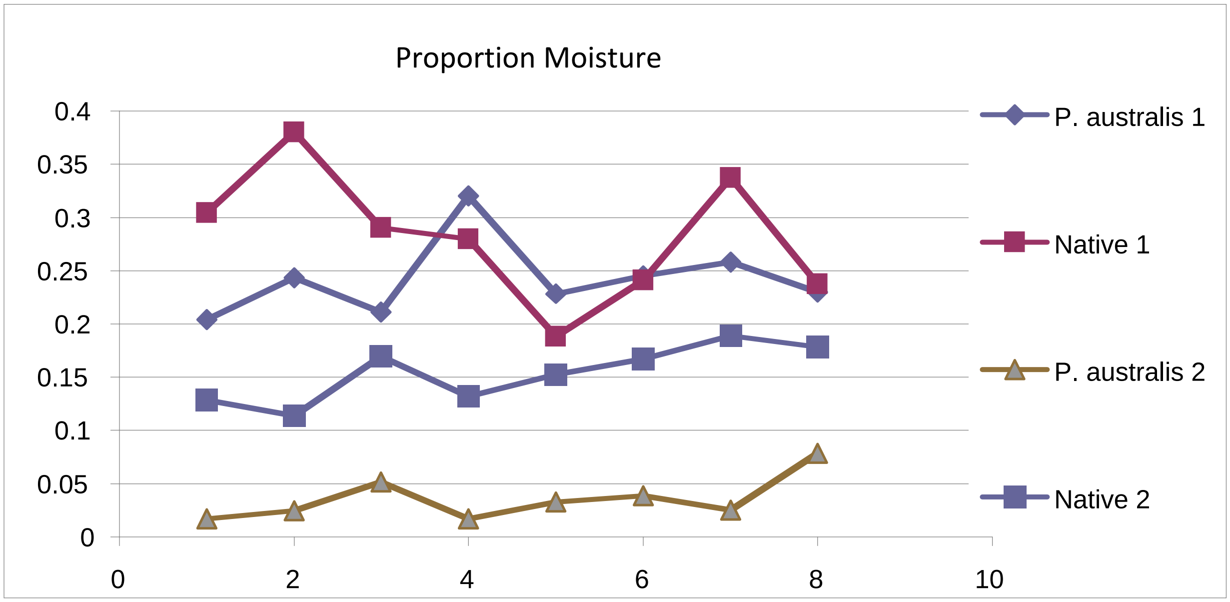


Figure 3. Mean proportion organic matter for soil samples taken in each quadrat at both sites and amongst all four patches. The proportion organic matter and mean proportion organic matter was highest (0.034 mean) and Native2 the lowers mean proportion organic matter (0.003). Overall, no general trend was found amongst *P. australis* patches and native patches.

Figure 4



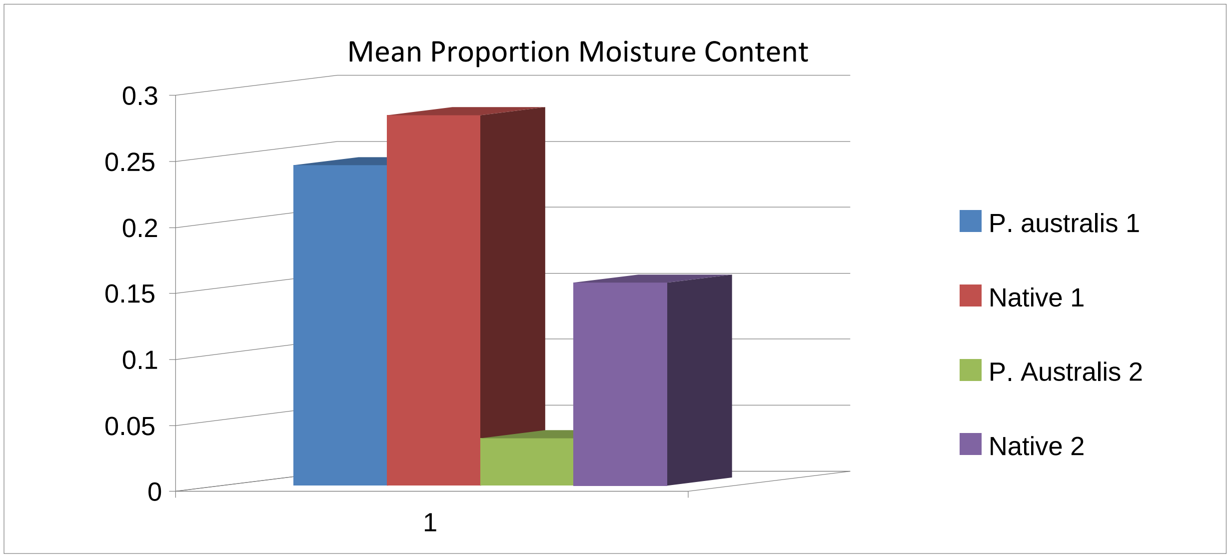


Figure 4. Mean proportion moisture for soil samples taken in each quadrat at both sites and amongst all four patches. The mean proportion moisture content was significantly different amongst sites, and at both sites *P. australis* has lower proportion moisture content on average than native soil patches.

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