SERG Restoration Bulletin 5

Microcatchment Water Harvesting for Desert Revegetation

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Microcatchment Water Harvesting for Desert Revegetation

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Q. What is water harvesting?

A. Water harvesting involves altering the topography and surface of a site to direct limited desert rains to plants. It is used in many arid and semi-arid regions of the world for both economic and environmental reasons and should be more widely used for revegetation projects.

Q. Where were microcatchments invented?

A. Ancient desert civilizations developed very effective systems for harvesting rain water in many parts of the world, including Australia, the Southwestern U.S., Africa and the MidEast. But

Seedlings in catchments

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no one developed these techniques to the level that the Nabateans did in the Negev desert (now Israel and Jordan) almost 2000 years ago. They used very sophisticated water harvesting to farm more than 700,000 acres in areas that only get 3-4 inches of rain a year. Israeli researchers were intrigued by these ancient Nabatean farms and, in the early 1960's, restored an area called Wadi Mashash to "relearn" these ancient water harvesting techniques. The positive results of the Wadi Mashash restoration inspired Israel to invest in water harvesting research as a means of supporting many types of crops and landscaping for desert parks.

Q. What is a microcatchment?

A. A microcatchment is a specially contoured area with slopes and berms designed to increase runoff from rain and concentrate it in a planting basin where it infiltrates and is effectively "stored" in the soil profile. The water is available to plants but protected from evaporation.

Water capture in catchments

Q. What are the advantages of microcatchments?

A. Microcatchment systems provide many advantages over other irrigation schemes. They are simple and inexpensive to construct and can be built rapidly using local materials and manpower. The runoff water has a low salt content and, because it does not have to be transported or pumped, is relatively inexpensive. Microcatchments enhance leaching and often reduce soil salinity. The use of microcatchment techniques in Arizona has returned land to productive use that was previously retired from agriculture due to high salt content from groundwater irrigation.

Q. What size is best?

A. Smaller individual catchments (microcatchments) have higher relative water yield per unit surface area than the larger runoff farm catchments. Modern microcatchment systems are typically small, sculpted basins which harvest runoff water in a laminar flow with water depth less than 1/8 inch and flow velocity less than 2.75 inches/sec. Catchment area can be tailored to provide an optimal runoff volume for individual plants.

Q. What have these microcatchments been used for?

A. Many crops have been grown using microcatchments, including citrus in North Africa. Water harvesting has also been used to supplement rainfall for native vegetation. Jojoba *(Simmondsia chinensis)* with microcatchments grew larger and produced more flowers and seeds than untreated plants (See Figure 1). Even native plants that are well adapted to hot, dry conditions will usually benefit from supplemental water. For example, creosote bushes *(Larrea tridentata)* adjacent to highways, cut slopes and other sources of runoff water are often much larger than shrubs not receiving runoff.

Q. What types of microcatchment systems are there?

A. There are three basic types of microcatchment systems: contour bench terraces, runoff strips and micro-watersheds. Runoff strips and contour bench terraces are best suited for agriculture as they require extensive mechanical re-shaping of the surrounding terrain and create regular patterns which are inconsistent with a natural landscape and revegetation project.

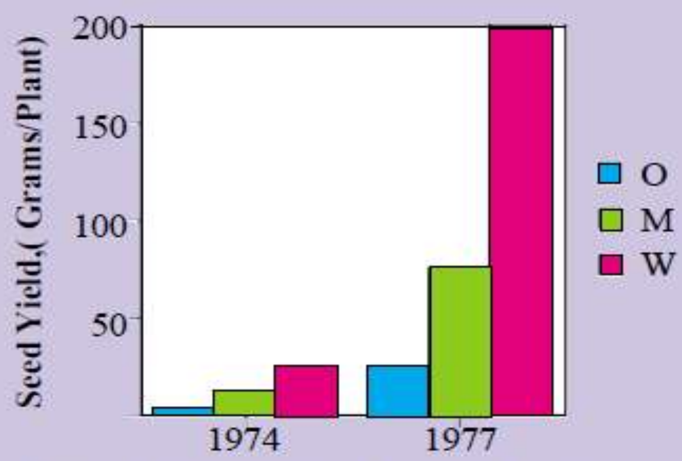


Figure 1: Seed production in Jojoba plants not receiving supplemental water (0) produce much less seed than those in microcatchments (M) and especilally those in wax treated microcatchments (W).

Micro-watershed systems are more appropriate for revegetation. These include mound, strip and basin collectors. In mound systems the soil surface is shaped by hand into 4-20 inch (10-50 cm) tall mounds spaced 2-5 meters apart. When organized into a regular pattern, this system is suitable for many types of farm crops, including melons and squash (this is one explanation for the mima mounds found in many semiarid areas). The mounds are also effective when arranged in a more random manner for revegetation and restoration efforts. In strip systems, either a recessed planting strip is bordered by ground level berms, or ground level strips are lined with raised berms. The strips can be built of earth or rocks with mechanical equipment or by hand. Basin collectors are most appropriate for most sites. These are dug by hand or with equipment.

Q. Where can microcatchment basins be used?

A. Microcatchments work best on gentle slopes (ideally less than 5%), but steeper slopes can be used if the catchment basins are small. Basins can also be made on flat ground.

Q. How are microcatchments made?

Microcatchment construction — Israel

A. The slope is divided into plots by small earth ridges 4-8 inches high and 8-14 inches wide. The ridges can be constructed by hand or with a small plow using the soil excavated from the planting basin. Catchment basins are susceptible to siltation and erosion if undesired runoff is allowed to enter the system, so protective diversion ditches and berms are often constructed above microcatchment areas subject to extensive ground flow.

The gradients within the microcatchments should be between 2% and 7%. Square or rectangular plots are easier to lay out, but basin shapes for revegetation sites should be irregular to suit the geography of the site, to reduce disturbance and to retain a more natural appearance.

Q. What information is needed to design microcatchments?

A. The hydrological data needed for an efficient design can be collected through observations over two to five years, even in areas with limited rainfall. Soil data on infiltration and runoff is also helpful.

Q. What has to be considered in site design?

A. Developing a site for microcatchments requires information on four main physiographic factors: the runoff producing potential, the soil surface condition (cover, vegetation, crust, stoniness), the gradient and evenness of slope and the water retention capacity of the soil in the root zone profile. These all contribute to the runoff threshold coefficient which is a key factor in determining the optimum size for a catchment. Other factors affecting the infiltration capacity of a particular area include the moisture content of the soil, macro-pores in the soil as a result of decaying roots or burrowing animals and the compaction of the soil.

Fruit trees in microcatchments — Israel

Q. How much water will they yield?

A. To determine expected yields from microcatchments, three rainfall characteristics must be evaluated: 1) the average annual rainfall, 2) peak rainfall intensity and 3) the minimum expected annual precipitation. The optimal size of the microcatchment for each species depends on many factors including normal precipitation, soil quality and the slope of the site. The size and depth of the planting basin in relation to the size of the catchment area is also important. These factors determine the size of the surface area wetted by runoff and the volume and depth of the water column in the soil. If the infiltration rate of the soil and the water demands of the plant are known, the desired size of a catchment basin can be calculated. If a particular species of shrub requiring 10 inches of rain per year is being grown in a region of 5 inch average annual precipitation, then an additional 5 inches of rain is needed. If the catchment soil has a runoff coefficient of 10% (a typical runoff rate for untreated desert soils), then a shrub with 10 square feet of root area (a young bush) would need a 100 square foot catchment (10 x 10). However, larger catchments are often used for insurance in very dry years.

Q. What can be done to enhance runoff?

A. Effective precipitation produces runoff, but modifying the soil surface can reduce the threshold required to get runoff. Basin runoff can be improved by defoliating the runoff area (an existing condition in many revegetation-restoration sites), by treating it with infiltration resistant compounds or by applying an impervious film. A tenth of an inch of rain equals more than one half gallon of water per square yard assuming 100% runoff. Materials used to enhance runoff include low melting point wax, sodium salts, synthetic membranes, asphalt and concrete and soil crusts.

Many types of synthetic membrane materials have been used to increase runoff. Plastic membranes, such as polyethylene and vinyl, have been used on hundreds of square miles of revegetation projects in China. They are very effective but generally last less than a year. Butyl rubber and chlorinated polyethylene sheeting last much longer. Any sheet type material is expensive and must be well secured to protect it from wind damage. A catchment system we built in Anza-Borrego Desert State Park provided water to storage tanks with as a little as 1/100 inch of rain. Asphalt, concrete and other hard surfaces can also be used to channel water to catchment basin plantings. Landscaping on streets and parking lots in Tucson is increasingly watered this way, and the potential for highway plantings is high, despite some water quality concerns from road surface runoff.

Catchment — Anza Borrego Desert State Park

Q. How do you build microcatchments?

A. The first step in constructing microcatchment basins is clearing the catchment area of weeds. Shaping can then be carried out with hand tools, plows or graders. Shaping is easier when soil moisture is near field capacity. The catchment area is smoothed with hand rakes following rough shaping. Soil treatments, if used, are applied after smoothing. The soil is compacted following the first rain storm. Compaction can be done by foot or with tools on small catchments, or with rollers on larger catchments.

Placing the catchment liner

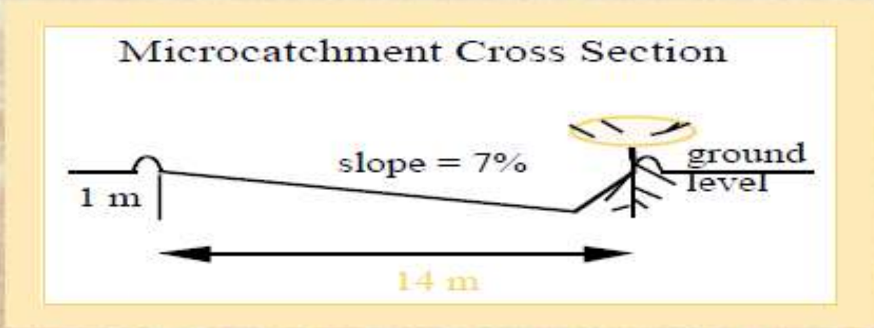
Basin size depends upon design requirements. Small basins can be constructed by hand labor, but larger catchments should be built with equipment. Basins should be shaped to form inverted truncated pyramids. The soil removed from the basin area is deposited and spread on the border ridges.

Q. How are they planted?

A. Microcatchments are typically planted with shrub or tree seedlings, but they can also be seeded. To take advantage of peak precipitation and favorable temperatures, plantings of native shrubs in the low desert should be planned before precipitation peaks. The soil around the planting spot should be loosened before planting as compacted soils retard tap root growth which can be essential for successful establishment. They can be watered with a water truck until it rains.

The best place to plant desert shrubs in catchments is usually immediately above the mean high water line, or near the top of the ridge where the topsoil from the basin is placed (Figure 2). Observations of conventional plantings reveal that both weeds and shrubs appear to thrive in such locations and are absent from the places where water stays longer.

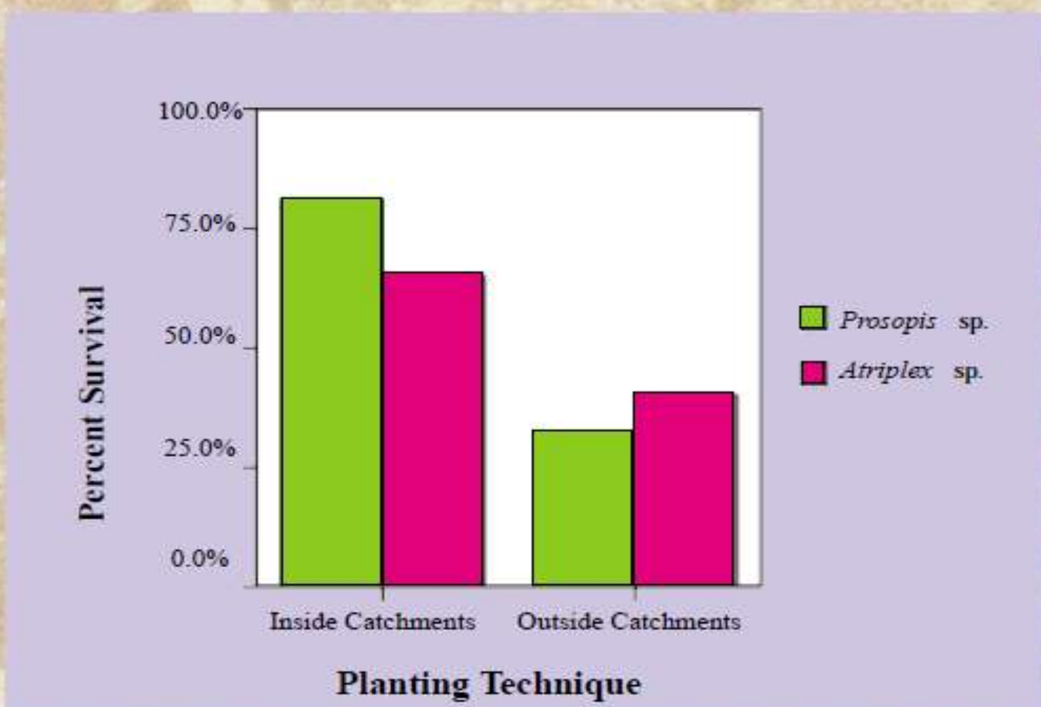
Figure 2. Planting on or near ridge tops protects plants from flooding. Water wets the soil above the water line by capillary action.



Q. Why aren't they used more often?

A. Microcatchments are an effective but little known technique for plant establishment and growth (Figure 3). As landscape designers and landowners become more familiar with them they will be used more often.

Figure 3. Fort Irwin Survival



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Report from the field

Fred Edwards and
David Bainbridge

Water harvesting - Jordan

Both of us have worked in developing countries. As we have worked, traveled and talked to people, we have become convinced that reversing desertification, reducing soil erosion and increasing production from arid and semi-arid regions are critical global issues. In developing countries, revegetation methods need to be economical and adaptable to hand labor, but in countries where labor costs are high, methods must be mechanized. Rainfall catchment construction can fill both needs. It is a simple technique adaptable to local labor and materials in drylands anywhere in the world. Like most revegetation techniques for arid lands, it does not work without rainfall; but, when the rain does come, rainfall catchments can be used to focus water where it will do the most good.

Like many great solutions to environmental problems, rainfall catchments are a reinterpretation of ancient techniques developed in the Middle East and Americas, but forgotten by modern science and technology. In the Mojave and Colorado deserts of California, we have found this simple technique can improve the survival of transplanted native seedlings by more than 20%. Because this technique is simple, additional construction costs are offset by the savings gained by increased survival and the reduced need to replant. We highly recommend this technique for restoration and revegetation projects undertaken in arid and semi-arid environments.

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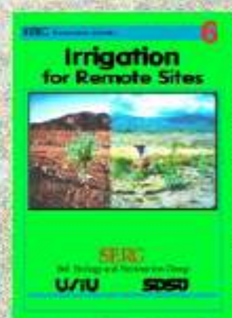

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