# The Abundance and Impact of Alien Annual Grasses on Hantam-Roggeveld Dolerite Renosterveld Vegetation at Nieuwoudtville, Northern Cape, South Africa.

Final Draft Paper

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**Abstract**

Alien annual grass species have been identified as a particular threat to the vegetation types that occur within the winter-rainfall region of South Africa. However, the impact that these grasses have on plant species richness in invaded areas is not well documented. In this study the impact alien annual grass species have on the plant species richness of Hantam-Roggeveld Doelrite Renosterveld is investigated. Data on the abundance of alien grasses and plant species richness was collected at 9 sites using 32 1m$^2$ samples at each site, giving rise to a total of 288 samples. The dominant alien annual grass species within the study area are Wild Oats, *Avena fatua* and Ryegrass, *Lolium rigidum*. Wild Oats was found to occur in 94% of the 288 samples, while Ryegrass occurred in 48% of the samples. Regression analysis revealed a significant relationship between both *Avena* and *Lolium* abundance and plant species richness. Although highly significant, the regression coefficients were very low, with *Avena* accounting for only 5% of the variance in the data and *Lolium* 12%. The data set however did not include very heavily infested areas where an impact is most likely. Indeed, the data indicated that impacts on species richness appear to become apparent only when the abundance of the alien grasses exceeds 30% relative cover, suggesting that the impacts in heavily infested areas may be more severe. Despite being less common, Ryegrass appeared to have a more severe impact on plant species richness than Wild Oats. This is most likely due to the ability of Ryegrass to establish quickly and form dense stands which smother indigenous species. Contrary to other studies, small-scale soil disturbances in the study area appear to alleviate rather than exacerbate the alien grass problem. The results of this study suggest that at low to moderate levels of infestation, other factors such as grazing pressure should be viewed as a greater influence on plant species richness than alien grasses.

Keywords: *Avena*, *Lolium*, Wild Oats, Ryegrass, Alien plant invasion, Disturbance.

**Introduction**

Alien invasive grass species have recently been identified as a potential threat to the biodiversity and functioning of South Africa ecosystems (Milton 2004). However, despite such assertions, a review of the impacts of alien species within the region, in the same journal and issue as the Milton (2004) paper, does not even mention annual grasses (Richardson and van Wilgen 2004). How is such a discrepancy reconciled? Is the impact of alien grasses so trivial as not to warrant mention, or has a bout of hay fever affected our vision? Certainly, there are many indigenous grass species within the flora of the region and alien grass species may not be as conspicuous in their company as, for example, large woody acacias in the fynbos are. However, it is important to recognise that size does not determine impact, and there is ample evidence from ecosystems elsewhere demonstrating that alien grasses can have a severe impact (D'Antonio & Vitousek 1992, Milton 2004).

The winter-rainfall region of South Africa was identified by Milton (2004) as an area under particular threat from annual grasses. Although there appears to be increasing awareness of the role that alien grasses may be having in the region (Shiponeni 2003, Midoko-Iponga 2004, Shiponeni & Milton 2006), the number of published studies on their impacts is still minimal at this stage. To date, the research focus has been on understanding the mechanisms leading to alien grass invasion (Kemper et al. 1999, Van Rooyen 2003) as well as appropriate control methods (Musil et al. 2005, Ruwanza et al. 2008). The actual impact that alien grasses have on local ecosystems remains very poorly understood, both in terms of their impact on ecosystem processes such as fire regimes and nutrient cycling as well as the impact on plant and animal biodiversity in invaded areas.

The studies that have been conducted to date consistently demonstrate that disturbance appears to be driving factor associated with alien grass invasion. Kemper et al. (1999) studied South Coast Renosterveld fragments and found that although smaller fragments had similar species composition to large fragments, they contained a greater abundance of alien grass species, which they attribute the greater levels of disturbance prevalent in the smaller patches. Similarly, Van Rooyen (2003) found that grazing and small scale disturbances were the key drivers of alien grass invasion into West Coast Renosterveld and that these impacts were more severe than those associated with edge effects. Musil et al. (2005) investigated various control options for invasive grasses in the Tienie Versveld Reserve near Darling, and found that both fire and hand clearing of alien grasses increased alien grass abundance while only mowing and herbicide treatment were effective in reducing alien grasses.

Although some of the studies mentioned above have identified a relationship between alien grass abundance and indigenous plant species abundance or diversity, it is not clear from these studies whether or not alien grasses simply occupy the open space created by other disturbances or whether they actually outcompete indigenous species and replace them. The objective of this study is to address this issue by investigating the relationship between the abundance of the dominant alien grass species and the species richness of Hantam-Roggeveld Dolerite Renosterveld in the Nieuwoudtville area. Specific questions that will be addressed include:

- What are the most important alien grass species in the area in terms of their frequency and abundance?
- Is there are relationship between alien grass abundance and species richness?
- Do specific grass species appear to be more important than others in this regard?
- What are the management and conservation implications of the results?

## Methods

### Study area

The study was carried out in the Hantam-Roggeveld Dolerite Renosterveld vegetation type (Mucina and Rutherford 2006) in the vicinity of Nieuwoudtville. Although this is classified as a Renosterveld vegetation type, it is not similar to most other Renosterveld types in that shrubs are largely absent and *Elytropappus* in fact does not occur in the vegetation type at all. This vegetation type occurs on heavy red dolerite soils which swell during the winter months and crack extensively during the summer, which may explain the general lack of shrubs. However, in common with Renosterveld elsewhere, the vegetation has an abundance of geophytes and forbs, many of which are endemic to the area. Perennial grasses such as various *Ehrharta* species are abundant in less heavily grazed areas. Annual grasses particularly those that are usually associated with cereal cropping are a particular problem in the area. These grasses not only decrease the grazing value of the vegetation, but also impact the scenic quality of the vegetation for flower viewing during the spring. The extent to which these grasses impact the local ecosystem and indigenous plant biodiversity has not been examined. Grazing appears to be the primary driver of ecosystem dynamics in the area since fire does not appear to be a natural phenomenon in the vegetation type.

**Data Collection and Analysis**

The data set used in this paper consists of plant cover data collected using 288 1m$^2$ plots distributed across 9 sites. The 9 sites are distributed across the vegetation type in the Nieuwoudtville area and occur on several different farms. At each of the 9 sites, thirty-two 1m$^2$ plots were distributed across an area of 10x20m and all species occurring within each of the 1m$^2$ plots were recorded and their canopy cover visually estimated during the spring season of September 2002. While this data was collected for an alternative purpose, it is well suited to the current analysis since it allows the impact of alien grasses to be investigated at various scales, and contains a relatively large number of samples thereby increasing the possibility that any effect present will be detected. The sites were also distributed across a range of grazing pressures as well as alien grass abundance from lightly to fairly heavily infested.

When analysing patterns associated with alien grass abundance, it is important to recognise that a simple correlation between alien grass abundance and species richness does not imply that the one is affected by the other. For example, alien grass abundance may be high at sites with above average moisture, however, such sites are also likely to harbour greater than average species richness of indigenous species. Thus, such sites might lead one to conclude that alien grass abundance and species richness are positively correlated and hence, that alien grasses promote diversity! In order to circumvent such a possibility, the species richness data from the 1m$^2$ plots at each site was relativized by the maximum species richness recorded in a 1m$^2$ plot at that site. Thus the species richness at each site was scaled similarly, and different sites with inherent differences in species richness could be compared, and the local impact of the alien grasses properly assessed.

The data set containing the relativized species richness data was analysed in the following ways to determine the impact of alien grasses at the community and landscape level. Firstly, regression analysis based on the data from the 32 plots collected at each site was used to determine if there was a relationship between the abundance of the dominant alien grasses and species richness at each site. Since *Avena* can occupy a significant amount of the available space, it might be expected that samples with greater *Avena* abundance will have reduced abundance and species richness of other species. However, if the impact of alien grasses is fairly homogenous across a site, then it is unlikely that there will be a clear pattern between alien grass abundance and species richness at the site scale. At the landscape level an effect should however still be apparent if the alien grasses are having an effect. Thus in order to determine if alien grass abundance impacted species richness at the landscape level, the mean grass abundance and species richness from each site were used in a regression analysis. Finally, since taking the means of the data at each site, may obscure a pattern that is weak at each site, but nevertheless apparent, the data from all the plots was pooled and regression analysis used to investigate patterns between species richness and alien grass abundance.

**Results**

The most common alien grass species in the study area are Wild Oats, *Avena fatua*, Stiff Brome, *Brachypodium distachyon* and Ryegrass, *Lolium rigidum* (Table 1). Although Stiff Brome and Ryegrass occurred with equal frequency, the cover of Stiff Brome was much lower than Ryegrass. This is because Stiff Brome is a small species, seldom exceeding 10cm height in the study area. Due to its small stature, it does not appear to play an important role in the area in terms of affecting other species, and no relationships between this species and other vegetation parameters were detected in the analysis and it is not considered further. Wild oats was by far the most ubiquitous species, occurring in over 90% of samples. Ryegrass was not as widespread as Wild oats, but tended to dominate much more in those places where it did occur (Table 1), indicating that it may be more of a habitat specialist than Wild Oats.

At a local scale, there were few significant relationships between alien grass abundance and species richness (Figure 1, Figure 2). For Wild Oats, the relationship was neutral in most cases and significantly negative in only one case. For Ryegrass, the case for a direct local impact was somewhat more convincing, with a significant relationship in one out of four cases, and the slope of the regression being negative in all cases. Overall, this suggests that the influence of alien grasses operates at a broader scale than the community, or least the $1m^2$ sample size used in this study. This may because the primary mode through which grasses impact adjacent plants is not through competitive effects, but rather through more general effects such as dispersal or pollinator limitation which operate a slightly broader scale.

When all the data is pooled, a significant influence of alien grass abundance on species richness was detected for both Wild Oats and Ryegrass. Although both regressions were highly significant, the regression coefficients were very low, indicating that the effect is probably small compared to other effects such as grazing and edaphic influences. The regressions also suggest that the negative effects of alien grasses on species richness really only become apparent above 30% relative cover. Thus more severely infested sites than those sampled in this study may reveal a larger impact on species richness than detected here.

**Discussion**

Given the high cover abundance of alien grasses encountered in many of the samples, it might be expected that the impact of the alien grasses on species richness would be greater than that detected in this study. Wild Oats in particular, despite being highly ubiquitous, did not appear to have a large effect on species richness. There are several possible explanations for this low impact. Firstly, unlike many of the other annual invasive grasses, Wild Oats is relatively palatable to livestock, especially early in the growing season. As a result, it is one of the major forage species in the area and is to a certain extent, kept in check by livestock grazing. In fact, under heavy grazing pressure, Wild Oats may be eliminated and replaced by much shorter stature grass species such as the alien *Brachypodium distachyon* and the indigenous *Tribolium echinata*. In natural vegetation, Wild Oats appears to reach maximum abundance in sites that are continuously or near-continuously grazed at low to medium stocking rates. The growth cycle of Wild Oats may also play a role in limiting its negative impact. Wild Oats usually matures relatively late in the season and flowers only during mid September to mid October. By this time the majority of the indigenous species have already flowered and set seed and are probably little affected by the heavy shading associated with the tall flowering culms. Furthermore, observations indicate that the abundance of Wild Oats appears to fluctuate significantly over different years (Figure 4), and reaches a high biomass only during years of above average rainfall, particularly those with high rainfall late in the growing season. Years of low to moderate abundance may give indigenous annuals and geophytes an opportunity to recover their populations. In areas where grazing is less severe, it might be expected that the importance of biotic interactions will increase, increasing the probability that Wild Oats will have a negative effect on the other components of the vegetation.

Ryegrass appeared to have a larger impact on the species richness of the Renosterveld in the Nieuwoudtville area than Wild Oats. This raises the question as to what is different about the biology of Ryegrass as compared to Wild Oats. The key aspect in this regard appears to be the ability of Ryegrass to establish earlier than the indigenous species and gain a competitive advantage over them. Furthermore, Ryegrass is able to establish extensive seed banks, and under optimal conditions 45 000 seeds per square meter have been recorded (McGillion & Storrie 2006). Ryegrass also appears to be less preferred by livestock, which may mean that in areas dominated by Ryegrass, the indigenous species are the focus of livestock grazing, whereas in Wild Oats infested areas, the Wild Oats is the preferred species. Ryegrass has the ability to form very dense stands which not only compete directly with the indigenous species, but may also negatively affect them through the heavy mulching effect that develops in areas densely infested with Ryegrass (Figure 4). Dense mats of dead material can accumulate which appear to smother many emerging plants, preventing them obtaining sufficient light.

The results indicate that factors such as grazing pressure have a greater influence on species composition than the abundance of alien grasses. This suggests that alien grasses largely take advantage of open space created by disturbance, rather than actively invading and displacing indigenous species. However, it is important to recognise that while such disturbances may encourage the invasion of alien grasses, when the disturbance is removed, the indigenous vegetation is not likely to spontaneously recover and displace the alien grasses. In fact observations indicate that Wild Oats may in fact increase when grazing is removed. Again this appears to result from the fact that Wild Oats is quite palatable and tends to be reduced by heavy grazing. Local farmers who manage certain parts of their properties for flower viewing, regularly use heavy grazing pressure early in the wet season to reduce the abundance of Wild Oats and encourage colourful displays of annuals and geophytes. Whether or not the increase in Wild Oats that occurs when grazing is removed is short-term or if the effect persists indefinitely is not known at this stage. The establishment of the new Hantam National Botanical Garden in the area obviously represents an opportunity in this regard as it is not currently grazed by livestock.

Some studies have indicated that small-scale soil disturbances caused by small mammals such as mice and mole-rats aid the invasion of alien grasses (Van Rooyen 2003). However, in the study area, disturbances created by small mammals and in particular those created by porcupines appear to reduce the abundance of alien grasses. This effect appears to be somewhat contingent on the timing of the disturbance. Porcupine foraging activity during early winter after the grasses have germinated creates spaces free of alien grasses because they are removed from the area of the foraging pit, as well as buried in the area where the soil is deposited (Figure 4). Similar foraging during the summer probably has little effect on the distribution of grasses, but indications are that it certainly doesn't increase them. Since porcupines in the area may dig as many as 3000 diggings per hectare annually this effect may be considerable at the landscape scale (Bragg 2004). The difference in response to disturbance in the study area as compared to other studies may be attributable to the dolerite soil in the study area. This is a very loose soil type which cracks and crumbles extensively during the dry summer months, making it easy for seeds to establish almost anywhere. This is in strong contrast to the adjacent Nieuwoudtville Tillite Renosterveld which occurs on the tillite-derived soils of the area. This soil becomes almost impenetrable during the summer and is very hard and capped the majority of the time. Indications are that disturbances here may encourage the recruitment of alien grasses as they create sites which are suitable for grass establishment in an otherwise unsuitable environment. These results indicate that it is important to consider both the timing and context of soil disturbances when assessing their effect in aiding or reducing the impact of alien species.

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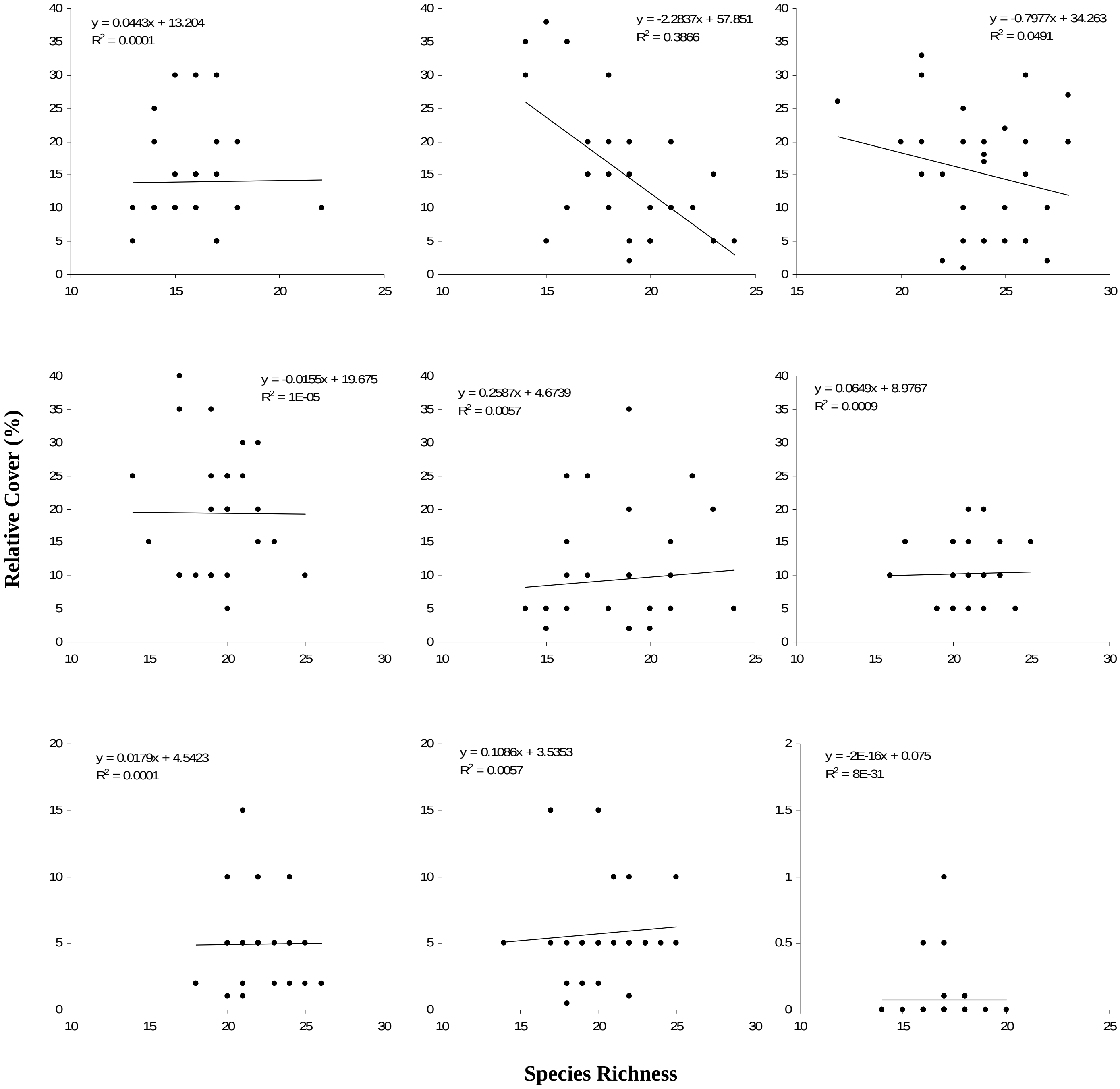
**Figure 2.** The relationship between the relative cover of Ryegrass, *Lolium rigidum*, and plant species richness in $1m^2$ plots at four of nine sites in Hantam-Roggeveld Dolerite Renosterveld vegetation around Nieuwoudtville. Ryegrass did not occur within the other five sites sampled and the graphs for these sites thus contain no data and are not presented.

**Figure 3.** The relationship between relativised plant species richness and the abundance of Wild Oats (a) and Ryegrass (b) in 288 $1m^2$ plots sampled at nine sites in Hantam-Roggeveld Dolerite Renosterveld vegetation around Nieuwoudtville. Both regressions are significant at or below the $P<0.0001$ level.

**Figure 4.** Various images of the Hantam-Roggeveld Dolerite Renosterveld in the Nieuwoudtville area. Clockwise from top left: Dolerite Renosterveld taken in January 2003, showing very little cover of alien grasses following a poor wet season. The same general area as depicted in the previous photo but during October 2007 following an above-average wet season, with a very dense stand of Wild Oats. An area disturbed by porcupines surrounded by dense early season vegetation comprising mainly Wild Oats, despite the foraging activity, a large number of geophytes can still be seen emerging from the disturbance. Finally, a picture of a dense stand of Ryegrass which has fallen over, forming a dense mat on the ground which is not grazed and which will prevent many species from emerging the following wet season.

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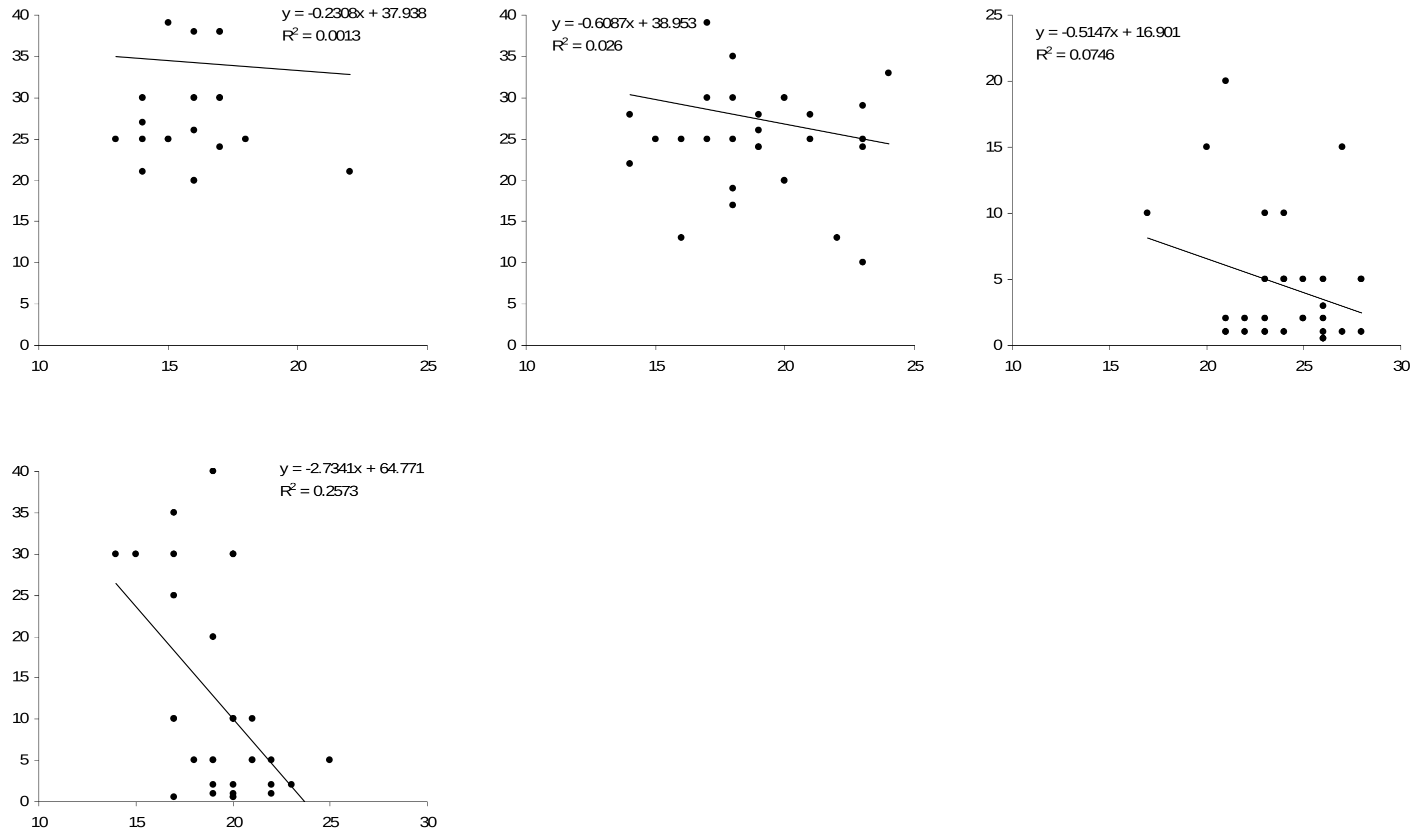


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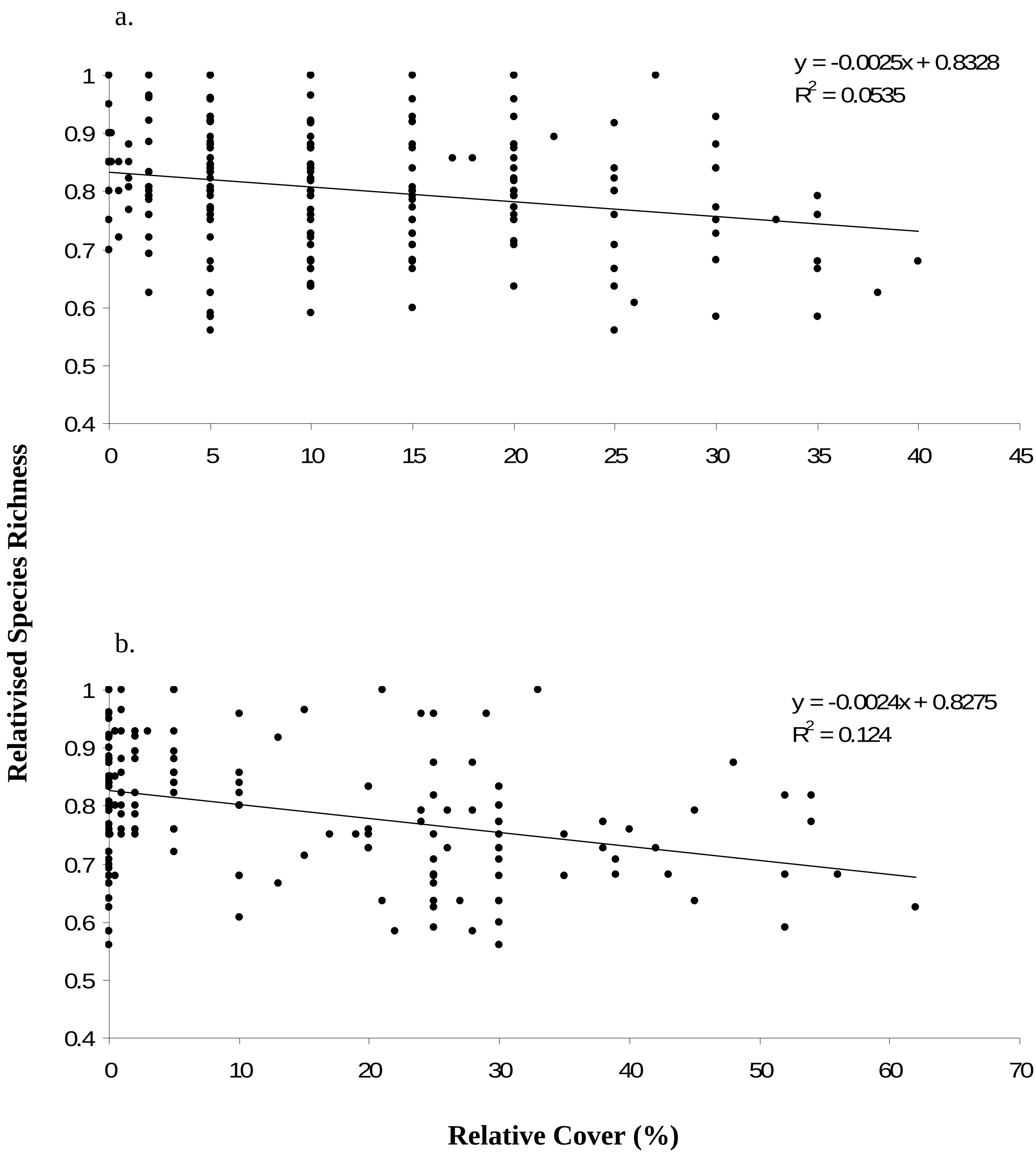


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**Table 1.** The six alien annual grass species recorded in the study and the frequency with which they were encountered in the 288 sample plots, as well as their local abundance, calculated as the mean cover in the plots in which the species was recorded as well as the overall abundance, calculated as the mean abundance across all samples.

| Species | Frequency (%) | Local Abundance (% Cover) | Overall Abundance (% Cover) |
|---|---|---|---|
| *Bromus diandrus* | 17.5 | 0.29 | 0.05 |
| *Hordeum murinum* | 1.43 | 0.30 | 0.004 |
| *Lolium rigidum* | 47.5 | 18.78 | 8.92 |
| *Brachypodium distachyon* | 47.9 | 8.23 | 3.94 |
| *Avena fatua* | 93.9 | 11.38 | 10.69 |
| *Phalaris minor* | 0.71 | 0.10 | 0.0007 |