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 practices.
- 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 smaller drought-tolerant plants (xeriscapes).

The prescribed steps to convert a lawn to xeriscape include:
1. Kill grass (herbicidal or spot 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.
2. Install drip irrigation. Drip irrigation will keep the spaces under plants more moist, and spaces between plants more dry.
3. 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.
4. Cover soil with rock mulch to retain soil moisture.
5. 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).

Questions and Hypotheses:

A tradeoff between conservation and contamination?
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).

1. How do soil nutrient pools vary between residential landscape types?
2. What are the mechanisms regulating N pool and flux patterns?
3. How do xeriscape N pools and N fluxes from mesic lawns compare to N fluxes from xeriscape of different age? Amount of N & C in soil
4. How do water inputs impact the rate of soil N transformation and the potential for N leaching in residential landscape types? Amount of N & C in soil
5. Differences in nutrient pools between mesic and xeric landscapes will depend on soil moisture, landscape age, nutrient inputs, and plant cover.

When in solution, nutrients are mobile in the soil.

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

In the Phoenix Metropolitan Area

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.

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

30 Xeric Landscapes

Figure 1. Nitrogen Cycling in a xeric residential landscapes. 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.

Xeriscape large have 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


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