INTRODUCTION

•Though the beneficial effects of arbuscular mycorrhizal fungi (AMF) to plants and ecosystems have been well documented, little research has been performed on AMF diversity or function in urban ecosystems. Distinguishing characteristics of urban ecosystems including spatial and temporal heterogeneity (McIntyre et al, 2001), higher proportions of introduced organisms (McDonnell and Pickett, 1990) and large areas of impervious surfaces (Vitousek, 1997) may influence AMF communities in urban environments compared with non-urbanized surroundings.

•The objectives of this project were to i) characterize the AMF community in terms of species composition, richness and spore density in the greater metropolitan area of Phoenix, Arizona, and ii) to identify potential factors (including soil type, vegetation, land use and land use history) influencing AMF community structure.

METHODS

•Three soil samples were collected from the rhizosphere of existing vegetation or bare soil at twenty sites representative of predominant land uses (agricultural, desert, residential, and urban) in the Phoenix metropolitan area as part of the Central Arizona-Phoenix Long Term Ecological Research (CAP-LTER) Survey 200 Pilot study in May, 1999 (Zisner, 2001).

•Spores were extracted from a subsample (50-100 cm^3) of each soil sample by wet sieving and sucrose density gradient centrifugation (Daniels and Skipper, 1982). Representative morphotyes were mounted on slides in polyvinyl alcohol-lactic acid-glycerol (PVLG) (Koske and Tessier, 1983) and PVLG mixed 1:1 (v/v) with Melzer's reagent and examined using a light microscope for identification.

•The percentage of healthy appearing spores in each sample was calculated and spore density was determined as the number of spores per 100 cm^3 soil. Species richness was determined as a count of the different AMF species detected at each site.

•Two generations of trap cultures were established to detect nonsporulating AMF species using a modification of the protocol by Stutz and Morton (1996) in which sudan grass plants were grown in 656 mL Deepots containing a 1:1:1 mixture of sample soil and steam-sterilized #20 and #12 grades silica sand.

•ArcView GIS layers were obtained from the Maricopa Association of Governments (land use; figure 5), National Cooperative Soil Survey (soil taxonomy; figure 6), and Landsat thematic mapper data (vegetation index; figure 7) and modified for analysis.

•One way ANOVAs were used to determine significant differences in AMF spore density and species richness among different soil orders, soil great groups, and land uses. Correlation of SAVI values with spore density and species richness was determined by linear regression analysis (SigmaStat).

RESULTS AND DISCUSSION

Spore densities were low (<50 spores /100 cm^3) in over half the samples and were significantly lower in agricultural sites versus desert or urban sites (figure 1). Low spore densities in many of the samples were expected due to the tendency for AMF to not sporulate in arid soils (Stutz and Morton, 1996). Conventional agricultural practices have been associated with decreased spore densities as well (Kurle and Pfleger, 1994).

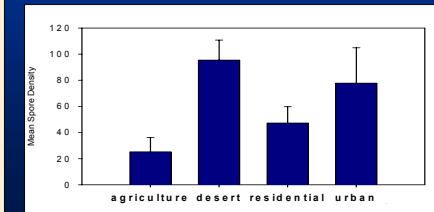


Figure 1. Mean spore density (spores/100 cm^3) in each land use category.

Patterns of species composition grouped according to current land use, land use history and plant host (figure 2). Cluster analysis showed that primarily urban and residential sites containing high proportions of nonmycorrhizal hosts were also similar in AMF species composition (see group 1). Other sites with highly similar species composition (see a, b, and c) were also similar to each other in host plants or land use history. Sites with the most dissimilar species compositions were previous-agriculture fields containing nonmycorrhizal hosts or no plants at all.

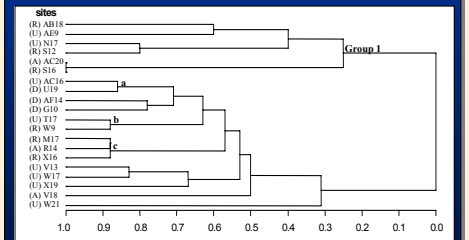
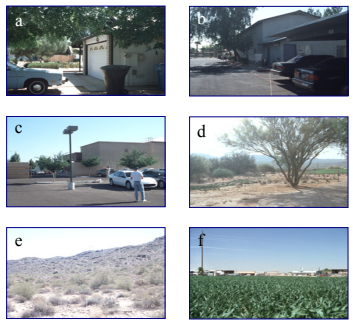


Figure 2. Complete-linkage cluster analysis based on percent similarity in species composition (R, Residential land use group; U, Urban; A, Agriculture; D, Desert).



Images of selected sites show range of characteristics in land use groups. a) Residential (mesic, small lot); b) Residential (high density apartment complex); c) Urban (commercial car lot); d) Urban (disturbed desert adjacent to golf course); e) Desert; f) Agriculture.

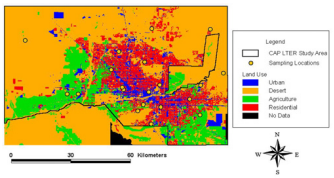


Figure 5. Land use types in the CAP-LTER study area.

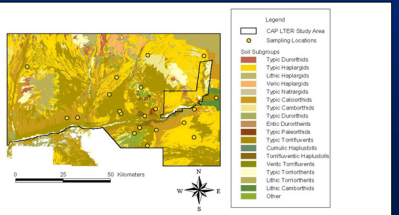


Figure 6. Soil subgroups in the CAP-LTER study area.

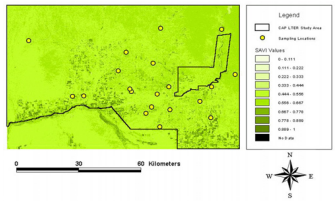


Figure 7. Soil adjusted vegetation index values for the CAP-LTER study area. Higher numbers indicate higher vegetation density.

Based on GIS analyses, there were no differences in AMF species richness or spore abundance among the land use types or soil taxa sampled. Species richness and spore abundance were not correlated with vegetation density. The land use classifications and soil taxa used in this study may have been too broad to adequately explain the variability present. Also, the use of classical soil taxonomy in urban areas may not be appropriate, as urban soils are significantly altered during development (Bullock and Gregory, 1991). Remotely sensed vegetation data may not be appropriate since they do not distinguish between mycorrhizal and non-mycorrhizal plants.

Eighteen AMF species were detected, with four species (*Glomus eburneum, G. microaggregatum, G. intraradices,* and *G. spurcum*) detected at nearly all sites and across all land use categories (table 1). Nearly all species in this study have been detected in other Sonoran desert localities (Stutz et al., 2000). The four predominant species detected are common to this region, indicating that some species persist through land change and/or dispersal from the surrounding desert.

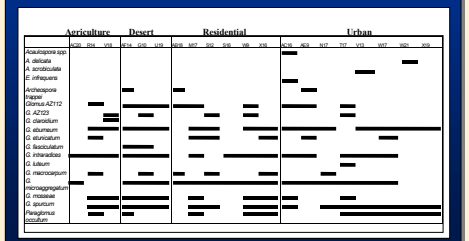


Table 1. AMF species detected across the sites and land use categories.

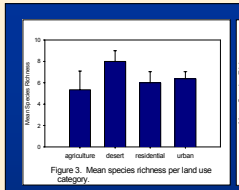


Figure 3. Mean species richness per land use category.

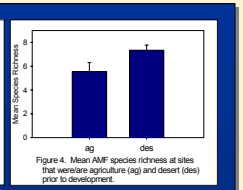


Figure 4. Mean AMF species richness at sites that were/are agriculture (ag) and desert (des) prior to development.

Mean species richness (6.35±0.5) was comparable with that of other Sonoran desert studies. No significant differences in species richness were found according to current land use (figure 3), but sites developed from agricultural land had lower species richness than sites developed from desert (figure 4). That no differences in species richness were found between land use groups was likely due to within-group variability in site characteristics. Species richness was most related to land use history, particularly if land was agricultural prior to development. Studies have associated agricultural practices with altered AMF populations (Kurle and Pfleger, 1994; Johnson, 1993), and based on our findings these changes persist over long time periods.

CONCLUSION

•AMF community structure in the Phoenix metropolitan area is comparable to that of the surrounding desert. However, current and historically agricultural sites were associated with decreased spore densities and decreased species richness, indicating that certain anthropogenic activities do impact AMF communities with effects persisting over long time periods.

•Similarities in AMF species composition between the urban environment and surrounding desert indicate a persistence or in-migration of desert AMF species. Changes in composition appear to be due to existence of nonmycorrhizal plant hosts, absence of vegetation, and land use.

•Because of the heterogeneity of site characteristics within land use groups, further studies on the effect of urban land use on AMF diversity should focus on differences within such groups. Moreover, future studies should investigate differences in AMF functioning under different land use regimes.

REFERENCES

Bullock, P. and Gregory, P.J. 1991. Soils in the Urban Environment. Blackwell, Oxford.

Daniels, B.A. and Skipper, H.D. 1982. "Methods for the recovery and quantitative estimation of propagules from soil." *In* Methods and Principles of Mycorrhizal Research. *Edited by* N.C. Schenck. American Phytopathological Society Press, St. Paul, Minn. Pp. 29-35.

Johnson, N.C. 1993. "Can fertilization of soil select less mutualistic mycorrhizae?" *Ecological Applications*. **3**(4): 749-757.

Kurle, J.E. and Pfleger, F.L. 1994. "The effects of cultural practices and pesticides on VAM fungi." In *Mycorrhizae and Plant Health*. Ed. F.L. Pfleger and R.G. Linderman. APS Press, St. Paul, Minnesota. Pp.101-131.

McDonnell, M.J. and Pickett, S.T.A., 1993. "Scope and need for an ecology of subtle human effects and populated areas." *In Humans as Components of Ecosystems: the Ecology of Subtle Effects and Populated Areas*. Springer, New York, NY.

McIntyre, N.E., Rango, J., Fagen, W.F. and Faeth, S.H. 2001. "Ground arthropod community structure in a heterogeneous urban environment." *Landscape and Urban Planning*. **52**: 257-274.

Stutz, J.C., Copeman, R., Martin, C.A. and Morton, J.B. 2000. "Patterns of species composition and distribution of arbuscular mycorrhizal fungi in arid regions of southwestern North America and Namibia, Africa." *Canadian Journal of Botany*. **78**: 237-245.

Stutz. J.C. and J.B. Morton. 1996. "Successive pot cultures reveal high species richness of arbuscular endomyccorhizal fungi in arid ecosystems." *Canadian Journal of Botany*. **74**: 1883-1889.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., Melillo, J. 1997. "Human domination of Earth's ecosystems." *Science*. **277**: 494-499.

Zisner, C.D. 2001. "Survey 200." <caplter.asu.edu/survey200/>. Accessed 23 May 2001.

Acknowledgements--This research was funded in part by the Central Arizona-Phoenix Long Term Ecological Research Project.

CAP LTER Central Arizona-Phoenix Long-term Ecological Research