

Hidden pools of nitrate in emerging sustainable landscapes

A tradeoff between conservation and contamination?

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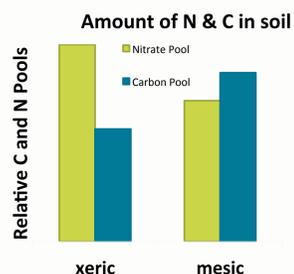
Are Xeriscapes Sustainable?

- 80% of the US population lives in urban areas. The increasing population density and expanding area of cities has contributed to pressure from federal and state mandates that encouraged cities to adopt new sustainable practices¹.
- In Metropolitan Phoenix, residents are encouraged through financial rebates to conserve their water intensive grassy lawns (mesic landscapes) to alternative landscapes that help conserve water by using drip irrigation and sparse drought tolerant plants (xeriscapes).
- The prescribed steps to convert a lawn to xeriscape include²:
 - Kill grass (herbicide or stop watering), then till soil to mix dead grass in or remove grass using a turf cutter. Dead grass left on site will increase organic matter content of soils.
 - Install drip irrigation. Drip irrigation will keep the spaces under plants more moist, and spaces between plants more dry.
 - After grass is removed, widely spaced shrubs are planted in the soil. Low, heterogeneous plant biomass may lead to low rates of plant nutrient uptake.
 - Cover soil with rock mulch to retain soil moisture.
 - Optional: routinely remove any dead leaves or debris that fall from the shrubs/trees.
- After a xeriscape is installed, sparse vegetation may lead to low rates of plant nutrient uptake. Under these circumstances, plant matter from the turf grass is left to decompose in soils, with few pathways to the atmosphere or living biomass (Fig. 1 & 2)^{3,4,5}.

Questions and Hypotheses:

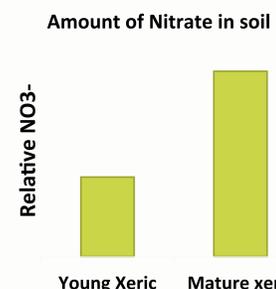
1. How do soil nutrient pools vary between residential landscape types?

- N pools will be larger in xeriscapes than mesic lawns and Carbon (C) pools will be greater in mesic lawns than xeriscapes.



3. How do xeriscape N pools and potential loss vary across time? How do N fluxes in xeriscape of different age compare to N fluxes from mesic lawns?

- A xeriscapes potential to either accumulate or leach nitrate will be different from a mesic system and the extent of differences will be different depending on its age.



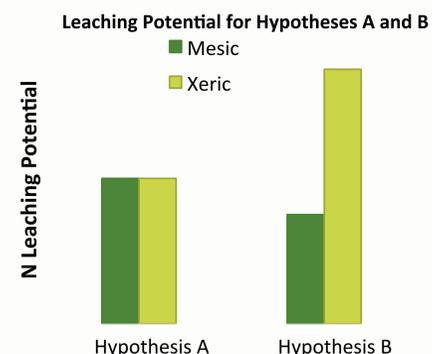
2. What are the mechanisms regulating N pool and flux patterns?

- Differences in nutrient pools between mesic and xeric systems will depend on soil moisture, landscape age, nutrient inputs, and plant cover.

4. How do water inputs impact the rate of soil N transformation and the potential for N leaching in residential landscape types? How do water inputs influence the physical location of N in soils?

- A. Increased water inputs will lead to a smaller available N pool due to an increase in plant uptake of water and N in both landscapes.

B. Increased water inputs will cause downward vertical movement of N in xeric soils. A large precipitation event will cause a disproportionate flux of N in leachate, specifically in inter-plant space, where plant uptake is not a factor. Mesic lawns will be able to utilize larger quantities of water because of greater plant biomass and homogenous distribution



Assessing Nitrogen in Xeriscapes

To explore if and how xeriscapes function as hot spots of N losses, I will compare soil N and C pools and N solute fluxes in xeriscapes and mesic yards. Xeric yards will be of varying age to assess differences in N over time.

Resin Bags:

To assess inorganic nutrients in solution. When in solution, nutrients are mobile in the soil.

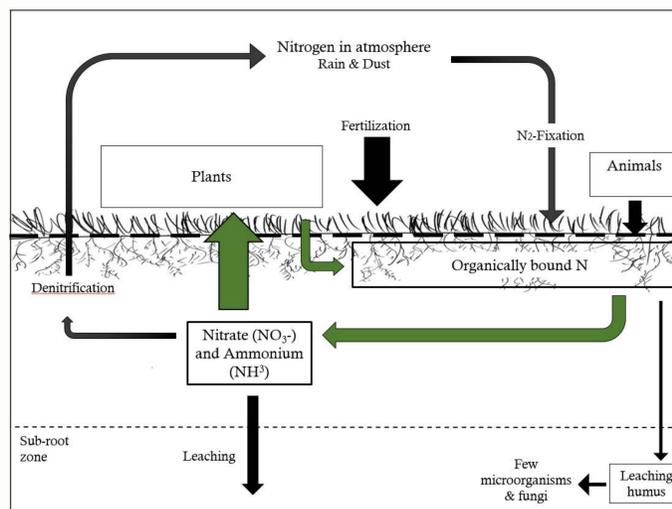
Soil Cores:

To assess inorganic nutrient content and basic soil properties.

Irrigation Addition:

To test the function of moisture in driving belowground nutrient movement.

In the Phoenix Metropolitan Area



Size of box indicates pool size. Size of arrow indicates flux size.

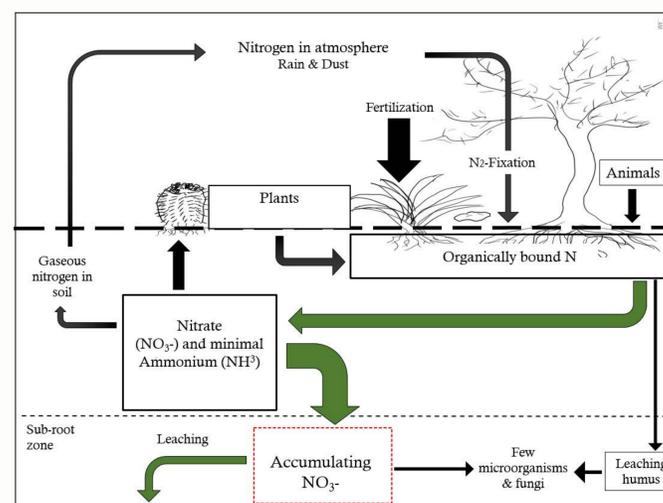
30 Mesic Landscapes

Figure 2. Nitrogen Cycling in residential mesic landscapes. A mesic lawn has the structure to recycle nitrogen in the system with little leaching.



30 Xeric Landscapes

Figure 1. Nitrogen Cycling in a xeric residential landscape. Diagram shows potential for a xeriscape to accumulate or leach large amounts of inorganic N.



Predicted Results

If a yard is converted from mesic to xeric groundcover, then low plant biomass and nutrient rich soil will lead to an excess of inorganic nitrogen. This nitrogen will accumulate at the bottom of the rooting zone or leach off the landscape.

- Xeriscapes have large pools of available N in sub-root soils and smaller C pools throughout the soil profile compared to mesic systems.
- The magnitude of difference in nutrient pools in mesic and xeric sites will be dependent upon the steps taken during conversion, the age of the site and the soil moisture.
- An initial pulse of N inputs will occur in the first 2 years after xeriscape conversion, then accumulation of N will occur at a slower rate. Accumulation rate will be dependent on soil moisture, as well as plant composition and fertilization rate.
- Older xeriscapes will have greater N pools than young xeriscapes. Older xeriscapes will have more time to accumulate belowground N. Accumulation is caused by fewer N outputs (via denitrification and plant uptake) than N inputs to the soil (fertilization, N-fixing plants, deposition).
- An accumulation of N in deeper soils may occur through vertical aquatic nutrient transfer. With elevated soil moisture, N transformations will occur at a higher rate and lead to faster accumulation of inorganic N in soils.

Broader Impacts

- My research has important implications for the success of current water conservation measures in a desert city.
- Without ecological analyses of both the benefits and disadvantages of alternative land-covers, future land management could reduce local ecosystem services and even create ecological dis-services.
- If xeriscapes create a tradeoff between water quality and water use savings, then this type of landscape will not be an ideal conversion or water conservation measure in the Southwest or across North American biomes.
- This information will be useful to urban planners, landscape designers, and local municipalities as they decide on the best ways to conserve water in urban areas.

References

- United States Census Bureau. 2010 Census Urban Area Facts. US Department of Commerce: 2010. Report nr No. 0607-0919-C.
 - Davies, Rachel, and Sharon J. Hall. "Direct and indirect effects of urbanization on soil and plant nutrients in desert ecosystems of the Phoenix metropolitan area, Arizona (USA)." *Urban Ecosystems* 13, no. 3 (2010): 295-317.
 - Walvoord, MA., Fred M Phillips, Davis A. Stonestrom, R Dave Evans, Peter C. Hartsough, Brent D. Newman, and Robert G. Srigl. 2003. "A reservoir of nitrate beneath desert soils." *Science* 302, 5647: 1021-1024.
 - Reichmann, Lara G., Osvaldo E. Sala, and Debra PC Peters. "Water controls on nitrogen transformations and stocks in an arid ecosystem." *Ecosphere* 4, no. 1 (2013): art11.
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- Images: [http://commons.wikimedia.org/wiki/File:HarringtonBirchett_House_\(Tempe,_Arizona\).jpg](http://commons.wikimedia.org/wiki/File:HarringtonBirchett_House_(Tempe,_Arizona).jpg); http://www.goodearthlandscapeco.com/c_7/Landscaping-Xeriscape-.htm