Fact Sheet – The Newly-Rebuilt Lysimeter Facility
at the
UC Hopland Research and Extension Center

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What Is A Lysimeter?
A lysimeter is a device to measure the quantity or rate of downward water movement through a block of soil and for collecting such percolated water for water quality analysis.

About the Lysimeter Facility
For more than 45 years, the UC Hopland Research and Extension Center (HREC) has maintained a unique research lysimeter facility—a set of 36 to 72 soil columns, used to measure leaching of compounds such as fertilizers and other plant nutrients as they travel through soil, carried by rainfall.

The amount and quality of water that flows through (“leaches” from) terrestrial ecosystems into rivers and streams is a major concern for land management world-wide, and is a particularly critical issue in California. When the land is unable to store or slow down the flow of water, major flooding and erosion can occur during storm periods. Moisture stored in soil is also critical for supplying water to both native and agricultural plants between rainfalls and after rainfall has ceased for the season. Water storage in the soil allows for more gradual release of water into streams and rivers—providing water for human and wildlife use by extending stream flow through some dry periods.

The water that leaches from the soil can also carry important dissolved compounds in it, both nutrients and pollutants. Loss of water-soluble nutrients can limit plant productivity, while the introduction of these nutrients into aquatic systems can decrease water quality for both wildlife and human consumption. Leaching of pesticides and pathogens can also have negative health and environmental effects. Nutrients can also be lost in the gaseous form. Lysimeter facilities allow the measurement of the loss of important greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, from soils and soil-plant complexes.

The Hopland lysimeter facility has recently been completely rebuilt, allowing it to again be used at full capacity to study such natural processes as water nutrient cycling in soils, plants, water, and air; and how land managers can better manage soils and plants in order to sequester carbon and to reduce pollutants in runoff that may negatively affect fish habitats or water for domestic use.

The Current Lysimeter Renovation
This recent renovation of the lysimeter facility, completed in October 2008, renewed and re-established 72 soil columns, each contained within 30-gallon steel drum tanks. The rebuilding was conducted by staff at UC-HREC, beginning in spring 2008. Funding was provided by a “Managed Ecosystems Program” grant from the National Research Initiative of the US Department of Agriculture’s Cooperative State Research, Education and Extension Service, which was awarded to Dr. Valerie Eviner, professor in Plant Sciences at UC Davis, and to Charles Vaughn, a researcher at UC-HREC. Additionally, HREC provided substantial labor and equipment contributions to this project. Total cost of the facility’s renovation was approximately $30,000.

Each steel tank is approximately 15 inches (38 cm) in diameter and 22 inches (56 cm) deep, and is plumbed to collect all water draining through the soil column for chemical analysis. The lysimeters are buried within a sloped hillside, which ensures natural soil microenvironmental conditions. The steel tanks also have a small lip above the level of surrounding soil, allowing them to be temporarily closed off to measure gas emissions from these soil columns. This facility is adjacent to the Center’s greenhouse, allowing access to irrigation.
During rebuilding of the lysimeter facility, it was found that the existing steel tanks were in essentially pristine condition, so they were able to be re-coated with an asphalt emulsion and re-installed. A soil filter fabric layer was placed directly on the bottom of each tank, overlaying the drain screen. Two inches of Monterey #20 clean sand was placed in the bottom of each tank, covered with another filter fabric cloth layer. Then, 13 inches of “B” horizon Laughlin soil was placed above the filter cloth, with any large cobble rock greater than 2 inch-diameter size removed by hand. Six inches of “A” horizon Laughlin loam was then placed above the “B” horizon layer, leaving about an inch of clearance to the tank lip. Laughlin soil is a typical HREC grassland soil in the North Coast region, and the soil used to fill the tanks originated on the Center’s property.

**Planned Research Uses**

For the next few years, this facility will be used to investigate questions funded by the USDA-NRI grant that supported the rebuilding of this facility. Dr. Eviner and her students and colleagues will focus on investigating rangeland dynamics and management to maximize forage quantity and quality, as well as soil carbon storage, while minimizing erosion, weeds, and nutrient leaching. In particular, this research seeks to better understand the key mechanisms underlying these processes in California’s annual rangelands. Despite decades of research in California’s rangelands, there are some substantial gaps in our understanding of the fundamental processes controlling this system:

1. Current estimates of plant nitrogen (N) sources (the sum of: litter decomposition, soil organic matter turnover, N deposition, N fixation) are lower than actual plant uptake; which is to say, an important source of plant nitrogen has not been accounted for
2. We have poor ability to understand and manage the variability in plant productivity across sites and years.

Both of these mysteries can be resolved by accounting for an overlooked source of N: high seed production, and subsequent death of those seedlings. In essence, plant nutrient supply and growth is fueled by dying grass siblings during the growing season. Recent work by Dr. Eviner and Charles Vaughn at HREC shows that 37-63% of annual N supply originates from the dying seedling pathway. However, we don’t know the timing and fate of these different N sources, or the ability of plants to take up different N sources.

The new lysimeter facility will be used to track nitrogen and carbon from plant litter, soil organic matter, and seedling thinning to assess how each of these sources differ in nutrient loss from the system, in the importance of supplying N to support plant growth, and in their contribution to soil storage of nitrogen and carbon. Plants have been grown with special “labels” (stable isotopes) to follow the nitrogen and carbon from each source.

*Application:* Currently, sustainable rangeland management practices are focused on residual dry matter (RDM) – the amount of above-ground plant material remaining at the start of a new growing season. This has limited ability to affect plant productivity and nutrient loss. Understanding the contributions of seed density and seedling thinning to these processes will increase our effectiveness and options to manage California’s rangelands.

Potential future projects include the study of impacts of restoration practices on water quality and quantity (e.g., seeding rates, composition, soil treatments); and study of impacts of different range management practices on carbon and nutrient storage and loss.

**Examples of Past Work in this Facility**

More than four decades of research at this facility have investigated such questions as:

- The effects of native vs. exotic grassland species on water loss, nutrient cycling, nutrient loss, and soil microbial communities (Hawkes et al. 2005, Hawkes et al. 2006, Eviner and Hawkes, in preparation)
- Measuring the effects of sulfur fertilization on annual pasture S uptake and leaching losses, and nitrogen fixation (Shock et al. 1983, 1984)
- Measuring nitrogen fixation by subclover during simulated grazing (Phillips et al. 1983)
- Rates of uptake and leaching losses of nitrogen applied to annual pastures (Jones et al. 1974, 1977)
- The impacts of soil type and waterlogging on sulfur loss (Jones et al. 1968, 1971)

**History of the HREC Lysimeter Facility**

The first generation of a lysimeter facility at the “UC Hopland Field Station” was built in 1962. It was comprised of 36 tanks, each of which held 2.18 cubic ft. of soil. Soils were of three types and from three regions of California. This facility was used to measure the fate of different sulfur (S) fertilizers, applied to annual pasture plants over several growing seasons and under varying conditions.

The second generation lysimeter facility was constructed in 1972 and consisted of 36, 30-gallon steel drum tanks filled with Josephine soil, a typical HREC annual grassland soil. This study used stable isotopes of N to study how different rates and times of N fertilization of annual grassland plants affected N uptake and leaching losses. The amount of N fixed by pasture legumes was also estimated.

The third-generation lysimeter facility rebuild took place in 1978. A total of 72, 30-gallon steel drum tanks were used. These were filled with Laughlin soil, another typical HREC grassland soil. These lysimeters were used in two studies. One study determined how various combinations of annual grassland plants competed for S, and how much applied S was taken up by the plants versus leached through the soil column. A concurrent study, using isotope-labeled S and N, determined how plant combinations competed for both S and N, and how S applications affected nitrogen fixation.

*Dr. Milt Jones (lower left) and Brown San Diego (upper right), spring 1976*
References to Historical HREC Lysimeter Facility-Related Research


*Dr. Bill Williams at lysimeter, November 1962*